COMMERCIALIZATION AND ITS DISCONTENTS

By

NORAINI ABU TALIB

A Thesis Submitted to the Faculty of Management
in Fulfilment of the Requirement for the Degree of
DOCTOR OF PHILOSOPHY

UNIVERSITY OF STIRLING

2007

ABSTRACT

Since the late 1990s the government of Malaysia has increased emphasis on its Intensification of Research in Priority Areas (IRPA) program, focusing scientific research in universities and government research institutes (GRIs) on activities most likely to enhance national economic performance. The IRPA's main purpose is to fund commercially viable research for the benefit of business. However, its 2001 mid-term review showed its rates and volumes of commercialization and technology transfer (CTT) to be inadequate.

This study aimed to explain the perceived low rate of adoption and commercialization of scientific knowledge in manufacturing in Malaysia by exploring the actions of companies, universities and GRIs. Two main models of technical change, the *Technik* and the STH ones, were used.

Fieldwork was carried out in Malaysia. Purposive sampling led to selection of 60 interviewees: 23 managers and professionals from companies, 17 scientists, eight Technology Transfer Office officers, six senior research administrators, three venture capitalists, two journalists and a politician. The interviews were open-ended.

It was seen that research findings were not always relevant to company interests, and companies often preferred their own or adopted, sometimes reverse-engineered, technology. Government CTT funds did not help much in with design, prototypes and pilot plants. Inadequate communication and lack of trust influenced the low uptake of research findings.

The commercial relevance of much scientific research was questioned. More government support for company risk-taking appeared to be needed. Differences in attitude and poor understanding of policies and principles tended to contribute to low uptake. Managers, professional, scientists, Technology Transfer Officers, senior research administrators, venture capitalists needed more flexibility, knowledge and skills to respond to profit-driven research findings. A specifically Malaysian approach to CTT was advocated.

ACKNOWLEDGEMENT

In the name of God, Most Gracious, Most Merciful. Praise is to God for His Mercy which has enabled me to complete this work.

I would like to express my gratitude to all those who helped me to complete this thesis. I would like to thank to the Government of Malaysia and the Universiti Teknologi Malaysia (UTM) for giving financial support throughout my doctoral study in the UK. I have furthermore to thank to all the respondents who kindly participate and gave sound interviews. My sincerely thanks also to all staff of the Department of Management and my thanks to all the Librarians of University of Stirling in assistance and supporting in my research.

It is difficult to overstate my gratitude to my Ph.D. supervisor, Dr. Ian Glover. With his enthusiasm, his inspiration, and his great efforts to explain things clearly and simply help a lot. Throughout my thesis-writing period, he provided encouragement, sound advice, good teaching, good company, and lots of good ideas. I would have been lost without him. Thanks also to my second supervisor, Dr. Tom Forbes for all the guidance and suggestions helped me in all the time.

My special thanks to my husband Hamzah Isa and my children whose patience and love enabled me to complete this thesis.

DECLARATION

This thesis is submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (Management) at the University of Stirling, United Kingdom. I declare that this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that this thesis has not been previously or concurrently submitted, either in whole or in part, for any other qualification at the University of Stirling or other institutions.

Signed

Noraini Abu Talib
6 June 2008

TABLE OF CONTENTS

LIST OF TABLES

Table

CHAPTER 1

INTRODUCTION

First, in this chapter, the main aim of the thesis is described, and explained briefly. Next, the research questions are spelt out in five short sections, the research methods described in the next, and the main contents of each of the chapters that follow are explained in the final one. Relevant literature is referred to at various points, but the task of reviewing of it is largely undertaken in the next chapters.

THE PROBLEM

The Main Aim of the Thesis

This is to describe, investigate and explain the perceived low rate of adoption and commercialisation of inventions and knowledge in Malaysian manufacturing companies (Economic Planning Unit [EPU], 1996, 2001). This aim is pursued in the knowledge that Malaysia is still a developing country, in spite of its generally high rates of economic growth since the early 1990s, and to a smaller extent before.

THE ROLE OF GOVERNMENT IN MALAYSIA

Research and Development (R and D) is regarded by the Malaysian government as critical for accelerating technical change. Malaysian researchers and engineers in universities and government research institutes have generated many discoveries, inventions, significant developments of products and processes, and so on. However, more downstream industrial and commercial activities such as detailed product design, mainstream and/or incremental improvement to improved manufacturing processes, marketing and selling do not appear to have followed on the scales desired and possible (Muhammad, 2003; National Productivity Corporation [NPC], 2003). Both the pace and the volume of commercialisation are causes for concern, as are both indigenous technology transfer and that involving foreign companies.

Government intervention in industrial and technical development can be traced to Malaysia's Five Year Plans, which began in 1971. For the Seventh Malaysian Plan, from 1996 until 2000, a program of Intensification of Research in Priority Areas (IRPA) included approval of a total of 3,705 projects worth RM698.3 millions or £116 million, a significant sum for a developing country with a population of 25 millions. From 2001 to 2005, a similar sum from the same budget was made available to support the same kind of technical development. The purpose of the IRPA Program is to focus R and D activities on developments with potential to enhance national economic performance.

The Malaysian National Council for Scientific Research and Development (NCSRD) allocates grants for IRPA. In doing so it follows four principles. (EPU, 2001). These are, first, to fund commercially viable developments which have high national priority. Second, projects are selected to help satisfy various gaps in the efforts of and needs of Malaysian industry. Third, projects should enhance collaborative efforts between researchers and research institutions. Finally, they should enhance R and D links between relevant public sector actors and firms. However this government intervention can be questioned inasmuch as the rates and volumes of commercialisation of broadly defined publicly-financed R and D have been low, especially but not exclusively in small and medium-sized companies (SMEs) (MASTIC, 2000; NPC, 2003; Sadullah, 2002).

Malaysia's government wishes to see its economy develop into a so-called knowledge one, ostensibly like those of Japan, North America and the European Union, in which the abilities of expert employees, human capital, are often thought to be ultimately more important for organizational success and national prosperity than financial and physical capital. As already noted, Malaysia has a population of 25 million, and its GDP per capita is about £4,500. Its rates of growth of GDP in 2000, 2001 and 2002 were 8.5%, 0.4% and 4.2% respectively. With 127,316 square miles, Malaysia is slightly larger than Mexico. It has a tropical climate, very or quite high levels of literacy and school attendance, and a workforce of nearly 10 million. Malaysia has made strong attempts to achieve the target of attaining a 60:40 ratio of science and engineering to arts student enrolments in public and private universities, and other tertiary institutions have been established with an emphasis on technical and scientific disciplines.

In 2002, about 27% of Malaysian's employees were in manufacturing, 21% in services, including government, 17% in trade and tourism, 14% in agriculture, 8% in construction, 6% in finance, 5% in transport and communications, 0.8% in utilities, and 0.4% in petroleum. Malaysia's exports of merchandise were worth US $94 billions in 2002, and included electronics, electrical products, palm oil, petroleum, liquefied natural gas, clothing and timber. Malaysia's main export markets were, by value, the USA 20%, Singapore just over 17%, and Japan 11%. It is a federal parliamentary democracy and a constitutional monarchy.

Malaysia wishes to become a wealthy, independent nation with a sophisticated economy. However, many of its manufacturers, and especially those with SMEs, appear reluctant to be innovative, both technically and commercially, on the scale and at the speed desired by the government (MASTIC, 2000; Chze, 2003). Certain problems that concern Malaysia's leaders are attributable in varying degrees to the ethnic composition of the country. This is about 65% indigenous Malaysian or Bumiputera, about 26% Chinese, about 8% Indian, about 1% other (Department of Statistics, 2003). Traditionally the Chinese Malaysians have been the most entrepreneurial of these ethnic groups, with the Bumiputera people, while far from lacking in entrepreneurial qualities, lagging some way behind them (Badawi, 2003). However some 75% of the many manufacturing companies in Malaysia are Chinese-owned, and these appear to be as likely as any others to fail to be as innovative as they could be.

Malaysia has put significant efforts into technology development, given the sizes of its population and of its GDP. However, putting more effort into R and D does not necessarily lead to more innovation and commercialisation and to higher company profits (Cebon and Newton, 1999; Dodgson and Hinze, 2000). Restraints on, or hindrances to commercialisation, efforts are thought to include weaknesses in the process of effective technology transfer between research centres and companies (Conceição, Heitor and Oliveira, 1998; Salmenkaita and Salo, 2002; Hayashi, 2003; Jacob, Lundqvist and Hellsmark, 2003), cultures of financial risk aversion in companies (Conceição, Heitor and Oliveira, 1998; Feldman and Ronzio, 2001; Gambardella, 2002), lack or faulty provision of venture capital (Feldman and Ronzo, 2001; Conceição, Heitor and Oliveira, 1998), and lack of entrepreneurial skills and 'spirit' (Colombo and Delmastro, 2003). Further, the outputs of university researchers and staff of government agencies have rarely been the most mainstream or traditional sources of technical change, which is usually industry-based, and incremental and/or continual.

Another interesting facet of the investigation concerns the understanding of relevant facts and ideas and the motives of Malaysia's leaders. They appear to be strong believers in the contemporary and, in the developed economies, fashionable, rhetoric of globalisation, accelerating change and the knowledge economy, although these notions have been subject to serious criticism by some sophisticated researchers in their countries of origin (see, for example, Hirst and Thompson, 1999; Harzing and Sorge, 2003; Sorge and van Witteloostuijn, 2004). Do these leaders really believe in all or some of the rhetoric? Or is it just used for convenience as part of a worldwide and legitimatory language of management (Bendix, 1956; Child, 1969; Enteman, 1993; Glover and Tracey, 1997; Glover, 2003). To help understand what they may genuinely believe and think, consideration has been given to their social and educational backgrounds and to their actions and apparent values over a number of years. Similar considerations have been applied to the wording of questions asked of all those interviewed, and to the replies that they gave.

REPRISE AND FURTHER POINTS

We have seen that the main concern of this thesis is the perceived low rates of uptake and commercialisation by Malaysian companies of the outputs of government-funded research and invention. The Malaysian government makes its efforts in this area through its ambitious Five Year Plans for its country's economy. The relevant efforts take the form its IRPA. This operates with four principles, as noted above, and which are used when the NCSRD allocates grants for its R and D projects. The principles are largely concerned with better use of R and D, and with making it more effective through enhanced collaboration. One important factor which was mentioned above is the unsurprising tendency for low perceived uptake of commercialisation to be more characteristic of SMEs than of larger firms. We have also noted how, in most countries, problems with commercialisation include risk aversion in companies, inadequate management of the provision of venture capital, lack of entrepreneurial skills and attitudes, and lack of effective technology transfer between research centres and companies. Only the last of these appears to be more problematic Malaysian than in most other countries (Conceição, Heitor and Oilveira, 1998; Hayashi, 2003; Jacob, Lundqvist and Hellsmark, 2003). Finally, the rather arm's-length language or rhetoric used in this context by the Malaysian government has also been noted.

In the literature on government participation in so-called science and technology development, several writers have offered reasons why government action is desirable (Goldfarb and Henrekson, 2002). In essence, a government is in a stronger position than most companies to obtain information about engineering inventions, scientific discoveries, new products and processes and so on. It is also more able to foster, manage and monitor the work of researchers, research institutes and universities. Further, it is clearly in a far stronger position to monitor the activities and development of whole industrial sectors than almost all individual companies can be. Therefore, it and its agents in universities and research institutes have both the capacities, and indeed the responsibilities, to inform, to encourage and to work with them (Hayashi, 2003, pp.1440).

TOWARDS AN ANSWER?

Both the relevant academic literature and the writer's experience suggest that Malaysia's difficulties with commercialisation are not particularly unusual. However, and as already noted, Malaysia appears to have a particular problem as regards the process of managing technology transfer from researchers and research institutes to companies through to markets, with each kind of party involved partly at fault. This may be because Malaysia is still a developing country with a fast-growing economy, which is lacking in long experience of the relevant processes.

According to Laperche (2002, p. 149), ‘the successful commercialisation of public research is the result of the application of an “organic paradigm” consisting of the four closely interacting factors of legislation, the economic environment and entrepreneurship, technical progress and university strategy’. Countries with very successful technically advanced industries like Germany, Japan and USA, and indeed to the United Kingdom in many respects, do seem to generate synergy between the main actors involved: government, industrial, educational and scientific, financial and legal, and they do also generally have long experience of the relevant processes and of appropriate building, use and adaptation of institutions.

THE RESEARCH QUESTIONS

This thesis is concerned with two main and two secondary questions, and with an important underlying issue. The two main ones address the main issue discussed above, inadequate uptake and commercialisation, by Malaysian industrial companies, of inventions and knowledge produced on their behalf by research government institutions, universities and others.

First, why do many Malaysian firms apparently fail to make use of relevant discoveries, inventions, ideas and knowledge produced by Malaysian government research institutes, universities and others?

Second, why do the government research institutes and the universities and other researchers, whose work is funded by government and intended to be commercialised by Malaysian industry, apparently fail to persuade many companies to use their discoveries, inventions, ideas and knowledge?

The two secondary questions concern two general possibilities that could be useful to explore because asking the relevant questions might bring important underlying assumptions that might simply have been taken for granted, out into the open:

First, could there be a specifically Malaysian route to the commercialisation of inventions and knowledge? And if so, to what extent is the Malaysian government aware of this and able to use it?

It was suspected that Malaysia is not particularly unique in this regard (for being unique!). Yet it was also recognised that even minor differences might have important practical implications.

Second, do Malaysia's government and its research managers and specialists provide information about relevant inventions and knowledge to companies in appropriate and persuasive ways? This was important because relevant problems could be ones of substance or ones of presentation.

The underlying issue, noted at the end of the previous section, concerns the general character and status of relevant interaction between government, industrial, educational and financial interests and institutions. Many observers of the technical and commercial success of advanced industrial countries and sectors, and of various industrial regions and districts, have emphasized the importance of productive relationships between such interests and institutions in them. In Malaysia, equivalent institutions and relationships tend to be newer, more small-scale and more fragmented. Therefore it might not be surprising to discover that technology transfer and commercialisation processes in Malaysia, with its developing economy, are rather less efficient than those in more developed economies. Further, hard-pressed managers of SMEs may be particularly suspicious of some of the language used by advocates of such processes, which may appear to them to be a little too detached from reality and complicated for comfort.

RESEARCH METHODS

To investigate these phenomena, a programme of 60 semi-structured interviews was conducted. The interviewees comprised 23 company managers and professional, 17 scientists, eight technology transfer office staff (TTO), six senior research administrators, three venture capitalists, two journalists and a politician. A few organizations which granted interviews also supplied some useful documentary data.

Relevant sources of knowledge and information about Malaysia’s economy, its economic and general history, geography, government, politics and society have also been consulted. Full details of the research methods and of the reasons for choosing them, and of their necessary and other limitations, are spelt out in chapter 5 below.

THE STRUCTURE OF THE THESIS

In the next chapter, Malaysian industry and its organisation, strengths and weaknesses, and possible futures, are described and explored. This is done in the context of discussions of the nature of Malaysian society and of industrialisation. The latter is a formerly very influential notion which is no longer the subject of social scientific attention in the established industrial countries on anything like the scale that it enjoyed eighty or even forty years ago. However an important assumption of this thesis is that industrialisation is the master process of human development since the sixteenth century, and that although it may not be possible to forecast the time of its ending with anything remotely like precision, it is incomplete, not only in developing countries, but in virtually all countries including the most highly developed 'advanced industrial' ones like France, Germany, Japan, Sweden, the UK and the USA (Ackroyd, Glover, Currie and Bull, 2000; Glover, 2003).

In this chapter, various general and other relevant features of Malaysia's history, government, economy and society are noted. Three particular foci are: the organization of relevant civil service departments; economic and employment structure; and the educational, ethnic, occupational and social backgrounds of Malaysia's administrative, educational, industrial, political and scientific elites.

Malaysia's economy is subdivided into four categories. Energy and extraction, including agriculture, fishing and forestry, is the first. Malaysia produces a considerable amount of crude oil, liquefied natural gas and hydroelectric power, with considerable state involvement. In 2002 about 17% of its labour force is in agriculture. The second category consists of manufacturing (24.1%) and construction (8.5%), which includes automobiles, building, civil engineering, ceramics, chemicals, clothing, electrical and electronic goods, engineering construction, furniture, plastics, rubber products and steel. The third category consists of directly goods-related services (49.9%), those which feed into or off manufacturing and construction. Examples include architecture, distribution, garage services, investment analysis, marketing research, plumbing, retailing, software engineering, and. Fourth and finally, there are government and other public services like defence, taxation, education, and health care.

Finally in Chapter 2, a number of conventional business strategy measures, namely the Boston Matrix, PEST analysis, SWOT analysis and Michael Porter's five forces, are applied to the Malaysian economy in general and to industry and to important industrial sectors in Malaysia in particular. This is done to help develop understanding of Malaysia's economy. Suggestions are then made, using my own thinking and the evidence of others, about barriers to commercialisation in Malaysia. Finally, various possible and likely futures, sustainable and other, of Malaysia's economy, are considered.

In chapter 3, 25 relevant concepts are explored. They are: Kunst, Wissenschaft and *Technik*, respectively the German words for the fine and performing arts, broadly defined science, engineering and technology, the arts and humanities and other 'making and doing' subjects; commercialisation, culture, design, development, discovery, production, sustainable development, entrepreneurship, innovation, invention, (the) management of change, performance, research and development (R and D), science, success, technical change, technological change and technology transfer. The three German concepts, which have direct counterparts in the most other Continental European languages, are relevant because together they constitute a different and arguably more realistic system for classifying subjects for study and of describing the relationship between the academic world and the practical one than that used in the main English speaking countries. The difference has major implications for this study, because it suggests that certain assumptions from the latter countries, influential in theorising about commercialization and technical change in the developing world, may be misleading. Commercialisation is a fairly uncontentious if slightly complex notion concerned with making ideas and inventions profitable. Culture is a much more complicated idea, one which 'says so much because it says so little', and which, when it is used explicitly, tends to involve writers glossing over its essence (Sorge, 1982-83). Hopefully the discussion of it in chapter 3 shows how it can be used both unambiguously and helpfully. The nature and generally underrated role of design in technical change and innovation, including commercialisation, is also clarified in this chapter. Development is considered as something that Malaysia is still undergoing in many respects and in several ways which have specific relevance to the study. Engineering and engineers are words which are often conspicuous by their absence in academic discussions of technical change and commercialization. Technology and technologist are often preferred. Yet, in most industrial and other countries, at least 90% of so-called technologists are engineers by qualification and job title (Glover and Kelly, 1987). To describe engineering as an '-ology' when it main outputs consist, not of scientific papers free for anyone to read, but mainly of three-dimensional artefact for sale, is normal in English-language discussions of relationship between science and engineering, in which the latter often precedes the former because it is mistakenly regarded as the main sources of development of the latter (Fores and Rey, 1979). Entrepreneurship is discussed because of its apparent value in commercialisation, and because the research evidence on it does indeed have considerable relevance to this study, both in detail and more generally.

The same points obviously apply with innovation and invention. Innovation is more than invention. Obviously, for an invention to be profitable, finance, design and marketing need to be involved: a technical development has to be commercialised. However innovation often does more than improve techniques, product and profit. It can help to spawn and spread generic technologies that develop industries and large-scale patterns of consumption too. Regarding invention, there is a longstanding element of controversy in debates about the contributions of the unpredictable technical ingenuity of much of engineering and of new scientific knowledge to the process (Sorge and Hartmann, 1980). Insofar as some of the views expressed in these debates may be mistaken or irrelevant in particular situations, they may affect the actions of companies, government advisers and so on in unhelpful ways.

The literature on the management of change contains some widely publicised prescriptions likely to be relevant to the present study, and these are discussed in some detail in this chapter. There are relevant mainly because most writers on the subject stress the need for managers of change to understand the backgrounds, interests, attitudes and influences on those whose lives will be affected, and because there at least some indications that the language and actions of those involved and affected in Malaysia that suggest the relevant changes could be managed with greater sensitivity and more effect.

Also clearly relevant, the notion of performance has many meanings, some less objective than others, so that a definition that is both relevant for present purposes and broadly valid is developed. R and D is another term covering a wide range of activities, and it is also controversial as regards the contributions of unpredictable technical ingenuity and existing (including new) scientific knowledge to technical change. This controversy is considered and resolved, at least for present purposes, in chapter 3. Science is usually defined using phrases like ‘verifiable knowledge of phenomena’ (Fores, 1976). Its role in technical change (and commercialization) is more controversial than many policy-makers assume. The notion, or rather many notions, of success, are dealt with, and they receive the same kind of treatment as that, or those, of performance, in that a valid and reliable definition, one concerned with the quality, volume and influence of output overtime, is developed. The main difference between the definitions of performance and those of success is concerned with influence. Success is thought of as a high level of performance (taking circumstances into account) that is influential or which has the potential to be so. Sustainable development, that which does not consume the earth's resources at faster rates than the ones at which they can be renewed, has relevance for business, industry and government everywhere. Technical change is defined as accurately and unambiguously as possible, against a historic backcloth in which engineering and science have been conflated and confused. Technology transfer is a notion that covers a number of ways of which expertise and knowledge are used in new contexts and in ways that are commercially viable.

Chapter 4 reviews thinking about the nature and state of technical change and commercialisation in Malaysia. First, points from chapter 3 are taken, along with relevant theoretical accounts and evidence-based debates, to discuss two master models of technical change, the 'linear' applied science (or science leads to technology leads to hardware) and the technique (or *Technik*) ones (Sorge and Hartmann, 1980). A tendency of the writer to prefer the latter is explained along with reasons why this preference does not exclude valid aspects of the former. Second, there is a discussion of commercialisation and innovation, of different kinds of them, of the institutions and kinds of individual involved, and of the history of relevant theories. Third, a number of relevant historical and other comparative dimensions are explored, such as the characteristics of technical change and commercialisation in different stages of industrialization, in different sectors and parts of the world, and relevant features of national and organizational learning. Finally, in chapter 4, overviews of what are known about innovation and commercialisation in Malaysia and of how they are influenced and organized, are presented.

In chapter 5 the reasons for deciding to use interviews of relevant interested parties, such as company owners and managers, professionals and politicians, civil servants and government, and university researchers in Malaysia, as the main sources of data, are explained, as are those for selecting the populations from which the samples of interviewees came. Relevant philosophical assumptions and their methodological implications for the study are discussed. The choice of critical realism as the research philosophy, and the definition and choices of the qualitative elements of the study are explained. Expectations about and, as far it was possible to discover, the reality of, response and response bias, are explained. Finally the limitations of the study are accounted for.

The next three chapters, 6, 7 and 8 explore the findings and in relation to the two main and two secondary research questions, and more in more diffuse ways, to the underlying issue described along with them above.

Chapter 6 addresses the reasons why many Malaysian firms, especially SMEs, do not make as much use of inventions, ideas and knowledge produced by Malaysian government research institutions, universities and others, as the latter want or expect them to. Conversely, chapter 7 is concerned with why the government research institutions and the universities, whose work is designed to be commercialised by Malaysian industry, apparently fail to persuade many companies to use their discoveries and inventions. Chapter 8 focuses on what seemed at the outset the uncertain possibility of a specifically Malaysian route to their commercialisation and discusses and draws conclusions from the complex reality of relevant findings. The titles of these three chapters are, respectively, Company Perspectives, Scientists’ and Public Perspectives, and Discussion: A Malaysian Way? All of these chapters are concerned at various times, in generally low-key but often quite significant ways, with the presentation versus substance issue of the fourth research question, meaning the second of the secondary ones, and also with the very important underlying issue of fruitful institutional co-operation in a fast-developing economy.

Chapter 9 consists of the conclusions and recommendations. It presents the theoretical contribution of the thesis. It summarises all that precedes it. It also describes the ways in, and the extents to which, the research questions have been answered and the underlying issue addressed. By doing this it arrives at a conclusion about how the main aim of the investigation has been achieved. The limitations of the investigation and the theorising presented herein are noted. In latter part of this final chapter, some ideas about future research are presented and discussed. The ideas include ones for methodology developments (e.g. the use of case studies and longitudinal studies); research which focuses on sectoral dimensions, (comparing and contrasting CTT in different industries; and research which explores regional dimensions of innovation (in Malaysia). Finally, the main academic and policy conclusions are spelt out, including their implications for theory and for practitioners in industry and commerce, government and administration, science and education, and finance.

CHAPTER 2

MALAYSIAN INDUSTRIALIZATION

INTRODUCTION

In the first chapter some of the hindrances to commercialisation in Malaysia were noted. In this chapter, the background of Malaysia and its industrialization are described and discussed. The background are includes the geography, demography, resources, history, society, economics, politics and government and the economic development of Malaysia. Discussion of education that emphasises the philosophy of Malaysian education from the pre-colonial era to the present is followed.

The industrial policy adopted by the country is discussed in detail. It considers the role of the government in developing industrial policy in terms of its five year more long term plans. There were series of policy developed by the government and related to the needs of it in the industrial development especially the problems of it. Important specific factors such availability of natural resources and the openness of the economy has affected economic development. A wider context of development in Malaysia is briefly focuses on globalization and its affects on developing countries. Many economic difficulties are based on the influence of more developed countries' policy on them.

GEOGRAPHY, POPULATION AND NATURAL RESOURCES

Malaysia is in South East Asia, and its combine's three major geographical parts, the Peninsular States, where the population is most concentrated, Sarawak, and Sabah. The first one the Peninsular, more developed in terms of infrastructure, while Sarawak and Sabah are richer than Peninsular in natural resources and occupy the northern and western parts of the island of Borneo.

Malaysia has many races, several religions and many cultures. Based on the Malaysian government's 2000 Census, its population was 23 million compared to 18 million in 1991, with an annual growth rate of 2.6% over the period. In terms of ethnic composition, the Bumiputera, the indigenous Malaysians, comprised 65.1%, Chinese 26.0% and Indians 7.7%. 80% of its population are in the Peninsular States. This demographic structure mainly evolved with immigration from China and India during the British colonial rule, from 1895 to 1957.

Using its natural resources, and with help from its immigrant labour from India and China, Malaysia became the world's major exporter of natural rubber and tin during the colonial period. Palm oil, together with timber, cocoa, pepper, pineapples, fisheries, livestock, coconut, fruits and tobacco, dominated the output growth of its agriculture. Palm oil is still a major foreign exchange earner. Tin and petroleum are the two main mineral resources of the

Malaysian economy. In the nineteenth century and for the most of twentieth, tin predominated in the extraction sector of the economy. In 1972 crude petroleum and liquefied natural gas took over from tin as the dominant export products of that sector. Since then, the contribution of tin has declined significantly. Crude petroleum and liquefied natural gas, which were discovered in oilfields offshore from Sabah, Sarawak and Terengganu, have contributed much to exports in particular and to the economy in general.

HISTORY AND POLITICAL BANCKGROUND

Early Malay kingdoms, namely Langkasuka (Kedah), Srivijaya (Palembang), and Majapahit (Java) existed from the ninth century. The emergence of the Malacca Sultanate in the early fourteenth century is widely held to mark the beginning of the known history of Malaysia. The Islamic Empire of the Malacca Sultanate covered the whole of Peninsular Malaya and the eastern coast of Sumatra and Brunei. Malacca enjoyed widespread fame, in Europe as well as the East, as a port for East-West trade. The encroachment of Western powers began with the Portuguese conquest of Malacca in 1511. The Dutch followed in 1641 (Winstedt, 1962; Simandjuntak, 1969; Snodgrass, 1980). Following the fall of the Malacca Sultanate, independent states emerged throughout the Peninsula, beginning with Johor in the mid-seventeenth century, Negeri Sembilan and Terengganu in the early eighteenth century, Kelantan in 1764, Selangor in 1766, Perlis in 1843, Pahang in 1881 and Johor in 1885.

By the end of the nineteenth century, nine kings were in power. In the mid-eighteenth century British traders established trading ties with the Malay kings. The British traders eventually set up trading ports and took over Pulau Pinang (1786), and Singapore, which was previously called Temasik, in 1819. With the endorsement of an Anglo-Dutch Treaty of

1824 the Britain tightened its grip on the Peninsula. It established the Straits Settlements in 1826. The Straits Settlement consisted of Penang, Melaka and Singapore. They formed a British Crown Colony with a governor who was also the High Commissioner to the Malay States. The Federated Malay States were formed in 1896, and they consisting of Perak, Pahang, Selangor and Negeri Sembilan. These states were administered by a British Resident General based in Kuala Lumpur.

The Unfederated Malay States, formed between 1914 and 1919, consisted of Johor, Kedah, Terengganu, Perlis and Kelantan. They had a British Adviser. The British Advice Officer offered advice these states except in matters concerning Malay customs and religion. The states agreed to accept British protection and to have no dealings with foreign powers except through the British. Later, in February 1942, Japanese forces invaded and seem occupied the entire Peninsula.

Following the Japanese surrender on 14 August 1945, the return to British administration saw the adoption of new policies. In January 1946 the British government, proposed a Malayan Union, which was to unite the whole of the Peninsula (except Singapore), which was to become a separate colony. The Malayan Union would have a governor and central government. This curtailed the authority of the rulers and the states considerably. The creation of the Malayan Union reduced the status of Malay rulers and led to a loss of Malay rights. The proposals were opposed and resisted strongly by the Malays. They came out in force to oppose the Malayan Union. Malay associations came together to form a political organization, the United Malays National Organisation (UMNO) in 1946. It was initially meant to fight against the British plan to reduce the Malay rulers' powers. The policies adopted in respect of ethnic relations had been largely those of the UMNO whose leaders have always taken pride in the country's strong economic growth and orderly political succession through democratic elections (Seah, 1977). In 1946 the Indians formed a political party known as the Malaysia Indian Congress (MIC) and in 1949, the Chinese formed their own political party, known as the Malayan Chinese Association (MCA). The UMNO, the MCA and the MIC formed the Alliance Party, which was later called National Front in 1951. The party was formed because the British wanted proof that the non-Malays could co-operate with the Malay before it would consider giving them independence.

As an essential condition of independence, the Malays were first given more political responsibility through a Legislative Council which was set up in 1951 (Milne and Mauzy, 1978). The British committed themselves to withdrawing from Malaya and insisted that Malaysia must be created quickly, regardless of the opposition, and they virtually ordered Malaya's leader Tunku Abdul Rahman to stand firm against British (Jones, 2002). The first general election in Malaya was held in 1955. The Alliance won a sweeping majority on the platform of early independence. A conference with the British government began in London in January and February 1956. This was followed by several months' work by a Constitutional Commission. As a result, the Federation of Malaya become a sovereign independent nation on 31 August 1957. After independence, a federation of eleven states was established with a parliamentary system and a constitutional monarch chosen from the nine Malay kings every five years. At this time, there were racial tensions in the Alliance and there was bargaining over the constitution by the three main communities (Simandjuntak, 1969, pp. 105-117). The representatives of each group jostled for advantages to protect the interests of their nationals. However the constitution came to favour Malays (Seah, 1977). In the constitution the Malays and other Malay–related people were recognised as the indigenous group, or Bumiputera. The constitutions contained articles that obliged the government to give special privileges to them respect with regard to the issuing of permits or licenses for the operation of certain businesses, educational opportunities, and positions in public services. The non-Malays were also granted full citizenship and they were known as non-Bumiputera, and there was to be no interference in their influence on the economy.

SOCIETY, THE ECONOMY AND MARKETS

As explained above, Malaysia is a plural society inherited from the British colonial era. Many Chinese and Indian immigrants were brought into Malaya to work in mining and rubber plantations, mostly during that era. They were purposely separated from the Malays, who mostly lived in the rural areas. The Chinese were generally from southern China and the Indians were generally from southern India. Together they have contributed greatly to the ethnically heterogeneous character of the population in Malaya. By 1833-34 there were about 24,000 Chinese, 15,000 Indians and 8,000 other non-Malays in Malaya, when the total population of all Malaya was about 750,000 (Population Studies, 1980).

The main British business interests focussed on tin and rubber, and large numbers of Chinese, Indians and Javanese immigrants from Sumatra entered Malaya. The British encouraged migrants to work in mining and rubber plantations, resulting in close identification between race and economic function in the Malay, Chinese and India ethnic communities (Jomo and Gomez, 1999, pp.10-11). Of Malaysia's 18 million populations in 1991, the Malays accounted for 61%, the Chinese about 28% and Indian 8%. By 2000, these proportions were Malays 65%, Chinese 26% and Indian 8% respectively. The total population was 23 millions (Statistic Department, 2000). The population in 2007 was 27.1 millions.

Malaysia's ethnic groups have had different historical experiences, not only before the major period of immigration, but also afterwards. In the British colonial era the Malays consisted of a small aristocracy and a mass of peasants in the rural areas. These peasants grew rice, fished and gathered jungle products. The aristocrats monopolised trading and mining. The former were effectively barred from social and the economic advancement. The British were more involved in business and the Malay community lost its opportunity to be involved in trade and commercial activities (Snodgrass, 1980. pp. 29). The British introduced an export-based economic system that superseded trading and self-sufficiency. The large influx of immigrant workers from China and India was the foundation of the ethnic, economic, social and political structure. Now most Malays who are not employed in agriculture and extraction work in the public sector, whereas the Chinese are significantly more involved in trade and business, and most Indians still work on the rubber plantations.

ECONOMIC POLICIES

Rapid economic development took place under British colonial rule. Rubber was introduced from Brazil in 1877 and was planted on a large scale in the early twentieth century. The rich land near and around Kuala Lumpur, Ipoh and Taiping was exploited for rubber planting and tin mining. Rubber and tin mining production were the main contributors to Malaya's export earnings. Kings, the wealthy rulers, were able, through patronage, to command support from the middle class group of Malays. The latter gave support to the Malay peasants. This economic structure of Peninsular Malaya has been characterised as feudal by Drabble (2000). Malaya was long a major producer of both tin and rubber, causing the country to develop rapidly during the first half of the twentieth century. Malaya was Britain's most single profitable colony and contributed more foreign exchange in pounds sterling to British coffers than the rest of British Empire in the last quarter of the 19th century.

From 1970 to 1990, Malaysia implemented its New Economic Policy (NEP). The NEP was an affirmative action economic policy based on ethnicity. Social unrest between races in 1969 stimulated formulation of this new policy for economic development. The policy was introduced in the Second Malaysia Plan (1971-1975). Two major features of the NEP were eradication of poverty among the entire population, and restructuring of society to remove identification of economic function with race. Combined with the NEP, the government has its first Outline Perspective Policy (OPP1) covering the period from 1971 to 1990. The OPP1 policy had three main features, an industrialisation strategy, an economic framework and the national objectives as presented in Table 2.1.

Table 2.1: Outline Perspective Policy 1971-1990

Industrialisation Strategy	Economic Framework	National Objectives
1. Shift from import substitution to export orientation industries. 2. Increase Bumiputera'skill, ownership and entrepreneurship 3. Address income inequality 4. Interdependence between economic development and equity 5. Expand industrial development 6. Promote human resource development	1. New economic policy 2. Economic expansion 3. Economic diversification 4. Economic balance	1. National unity 2. National integration 3. Poverty eradication 4. Eliminate identification of occupational by race 5. Entrepreneurial economy 6. Human resource development

Source: EPU, 2002

The OPP 1 covered the 20 years from 1971 to 1990, and encompassed four national plans, namely the Second to the Fifth Malaysia Plans. These development plans were implemented in the framework of strategies of the NEP. As part of the restructuring of society, the OPP1 also deliberately tried to reduce regional disparities between states and regions, especially those in the east coast of Peninsular Malaysia, as well as in Sabah and Sarawak. The 20-year time frame for attainment of objectives and targets set in the OPP1 for the restructuring of society was to end by the completion of the Fifth Malaysia Plan (1986-1990).

In the event, however, and due to the underachievement of the targets, the objective of equitable restructuring of society and wealth was carried forward to the OPP2 (1991-2000) under the Sixth and Seventh Malaysia Plans. The performance of the Malaysian economy under OPP1 had been satisfactory as far as the government was concerned, with the average GDP growth rate of 6.7 percent per annum, with the exception of 1985, when the country registered a negative growth rate. Exports grew by 9.2 percent per annum, exceeding the 7.15 percent target. The OPP1 also saw distinct changes in the composition of exports from rubber, which declined from 33.4 percent in 1970 to 3.8 percent in 1990, to the contribution of oil and gas, which rose from 4 percent to 16 percent.

Under the OPP1, the process of development involved the modernisation of rural areas, rapid and balanced growth of urban activities, and the creation of more share capital ownership among the Malays. The NEP thus called for a financial redistribution from the minority of wealthy non-Bumiputera racial groups to the Bumiputera. Malays had not received a proportionate share in the general economic progress, particularly in the expanding non-rural sector. Of ownership of corporate wealth, 63 percent was in foreign hands, 35 percent other Malaysian, predominantly Chinese, and merely 2 percent Malay (Drabble, 2000, pp. 197-198). In other words, this NEP was designed to address racial and regional imbalances in the ownership and control of wealth. The NEP was seen as emphasising the reduction of the inter-ethnic economic disparities rather than poverty reduction (Gomez and Jomo, 1999).

While the development of agriculture and industries based on natural resources remained important throughout the period, Malaysia looked increasingly to manufacturing to fuel economic growth. Policies passed through several phases, each defined by a dominant strategy. The first phase, from 1958 to 1970; was first round of Import-Substitution Industrialisation (ISI). From in 1970 to 1980 there was the first round of Export-Oriented

Industrialisation (EOI). From in 1980 to 1985 there was the second round of ISI and from 1986 and onwards; a return to EOI. Underlying these phases were the successive five-year Malaysia Plans (numbers one to five in this period) from 1966 onwards, and the NEP from 1970 to1990 (Drabble, 2000).

Before the mid-1980s industrialisation policies comprised a range of initiatives scattered over time. They included policies emphasising pioneer industries (1958), investment incentives (1968), and industrial co-ordination (1975). Atul (1994) concluded that during the period of the NEP, the role of manufacturing was emphasised more than anything else. The objectives of the post-1990 economic development policy were first set out in 1991 by Dr. Mahathir, who was former prime minister two months into the post-NEP period, when he presented his Vision 2020 plan. Containing nine 'central strategic challenges', the plan's goal was for Malaysia to achieve 'fully developed country' status by 2020, mainly by accelerating industrialisation, growth and modernisation.

The nine main objectives of Vision 2020 were to establish, first, a united, peaceful, integrated and harmonious Malaysian nation. Second, it sought a secure, confident, respected and robust society that was committed to excellence. Third, a mature, consensual and exemplary democracy was desired. Fourth, it sought a 'fully moral' society with citizens strongly imbued with spiritual values and the highest ethical standards. Fifth, it sought a society that moulds its cultural, ethically and religiously diverse, liberal, tolerant and unified society. Sixth, society should be scientific, progressive, innovative and forward-looking. Seventh, it would be a caring society with a family-based welfare system. Eighth, it would be a caring society that was 'economically just', with inter-ethnic economic parity; and ninth, it would have a 'fully competitive, dynamic, robust, resilient and prosperous economy'. This vision sought a more competitive, market-disciplined, outward-looking, dynamic, self-reliant, resilient, diverse, adaptive, technologically proficient and entrepreneurial economy with strong industrial links, productive and knowledgeable human resources, low inflation, an exemplary work ethic and a strong emphasis on quality and excellence (Gomez, 1997, p. 169)

Towards the end of 1990, the Second Outline Perspective Plan (OPP2), covering the period 1991-2000 was formulated. It was based on the policy called the New Development Policy (NDP). The NDP was built on the achievements of the OPP1, so as to accelerate the processes of eradicating poverty, and restructuring society to correct social and economics imbalances. It provided a framework for achieving these socioeconomic objectives in the context of a rapidly expanding economy. In formulating the NDP, the Government considered the views and proposals from various groups including those spelt out in the reports of the National Economic Consultative Council (NECC) on the post-1990 policy for the country.

The government had endorsed national unity for the ultimate goal of socioeconomic development because it believes that a united society was fundamental to the promotion of social and political stability and sustained development. Development policies and strategies under the NDP, (covering the period 1990 to 2000), take the cognisance of the diversities of Malaysia, ethnic, linguistic, cultural and religious as well as regional, so that a harmonious, tolerant and dynamic society can be achieved. The NDP maintains the strategies of the NEP. Its new dimensions were first, the focus of the anti-poverty strategy on eradication of absolute poverty and at the same time reduction of relative poverty. Further, it focused on employment and the rapid development of an active Bumiputera Commercial and Industrial Community (BCIC) to help the meaningful participation of Bumiputera in more advanced sectors of the economy. Then, its relied more on the private sector to be involved in economic restructuring by creating greater opportunities for its growth. Last, it focused on human resource development as a requirement for achieving the objectives of growth and redistribution. These are of course the formal, stated, policies of the government.

The stated objective of the NDP during the period of the OPP2 is to attain more balanced development, to help to establish a more just and united society. Building the thrust of the NEP in eradicating poverty and restructuring society, the NDP encompasses the social aspects. The NDP tried to assure an optimum balance between the goals of economics growth and equity. Further, it worked to ensure balanced development of the major sectors of the economy, and reducing and ultimately eliminating the social and economic inequalities and imbalances in the country, to promote a fairer and more equitable sharing of the benefits of economic growth by all Malaysians. Also, it aimed to promote and strengthen national integration by reducing the disparities in economic development between Malaysia's states and between urban and rural areas. This was also meant to help develop a progressive society in which all citizens enjoyed greater material welfare, while simultaneously being imbued with positive social and spiritual values, and a strong sense of national pride and consciousness.

Promoting human resource development including creating a productive and disciplined labour force and developing skills for industrial development through a culture of merit, without jeopardising the restructuring objective. The government also wanted to develop advanced engineering and strong scientific research, and educational planning and development, including building activities in generic technologies, and promoting an advanced technical and scientific culture as part as an advanced industrial economy. There was also the aim of ensuring that, in the pursuit of economic development, adequate attention was given to the protection of the environment and ecology, to maintain the long-term sustainability of the country's development.

For Mahathir Mohamad, the ex-prime minister (to 2003) of Malaysia, the Third Outline Perspective Plan (OPP3), which covers 2000 to 2010, marked the second phase of the plan to realise Vision 2020 that had been embarked on 1991. Since the launching of the New Economic Policy in 1971, the nation has clearly undergone rapid economic growth and attained significant social improvement, especially in the alleviation of poverty and social restructuring, for example by getting more Bumiputera people engaged in business and industry.

The success of these policies is apparent in the relative prosperity and quite harmonious ethnic relations that Malaysia enjoyed since the early 1970s. Industrialisation and trade liberation have led to greater use of information and communications technology (ICT), helping to create a business environment in Malaysia which is more dynamic and productive than ever. The OPP3 focuses on a few strategies for achieving sustainable growth. The future competitive position of Malaysia will of course be influenced by how successful the country at innovation. Education and training are being developed by upgrading teacher training and by strengthening the teaching of English, and mathematics and other scientific subjects, for example.

The main focus of the OPP3 period is the creation and promotion of new resources for growth in manufacturing, services and agriculture. The sector strategies are intended to produce strong and sustainable growth. The sector aims that will be pursued include strengthening manufacturing by developing industrial clusters and small and medium-sized enterprises (SMEs) as well improving standards and levels of education and training, and relevant developments in agriculture, services, utilities and infrastructure. In OPP3 manufacturing has been into a phase of development. This seeks to consolidate and strengthen the resilience and competitiveness of manufacturing as well as promoting new sources of growth. At the same time, the development of industrial clusters is critical move for contributing to the future of manufacturing.

Apart from OPP3, the National Vision Policy (NVP), which incorporates Vision 2020, introduced new policy. The NVP covers the period of 2000 to 2010. It emphasises development on both domestic and international fronts, and necessitates a change in mindsets of policy makers and implementers and all other stakeholders involved in development. One of the policies introduced in the NVP is acceleration of development capacity of industry and capabilities in engineering and science to enhance competitiveness further and to increase the use of information and communications technology (ICT) so as to enhance productivity. The government has tried to improve the economic performance despite the problem of low Bumiputera share ownership.

GOVERNMENT AND POLITICS

Many features of Malaysia's civil service, including its management and organizational practices, were inherited from the period before 1957, when it was a British colony. Malaysia is a constitutional monarchy and parliamentary democracy. It consists of 13 states as well as two local territories, including Kuala Lumpur and Labuan Island. Each has its own head of state and elected assembly. Hereditary kings, under a unique system, elect one of their own to be the constitutional monarch, or Yang di-Pertuan Agong, of Malaysia for five years periods. Malaysia has a non-political, professional civil service, army and police force and also an independent judiciary. The Malaysian Parliament consists of the Senate and the House of Representatives. These correspond very roughly, respectively to the UK's Houses of Lords and of Commons. There are also the Senators, whether appointed or elected, serve six-year terms. Members of the House of Representatives are elected for five years. Since Malaysia gained its independence from the UK on 31 August 1957, elections to the House of Representatives have been held regularly, every five years or less. The Prime Minister and a few ministers administer the Federal Government.

Malaysia has fairly a strong new tradition of parliamentary democracy. The country has been ruled by the National Front coalition which is dominated by the United Malays National Organization (UMNO) since the first general election in 1957. As noted earlier, initially known as the Alliance Party, the coalition consists of the UMNO, the Malaysian Chinese Association (MCA) and the Malaysian Indian Congress (MIC). The main reason for the formation of the Alliance Party was to claim independence for the Confederated Malay States. In 1971, it was expanded to create the National Front, which presently consists of 14 political component parties. The 'Malaysian National Philosophy' is the nation trust. This philosophy stands as the country's guide to social unity and to its development.

The formation and pursuit of the NEP by the government, as mentioned above, has been seen as failure by various critics. Although its approaches to have sought to eradicate poverty and to reduce economic disparities between Malays and non-Malays, it critics have argued that most government projects and contracts have been awarded to those super-rich non-Malays who allied themselves to with the more wealthy and politically empowered Malays. Government leaders and politicians have been accused of abusing and violating the NEP and the Malaysian Plans and profiting from the system's failures. Many Malaysian leaders have been accused of corruption. Based on the Transparency International, Corruptions Perception Index (CPI), Malaysia was ranked at 39 among 158 countries. This ranking is considered not good. Its rating on the CPI is 5.1 compared to the highest ranking country, Iceland, with 9.7; Singapore was fifth with a CPI of 9.4. Malaysia was categorised at 24 percent of people where corruption affects political parties (Transparency International, 2003). Political parties were perceived as far and away the most corrupt institutions in Malaysian society. The UMNO has been accused of using political bribery to stay in power (Gomez and Jomo, 1999).

EDUCATION

Malaysia's education system has a guiding philosophy based on the Malaysia National Philosophy, or *Rukun Negara*. One the objective of this is to achieve unity of all the Malaysian people. A newly adapted philosophy is known as the National Ideology of Malaysia, and is based on the Vision 2020 of 1999. The latter defines present and future human resource needs. As mentioned above, Vision 2020 was written to help implement the development of Malaysia based on its own determination of the nature of its values and development, so that the country would not copy of ideas of progress derived from other nations (Barjunid, 1996). Education has become a major priority of the Malaysian government and a very large proportion, 27% in 2003, of the national budget has been allocated to it. Literacy has improved since 1990s is revealed in Table 2.1. Pre-school education starts from age five for two to three years, primary education is from age seven for five to seven years, lower secondary education is from age 13 for three years, upper secondary education is from age 16 for two years, post-secondary or sixth form education is from age 18 for one or two years, higher education at first degree level is from age 20 for three to five years, and postgraduate studies can last for one to five years.

Table 2.2: Malaysia, Illiteracy and School Completion

Year	1998	1999	2000
Illiteracy total (% age 15 and above)	14.5	12.6	12.1
Illiteracy female (% of age 15 and above)	19.1	16.6	16.0
Net primary enrolment (% relevant age group)	..	98.5	..
Net secondary enrolment (% relevant group)	..	70.2	..

Source: World Development Indicators Database, 2003

Malaysia's education system serves about 4,800,000 school children and over 200,000 students in university at home and abroad (Barjunid, 1996). Governments have sought to tailor the system to suit Malaysia's multifaceted society. After the British left in 1957 education was revamped. The late Tun Abdul Razak, Malaysia's first Minister of Education, signed a Report of the Education Committee, known as the Razak Statement Report, in 1956(Barjunid, 1996). The aim has been is to develop a national education system that would contribute to the social, economic and political development for all the people of Malaysia. The unity of the nation was a major educational concern. This was the beginning of a specifically Malaysian curriculum.

There then followed the 1960 statement report from Rahman Talib, which sought to speed up integration of the society (Barjunid, 1996). The 'Rahman Report' led to the Education Act of 1961. This was also intended to speed up the process of national assimilation and unification, and Bahasa Malaysia, the national language, became a compulsory subject in all primary and secondary schools and the only major medium of teaching. Further, the Rahman Report emphasized technical and other vocational education, and religious education as a vehicle for the fulfilment of spiritual needs.

In 1979, Dr. Mahathir Mohamed, the ex-Prime Minister who was then the Education Minister, produced a report of the Cabinet Committee on the implementation of the 'Principles of Learning' (Barjunid, 1996). This sought to increase patriotism and the production of more skilled people for national development. It also prioritised balancing educational provision in urban and rural areas. It wanted education, its management in education and the development of curricula to be tailored to Malaysian conditions. In 1995 and 1996, the Education Act of 1961 was amended to help Malaysians think more often and effectively, and into 21st century, about their futures. The stated ideal for the Malaysian education system was one that sought to develop individuals who were responsible and capable of achieving high levels of personal well-being, as well as being able to contribute to the harmony and wealth of Malaysia.

The education system is organised by the Ministry of Education (MOE). This is the largest Ministry in the Malaysia's government. The public sector is the largest provider of education from primary schools through to universities. Private sector education is governed closely by rules, regulations and procedures monitored by the Registrar of Schools and Teachers Division of the Ministry of Education. The main task of primary schools is to teach basic skills of reading, writing and arithmetic. Secondary school pupils are divided into six often overlapping categories: regular, fully residential, vocational, technical, religious and special.

In the 1980s greater priority was given to 'science and technology' due to the perceived needs of economic development. Vocational and technical pupils became foci of government attention in some respects. To some extent, technical education has been reinforced to meet the country's need for engineers for production, design, development and so on, and for less highly qualified technical competent and knowledgeable employees including skilled production staff. A loan of US$40 million was given by the Asian Development Bank to the

Technical Education Project under the Seventh Malaysia Plan 1996-2000 (Asian Development Bank, 1997). The aims of this included improving the quality and expanding the capacity of Malaysia's technical education by building four new technical schools and upgrading 17 other secondary vocational schools in Malaysia.

Ingress (1979) studied Malaysian educational policy and its relationship with the occupational structure, and suggested that the government had had some success in using education to develop access to technical occupations. In the first Malaysian Plan, education had the major aim of restructuring society to increase economic equality, especially for the Malay population, and of narrowing gaps in educational opportunities between rich and poor, and between the various regions and races in the country. However, Ingress felt that although the British had been seriously concerned with Malay education, they had developed two different strands of it. One major action had been to use was the Malay primary schools to replace the Koran schools (Ingress, 1979). This sought to avoid promoting social mobility and the social and the social dislocation believed likely to result from educating rural children beyond their stations so that they became discontented with rural life. These schools were designed for mass education of a low level kind. The other strand of British education policy for Malays was aimed at small Malay elite. Pupils were mainly from the Malay aristocracy, along with a few talented commoners who were meant to fill administrative positions in the civil service. The selective English-medium schools were academically oriented and based on principles associated with British public schools and their traditions. Snodgrass (1980) argued that, in the post-independence era, the kinds of Malay people educated in these schools have had access to many higher forms of managerial posts.

INDUSTRIALIZATION IN MALAYSIA

In 1960s, Malaysia was faced with a problem of high unemployment, which rose to more than 8 per cent in 1969. The economy depended largely on exports of primary commodities such as rubber and tin, which made it vulnerable to price fluctuations in world markets. There was the added problem of income inequality between its racial groups. The plans to diversify the economy were potentially helpful politically and socially, as well as economically.

Government support also included enhancements to the environment for private investment. In addition to the provision of tax incentives, the Government provided infrastructure such as industrial estates, and power and telecommunications facilities. The Malaysian Industrial Development Authority (MIDA) was established in 1967. This supports and co-ordinates all industrial development. The Pioneer Industries (Relief from Income Tax) Ordinance 1958 was replaced by the Investment Incentives Act 1968, which provided a wider assortment of tax incentives. During the 1960s the private sector was left to assume the leading role in industrial development and this involved the development of sectors such as food, beverages and tobacco printing and publishing, building materials and chemicals and plastics, largely for domestic markets.

In the 1970s strong efforts went into the promotion of export-oriented and labour-intensive sectors. Unemployment was still high and the small domestic market constrained the economy's development. Lack of domestic capital and professional and managerial expertise also held back industrial development. To promote foreign direct investment (FDI), the Government enacted a Free Trade Zone Act in 1971, following which the Bayan Lepas Free Trade Zone was established in 1971. Licensed Manufacturing Warehouse (LMW) facilities were established in 1974. The Industrial Co-ordination Act 1975 was also passed to promote industrial and other sectors. Nine Free Trade Zones (FTZs) were developed in 1974 to offer tax-free areas with liberal customs controls for manufacturers that assembled at least 80 percent of their products locally. However, and in spite of all these efforts, the industries concerned were largely labour-intensive with simple technologies (Lim, 1994). The shallowness of technical and industrial development in this period clearly reflected its youth.

To develop Malaysian industry beyond this stage, the government promoted investment in various ways. An overseas investment promotion mission was organised in 1972. In 1992, a new investment office in New York was established as part of MIDA investment promotion drive for foreign direct investment (FDI). The 1970s also witnessed the establishment of electrical and electronics industries and other more labour-intensive ones such as textiles. Such developments resulted in Malaysia becoming a leading exporter of semiconductors. Incentive packages were offered to promote various labour-intensive industries, and help from the United Nations Industrial Development Organisation (UNIDO) was obtained to identify special projects for promotion and training of MIDA staff. Malaysia thus embarked on a structural transformation from an agricultural economy to an industrial one. The factors that have helped this transformation are inter-sectoral dependence, terms of trade being in favour of industrial sectors, and the openness of the economy.

The 1980s constituted a decade of structural adjustment and of deregulation. In the first half of the 1980s industrial policy focused on the widening and deepening of the industrial base. Heavy industries such as the motor vehicle, steel and cement ones were developed. The Heavy Industries Corporation of Malaysia (HICOM) was established in this decade and the first Proton cars were made in 1984. Heavy industrial projects are generally large-scale and require large investment outlays, and have long gestation periods and offer relatively low rates of return (Lim: 1994, 247).

For the indigenous natural resource-based sectors such rubber, palm oil, timber and cocoa, the government's focus was directed towards increasing the processing of Malaysian resources for export. In the mid-1980s Malaysia was also affected by a worldwide recession. Manufacturing recorded a 4.9 per cent growth rate from 1983 to 1986 compared to the 12 per cent annual growth rate of the 1970s. In 1986, the first Industrial Master Plan (IMP1) covering the period 1986-1990 was launched. The Promotion of Investments Act of 1986 was replaced the Investment Incentives Act of 1968. Thus, this liberalisation instrument was designed to promote manufacturing. It included raising the threshold levels connected to licensing requirements under the Industrial Co-ordination Act of 1975. Other development included liberalised action of foreign equity policy and granting expatriate position approvals for companies with certain levels of paid-up capital. These measures generated a surge in FDI inflows and created job opportunities. Oleo-chemical projects based on palm oil were established and Malaysia became a leading exporter of rubber-latex products and oleo-chemicals. Manufacturing registered a growth rate of 13.4 per cent for the second half of the 1980s.

Industrial growth in the late 1980s and early 1990s resulted in labour shortages in the 1990s. The unemployment rate was 3.1 per cent and 2.5 per cent in 1995 and 1996. This was said a situation of full employment. Table 2.3 shows the size of the labour force and rates of unemployment from 1982 to 2000.

Table 2.3: Labour Force and Unemployment Rate 1982-2000, Malaysia

Year	Labour force in thousands	Unemployment rate as % of the labour force
1982	5,431.4	3.4
1983	5,671.8	3.8
1984	5,862.5	5.0
1985	5,990.1	5.6
1986	6,222.1	7.4
1987	6,456.8	7.3
1988	6,658.0	7.2
1989	6,779.4	5.7
1990	7,000.2	4.5
1991	-	-
1992	7,319.0	3.7
1993	7,700.1	4.1
1994	-	-
1995	7,893.1	3.1
1996	8,616.0	2.5
1997	8,784.0	2.5
1998	8,883.6	3.2
1999	9,151.5	3.4
2000	9,616.1	3.1

Source: Department of Statistics, Malaysia, 2000

From this amount, manufacturing and services employment constituted significantly more then 70 percent of the labour force in 2001, as shown in Table 2.4.

Table 2.4: Employment in Malaysia by Sector in 2001

Year	2001
Total	9,512,000
Agriculture	17.0 %
Mining	0.4 %
Manufacturing	24.1 %
Construction	8.5 %
Services	49.9 %

Source: Ministry of Trade, 2002

To satisfy the needs of manufacturing over 200 industrial estates were established throughout the country from 1975. These were developed by such government agencies as the State Economic Development Corporations (SEDCs), Regional Development Authorities (RDAs), the Port Authorities and the Municipalities. New industrial estates are continually provided by these agencies to meet increasing demand. Private developers are also involved, as well as government agencies, in the development of industrial estates in different States. Foreign Trade Zones (FTZs) are designed specially for manufacturing companies, which make or assemble products mainly for export. Free Trade Zone facilities are provided to export-oriented companies to enable them to enjoy minimum customs formalities and duty-free imports of raw materials, component parts, machinery and equipment, as well as minimum formalities in the export of their finished products. With this help from the government, manufacturing contributed most compared to other activities to GDP between 1999 and 2003, as shown in Table 2.5:

Table 2.5: Gross Domestic Product (GDP) by Sectoral Origin (RM million), 1999-2003 (at 1987 prices)

Years	Agriculture, forestry and fishing	Manufacturing	Mining and Quarrying	Construction	Services	GDP (at market prices)
2003**	19,114 (3.4)	72,470 (8.5)	16,629 (2.5)	7,772 (4.5)	132,454 (5.9)	232,447 (5.6)
2002*	18,478 (1.1)	66,808 (5.1)	16,217 (2.0)	7,434 (3.8)	125,117 (5.3)	219,400 (4.1)
2001	18,269 (1.8)	66,808 (5.1)	15,892 (1.6)	7,159 (2.3)	118,764 (5.7)	210,480 (0.4)
1999	17,596 (0.5)	56,841 (11.7)	15,344 (6.9)	6,926 (4.4)	106,292 (4.5)	193,422 (6.1)

* Estimates by Ministry of Finance

** Forecast by Ministry of Finance

Figures in brackets are annual percentage changes

Source: Economic Report 2002-03, Ministry of Finance

So far, 14 FTZs have been established. They are at Bayan Lepas, Prai, Prai Wharf, Batu Berendam, Tanjung Kling, Sungei Way, Ampang, Hulu Klang, Telok Panglima Garang, Johor Port, Jelapang, Kinta Phases I and II, Tanjung Gelang and Sama Jaya. Licensed Manufacturing Warehouse (LMW) facilities were established from 1974 onwards to enable export-oriented companies to set up factories in areas where the establishment of FTZs is neither practical nor desirable. Another objective for providing this kind of facility was to encourage the dispersal of industries. LMWs are accorded facilities similar to those accorded to factories operating in FTZs.

The Malaysian government recognises a number of problems with its country's industrialisation. These are manufacturing's narrow base, vulnerable industrial links, weaknesses in local supply of intermediate products, inadequate development of indigenous technology, small value added of products, rising labour costs in production, and bottlenecks in transport and ports. There are also serious shortages of skilled people, a need to diversify products and markets, various problems caused by protectionism, trade blocs and managed trade, local private sector performance, a need for agrarian reform, and various resource and environmental problems (Gomez, 1997, p. 172). To address these, the government drew up its institutional framework under the Industrial Master Plan Two (IMP2) from 1996 to 2005 under which an Industrial Coordination Council (ICC), chaired by the Minister of International Trade and Industry (MITI), to provide the policies and direction for its implementation. The Council's members consist of representatives of the public and private sectors. The Industrial Policy and Incentive Committee (IPIC), chaired by the Secretary General of MITI, steers and guides Industry Task Forces and considers policy proposals from them before its proposals are submitted to the ICC. Its members consist of representatives from the public and private sectors. Each Industry Task Force promotes the further development of its sectors. Its focus is on enhancing industrial cluster-based development and manufacturing in its industry clusters with a view to enhancing their competitiveness.

Government policies under the IMP2 have four main features. First, there is an international orientation. There is reorientation from being export-oriented to being 'internationally-oriented'. The foci are on developing world-wide marketing, manufacturing and sales capabilities. Second, they seek enhanced competitiveness. This is meant to be achieved by industrial cluster development, deepening and broadening industrial link. Third, they seek improvements to relevant economic foundations. This includes the development and management of people and technology, enhancing diffusion capacity, physical infrastructure, administrative support, tax and non-tax incentives and business services. Fourth, they seek growth of Malaysian-owned manufacturing companies, particularly in the clusters.

The IMP2 thus aims to develop more broadly-based, resilient and internationally competitive industries (MITI, 1996). The government pursues two strategies. Its so-called

Manufacturing Plus-plus strategy emphasises aspects of value chains like design and technical development, integrated supporting industries, packaging, distribution and marketing services. It sought a shift from assembly-based and low value added activities, to the use of advance technology including automation and increased total factor productivity. The second strategy under the IMP2 was a cluster-based industrial development one with an emphasis on developing competitive industry clusters by integrating key industries, suppliers, supporting industries, supporting business services, infrastructure and institutions, generating backward and forward linkages, domestic spin-offs and value added, and the development of domestic small and medium-sized enterprises (SMEs).

Since 1991, the Government has made high levels of investment in R and D activities to help strengthen the technical capabilities of the nation with the ultimate objectives of accelerating growth and enhancing competitiveness. Policies and institutional reforms have been geared towards strengthening science and engineering and improving R and D. Even before the Government launched programmes to promote technology and R and D, Malaysia's conducive investment environment had attracted multinational companies to establish or intensify their research and development activities in Malaysia as steps towards strengthening their operations there. Multinational companies (MNCs), besides regarding Malaysia as an investment centre for manufacturing, have also begun to look at Malaysia as a research and development centre. Motorola, Intel, Grundig, Hewlett Packard, Komag, Matsushita, Robert Bosch and the Sony Corporation are among the companies which have set up R and D facilities in Malaysia. However, Jomo (1993) argued that there are limited levels of technology transfer, technical innovation and of links into the domestic economy. These MNCs can apparently operate as enclaves with a few spin-offs to locally controlled firms.

Under the Malaysia Ministry of Science and Technology and Environmental (MOSTE), the Intensification of Research in Priority Areas (IRPA) Fund was launched in 1988 to provide financing for research in areas of new and emerging technologies such as automated manufacturing, electronics, biotechnology, information technology and advanced materials technology. The IRPA Scheme was redesigned in 1991 to ensure that R and D resources of the country are invested in areas that can enhance industrial efficiency, productivity and competitiveness as well in the creation of home-grown technologies. The objective of this scheme is to direct the attention of Government-owned R and D agencies and universities with R and D facilities and capabilities in areas of commercialised R and D. Under the Seventh Malaysia Plan, R and D funding under the IRPA Programme was increased to RM1 billion from the RM600 million under the Sixth Malaysia Plan, in line with its emphasis on productivity-driven growth (EPU, 1999). The figure increased to RM1.2 billion under the Eighth Malaysia Plan.

To enhance private sector participation in R and D, in the 1997 Malaysian budget, the private sector was provided with access to the IRPA Fund through the Industry R and D Grant Scheme (IGS) which was established to provide grants to business enterprises on a matching basis to undertake R and D in government-designed priority technology areas. The IGS links between private and public sector linkages in R and D activities. To support R and D activities, a Science and Technology Human Resource Development Fund was established in 1989. Another catalyst for the commercialisation of R and D findings was the establishment of the Malaysian Technology Park (TPM) in 1988. The TPM’s main role is to support industrial entrepreneurship, especially the growth of advanced technology sectors, to promote industrial competitiveness, to encourage reverse engineering and to accelerate technology transfer; and provide a link between industry, government, other R and D institutions and universities.

Another institution linked to R and D in Malaysia is the Malaysian Technology Development Corporation (MTDC). Established in 1992, it focuses on the commercialisation of university research results. There is also the Malaysian Industry Government Group for High Technology (MIGHT) which was set up in 1993 to exploit innovative engineering research for new business opportunities. In addition to the various funds and schemes available to accelerate R and D activities and technological development such as the MTDC-administered commercialization Research and Development Fund (CRDF) and Technological Assistance Fund (ATF). Contract R and D company, R and D company, In-house Research and Double Deduction for R and D are incentives for research and development are provided under the Promotion of Investments Act of 1986 and the Income Tax Act of 1967.

MALAYSIAN DEVELOPMENT IN A WIDER CONTEXT

The economic policies of the Malaysian government are based on fairly conventional approaches to development. Since independence, the main policy has been to maximise GDP. However there is growing concern about the rate of use of natural resources and about whether continued growth is sustainable. The policies adopted by Malaysian government continued the colonial open-door approaches to trade and industry. Import substitution-based industrialization was the earliest policy adopted. The strategy of the government in the post-colonial era was to promote investments favourable to private enterprise (Lim, 1992). A rather narrow base of sectors was promoted. Its main components were electrical and electronic engineering and textiles and footwear. High proportions of the intermediate inputs for these industries were imported. Various incentives have been introduced to help develop local capital goods industries and the domestic production of intermediate goods, in particular that of components for electrical and electronics ones. As the import content is are still high for many products, rapid responses to external economic pressures with a view to increasing domestic sourcing of raw materials have been limited.

Athukorala (2005) argued that Malaysia's economic development policy had a long way to go in bridging its 'development gap' with the East Asian NIEs, let alone with the major OECD countries. It had been in the first phase of the East Asian model of export-led industrialization. Its manufacturing sectors tended to make labour-intensive goods, using low-cost labour with intermediate inputs and capital goods. The future growth of the Malaysian economy depended on its capacity to follow the 'the second phase' of the East Asian countries' development, that of the 1970s, which had relied on higher capital inputs and more sophisticated manufacturing.

Stiglitz (2002) argued that the IMF and the USA's Treasury Department and the World Bank had forced weaker economies to do the opposite of what the United States has done and still does when faced with the economic difficulties. While the USA practiced deficit spending in times of downturn, the USA and the IMF forced weaker economies to balance their budgets. In contrast to its own protectionism and its major government subsidies for sectors like agriculture, the USA had pressurised the smaller economies to drop all protection and to end all subsidies. Regardless of specific circumstances or the national conditions, so-called 'free market' solutions were forced on all dependent countries, even when clear evidence showed that such policies had led to further economic distress. The IMF had worsened the Asian economic crisis of the late 1990s and the economies of Russia and other formerly Communist countries which were forced to follow advice from the IMF and the USA.

Jomo (2005) contended that global inequality based on the consequences of international economic liberalization or 'globalization', had affected international trade, investment, finance, intellectual property and the form of international economic governance. Most critics of international economic governance like Jomo (2005) and Stiglitz (2002) had suggested that the IMF had made serious policy errors that had reduced cumulative economic growth and welfare for hundreds of millions of people. The IMF had seriously failed to help devise more effective crisis avoidance safeguards (Jomo, 2005).

Many developing or ‘late industrializing’ countries have established export-processing zones (EPZs) but these are often seen as policy instruments benefiting MNCs from the first world rather than developing host countries (Adnan, Ali and Ali, 1996). The liberal policies of developing countries had sought to encourage SMEs from the developed world that make standardised parts and products to relocate in developing low-cost countries. However, this had only created, and would continue to create, inter-industry links with their larger counterparts overseas, rather than with local enterprises. Therefore it would stifle the entry of local businesses into simpler kinds of manufacturing.

Another problem with the practice and theory of globalization was the development of emerging technologies, for example, new developments in electronics, information technology, robotics, biotechnology and new advanced materials. These are gradually absorbed into manufacturing processes and then begin to affect relative factor costs and comparative advantage. Thus Rajah and Ishak (2001) stated that Malaysia’s lack of such ‘technology-deepening’ potential had blocked the country’s capacity to move beyond simple and basic manufacturing activities to more original design and branding activities. Rising production costs alongside the emergence of more attractive lower cost sites, such as China with its cost-advantage and economic overheating had threatened to stall further expansion. Yet although Malaysia was still a major source of primary products, there has been a significant shift in the country towards higher value-added manufacturing from the 1980s onwards. In terms of the economic development as by evidenced growth of GDP from 1990 to 2000 based on World Bank (2006, Table 4.1) estimates, Malaysia is now regarded as a an 'upper middle income country'. The indicator showed that the GDP average growth for 1990 to 2000 was 7 percent, and that from 2001 to 2004 it was 4.4 percent. The decline in the latter period suggested that Malaysia became increasingly exposed to international trade and capital flows.

A lengthy argument about the conventional conception of development was put forward by Turner (2001). Conventional development theory had been developed by advocates of modernization, Dependency Theorists, and Marxists. Some countries had been slower to develop than others; and some countries were more or less exploitative or exploited or independent than others, and such factors were responsible for economic disparities between developed and developing countries. Most development theories adopted in developed countries and most supranational and international institutions and organizations concerned with development recognized the affluence of the rich countries as its goal. Thus all of the focus of thinking about development tended to be on increasing levels of industrialization, economic activity and wealth, trade, investment and living standards. Such thinking had also assumed that by increasing the GNP, all other aspects of society beyond the purely economic would improve.

However, the advocates of development theories in particular, and of capitalism in general, had led to economic failure in many developing Third World countries. High proportions of their resources of land and labour now produced for export, while billions of their people remained poor, and their ecosystems deteriorated. Others have argued against the inefficiency of globalization, as others perceived that globalization had not benefited most of Sub-Saharan Africa and the former Soviet Union economics (Morrissey and Filatotchev, 2000). Stiglitz (2002) criticized major international financial institutions for advising developing countries to embrace globalization by implementing formulaic and largely unsuccessful approaches to liberalizing their economies. Since the markets were not immediately self-correcting, Stiglitz argued that a more balanced approach to economic development was needed. This would consist of a return to less ideological policies promoting Keynesian counter-cyclical fiscal measures, gradual transitions towards freer markets rather than strong pressure to change quickly, and more involvement by the countries and peoples affected in devising the policies that they would pursue.

Bose (2001), in his arguments against the free market ideology advocated by the World Trade Organization (WTO), wrote that the ideology was belied by the facts. Well-known elements of the relevant beliefs included the WTO's dislike of direct production subsides for agriculture, its tendency to forget the fact that productivity varies for many reasons, its belief that world market prices are the only valid relevant criteria for guiding output, and that free trade is the only trustworthy engine of economic development. However, for Malaysia, the WTO's trade policy helped to create a recession in 1997 as a consequence of lack of short term regulation of foreign currency movement and the instability of the financial system (Salih, 2002). Other dubious attributes included modest investment in R and D, which included the training of engineers, scientists and other professionals; technologies that meet internal conditions, but may not meet external ones; technical advances that were sound enough in Malaysia but not exportable; and limited access in many sectors to technology, funds and international markets.

CONTEXT I: INDUSTRIALIZATION, GLOBALIZATION AND HUMAN RESOURCE MANAGEMENT

Here we consider general background factors to Malaysia's industrialization. In the next, 'Context II', section the facts of it are spelt out. Although industrialization began in the UK in the second half of the eighteenth century, its basis was established much earlier on. Contemporary patterns of world trade owe their origins to the fifteenth and sixteenth centuries and the trade of European maritime nations like Spain, Portugal, England and the Netherlands. Long before that, however more local trade had been evolving into a regional and international expansion of trade. At first, much international trade focused on luxury goods and other rare items. Examples included spices and fine cloths and other exotic goods from distant parts of the world (Wallerstein 1979). However industrialization in the West from the eighteenth century was increasingly a stimulus to trade in commodities like cotton and relatively simple products like clothes, domestic hardware and simple machinery, and slaves.

The UK, the USA, Germany and France dominated world manufacturing in the late nineteenth and early twentieth centuries. The UK helped to spread manufacturing investment overseas since the middle of the nineteenth century, for example, for agriculture, transport, mechanical and chemical engineering. Between the First and Second World Wars, manufacturing investment in Europe was largely in chemical and electrical engineering. After 1945, manufacturing was still dominated by industrial economies like those of the UK, Germany, France and the USA. Seventy per cent of the world production was still concentrated in four countries and almost 90 per cent in only eleven countries. Around 1950s, Japan produced only 3.5 per cent of the world total (Dickens, 1998).

Freeman and Perez (1988) argued that industrialization had had five phases. They called the first, from about 1770 to 1830-40, the First Industrial Revolution. This had been based on use of steam power in textiles, iron working and potteries. The second phase was from the 1830s to the 1880s. It is involved using steam power for railways and in ships. Also, machine tools emerged as a key sector, followed by transport equipment, some heavy engineering and synthetic dyes. The third was from the 1880s to the late 1930s. It was the age of electrical and heavy engineering. The dominant industries produced steel ships, armaments, heavy chemicals, synthetic dyes and electrical machinery, and this phase also included the emergence of such industries as cars, aeroplanes, radios and various consumer durables. The fourth phase was from the Second World War (1939-1945) and after, between 1939 and the late 1970s. The dominant industries were automobiles, aircraft, chemicals and petrochemicals, electronic engineering and various consumer durables. The fifth phase (1980s and 1990s) was one of information, communication and so-called new technology. Electronic technologies, software, telecommunication, robotics, new materials, biotechnology, chemicals and aerospace dominated it.

It is generally agreed that industrialization began in the middle of the eighteenth century in Britain on the basis of invention of, or the search, for better products and processes by small-scale firms (Amsden, 1989). Industrialization from around 1860 or 1870 to early 1900 in Germany, the USA and elsewhere occurred on the basis of innovation, or commercialization of inventions through processes sometimes involving more systematic problem solving, sometimes with the use so-called R and D laboratories of enterprises. While these two modes of industrialization differed, if only in their degrees of ‘scientific’ input and firm organization, they shared one key characteristic, the generation of new techniques and technologies by leading companies (Amsden, 1990). Developing them gave the UK, Germany and the USA sustained competitive advantages for long periods.

Hirst and Thompson (1996a, 1996b) and Sorge (2005) have cast great doubt on the idea that globalization is the master trend of our age, by pointing out that levels of international trade have long fluctuated over time and that resistance from nation states and grouping of them and the rises and the falls of nations and empires have long been affected by international economic relations. Ackroyd, Glover, Currie and Bull (2000) and Glover and Walker (2007) suggested that the main trend in the more developed human societies since the sixteenth or eighteenth, according to interpretation, century, has been a process that is more fundamental and permanent, and one which has not ended: industrialization. The arguments of these authors also cast doubt on the currently popular ideas that the pace of technical and economic change is accelerating (see especially Ackroyd, Glover, Currie and Bull, page 290 to 294, including Table 14.1), and that competition between firms and between nations is intensifying. They point to the very often more incremental character of technical change in the period from 1950 around to around 2000 and to its very often much more dramatic, fundamental and discontinuous character in the decades around 1900. They, especially Ackroyd (2002; also see Glover 2003), point to the growth of *co-operation* between firms with inside and across national boundaries, to suggest that conventional assumptions about intensifying competition, as well as those about accelerating change, are simplistic, and possibly dangerous because they may encourage unnecessarily aggressive business and government.

However technical and commercial competitiveness, clearly remains crucial for developing countries that have insulated themselves or been insulated from world markets (Lall, 2001). Gaining competitiveness is often difficult, needing much more than relatively passive freeing up markets. It has to be built, and generally the process is complex, demanding and costly (UNIDO 2002). Stiglitz (2002) argued that growth of international trade since the 1960s, involving elements of globalization, has often harmed developing countries. So-called globalization had not brought them anticipated economic benefits. Third World poverty had often increased and there have been serious economic crises in Asia and Latin America. Critics of globalization had accused the industrial countries of hypocrisy for promoting economic interconnectedness in ways that had only benefited themselves.

By the 1990s, the term globalization had come to mean higher levels of trade between nations, and especially of trade within multinational companies (Hirst and Thompson, 1996a, 1996b), as well as reduced trade barriers, more international capital flows, declining transport costs, the portability of new technologies and more integrated financial markets. Multinational companies (MNC) could readily transfer production, in whole or part, to wherever mixes of materials, infrastructure, skilled workers, employment costs and regulatory requirements offered the potential to compete in international markets. Yet Hirst and Thompson argued that if globalization is conceived as a process that promotes cross-border exchanges and transterritorial agencies at the expense of nation states, then it is dubious. The problem for countries was loss of benefits of domestic governance and increased exposure to international pressures. Critical future threats would be climate change and its consequences, population turbulence, and inequalities of national income. Government would have to protect their populations and to monopolize and control the distribution of key resources either by political activity or military force. Some major states had already thought about access to water and oil.

Hirst and Thompson (2002) argued further about the limitations of globalization. Globalization had been defined as increasing trade interdependence and integration of investment. Ohmae (1991) had argued that power of nation states was increasingly irrelevant and being transcended, hollow and defective (also see Strange 1985). However, there was no real increase of trade in goods between North America, Western Europe, Japan and other parts of East Asian. Hirst and Thompson argued that, far from market exchanges sweeping unhindered across the world, real limits to the further expansion of international trade, set largely by the continuing power of national territories and borders, were likely to continue. Second, the real constraints on any further development of global trade were more likely to be institutional, social, and political, or geographical, rather than economic. Third, there was some evidence that world trade growth had slowed in recent years (meaning in the early-to-mid 1990s). Globalization was broadening mainly from international trade, but there was nothing so new or so special about it since the 1970s, except the greater and faster internationalization of information, communication, finance, news and entertainment.

Amaravodi (2003) claimed that the fourth industrial era started during the early twenty-first century. Steel and steam existed in the first industrial revolution; the second industrial era was one of electronics, and the third one of the Internet. Amaravodi had found a few key innovations in fields such as Artificial Intelligence (AI), Molecular Engineering and Power Generation. In the next decades, the fourth industrial era fuelled by evolution in power, genetics, space exploration and information in industries as diverse as utilities, retailing and pharmaceuticals as well as the government (ibid, pp. 373).

From 1750 to 1850, the world has experienced economic changes in the international trade. The Northern countries experienced the shift from agriculture to industry, and their economic growth took off. In 1990 the world's richest nation is 4,500% richer than the poorest; in 1870 the figure was 900%, and before the first industrial revolution, beginning around the middle of the 18^{th} century, Western European per capita incomes were only 30 % above those of China and India (Maddison, 1983; Bairoch, 1993). Further, to this, the diverse figures by Maddison (1991), Baumol (1994) and Kuznets (1965) asserts that the big north-south income divergence appeared with the first Industrial Revolution. Thus, the industrial revolution caused rapid income divergence by triggering industrialization and growth take-off in Europe while incomes stagnated in the many poor nations (see Baumol 1994). The world experienced rapid incomes divergence by triggering industrialization and growth take-off in Europe while income stagnated in poor nations (see Baumol 1994). The world experienced rapid expansion of international trade. The most striking feature of the Industrial Revolution concerns the increase of growth rates. For example, the UK's per capita income rose by 14% between 1700 and 1760, by 34% between 1760 and 1820, and by 100% between 1820 and 1870 (Maddison 1983). Moreover, since population growth also increased sharply during this period, due to better economic conditions, the UK's GDP rose even faster than the per capita figures suggest. Crafts (1989) argued that at the same time the UK became a large food importer and a large exporter of industrial goods. He noted that in 1700, 18.5% of the labour force was in industry, in 1899, 29.5% and in 1840, 47.3%. Hirst and Thompson (1996) argued that the success of East Asian newly industrialized countries (NIEs) is due to high savings and careful state intervention, not to *laissez-faire*. This demonstrates that it will be hard for most LDCs to follow NIEs, especially if they are forced to accept the new liberalism of the World Trade Organization Therefore only a few labour intensive sectors are likely to flee to low-wage LDCs, and high levels f FDI will lead to volatile and fragile growth (Radice, 1997).

Glover (1992) produced two arguments in favour of manufacturing, especially in Britain. First, most services do not add as much value compared to production and manufacturing, as they tend to be less capital intensive. The 'strategic reason' (p. 38), that most countries need to have some ability to make armaments if they are to defend themselves, is also relevant, as attempts to encourage growth of production are much more likely to succeed in countries that retain capacities for example such those for steel–making and machine-tool manufacture. The second argument is the 'rise of the self-service economy'. The standard of living and employment were increasing, dependent of manufacturing as households replace services with goods and because a high proportion of jobs in services are good-related or goods-dependent rather than 'pure' services jobs (Godley, 1986; Cohen and Zysman, 1987). Ackroyd (2002) took this sound argument further into the early twenty-first century.

The importance of industrialization to developed and developing countries was emphasised by Myrdal (1956), who that 'industrialization, and the growth of that part of the working population that is engaged in industry, is therefore a means of rising national income per capita'. Another major motive of industrialization is to improve the stability of foreign exchange earnings and the national income through the diversification of exports. Uniform powers, transport and communication grids have improved international trades (Amaravodi, 2003). GNP growth rates have doubled in many countries and industries now beginning to stratify along national borders based on established competencies (Porter, 1990). Factory automation are mostly engaged in Germany, Japan and Taiwan, while the technical development of such agricultural methods, such as genetic farming, hydroponics and soil engineering have increased agricultural yields (Shapiro, 1999).

In the USA, Cohen and Zysman (1987) emphasised why, manufacturing matters. It mattered to the wealth and power to the USA. The point is the USA could not just shift out of manufacturing and only engage in services. They stressed the directness linkages between services employment and manufacturing. Services were a complement to manufacturing, not substitutes nor successors to it. Their argument thus attacks the side of a services-based, 'post-industrial' economy as the natural successor to an industry-based one, as in some versions of the 'stages of development' idea (1987a, p. 5). In such a view, agriculture is the first stage of development, industry is the second, and a knowledge-base service economy is the third. Alic (1997) argued that a post-industrial economy is largely a services one; in the

United States, services firms accounted for about 80% employment, while the manufacturing share had fallen to 15 %. However, Glover (1992) argued that employment statistics for manufacturing and services tend to mislead. The main change of employment out of agriculture had occurred in Britain after 1840. In 1840 more people worked in services than in either agriculture or manufacturing, and this had always been the case since then. And many, in fact most, jobs in manufacturing were of services kinds. Manufacturing employment had never ever approached a figure that exceeded all other kinds. Most services jobs, like those in retailing, depended for manufacturing for their existence. Most of people worked in quite routine and/or intellectually undemanding jobs. Further, many services were performed by manufactured goods, as when, for example, television and filmed entertainment replaced live entertainment, and washing machines bought by home owners replaced hand washing and public laundries.

Those last arguments drew on those of Gershuny and Miles (1983). They argued in some detail that there are tight links between services and manufacturing jobs. Services complement manufacturing, just as, for example, there are tight links between agricultural production and the food processing industry. There are many activities bound to farming that are backward links: crop dusters, veterinary surgeon, harvesters, tractor repairers, mortgage lenders, fertiliser salespersons, agronomists, chemists, and lorry drivers. Other sectors such as finance, insurance and agricultural machinery and agricultural chemicals manufacturing, all linked to agricultural production. The same points also applied to most services and manufacturing. For Cohen and Zysman (1987), the organization of manufacturing production in the USA in the mid-1980s made the employment of perhaps 40 or 60 million Americans, half or two thirds of whom were conventionally counted as service workers, depend directly on manufacturing production. Thus, Gershuny and Miles argued that many service workers did not ultimately produce services. Services occupations and employment sectors divided into, first, goods-related services and, second, services ones proper (p. 34). Good-related jobs were such as those in communications, wholesaling, retailing, banking, finance, insurance, property, technical services, marketing research and advertising, the hiring, maintenance and repair goods and so on. In general they produced inputs to manufacturing (upstream jobs) or depended on its outputs (downstream of factories). In the second category, most 'services jobs proper' are goods-dependent, if not goods-related, because they could not be performed without use of hardware of some kind, examples included catering, dry cleaning, entertainment, hairdressing, health care, teaching and tourism. For Glover (1992:34), if the goods-related services jobs were added to those in manufacturing, or more broadly defined 'industry', then industrial/manufacturing jobs remained extremely important, and constituted at least a half and often considerably more of all jobs in many industrial countries.

The transition that we are experiencing now therefore is not out of industry into services, but, forms one kind of industrial society to another. Cohen and Zysman (1987) argued that there was no such a thing as post-industrial economy. The wealth and power of a country depended on maintaining at least mastery and control of production, and another was that of Glover (1992) who noted how in the UK and other industrial countries, employment in services had come to include about two-thirds of labour forces (p. 33), with manufacturing only accounting for around a fifth or a quarter. However, this suggestion of manufacturing as a source of employment and wealth was very misleading and should be avoided (Glover 1992; Lawrence 1989; and Cohen and Zysman 1987). The truth was that the significance and weight of manufacturing was growing, with its output and capital-intensiveness. Glover (1992) also argued that manufacturing was the core activity around which most others revolved, even if it much of it took place outside relevant national boundaries, and that look down on and to opt out of it was illogical in terms of pursuits of one's own interests, and also selfish(p. 40).

Most developed countries have experienced periods when economic success was synonymous with manufacturing. Birmingham was once 'the workshop of the world' for example (Inkster 1999). Success in manufacturing was linked to geopolitical power. Germany was defeated in two World Wars partly because of the production by the USA's, the UK's and the USSR's industries of machines like tanks, and bomber aircraft.

Cohen and Zysman (1987) argued that many sectors like farming, textiles and insurance did not perform their own R and D. They were the users of R and D performed in supplying industries and in specialized non-industrial centres. It was the historical development of an industry, its relations with its suppliers, and its competitive and institutional structures, not only or even necessarily the nature of its product, that influenced whether or where R and D would be performed.

In his chapter under discussion Glover (1992: 188) suggested that for much of the last century, British education had over-valued the pursuit of knowledge for its own sake, and that this had led to an arm's-length approach to manufacturing, and to top-heavy management of it. This tended to make educated British people look down on engineering and industry.

On Japan, since 1950, Maddison, Roa and Shepherd (2002) argued that to understand its economic growth from then to 1973, one must appreciate the contributions of capital, education and training, technical progress and the organization of production. Also Japan had been a unified country for a long time, had a homogeneous culture and a single language, had achieved a savings surplus long ago, and had possessed significant social capability, e.g. literacy, infrastructure and central government, had never been colonised, and its government played a positive economic role. On human resource management (HRM) Legge (1989) had noted that some versions of it emphasised the importance of high commitment, workplace learning, and leadership for productivity. Most American or British HRM models, had suggested that human resources were valuable assets of employers, not a variable cost and emphasised the potential of employees as sources of competitive advantage.

However, and in ways rather opposed to the points about the importance of education and knowledge to industry from Maddison, Roa and Shepard (2002), and Legge (1989), Illich (1971) and Dore (1976) argued that expectations of formal educational institutions, and the institutions themselves, are often flawed. Illich (1971), a Roman Catholic bishop in Central America, wrote that formal education's mix of compulsion, indoctrination and certification created an authoritarian mentality. He argued that the mere existence of schools discouraged and disabled the poor from taking control of their own learning. Clearly, anyone who sees freedom and self-direction as essential to educational processes can recognise a contradiction between education and coercion. Yet Illich is surely right to make his criticisms and to report his scepticism about the role of education in developing countries. Illich (1971: 34) recognised four distinct 'channels' which could contain all the resources needed for real learning; things; people who serve as models for skills and values; peers who challenges, argue, compete, co-operate, and have understanding; elders, experienced people who really care about others and expose learners to confrontation through of criticism. For example he proposed skill exchanges which could allow people who could serve as models for skills and values to list their skills, the conditions under which they are willing to serve as models for others who want to learn skills, and how they can be reached.

Dore (1976) argued that the basic general education which some of the entrepreneurs and inventors of the late eighteenth and early nineteenth centuries received was probably not irrelevant to their later achievements which were accomplished by 'hard heads and clever hands' (Ashby 1961). Training took place almost entirely in the factories, mines, workshops and mills, and not in schools, providing the skills which fed Britain's industrial advance (Dore 1976). In the pioneer era of industrialization progress took place through invention or by its importation and development.

According to Illich (1971) school was not the only institution could shape human visions of reality. The curricula of family life, crafts, health care, profession, and the media played important parts in the institutional of manipulation people. They used various kinds of vision, language, and demands. Along similar lines, Dore (1976) argued that the imagination, creativity, honesty, curiosity, and determination to get to the bottom of things, and the desire to do a good job were unlikely to be bred in school. To Illich, school enslaved people profoundly and systematically, since only school was credited with the function of showing people how to form critical judgements, and paradoxically, tried to do so by making learning about oneself, others and nature depend on a pre-packed process. He argued that the discovery that most learning required neither could be manipulated nor planned and that 'each one of us is personally responsible for his or her own deschooling and only we have the power to do it'. By deschooling Illich meant a process which individuals, organizations and societies should use to free themselves of the rigid and authoritarian assumptions, practices, structures and other institutions of formal education and professional and occupational formation and development. Illich (1974) thus offered a critique of formal education and professions. Lister (1974) agreed with Illich that the notion of deschooling increased the range of alternatives to school and school-limited education and life-long learning, and that these (too check) are both vital areas for development (p. 17).

Dore (1976) felt that schooling altered people's capacities and will to do things. These did not only depend on what people learned. Education aspired to be about far more than qualifications, and a mere process of certification. Employers needed to understand this better and to be more critical of formal qualifications and more informative about the abilities and attitudes that job really demanded.

I support that Illich and Dore would have preferred German education and management to them in most other industrial countries. According to Warner (1998), the typical German approach to starting jobs was based on their technical requirements. Technical expertise was regarded more highly in Germany than management or other statuses. In German companies, engineering skills and managerial expertise were often combined in the hands of owners and professionals. Managers in Germany were far keener on making things than those in most other developed countries. German management (although according to Sorge 1978, Lawrence 1992, and Locke 1996 Germany mistrust the whole idea of management) is traditionally specialist rather than generalist. More than a half of senior and middle mangers in German industry have been educated as engineers, and German management was more task-oriented and technically focussed than most managers elsewhere. German managers focussed on details, avoided uncertainty and had fairly consistent ways of managing. Lawrence (1992) reviewed the Anglo-German comparative evidence and literature to discuss the well-known high status of German engineers, the unusual dominance of engineering as the main route into industrial management, the higher pay ranking of German engineers relative to most other management-level people in Germany and elsewhere. Lawrence has also emphasised the strong learning by doing emphasis in German technical universities and companies (Lawrence, 1980; Hutton and Lawrence 19881).

CONTEXT II: THE MAIN FACTS OF INDUSTRIALIZATION

Malaysia's economy has experienced rapid economic growth since 1960s. This growth has been accompanied by low inflation and reduced unemployment. Manufacturing has played a decisive role in this contributing significantly to output, investment, employment and exports. The export sectors have been at the forefront in improving the economy, but have made the country highly dependent on buoyancy foreign markets. In East and South East Asia, foreign corporations have been major forces in the development of exports, especially of goods. For example, in the late 1980s and early 1990s, the shares of foreign affiliates in national exports were as high as 57% in Malaysia (all industries), 91% in Singapore (non-oil manufacturing) and less at 24% in Hong Kong (manufacturing) and 17% in Taiwan (manufacturing) (UNCTAD (1995 p. 214).

It seems sensible to make comparisons of GNP per capita (US$) in Malaysia with selected high income countries like Germany, Japan, the UK, and the USA, and the Newly Industrialized Countries (NIEs) like Hong Kong, Singapore, South Korea, Taiwan, and other ASEAN countries like Indonesia, the Philippines and Thailand. In 1990 Malaysia's GNP per capita was $2,000, compared to $18,000 for Germany; $24,000 for Japan; $17,000 for the UK; and $22,000 for the USA. In of relevant NIEs, the figure for Hong Kong was $12,000; $12,000 for Singapore; South Korea $5,000, and Taiwan $8,000. In other ASEAN countries, GNP per capita for Indonesia was $562, to the Philippines was $720, and Thailand $1,404. By 1995, Malaysia's GNP per capita (US$) had increased rapidly to $4,000, compared to Germany's $30,000; Japan's $38,000; the UK's $21,000 and the USA's $27,930. Rapid increases also occurred in the NIEs and in other ASEAN countries. For Hong Kong it was $23,000; Singapore, $28,000; South Korea, $10,000; and Taiwan, $12,000. Indonesia and Philippines was $1,000, and Thailand was $3,000.

Data on GDP show that the slowdown of the world economy in 1998 and 2002 led by a downturn in many major industrial economies. The economies of the USA and Japan performed badly for various reasons, and there was weakening domestic demand growth and consumer confidence in Europe. Also, investment in information and communication technologies fell in most countries (EPU, Malaysia, 2002). The slowdown that began in late 2000 was influenced by the fall in ICT equipment and software spending, high interest rates, rising energy prices and a significant decline in equity prices, particularly of technology stock. The fall of stock markets slowed down economic growth further through negative wealth effects leading to marked decline in domestic demand and continued weakening of consumer and business confidence. Manufacturing output was either static or reduced due to lagging sales and the resultant build-up in inventory, particularly in semiconductors and personnel computers, which then led to further cutbacks in production (Ministry of Finance, Malaysia, 2002).

The average annual growth of industrial output for these countries in the same period (1998 and 2002) was Australia 3.1% and 2.8%, China 11.1% and 12.6%, France 1.4% and 1.5%, Germany 1.4% and negative 0.1%, India 6.9% and 6.0%, Japan 4.2% and negative 0.0%, Korea 11.4% and 6.2%, Malaysia 6.8% and 7.5%, Myanmar 0.5% and 10.5%, the Philippines's negative 0.9% and 3.5%, Singapore 5.2% and 7.3%, Thailand 9.8% and 4.9%, United Kingdom 3.35 and 1.2%, United States' 3.0% and 2% and Vietnam 4.4% and 11.9%.

THE FOUR MAIN SECTOR GROUPS

Four main sector groups in the economy are examined below. The first is energy and extraction, which includes farming and fishing, natural gas, mining and crude oil. The second is manufacturing and construction. The third and fourth are privately financed services and publicly financed ones. Output in 1998, 1999, 2000, 2001 and 2002 in farming, forestry and fishing was worth RM 17,415 million, RM 17,596 million, RM 17,943, RM 18,269 million, and RM 18,478 million. The contribution of manufacturing to GDP in those years was RM 50,899 million, RM 56,841 million, RM 67,717 million, RM 63,536 million and RM 66,629 million. Private services, including finance, insurance, property and business services contributed RM 23,246 million, RM 24,976 million, RM 26,064 million, RM 28,548 million and RM 30, 902 million (Ministry of Finance, 2003). Manufacturing, finance, insurance, property and business services contain and consist of relatively fast growing sectors. From 1990 to 2000 the average growth rates of other sectors, 0.5% for farming, 10.4% manufacturing, 3.4% mining, 7.0% construction, and 8.3% for private and public services (EPU, Malaysia, 2001). Details of the contribution of many sectors under these four main group sectors are given below.

The *energy and extraction* sectors consists mainly of farming, fishing, forestry, crude oil, natural gas, crude oil and tin. Farming, livestock, forestry and fishing contributed RM16,185 million to GDP in 1987, RM17,308 million in 1990, in 1995 RM17,115 million and in 2000 RM17,687 million. Much of this growth was due to increases in hectares planted for palm oil and cocoa. For example, in 1959, planted hectareage of palm oil was 51, 053 hectares, 103,441 hectares in 1970, 545,462 hectares in 1980, with 912,131 in 1990 and 2,024,286 in 2000 (Department of Statistics, 2001).

Production of rubber in 1930 was 45,700 tonnes. By 1950, production consisted of 703,700 tonnes and in 1970, 1980, 1990 it was, 904,823 tonnes, 1,268,200 tonnes and 1,529,900 tonnes respectively, and in 2000 it was 615,000 tonnes. This might suggest that the main weight of exports has been shifting in the last half century from primary products to manufacturing and services. Palm oil is cultivated largely as an estate crop, with 9.5% of the total hectares in the country under cultivation. Farming, forestry, fishing and livestock contributed 28.8% of GDP in 1974, 22.9% in 1980, 18.8% in 1990, and 8.6% in 2000. This reduction in contribution has been due variously to the volatility of primary commodity prices, to the development of synthetic substitutes, to growing emphasis on secondary and tertiary sector output, and to changes in intermediate and international markets and market conditions.

Mining in the Malaysia Industrial Classification of 1972 (updated in 1979) is defined as the extraction, and improvement of minerals occurring naturally, including solids as coal and ores, liquids such as crude oil, and gases such as natural gas. Production of crude petroleum was 52,000 tonnes in 1963. As in the 1960s and 1970s, discoveries of oil and the growth of oil prices have generated the so-called ‘Dutch disease’, when Malaysia sought to extract the maximum rent from the exploitation of oil resources. By 1980, oil production had increased to 12,245,000 tonnes. In 1990, it was 29,556,000 tonnes. The peak production was in 1998, at 33,934,000 tonnes. In 2000 it was down to 31,931,000 tonnes. Extraction of natural gas only started in 1973. The data that follow refer to crude gas in gross extractions of associated gases. The figures for the production of these in 1973 are 3,187,000 tonnes. By 1982 it had increased to 113,565,000 tonnes. The production of natural gas only began in 1983, when it amounted to 157,409,000 tonnes, increasing to 502,538,000 tonnes in 1990 and to 1,598,325,000 tonnes in 2000. The extraction sectors which include crude oil, natural gas and tin, contributed 6.1% to Malaysia’s exports in 1970 and 17.5% in 1990 (Department of Statistics, 2001). The extraction sectors were producing around 7% of Malaysia’s GDP in the early 2000s. The primary sector, although important to the economy, saw its share of GDP decline from 28.1% of GDP in 1990 to 18.3% in 2000. In contrast, the share of GDP from the secondary sector, manufacturing and construction, expanded from 30.2% in 1991 to 38.7% in 2000 (EPU 2004).

Tin output has been falling for many years as reserves had fallen. Production of crude oil and natural gas has increased over the three decades since 1970s. This was partly due to higher revenues being expected from exports. Efforts were made to increase the nation's oil reserves, including the exploration of deep sea oil fields. For example, 10 oil exploration wells and 13 development and production wells were identified in 2001 (EPU, 2001).

Malaysia has been a significant producer of crude oil and natural gas since about 1980. Malaysia's recorded reserves of crude oil declined by 17%, from 4.1 billion barrels to 3.4 billion barrels from 1995 to 2000. This was due mainly to the maturity of existing fields. Although new fields were discovered, they were smaller than previous ones. The Petroleum Nasional Berhad (PETRONAS) ventured into upstream activities abroad by securing exploration acreage in Algeria, Angola, Chad, Gabon, Govan, Indonesia, Iran, Libya, Myanmar, Sudan, Tunisia, Turkmenistan and Vietnam (EPU, 2000). As Malaysia's domestic crude oil is of a premium quality, largely it was exported. The value of all such exports was RM6.7 billion in 1995, RM14.24 billion in 2000 and RM9.13 billion in 2003.

Malaysia accounted for approximately 14% of all world Liquefied Natural Gas (LNG) exports in 2002. Malaysia had about 75 trillion cubic feet (Tcf) of proven natural gas reserves in 2003. It exports this mainly to Japan, South Korea and Taiwan. The Bintulu Sarawak facility is the largest LNG liquefaction centre in the world, with a capacity of 23 million metric tons per year (Petronas, 2003). The government has a highly integrated form of involvement with Petronas, as this makes a substantial contribution of about 20% to government revenues in the forms of taxes, royalties and dividends. The last 40 and 50 years have seen both the output and the exports of the energy and construction sectors become more diverse, with most kinds of output growing, but with manufacturing and services becoming more important as components of both GDP and international trading activities. Oil, gas, and palm oil are the partial exceptions to these trends in the energy and extraction group.

Manufacturing has been responsible for between 30% and a third of GDP since 1990s. Of a total RM79,646 million worth of exports in 1990, manufacturing contributed 58.8%; farming including palm oil, rubber, forestry and fishing 19.6%; mining, which included crude oil, tin, and natural gas 18.3%'s and others 3.3%. In 2000, of the total value of exports of RM 373,307 million, manufacturing contributed 85.2%, farming 6.0%, mining 7.3% and other 1.5%. Among goods exported in 1990, semiconductors constituted 14.7%, electrical machinery 14.0%, textiles, wood, rubber, paper and petroleum products 10.4%, electronic equipment and parts 4.6%, transport equipment 2.4%, chemical products 1.8%, and other manufactures 10.8%. The composition of manufactured exports has changed significantly, especially as regards electronic equipment and parts. In 2000 electronic equipment and parts contributed the largest share of manufacturing exports at 26%, followed by semiconductors 19.0%, electrical machinery 17.0%, other manufactures 10.3%, and textiles, wood, rubber, paper and petroleum products 8.4% and chemical products 0.8% (EPU, 2001).

In evaluating the growth of manufacturing in terms of Total Factor Productivity (TFP), growth is recorded as positive and negative in different industries or sectors. TFP in concerned with such things as how additional output comes from improvements to methods of production, with inputs of labour and capital unchanged. It included the improvements in know-how, innovation, and employee education, skill and experience (EPU, 2000). For example, for food and beverages, growth for between 1985 and 1990 was 5.6%. This increased to 9.7% from 1990 to 1995. However, the growth of TFP from this sector was only 2.5% from 1995 to 1999. General machinery recorded growth of TFP from 1985 to 1990 of 7.6%, and 11.0% and 13.3% from 1990 to 1995 and from 1995 to 1999 respectively. Perhaps surprisingly, the furniture industry recorded the fastest growth of TFP with figures ranging from a negative 2.6% to 7.3% and 9.8% in periods. TFP growth rates in manufacturing, in chemicals, rubber and plastic products, and transport equipment, were recorded as between 1990 until 1999. However the parts of the rest of the manufacturing group in which growth was positive included textiles and apparel, wood products, paper and printing, glass and clay products, basic metals, fabricated metals, electrical machinery, and various others.

As regards capital investment in manufacturing, electronic and electrical products received the highest amounts of capital investment: RM38.5 million between 1998 and 2002. Petroleum products, including petrochemicals, followed this with RM12.5 million. For chemicals and chemical products, the equivalent figure was RM8.6 million, and for paper, printing and publishing it was RM8.2 million, for transport equipment RM7.2 million, for natural gas RM7.3 million, and for food manufacturing RM4.2 million (MIDA, 2004).

The numbers of industrial establishments in the manufacturing sector grouping in the five years from 1998 to 2002 are interesting. The electronic and electric products establishment total had 1,087 from a total of 4,191 units. Machinery manufacturing had 428 units, fabricated metals products 253 units, food manufacturing 285, chemical and chemical products 256, and transport equipment 269 units. Petroleum processing establishment has high level of capital investment, because of its capital-intensiveness and the high cost of equipment, the number of establishments was only 56. The numbers of jobs created in the same years were highest for electronic and electric products, amounting to 170,320 of a total

403,299. In other sectors, job creation figures were: food manufacturing 20,674 jobs, furniture and fixtures 20,881 jobs, rubber products 21,485 jobs, machinery 22,911 jobs, transport equipment 22,936 jobs, textiles and textiles products 19,961 jobs, wood and wood products 18,821 jobs and fabricated metals products 16,158 jobs (MIDA, 2004).

Construction includes new construction, alterations, repairs and demolition work. Construction's contribution of GDP for 1997 was 4.8%, and it employed about 9.2% Malaysian workforce (MTEN, 1998). In 1997, the share of GDP had only been 1.0% but it increased to 4.9% by 2000. This was due to the expansion of fiscal spending by the government and by banks.

According to the principal statistics on construction (Department of Statistics, 2001) the gross value of its output in 1964, 1970, 1979, 1990 and 1998 was RM364,167 million, RM487,278 million, RM3,367,436 million, RM11,938,881 million and RM40,270,328 million respectively. Figures for value added by constructions in the same years were RM188,755 million, RM207,775 million, RM 1,313,975 million, RM4,387,652 million and RM15,549,376 million. Civil engineering output was increased by the privatization of large infrastructural and civil engineering projects, such as roads, highways, airports, power transmission networks, telecommunications, rail transport and ports. Increases in activity in the residential sub-sector and in tourism helped. Other than this, the industry has strong links with others such as sawmills, distributive trades, and construction-related manufacturing. However, construction faced problems with supply space, lack of financing facilities and rising costs of imported construction materials (MTEN, 2000). Further to this, the construction industry also had low levels of productivity, with contributing factors including heavy reliance on large numbers of unskilled foreign staff, multi-layered subcontracting involving many small firms, and other sectoral forms of segregation of the activities of the industry (Wong, 2004).

The third main sector group is private services. These include professional services such as accountancy, architecture, engineering, law, surveying, veterinary surgery, private schools and private health care. Other commercially-oriented private sectors include shipping, property, bus transport, road haulage, entertainment, tourism and travel, and banking, finance and insurance. Such services contributed 55.1% to GDP in 2000 and in 2004 (EPU, 2001). The main contributors to this were transport and finance. In 2002, services contributed 45.9% to GDP. Manufacturing and construction contributed 30.7% in the same year. Services used 50.2% of the workforce in 2002 compared to 27.1% in manufacturing. In 2002, Malaysia was the world's 27th largest exporter and the 26th largest importer of commercial services compared to its position as the world's 18th largest of exporter of goods. Malaysia's exports of commercial services were worth RM14.06 billion in 2002 compared to the world's total for exports of RM2,972.36 billion. The share is 0.48%. A fast and significant increase occurred in 2002, when the exports were RM53.58 billion compared to total world exports of RM5, 853.9 billion with the share 0.92% (EPU, 2003).

In the public services sector grouping, the government's work has economic, social, security and general administrative aspects. This so-called economic sector of the public services grouping includes agricultural development, mineral resources development, commercial and industrial development, other communications, energy, water and research and development which all involve employment of government staff, and government spending. The social services budget and employment sector includes education and training, health, information and broadcasting, housing, the 'arts', youth and sport, local authorities and welfare services, village and community development, and the purchase of land. There is also defence and internal security, and finally, general administration, which means the employment and management of public sector staff, and the management, upgrading and renovation of government establishments and property. The government finances most new roads, bridges, airports, educational facilities and low-cost housing. Other housing, and shops, offices, hotels, industrial plant and other non-housing properties are financed by the private sector.

The expenditure data on this main sector grouping shows that it spends the most on its economic sector, on things such as transport and commerce and industry. From 1996 and 2000 (inclusive), the government spent RM4,166 million, compared to the social sector RM31,283 million, defence RM11,641, million and finally, general administration, spent RM8,923 million (EPU, 2001). RM20,825 million or 21%, was spent on transport and the cost of education was RM1,967 million or 19% from 1996 to 2000 from the total amount of expenditure on public services. Commerce and industry, with 11.4% defence with 9.6%, general services with 8.8% and agricultural development with 8.2% followed it. In 2001, a social service spending was RM3,108 million, defence and security RM8,309 million, general administration RM8,631 million and economic services RM5,145 million. Expenditure in education has been growing more and more over the years. In 2002, it was RM16,982 million and in 2003 and 2004, it was RM19,432 million and RM20,884 million respectively. In various Malaysia Plans, public services expenditure from 1971 to 1975 under the Second Malaysia Plan was RM27.804 million, and from 1976 to 1980, for the Third Malaysia Plan, it was RM78,799 million. For the Fourth Malaysia Plan (1981-1985), it was RM99,897 million and almost the same amount for the Fifth Malaysia Plan (1986-1990). For the Sixth Malaysia Plan (1991-1995) it rose significantly for RM117,656 million (EPU, 1998). Public sector development expenditure, in 1995 it was RM29,799 million and in 2000 it was RM58,975 million. Such a significant increase was due to the government supporting and facilitating the private sector especially trade, industry and transport, and on education as a form of human resource developments.

The rate of growth of imports was 14.7% per annum for the 10 years (1990-2000), compared to 16.7% for exports. Capital goods imports included transport equipment, and intermediate goods which included industrial supplies, parts and accessories for capital goods, and transport equipment and fuel and lubricants, consumption goods, that included durable and non-durable food and beverages for industry, food and others, and re-exports. Between 1990 and 2000, imports of capital goods were 18.9% and 15.0% respectively. A significant change was in imports of intermediate goods which rose from 65.1% to 73.8%. The highest composition was imports of parts and other accessories for capital goods and transport equipment.

Data on employment by major occupational groups showed that, of the total 7,999.2 million employees in 1995, professional, technical and related staff held 791.9 jobs, service staff 887.9 thousands, production and related staff, 2,711.8 thousands and farming, forestry, and fisherman 1,607 thousands. Between 1995 and 2000, professional technical and related staff increased to 1,019.8 thousands, services staff to 1,094.0 thousands or 11.8%, production and related ones staff to 3.355.4 thousands in 2000. Together the main occupational groupings grew by more than 4%, but growth of employment in farming, forestry and fishing was only 0.9% between 1995 and 2000 (EPU, 2001). Proportions of all employment in 1990 were, farming 26%, mining 0.5%, manufacturing 19.9%, construction 6.3%, and services 47.3%. The corresponding figures for 2000 were 15.2%, 0.4%, 27.6%, 8.1% and 48.7% (EPU, 2001). These figures show the most significant increase to have been of jobs in the manufacturing sector grouping. Principal manufacturing products include semiconductors, consumer electronic and electrical products

Growth of employment of professional and technical category was 5.2% per annum from 1990 to 2000. More than a quarter of the employment generated in this category was in technical occupations due to the greater capital intensity and expansion in the use of ICT in most sectors. The requirement for people with IT skills such as systems, engineering, software analysis and design ones totalled 108,000 in 2000. Demand for engineers was mainly in the fields of electrical and electronics, mechanical, civil and chemical engineering. The employment figures of engineers increased to 61,030 and 143,320 respectively in 2000 (EPU, 2001).

A PRELIMINARY EVALUATION

PEST analysis

In this PEST analysis, it includes political, economics, social and technology scenarios in Malaysia. Malaysia is a multiracial constitutional monarchy with a parliamentary system of government. It is recognised as an active and a leading member of the Association of Southeast Asian Nations (ASEAN). The formation the ASEAN Investment Area (AIA) is a form of ASEAN efforts to meets threats and challenges, not only from China and Malaysia but also from non-ASEAN competitors. It has played an important role in Asia-Pacific economic cooperation, which includes most Pacific Rim countries. Its member countries trade with neighbouring countries like Singapore, Indonesia, Thailand and Brunei. The highest amount of FDI comes from Japan, followed by the USA, Taiwan and Korea. Malaysia has supported the formation of the ASEAN Free Trade Area (AFTA), which is an ambitious attempt by ASEAN to integrate a market of 500 million people in South-East Asia, to promote intra-ASEAN industrial links, and develop South-East Asia as an international production centre.

Malaysia has maintained high growth rates. A low and stable inflation rates has generally existed since 1960s. Inflation in Malaysia was higher in 1973 and 1974, in 1980 and 1981, and low between 1985 and 1987, and stable between 1988 and 1996. FDI has played a major role in the development of the economy. Malaysia's success in attracting FDI was due such factors as favourable business environment, good infrastructure and an educated workforce (Rasiah, 1995). The main exports destinations of manufactured goods from Malaysia include are ASEAN, the USA, the EU and Japan. Among the ASEAN countries, Singapore is the main importer of Malaysian products.

The proportion of people living in urban areas has risen as the relative importance of agriculture has waned. Even among households remaining in the rural areas there is evidence of diversification of income sources away from reliance on agriculture, and especially so amongst the wealthier rural families. Nonetheless, poorer rural families still derive significant fractions of their incomes from it. Unfortunately some policies designed to address rural poverty may have served to tie poorer households to other economic activities. A number of policies have been explored in an attempt to alter the distribution of assets and incomes derived from them. A New Lands Programme has been a component of this, yet it is very expensive per family reached, and was never intended give direct help to the poorest households. Significant progress has been made in the proportions of public company equity owned by Bumiputera people; yet the proportions of manufacturing assets in public companies have declined, perhaps partly as a result of ethnic equity distributional requirements under the NEP. As elsewhere in the world, identifying and promoting small firms, in this case of Bumiputera entrepreneurs, has proved difficult to implement (Lucas and Verry, 1999).

Technically, this country has supported the development of engineering and science through technical, business and management education. Malaysia's Silicon, Valley' its Multimedia Super Corridor (MSC) was designed in 1990s to help create a so-called knowledge-based economy (Malairaja, 2003). However, although the numbers of companies registered with MSC status have exceeded targets, the quality of the growth can be questioned.

A SWOT analysis

Strengths

Malaysia's strengths are ones that it has as a relatively small, middle-income open economy, relatively rich in natural resources, and industrializing rapidly. Factors encouraging foreign investors to locate in Malaysia include politically stability, labour availability, quality of infrastructure and exemptions from export and import duties (Lim and Ong 2002). Other strengths may concern policies and programmes. In various ways, these are designed link exports, employment, training, joint ventures, domestic equity levels and R and D. FDI has been and is strong in Malaysia, because most of it has come to take advantage of lower costs of labour to help sustain exports to markets in the USA, Japan and Europe (Lim and Ong, 2002).

The Malaysian economy has been acknowledged for some years for its emphasis on manufacturing in electrical and electronic engineering. In 1991, the Office of Prime Minister initiated the Vision 2020 to accelerate Malaysia's progress into a developed nation status in

20 years. Its economic stability, openness to foreign trade and investment and rapid accumulation of assets have played very useful roles in promoting Malaysia's transformation from the relatively poor, predominantly agrarian, developing country of 1970 to a middle-income, industrial country by the mid-1990s. FDI has played a key role in this. Malaysia has been one of the most important hosts among developing countries to FDI. However, the contribution of FDI to accumulation has varied, declining in the early 1980s when public sector investment predominated, and then reaching much higher levels in the early 1990s.

Weaknesses

Proprietary weaknesses in Malaysian state dependence on information appear to be due to traditional ethnic divisions on and uncertain levels of trust between the public and private sectors. Other weakness includes Malaysia's vulnerability to short-term capital movements, in a very open economy with exports accounting for 103 percent of GDP (Choo, 2002). As part of an often inadequate regulatory infrastructure, the related unprepared of industries and enterprises is another definite weakness.

On the regulatory environment, the development of small to medium-sized industries (SMIs) in manufacturing was initially constrained by weaknesses of government support instruments (Rasiah 2001). During the colonial era, the British introduced financial support for craft and other small industries under a Rural Industrial Development Authority (RIDA), largely to reduce discontent among the Malays. Such initiatives were continued with greater financial support after independence under the Rural Development Ministry. It was not until the late 1970s that official policies attempted to earmark SMIs for support, but their development remained uncoordinated and cumbersome until SMI activities were given direct prominence by the Ministry of Industrial Development, following the launching of the Industrial Master Plan in 1986.

Opportunities

Malaysia has been one of the second-tier NIEs, classified as economically and politically liberal, and with its export-oriented industries governed by markets. Liberalisation of government policies of industrialization in the mid-1980s apparently helped to increase growth and to enhance the international competitiveness of Malaysia (Salleh and Meyanathan 1993; World Bank, 1993). Other examples of successful liberalisation involving selective government intervention to overcome market failure and enhance economic performance have been South Korea, Taiwan and Singapore (Lall 1996; Amsden 1990; 1991). Rasiah (2001) argued that political and economic factors skewed government policies towards medium-sized and large firms and away from micro and small firms. Incentives had shown bias towards large firms. Despite micro and small firms dominating in terms of numbers of establishments, medium-sized and large firms continued to lead in terms of employment, investment and value-added.

Other opportunities include demand from export-oriented industries, such as those making electrical, electronic and wood products. More specific examples are air-conditioner, home machineries, as well as radios and television sets. These are exported to the USA, Singapore, Japan and Taiwan. Ariff and Ahmad (2000) have pointed out that the persistence of capital flows into the country through the 1998 financial crisis was due to low inflation, a large interest rate differential between Malaysia and the rest of the world, and the very open nature of relevant financial markets. The money flows into Malaysia took the forms of FDI, bank lending, and especially portfolio capital.

Threats

Malaysia has ample and cheap labour. According to Foong (1999, p. 81) 'The relatively low contribution of Malaysian SMEs to the total value added of the manufacturing sector is seen as a bottleneck in achieving the rapid industrialization of the nation'. This bottleneck could be addressed through an increase in SME exports and imports. The share of SMEs in Malaysia's total exports is only 15 per cent, well below the 26.1 per cent average for a sample of OECD countries (Hall 1995). More could probably be achieved by increasing the involvement of SMEs in international trade in such APEC countries as Malaysia.

Surveys of Japanese investors' intentions (see Tejima 1992, for example) have suggested that the large-scale assembly of electronic products by Malaysian subsidiaries for export declining in favour of locations in China, where assembly production is aimed at Asian markets, and in Mexico, which produces for NAFTA markets. However Edgington and Hayter (2001) argued that there remained a substantial opportunity for Malaysia to shift away from assembly production *per se*, to a new role, that of an international procurement centre for Japanese electronic firms, supplying parts and components to a wide overseas network of assembly factories. Survey data collected by Ling and Yong (1997) has shown that East Asian NIEs such as Korea, Taiwan and Hong Kong, in that order, were already developing as electronics suppliers for Japanese assembly companies in Malaysia.

Before the Technology Transfer Unit in various universities in Malaysia was established in the late 1990s, Malaysia licensees generally had to pay high costs for technology. This was because foreign licensors generally insisted on higher rates of technology transfer. The weakness of many technology buyers in developing countries, including Malaysia, was that they lacked the technical, financial, legal and commercial expertise needed for the acquisition of more technical information and for the evaluation of relevant alternatives (Lim 2004).

The Boston Consultancy Group (BCG) Matrix

The Boston growth share matrix assumes that there are two main factors that influence the strength of a company's or a country's market position. One is the growth rate of the segments that it serves, and the other is the relative market share that the company's business enjoys. Splitting each of these two factors into high and low produces the matrix. Four types of business are identified. It based on the manufactured goods in the country, there are divided into two; the non-resource-based industries (includes electrical and electronics, transport equipment, machinery and engineering products) and the resource-based industries (includes food processing, rubber, palm-oil, wood-based, chemical and petrochemicals). The importance of manufacturing in Malaysia has been noted above. Its annual growth rate in the early 2000s was above average 10%, with its share GDP 32% and 30% in 2000 and 2003 respectively. Its share to GDP was above 85%, and its share to total employment was 27% (EPU 2003).

Dynamic Capabilities

The resource-based view of the firm, initially developed by Penrose (1959), proposes that a firm's competitive advantage is constituted in large part by its unique resources and capabilities. A central premise of this theory in that those firm capabilities which are rare, inimitable, and difficult to trade tend to the basis for sustainable competitive advantage (Barney, 1991). Subsequent researchers have emphasized the importance of intangible resources for competitive advantage (Henderson and Cockburn 1994; Kogurt and Zander

1992; Petraff, 1993). The word dynamic is used because the capabilities that on emphasized tend to be human and active, rather than more passive, like capital and land. These tend to be tacit, complex, and firm-specific, rendering them inimitable by rivals (Reed and DeFillipi, 1990). One of the main arguments in favour of the Dynamic Capabilities approach to business builds on the assumptions of resource-based theory through its assertion that unique firm capabilities develop over time. This accumulation of capabilities is driven by organizational learning and moulded by path dependencies, complementary assets, and industry opportunities (Teece, Pisano and Schuen, 1992). This approach emphasizes that it is not only the bundle of resources which matters but also the mechanisms through which firms accumulate these skills and the contingencies which constrain their direction.

Therefore, according to Dynamic Capabilities theory, firms accumulate knowledge, expertise, and skills through organizational learning. Learning enables firms to perform their activities in improved ways. Organizational learning occurs as individuals interact with each other and develop common codes of communication and co-ordinated search procedures. Moreover, organizational learning is not limited to internal activity but also results from assimilating and using of knowledge from outside the firm. The accumulated knowledge generated by organizational learning is, of course, not static but dynamic as organizations continue to learn. This firm knowledge is not boundless, however, as each firm is constrained in its knowledge development by path dependencies. Thus each firm learns in areas which are related to previous activities (Hill and Deeds 1997; Teece, Pisano and Schuen, 1992).

It is said that the path of firm knowledge is also constrained by a firm’s complementary assets. Firms establish assets bases before starting their activities. Any new product or process can require radically different complementary assets, particularly in terms of manufacturing and downstream activities, which can enhance or destroy the value of previously established assets (Leonard-Barton, 1992). Consequently, because of path dependencies and complementary assets, organizational capabilities, although dynamic, are constrained in their directions. Pringle and Kroll (1997) used the Battle of Trafalgar of 1805 and the relation with resource-based theory. Napoleon Bonaparte has ordered a French-Spanish fleet from the West Indies to the English Channel, either to defeat the Royal Navy or to divert the British fleet away from the Channel. However, by using the Royal Navy's intangible and partly inimitable human and organizational resources, Lord Nelson, destroyed or captured 18 out of 33 French and Spanish ships and seized thousands of prisoners without losing a single vessel, while only having 27 ships himself, which were older and generally somewhat smaller and less heavily armed than their opponents'. But the British were very experienced sailors with about 1,000 years of naval history and pride behind them, whereas the French and Spanish, although brave, were mainly soldiers having to fight a major sea battle.

Thus the story of Nelson and Trafalgar was one of a Royal Navy with very high levels of eagerness and aggressiveness, ready to decide the issue of the 'world naval supremacy once and for all' (p. 8). From Nelson down to the ordinary seaman, the British sailors craved a decisive battle that would put an end of their years of chasing French and Spanish ships across the Atlantic, and in the Mediterranean, and Caribbean. Pringle and Kroll argued that firms can learn lessons from the Battle of Trafalgar such as the one that while all firms usually have equal access to environmental information, they can usually duplicate it, and that such information loses value as environments become increasingly dynamic, and that the information becomes less subject to imitation over time, and that in time it cannot usually be purchased on open markets. Also, firms had to understand their own and rival organization's heritages. This should instil a sense of pride and thus help to motivate their members. Firms developed Dynamic Capabilities whenever they chose to implement innovative strategies, where creative strategists can take competitors by surprise. This could lead to sustained advantage. For this, the leaders of firms should serve as role models. Training could be important for building skills, conveying senses of permanence to employees, enhancing individual self-efficacy, and opening the door to greater participation and decentralization. Firms should usually empower their staff and let them set their own targets as far as possible (Jenkins, 1997, 2005). This would enhance creativity, motivation, satisfaction, commitment, skill levels and decision quality.

Dynamic Capability is a function of a firm's 'scientific, technological and managerial skills' (Deeds, DeCarolis and Coombs, 1999). Firms should manage the balance between building and exploiting capabilities in response to technical change (Hamilton and Singh 1992). Established firms might under-emphasize the importance of building capabilities because they tended to base their work on their existing products and markets. By emphasizing building capabilities early in the evolution of its industry and the exploitation of those capabilities after technical uncertainty is largely resolved, a firm could have sound long-term approaches to competing in the face of new technical changes.

Such views can be extended by using arguments offered by Bowman and Ambrosini (2203). They felt that using a Dynamic Capabilities perspective, resource-based views could be extended to be applied to corporate-level strategies. They suggested that where a multi-business corporation has a distinct centre, separated from SBU-level processes, the centre can only be justified on one of three grounds. Either the centre provides resources, or it uses processes that create resources, or the centre has Dynamic Capabilities itself.

These Dynamic Capabilities can be used in Malaysia's economy, depending on the extent to which Malaysian companies have their own capabilities. Hashim and Mahajar (2001) studied manufacturing firms in Malaysia that had problems with exporting. They argued, from their findings, that relevant SMEs lacked capital for financing expansion into foreign markets; that there were differences in product use in foreign marketplaces; lack of foreign distribution channels; differences in relevant product specifications; difficulties in collecting payment from foreign customers; foreign business practices that were hard to understand; risks involved in selling abroad; difficulties with providing after-sales service; high cost of abroad; managerial hesitation about exporting; difficulties with quoting prices in foreign currency; and a lack of capacity for exporting. Such difficulties are experienced by SMEs everywhere, but Malaysia's are relatively inexperienced by many international standards. They also operators in markets in which the growing presence of competition from China is not likely to make life easier for them (Yusuf, 2003).

Yusuf suggested that Malaysia should co-operate with counterparts in other East Asian countries so as to gain experience and capabilities. In manufacturing especially, they should try to invest and grow, with government help if necessary. He also argued that there should be promotion of new sources of growth and exports, particularly in services, including tourism, education and health. Also because certain companies in Malaysia had relocated their operations to China to take advantage of lower labour costs there, with examples including Motorola, Sony, Acer, Philips, Seagate Storage Products and Astee, Malaysia should upgrade its manufacturing industries and value chains (Yusuf, 2003). To encourage higher value-added industries, more skilled labour would be needed, and through redesign of education and training (Lucas and Verry 1999; Yusuf, 2003), human capital capabilities could be developed. With more emphasis on technical development, scientific understanding and research, technology transfer and the supply and use of venture capital, the resources and capabilities of industries and firms could be enhanced considerably (Power and McDougall, 2004)

Wafa, Hashim and Mohamad (2000) argued that export-oriented SMEs have higher levels of capability than to domestic firms. More significantly, such SMEs had higher capabilities in marketing, finance, operations, product development and human resource management.

COMMERCIALIZATION: SECTORAL AND GENERAL RELEVANCE

This chapter has described and discussed the background of Malaysian industrialization. The idea of comparative institutional advantage is useful in this context. Hall and Soskice (2001) suggested that effective specialisation in international trade depended not only on the relative factor costs of classical trade theory, but on the national institutions that support relevant industries. Institutions may be able to create nation and sector-specific sources of comparative advantage (Lehrer and Asakawa, 2004), that also affect such economic factors as cost, the flow of ideas, and incentives to innovate (Zysman, 1983; Ziegler, 1997). Malaysia has advantages in mostly resource-based industries (such as food processing, rubber, palm-oil, wood based, chemical and petrochemical) but institutional changes have more effects on more than company-led factors such as product design, distribution, logistics, marketing and technical advancement.

Some university research is very relevant to companies and some is of little relevance. Klevorick, Levin, Nelson and Winter (1993) argued that food processing and pharmaceuticals relied quite directly on university research. Yet while research in subjects like industrial science and computer science was often highly relevant to many industrial sectors geology, for example, did not have high relevance to any but a very few. Schibany and Schartinger (2001) argued that most spin-off companies were found in producer-related services, such as economic, technical and legal consultancies. According to Wah and Narayanan, commercialization of research findings in Malaysia was mostly done in improvement of machinery and equipment sectors, chemicals, electrical and electronic engineering and the resource-based industry group. One of the arguments about the technical competence of MNCs in electrical and electronics engineering in Malaysia was that high and medium levels of technical change were dominant (Wah and Narayanan 1997).

FURTHER CONSIDERATIONS

Further consideration should be given to manufacturing as it accounted for 84% of the exports from Malaysia and in 2003 it is a significant contributor to employment and has great potential for innovation, growth and change. Manufacturing and services sectors are increasingly interdependent in increasingly complex ways. Therefore studies of innovation concern manufacturing and services. Complex manufacturing tends to use more complex services than simpler kinds of manufacturing. The former tend to be foreign-owned than the latter, and also to be undertaken by larger firms.

Industries develop in different ways and FDI entering Malaysia tends to be in highly skilled sectors. At the same time, technical diffusion mainly involved acquiring techniques by importing goods particularly equipments and machineries (passive technical spill-over) instead of learning directly from the people who created foreign technical change (active technical spill over). It is also necessary to increase employees' skills and knowledge. This is particularly so in such newer areas as biotechnology, aerospace, advanced materials, and nanotechnology.

CONCLUSION

Industrialization and manufacturing have emerged as the main contributors to the economic growth of Malaysia. From the 1960s Malaysia has become one of the newly emerging economies in the Asia Pacific region. It was an agricultural economy with manufacturing limited to primary industrial activities, and then after independence, its industrialization became the core of its strategy for its economic development.

Malaysia is now a middle income developing country. From being mainly a producer of food and raw materials such natural rubber and palm oil, its economy has become a diverse one with strong tertiary as well as primary and secondary sectors. Its manufacturing exports have been traded with its three largest importers, the USA, Japan, and the other ASEAN countries, especially Singapore. There is however growing emphasis on trade with such other countries as China, India and several Middle Eastern ones. Natural gas and oil are also currently major exports. The factual parts of the Chapter have described these and related economic developments in some detail.

The arguments of the chapter have emphasised the ongoing power of industrialisation as the main change of recent world history and among current and future events. They stressed the need to regard services and manufacturing as interdependent and mutually supportive activities. They queried the widespread belief in education and human resource development and management as the main keys to economic development.

The evaluative elements of the Chapter overlap with parts of the factual ones, but they also include a discussion of some future possibilities for Malaysia's economy, and such general perspectives as those provided through use of SWOT and PEST, BCG Matrix and Resource

Based/Dynamic Capabilities analyses. They contain, too, discussions and evaluations of the relevance of commercialization in Malaysia, both generally and for particular sectors. Commercialization and technology transfer are increasingly regarded as relevant in a wide range of mainly more advanced sectors, not only including those in which ICT is important, but also, for example, aerospace, biotechnology and nanotechnology.

CHAPTER 3

CONCEPTS AND CONTEXTS

INTRODUCTION

This chapter discusses concepts, assumptions and questions that concern apparently problematic rates of commercialization in Malaysia. It seeks to alert readers to such possible sources of confusion as lack of knowledge, wishful thinking and self-interest. The chapter first focuses on conceptual and definitional matters and on how thinking about the practical use of scientific and other knowledge tends to fall into two main camps. Two master theories of technical change are presented, compared and contrasted, next, and located geographically and historically. Finally, in the more theoretical part of the chapter, 25 relevant concepts and phenomena are discussed [with more details in Appendix 2], and with the seven most relevant ones to the thesis considered at more length in Appendix 3. Understanding the relevant concepts is vital for discussing the demands, needs and expectations of companies in using discoveries and inventions from universities and GRIs.

The two master theories of technical change were compared and contrasted by Sorge and Hartmann (1980). So-called ‘Western’ or ‘developed’ countries which dominate influential international institutions like the International Monetary Fund (IMF), the Organization for Economic Co-operation and Development (OECD) and the World Bank have been accused of imposing ‘one size fits all’ thinking about economic development, innovation and so on, on Less Developed Countries (LDCs). However the ‘Western’ or ‘developed’ countries are not homogeneous. The contrasts apparent in these two master theories of technical change help demonstrate this.

Following its more theoretical discussions, the chapter moves on to more practical, ontological, concerns. It discusses the practice, theory, and institutions of commercialization in Malaysia, along with government, university and other efforts to support it as in Appendix 4. There is also discussion of relevant recent thinking about technology transfer. Then, eight models of commercialization and technology transfer (CTT), those regarded as the most relevant, are described and evaluated. Next, the researcher’s main preconceptions, her ideas about the findings of her research, before she undertook it, described. The research questions, concerning apparently low uptake and how and why it exists - or seems to - are presented and justified.

RESEARCHER AND THEORETICAL BACKGROUNDS

The comparisons between the two master theories of technical change draw on historical understanding and international comparisons. The theories are quite opposed, being based on contrasting views of human nature, attitudes, knowledge, skill and work, and of the use of knowledge for practical ends. Before they are considered, the qualities of the two main, and significantly different, kinds of academic who have concerned themselves with technical change are discussed. The purpose of this is not to undertake an exercise in the sociology of knowledge. Rather it is a simply to suggest that the theory which tends to be preferred in this thesis is based on broader and deeper factual and intellectual foundations than the other.

The theory preferred here, the *Technik* one, draws partly on critiques made in the 1970s and 1980s of British and North American industrial management and higher technical and other vocational education. These critiques had taken cognisance of studies of invention and innovation conducted in the 1950s and 1960s (Jewkes, Sawers and Stillerman, 1969; Langrish, Gibbons, Evans and Jevons, 1972), and also of studies of industrial organization and the use of microprocessors in manufacturing in France, Germany and the UK in the 1970s and 1980s (Sorge, Hartmann, Nicholas and Warner 1983 and Sorge and Warner 1986). The researchers were experienced, with access to a wide range of intellectual resources. On the European continent, and in the context of industrial employment, there were, it made sense to argue, no professions, and a clear and real tendency to reject the development and use of American, later Anglo-American, managers, management and management qualifications (Sorge 1978; Glover 1980; Locke 1996). Nor were engineering and manufacturing sensibly understood as the application of science, or as being part of and dependent upon science. In Continental industry, production was the central, sector-defining, function in industrial companies around which lesser stars, like finance, marketing and personnel management revolved, and which contained almost all of the technical functions like design, maintenance, engineering, and what English speakers called R and D. Not only was engineering not regarded as part of science or as its ‘mere’ ‘application’; its successes had made the funding of modern science possible, and although science now played vital parts in engineering education and in contributing ideas and knowledge to industry, it would always be fundamentally different to and separate from engineering.

It is sometimes said that most academics can be grouped into one, two, or all of three types. The first are technical college teachers. They mainly teach, and do very little or no research. They may be intellectuals, but as academics, are rarely public ones. Many tend, in the UK, to be employed in newer and less prestigious universities. The second are provincial academics. They do do research, much of it very good, as well as teaching. The third consists of cosmopolitan intellectuals. They also do research and teach, but they tend to teach less than provincial academics, who in turn teach less than technical college teachers. The main differences between cosmopolitan intellectuals and provincial academics concern the nature of their research, writing and scholarship. Cosmopolitan intellectuals often, some cases always, operate outside the parameters of established thinking and of single disciplinary concerns, and ‘normal science’ (Kuhn, 1962). They are both convergent and divergent thinkers (cf. Hudson 1966) and are likely to be more confident, experienced, mature and successful than the average researcher, scholar and intellectual. Provincial academics on the other hand, tend to be more focused, conventional, convergent, less confident, experienced, successful and sophisticated. They tend to think ‘within’ the boxes, of their topics and disciplines, whereas cosmopolitan intellectuals can seem unaware that boxes exist.

When considering technical change, invention, discovery, commercialization, innovation, entrepreneurship, technology and so on, cosmopolitan intellectuals are more likely to question the meaning and relevance of such terms, whereas provincial academics are readier to follow lay, patrician, and sometimes confused usage. Since the early 1990s, for example, a notion of researchers into the use and management of ICT in business and other organizations has been that of the ‘hybrid manager’, who is meant to combine technical and business knowledge and expertise. The problem that the hybrid manager was intended to solve was that of lack of understanding, empathy and shared bodies of knowledge and expertise between technical (ICT) professionals and managers with qualifications like arts, science and social science and business-related degrees. Research into the perceived lack of hybrid mangers and its effects, into their formation and employment, was normally the product of provincial academics interested in technology management. Such research and writing was concerned, although most of the business and management graduates conducting it seemed unaware of the fact, with a problem debated since the 1920s and 1930s, largely by American and British sociologists, namely the employment of technical and other professionals in large-scale formal bureaucratic business and other organizations, and the associated problems of supposedly 'narrow' professionals and more gentlemanly liberal arts and pure science graduates coming from different social and educational backgrounds and often having opposed assumptions about which types of professional and manager should be 'on tap' or 'on top' in organizational hierarchies (Currie and Glover, 1999). Here, there was an important sense of researchers reinventing the wheel, badly. It was an example of 'crass empiricism', of ignoring highly relevant work, concepts and theories because of the narrow and time-limited, culture-bound and ahistorical, nature of researchers' educational backgrounds.

The notion of commercialization was criticised along similar lines by Hughes (1985). For Hughes, commercialization was a word used to replace and reframe innovation by politicians and others and in and around government who wanted to channel, control, structure and monitor relevant processes, and perhaps subconsciously to stifle them. Their mentality could be convergent, inward-looking and small-minded. Successful innovation needed confidence, energy, imagination and relatively uninhibited effort. The state should be supportive and permissive, within reason, although even if entrepreneurs and innovators received excellent help and advice from state agencies, they could still fail if their own efforts as regards cost, quality and marketing were inadequate. There is always tension between innovation and control in organizational life, and those who seek to narrow the notion and practice of innovation down by renaming it commercialization are perhaps revealing their own prejudices and other inadequacies (cf. Child, 1981).

For innovation and/or commercialization to succeed, it seems that the business people, entrepreneurs, managers and professionals responsible must be competent and motivated enough, with any external support helping to clarify and energise their efforts, and not confuses and dissipates them. Confusion may arise because some of those involved misunderstand about the nature of technical change and business management. Graduates in industrially non-relevant subjects or in relevant subjects who may encourage over-confidence in technical, professional, managerial and business contexts, may also be sources of confusion in similar ways, so that when employed in government or powerful positions in universities or industry, they also may make poor decisions about innovation. Some of the reasons for such problems may be inferred by comparing the following two major theories of technical change.

THE *TECHNIK* VERSUS THE SCIENCE LEADS TO TECHNOLOGY LEADS TO HARDWARE MODELS OF TECHNICAL CHANGE

When considering these theories and their implications, historical understanding and an ability to make international comparisons are needed. The theories embody opposed views of human nature, knowledge use, skill and work. Their concerns involve the main influences on, and effects of, technical change.

According to Sorge and Hartmann (1980), who spelt the theories out, the first was prevalent on the European continent and in Japan and other countries whose systems of education, training and dividing labour had not been designed largely along British and North American lines. In their *Technik* theory, technical work consists mainly of art and skill. Technical change was created in response to socio-economic and technical problems, consisting of gradual improvements to processes and products. It largely involved learning by doing, 'unpredictable ingenuity'. Scientific knowledge was useful to it but it was insufficient to guide design, which relied primarily on technical knowledge or 'know-how'. Technical work was an autonomous or separate cultural area, *technik* or engineering. It was not dependent on scientific discoveries, not 'mere' applied science. Innovation was continuous: technical changes were spread by industrial absorption plus modification. People slowly conquered nature by ever more sophisticated 'tooling up'. The effect of technical change on employment was to relocate work towards new targets. The total amount of work done was unlikely to be reduced. Man or humankind was described and thought of as *homo faber*, namely the relatively intuitive 'maker and doer', who produced constant interaction of socio-economic and technical problems. The *Technik* theory tended to emphasise action, more than structure, in interpreting human events and relationships.

The second theory was prevalent in the UK, the USA, and other former British Empire countries. Sorge and Hartmann called it the Science leads to Technology leads to Hardware (STH) theory. This had a slightly more dramatic emphasis than the *Technik* one, in spite of its greater emphasis on structure, over action, in its interpretations of events and social relationships. New scientific knowledge was increasingly seen as the major source of technical change. Technical change was 'revolutionary', involving 'basic' innovations. It involved learning from academic knowledge, which was seen as the key to innovation, and was increasingly important with modernization. Technical work was seen as a dependent cultural area or as applied science, the industrial use of science. Innovation was seen as discontinuous, involving revolutionary and other dramatic changes. Technical changes were thought to be spread by technology transfer, by self-conscious decisions by managers to use new knowledge, techniques and processes. Rationally-guided search behaviour thus prevailed, rather than the unpredictable and less articulate ingenuity of the *Technik* theory. People were felt to be increasingly separated from nature or the environment as it increased. Technical change - often called technological change by its proponents - saved labour by displacing it into leisure or unemployment. People were was defined using the term *homo sapiens*, literally man the thinker, the creature with the large and capable brain, increasingly concerned with socio-economic issues and less and less concerned with mere technical matters and detail.

What are the origins of these theories? Their links with Continental European countries (the *Technik* theory) and the UK, USA and other former British empire countries (the STH one) have been noted. Why do *Technik* countries value engineering and production in particular, and manufacturing in general, more? Why do they value science and R and D less, preferring the words engineering and engineer to technology and technologist? Also why have they had relatively little time, at least until recent years, when the following have been more useful to them in any case, for American and Anglo-American notions, institutions and practices of management?

The theories differ because they have different historical and national roots. From the 1560s France, later followed by other Continental countries, began to develop very high-status university-level schools of engineering and mining, and later, government and higher commercial studies. On the other hand, ‘Anglo’ nations became more consistently and strongly interested in imperial expansion and international trade. The Continental countries focused more, from the nineteenth century onwards, on manufacturing and on state-dominated systems of education and training for all almost levels of industrial and business employment. The British focused more on such traditional professions as law and medicine, and especially on government and imperial administration, and high finance orientated towards international business. Continental countries were focused more on manufacturing, engineering and production.

British, Anglo-American, and other former British Empire thinking tended to be more arms'-length towards these. Such thinking influenced language. For example, they increasingly tended to prefer the words technology and technologist to engineering and engineer, although nearly all 'technologists' are engineers by job title and qualification. They tended to call technical development work 'R and D' although very few industrial companies employ scientists to conduct research. Modern, say about 100 years'-old, American and Anglo-American management thinking and practice was long resisted, at least until recently, in Continental Europe. This has been because broadly educated and sector-specifically specialised Continental engineers have regarded management as part of particular kinds of engineering, and inferior to them, rather than the other way round, as in Anglo-American countries. In the latter, management thinking and education were developed to compensate for apparent lack of practical knowledge of executive and senior managers with, for example, liberal arts and pure science degrees, and for presumed narrowness of their professional specialists in, for example, accountancy and engineering.

Sorge and Hartmann (1980) described the *Technik* and the STH theories in some depth. Their thinking about them informed two books reporting large research program findings, to which Sorge made major contributions (Sorge, Nicholas, Hartmann and Warner, 1983; Sorge and Warner 1986; and articles by Sorge (1989, 1995). The wider relevance of the work of

Sorge and various colleagues and its contexts were discussed by Glover and Kelly (1987, 1993) and influenced by numerous papers by Fores (for example, Fores, 1977, 1979, 1979b, 1979c, 1981, 1982a; also see Fores and Sorge, 1981). Fores was an influential adviser to the UK government on industrial, engineering and vocational higher education policy in the 1970s, and published with Sorge at various times. Sorge's thinking led him to write highly theoretically sophisticated and internationally informed, accounts of relationships between technical change and work organization, and between the latter and long-term political and socioeconomic change (see especially Sorge 1982-83). The *Technik* theory to be supported by two major studies of over 130 important innovations conducted from the UK in the 1950s and 1960s (Jewkes, Sawers and Stillerman, 1969; Langrish, Gibbons, Evans and Jevons, 1972). More recent research, including that by Sorge and his colleagues, has produced similar conclusions (Mowery and Rosenberg, 1979; Schrer, 1982).

There is a widespread tendency to assume that technical work becomes 'more scientific' over time. Clearly, as technical work grows in complexity it generally relies on more, and more complex and sophisticated, scientific information and thought. However, as Fores (1977, 1981, 1992) argued in different contexts, its essence is unchanging. It does not produce the outputs of science, namely academic journal articles and other accounts of empirical studies inscribed two-dimensionally on paper, free for anyone to read, and to be judged primarily by the criteria of truth or rightness against some scale. Instead, the outputs of technical work or engineering consist of three-dimensional objects for practical use, which are made available for sale in commercial market places, and which are judged by criteria of usefulness, cost and profit. Whereas science analyses existing phenomena to study them, technical work synthesizes material resources and human expertise to make new and improved physical artefacts and processes.

This means that engineering and science are different activities with different aims and outputs, although they do indeed usually inform each other. Science informs engineering through its knowledge of such things as energy and force, number, and the properties of raw materials, through the education of engineers and through the ways in which engineers draw on its banks of knowledge for all kinds of purpose, in design, development, maintenance, production, testing and so on. Engineering informs science in the design of the experiments, and the design and constructions of apparatus, and in all kinds of research in which practical knowledge or 'know-how' is relevant. The German word for the practical arts and techniques of research is *forschungstechnik*. *Forschung* means research. The main point is that for all their overlaps and similarities, engineering and science are genuinely different activities, one belonging mainly in business, the other mainly in universities. Each builds on its own achievements in the course of its development, and neither is at all sensibly conceived as a part, or the 'application' of the other.

The arguments suggest that commercialization of new scientific knowledge will not always be the main form that technical change and development, and innovation, take. It also means that commercial and political expectations about the industrial fruits of new scientific knowledge may be too high, especially in national and other contexts in which the STH theory is ideologically, managerially and politically dominant. Malaysia was influenced by its former status as a British colony, and it appears to be one such context in several respects.

RHETORIC, ASPIRATION AND HOPE

Attempts to stimulate change by policy makers in government, business and industry are accompanied by rhetoric (Legge, 1995). This involves claiming that desired changes are more feasible than rational appraisals suggest, or as if they had already occurred, with little or no real evidence available to support relevant claims. Such ‘talking-up’ or ‘boosting’ can indeed make people think that something is real, so that it becomes so in some respects. This initiates reification, a process whereby social relationships that are firmly established seem to be beyond human control, apparently fixed and unmanageable, and features of the natural, rather than of the social, world (Lukacs, 1923; Merton, 1968). In some cases the rhetoric has a *post hoc* quality, when theories and concepts are used to described and dignify events according to the relevant management consultancy’s or fad’s gospel, when they already existed or would have taken place irrespective of whether or not the theory, concept or fad existed or not.

In the 1970s, for example British industrial management was criticized for being turned in on itself, with its constituent professional occupations and functions like accounting and finance, marketing/sales, personnel/HRM, engineering/operations and design/technical development competing with each other for managerial power at the expense of co-operation, performance and output (Child, Fores, Glover and Lawrence, 1983). However market and other forces and the need to survive in the 1980s forced management teams to co-operate and unify to the mutual benefit of most of those involved (Owen, 1999; Glover, Tracey and Currie, 1998). Similar behaviour was observed in the motor industry in the USA (Abernathy, Clark and Kantrow, 1983). In both countries, business processes were clearly, and according to most definitions of business process re-engineering (BPR), being re-engineered in a variety of ways, and before, during, and after BPR began to be publicized and advocated, and however the relevant activities are or were conceived and described. Thus the rhetoric of BPR and the reality of management were mutually supportive but not always linked or interdependent.

In theory, commercialization is likely to exhibit similar patterns. Academics and industry seek mutual support, and wide ranges of mutual benefits follow. Scientists show engineers in industry how products and processes can be improved or reinvented, or engineered for the first time. Companies sometimes fund, inform and otherwise stimulate scientific research. Ideas and mixtures of technical and scientific knowledge flow in all directions, and the politest, because the most economical and accurate, way of describing the often very complex process, is to call it the commercialization of new scientific discoveries and engineering inventions. The process actually consists, *like all engineering*, of far more than the application of new scientific knowledge, although it does often include it, and it is often a vital input. There is a sense in which commercialization might be usefully renamed as knowledge engineering, remembering that if engineering is not commercially effective, it is usually pointless. The old American saying that an engineer who is 'someone can make for one dollar what any bloody fool can make for two', is not irrelevant. Yet the knowledge involved here is variously commercial, scientific, social and technical.

The main points to be made, first, to repeat the one made above, after describing the two major theories of technical change, that the focus of many researchers into technical or 'technological' change, or technology management, on the commercialization of science may be a product of bias towards the STH theory on their part. Second, elements of rhetoric clearly surround and permeate such research and thinking, which 'talk up' its concerns by associating them more with universities and science and less with industry and engineering than the facts merit. Much of the confusion is fed by state funding of scientific research, and of management and social scientific research into the effectiveness of the former. Societies in which the STH theory is implemented, in which the rhetoric of 'R and D' and 'science and technology' are prominent, and in which much management and social scientific research draws expectations of R and D and science, will tend to be those in which commercialization is talked up.

Many researchers have noted how complex, varied and confusing relationships between states, academic science and industries can be. Senker (1996), for example, discussed patterns of biotechnology-based industrial development in the USA and the UK. There had been significant differences between the two in the early years in the 1970s. The UK government began to intervene in the 1980s, two to three decades after the USA's government. There were also changes in financial environments. In both cases, the governments played important but different roles in helping to develop emerging technologies. The rhetoric of commercialization embodies expectations about the funding of the research institutions by governments. Some evidence on the aspirations and abilities of scientists and policy makers has suggested that such expectations are hard to satisfy. For example Moncada-Paternò-Castello et al (2003 p. 665) noted that scientists, while they may master technical details of their discoveries, lack the vision to appreciate their potential economic benefits.

According to Inkster (1998, p. 54) early British industrialization was a product of individual inventors and commercial visionaries. Technical education, professional associations and government R and D funding came later. But in newer industrial countries the processes tended to take place the other way round, with governments, politicians, powerful firms and so on creating public institutions of industrial societies as well as industries themselves, at the same time or even earlier.

These arguments simply indicate the considerable real-world variety of relevant phenomena. Yet, as noted, nothing can alter the difference between engineering and science, and that between tacit technical and explicit scientific and other knowledge. However complex, varied and indeed confusing technical and industrial phenomena become, air is still air, engineering is still engineering, food is still food, science is still science, and water is still water. Engineers design and make things. Scientists study, describe and explain them.

EVIDENCE: ENGINEERING ACHIEVEMENT VERSUS SCIENTIFIC ASPIRATION

According to Hawthorne (1978), humankind developed industries and technical knowledge as a result of a series of innovations in three main fields of activity: the use of materials, the exploitation and transformation of energy, and understanding and use of scientific principles and facts. The development of technology could be characterised by evidence of engineering achievement through different technological routes, each of which constituted a particular combination of materials, energy, and development and application of knowledge and principles to result in generic and/or sector-specific bodies of technical knowledge and new manufacturing processes and products. Examples of such routes might focus on the blast furnace, the internal combustion engine, the electric motor, and the steam engine, each of which offered separate routes to the technical satisfaction of material, transport, power and other needs. Mathias (1991, p. 35) argued that until the nineteenth century 'great areas of advanced technology' remained relatively untouched by formal scientific knowledge. They included agriculture, canals, machine-making, iron and steel making, and the mechanization of cloth making. A very small proportion of the UK's labour force was engaged in activities where the links were even superficially high, as in chemicals and steam power. It was questions of 'great determination, intense curiosity, quick wits and clever fingers, getting a backer to survive relatively expensive periods of experimenting, testing and improving', which of were more important than scientific education. Most innovations were the product of 'inspired amateurs or brilliant artisans trained as clockmakers, millwrights, blacksmiths, carpenters, or in the Birmingham trades (Mathias, 1991, p. 38).

Through the nineteenth century, in Britain and elsewhere on either side of the Atlantic, mechanical and civil engineering developed in sophistication, and chemical and electrical industries were developed. Somewhat later, engineering education included more science and became more theoretical in emphasis. At the same time, and not only in the UK (cf. Wiener, 1981), but also in Germany, the USA and elsewhere (Gispen 1989, Lee and Smith, 1992 and Smith, 1987), educational provision in the natural, physical and social sciences and the humanities expanded the numbers of those who often felt intellectually and/or morally and socially superior to most engineers. During the twentieth century, in the UK and to a smaller extent the USA, engineering found it increasingly difficult to recruit its share of the most able members of each generation (Glover, 1985). It was regarded in many quarters as 'the dirty end of applied physics' and, as noted earlier, as generally failing to offer employment fit for a gentleman or intellectual (Coleman, 1973; Glover, 1980).

The other industries referred to above, chemicals and electricity, were regarded differently by economic historians from those established in the century or so up to 1850. Their introduction constituted a 'second industrial revolution', which unlike the first, was called 'science-based' by economists and economic historians (Cardwell 1957, p. 7). They used cleaner sources of power than coal and steam, and in due course proportionately more white-collar professional and managerial employees, than mechanical engineering, mining and construction. In a society in which much energy and social aspiration were focused on administration, government, imperial and foreign affairs, universities and the professions, and more recently high finance and the media, compared with manufacturing, construction and mining, and in which the former had generally adopted arms'-length attitudes towards the latter, science took much credit for engineering achievements, and allowed it to shelter under its wing, and engineering and production were often regarded merely as effects, and even parts, of scientific endeavour.

THE DECLINE OF THE STH OR LINEAR THEORY?

The STH theory (Sorge and Hartmann, 1980) depicts the so-called linear theory of technical change comprehensively. Research on many specific inventions and innovations built up from at least the 1950s onwards has cast increasing doubt on it. In the 1970s and 1980s examples involving international comparisons emerged increasingly from more economically successful competitor nations that had espoused the *Technik* theory. The weaknesses of the STH theory became even more apparent, even those who believed strongly in the cause of helping industry to use the fruits of science more quickly and profitably. Even so, advocates of linear approaches, who regarded research as the key to much or even most technical development and industrial innovation, continued to defend modified versions of it, which tend to differentiate between innovation that was technology-driven (technology push), and relatively linear, and that which is pulled through or out of companies by market forces (market pull), and with more of a holistic quality, neither version is particularly strong in defence of the role of scientific discoveries. The enterprise tends to be regarded as the main source of innovation, with university science playing mainly background roles.

The linear model has always seen innovation as happening by a sequence of separable stages such as discovery, design, production and marketing. There are two main variants of this model, which usually concern design for product innovation. First, there is the much more assertively linear technology-driven version where new ideas are developed by R and D staff, then sent to engineering and manufacturing to design, tool up and produce, and then sent on to marketing for advertising, selling and distribution to customers. The second is the much more holistic need-driven model with some linear elements: marketing comes up with ideas that drew on interaction with customers, which in turn are sent to R and D for prototype development, and then to design, engineering and manufacturing for design, tooling up and production (Galbraith, 1982). Galbraith also suggested that innovation is more efficient when the relevant ‘stages’, or parts, of it are undertaken as simultaneously as possible, with continuous knowledge-sharing and other forms of communication between departments (Galbraith, 1982, p. 16-17).

Verhaeghe and Kfir (2002) argued that, in so-called knowledge-intensive organizations, a linear view of innovation was more relevant than a holistic view. A process classified as linear is where there is a little indication of feedback. However, in the holistic view, the results are continually fed back into new cycles. Newer models of innovation based on the idea of a knowledge-based economy go beyond the linear or chain linkage notion that has been used in innovation theory and in regional economics to explain processes in high-technology industries (Strambach, 2002).

The idea of a knowledge-based economy is dubious because many of the most directly useful elements of the so-called knowledge that is involved consist of situation-specific pieces of *information* about particular artefacts, processes and people, rather than scientific facts, laws or principles (Ackroyd, Glover, Currie and Bull, 2000); and because the idea that the knowledgeable are taking over the reins of power from the wealthy is a politically naïve and regularly discredited old one (Nicholls, 1969; Enteman, 1993; Glover and Tracey, 1997). Even so, the view of Verhaeghe and Kfir (2003), that in so-called knowledge-intensive organizations a linear view of innovation can be more relevant than a holistic one, does have some relevance for the present study.

Science or technology-push models are clearly linear ones. Market-pull models are much more holistic. Linear models give indications of feedback between stages or parts of innovation processes, but market-pull ones suggest that feedback occurs between all stages and parts, especially when lessons of a given 'cycle' of innovation, are fed back into the start of a new cycle. This approach treats innovations like biological evolutionary processes. From a distance, they probably are. However, for present purposes, the arguments of Verhaeghe and Kfir (2003) are particularly relevant in two ways. First, their point that the linear model continues to be useful for understanding innovation in knowledge-intensive technology organizations may be valid because such organizations tend to be small and responsible for relatively few discrete projects, with relatively clear beginnings, stages and ends. Yet, and second, and more importantly, almost all kinds of linear or 'chain linkage' models may simply be largely out of date for explaining the general character of innovation in an ever more complex and sophisticated world in which engineers, scientists, marketing professionals, financial professionals, customers, policy-makers, policy advisers, policy implementers, staff of research grant awarding bodies, and firms, universities, research institutes and government agencies and departments co-operate, compete and otherwise interact and spawn innovation continually (Strambach, 2002).

Newer models of innovation from regional economics, used to explain processes in advanced sectors that are also used more generally in innovation theory go, according to Strambach, far beyond the simplicities of the linear model (Clark and Tracey, 2004). They fit well with the view of Crook, Pakulski and Waters (1992; 32) that differentiation, commodification and rationalization 'define the transformation of premodern into modern systems as well as being the central processes of modern societies'. Modernization produces highly differentiated societies, with high levels of specialization and complexity, and highly organized with high levels of rationalization and commodification. Moreover, 'postmodernization may be analysed as the consequence of the extensions of modernization processes to extreme levels'. Hence they focus on hyper-differentiation, hyper-rationalization and hyper-commodification. It is not necessary to be a postmodernist to see the strengths of this line of thinking. The superficially chaotic character of contemporary innovation and the now limited, albeit still sometimes very significant, relevance of linear models has also been spelt out by Tirole (1989, p. 389). Verhaege and Kfir (2003) were thus right to emphasize the continuing and often considerable importance of science-push and the linear model in many specific situations, but for general explanations and most specific situations, the *Technik* model remains superior.

TWENTY-FIVE CONCEPTS AND THE SEVEN MOST SALIENT ONES

These concepts are grouped under five main headings: subject classifications; socioeconomic development; academic; industrial; and ones linking universities and industries. The reasons for choosing them are explained under each heading. After each is discussed briefly (see Appendix 2 for more details of each) the seven most salient are discussed at more length in Appendix 3 with particular regard to the relevance of specific aspects of them to this study.

1. Subject Classifications:

1. a. *Kunst, Technik* and *Wissenschaft*

These Continental European definitions, in German, are included because they separate engineering and science, unlike such English language terms as applied science and technology. They make a clear distinction between those who make things, *Techniker* or engineers, and those who study them, scientists or *Wissenschaftler*.

1. a. i *Kunst*

Kunst means the fine and performing arts, which are meant to be beautiful and inspiring. They are taught in German and other Continental art colleges.

1. a. ii *Technik*

This means engineering and technical excellence, and it includes many practical subjects. It is concerned with usefulness and cost. It uses unpredictable ingenuity far more than ‘application’ of scientific principles. On the Continent, university-level *Technik* subjects have long been taught in institutions with high or very high social status.

1. a. iii *Wissenschaft*

Wissenschaft means science and scholarship, and includes all subjects concerned with discovering and recording the truth, for example history, economics, sociology and political science, as well as mathematics and physical sciences. These are taught in traditional universities. Their outputs are judged in terms of truth or rightness against some scale and consist of public and verifiable knowledge of phenomena (Ziman, 1968; Fores and Rey, 1979).

1. b. The ‘pure’ and ‘applied’ sciences and the arts and humanities

These are included because they appear less than logical compared with the previous classification, and because in the cases of the ‘pure’ and ‘applied’ sciences their character informs much conventional and/or English language research, thought and rhetoric about technical change and commercialization.

1. b. i Science

Science has two-dimensional paper outputs and the best short definition of scientific activity is the production of verifiable knowledge of phenomena. The scientist aims to get as close as to truth as possible, and is not primarily interested in usefulness or profit.

Scientists use research to study things. Scientific knowledge is a public good like air, always free for anyone to use. Since it is impossible to predict whether new scientific knowledge will be used or not, the idea of ‘pure’ science is very questionable.

1. b.ii Engineering

Engineering is not applied science, and not a part of science either, because it does not produce knowledge as its primary output. Its outputs consist of hardware and supporting software. Most working engineers will agree that engineering is sensibly called the ‘industrial arts’ because it is much more art than science (Fores, 1978b).

The root of the word engineering is ingenuity. Engineering is a, in fact the, useful art. It is intuitive, unpredictable, and private to its creators in many respects. Engineers make things, and their work includes the design and technical development of processes and products, and the production of three-dimensional artefacts of all kinds. Although engineers use technical, scientific and other knowledge in their work, but their work is not part of science. Whereas the output of science is verifiable and published knowledge of phenomena in the form of scientific papers, books, and so on, that of engineering consists of commercially viable products. Engineering is ahead of the frontiers of scientific knowledge, with there being no science to apply, as when drugs are marketed without full knowledge of why they are successful, or when bridges are built without complete certainty about their long-term future and safety. Engineering has existed since prehistoric humans began to make and use tools. The most comprehensive definition of our species is *homo faber*, the maker and doer (Glover and Kelly 1987). Engineering also uses all kinds of accounting, financial, marketing, and people management expertise. It has many branches, for example aeronautical, biological, chemical, civil, electronic and electrical, mechanical, mining and software.

1. b.iii Technology

This word currently appears to be identified mainly with information and communication technology (ICT). It is often used to differentiate ICT from apparently older and 'cruder' technologies, like those of electrical, mechanical, mining or civil engineering. It is more complex word, and the gently implied criticism of it being a status-concerned substitute for engineering has more than a grain of truth in it.

Dictionary definitions of technology tend to note and stress the relevance of the literal translation from the Latin: knowledge or study or the science of technique and/or techniques. In both everyday and academic usage, however, and as just suggested, the word generally has more practical connotations, ones 'traditionally' and more accurately identifiable with engineering. Most practising 'technologists' are engineers by qualification, function and title, so this is unsurprising. Fores and Sorge (1978) asked how engineering, which principally aims to produce three-dimensional objects for sale, could sensibly be described as '-ology'. They also wondered whether technology means 'ideas, hardware, or something that arts graduates love to hate'. Such implicit criticisms do provide support for the suggestion that technology is a rather vague notion. Because it quite literally means so much, it is easy to use it in several different ways, usually without straying too obviously from the truth.

In management and organization studies, the term technology has different levels of meaning (Loveridge, 2001). At the highest level of abstraction, technology means, 'all modes of organizing people for the purposes of controlling or co-ordinating their activities' (p. 6375). At a lower level (p. 6376) it means 'bodies of disciplined knowledge [that] have emerged in which causal and systematic relations between material and/or social elements in specified situations are postulated and related to empirical observations'. This means, the bodies of knowledge and skill, of virtually all kinds, that enable particular ways of producing and doing things to be repeated more or less predictably and reliably. Examples could include assembly line technology, biotechnology, and the technologies of chemical processing, information processing, guided missiles and waste disposal. For Loveridge, the ways in which those relations and processes are categorised and explained 'can be seen as constituting more or less scientific knowledge in terms of its reproducibility and generalizability' (p. 6376). However the knowledge used within each type of technology is, of course, mainly technical knowledge.

A third, 'lower level', and more practical kind of definition focuses on the 'techniques or procedures adopted in processing information [about] data on social or material operations' (p. 6376). Loveridge regards techniques that are incorporated in the mechanical, material or electronic design and programming of hardware and software, in other words in machines and capital equipment, as ‘the most articulated forms of technology’ (p. 6376). This is his fourth way of defining technology.

From all of his definitions, we can see how the word rivals and indeed potentially surpasses culture (qv) in terms of complexity. Clearly it is partly synonymous with technical knowledge or know-how, but it is self-consciously upmarket and ‘modern’ in the way in which, in use, as well as etymologically and in theory, it makes rather biased claims about the science upon which practical procedures are, or should be, ‘based’. Loveridge also discusses ‘technological innovation’ or change and the distinctions between product and process or production technology (p. 6376).

Perhaps the best (short) working definition of (a) technology that emerges from this discussion is that it constitutes a generic, cross-sector and/or sector-specific bundle of information, knowledge and skill.

1.b.iv The arts and humanities

Arts subjects in the UK and other former British Empire countries are normally of three kinds: the humanities, languages, and the fine and performing arts. The humanities are often thought of as including languages, but they are principally those subjects which study humankind and its experience, such as geography, history and study of literature and various other manifestations of human artifice. Partly because the social sciences, like anthropology, economics, political science, psychology and sociology, study human artifacts like tools, products, services, thoughts, motives, attitudes, and social institutions, processes and actions, they have often been classified as arts rather than as sciences, rather, that is, as part of what would be *Wissenschaft* in German. Language subjects often cover the study of the histories, economies and institutions of the societies whose languages are being learnt, and can therefore be regarded both/either as humanities and/or social scientific subjects. The fine and performing arts subjects are more or less the same as the *Kunst* ones in German and on elsewhere the European Continent. They are directly vocational than the other arts and humanities subjects. Those who qualify in them are proportionately less likely to teach them than those with other arts and humanities qualifications, or not to use what they have learnt at all in subsequent employment, or more likely to make careers out of them outside teaching.

What is of specific interest here is the tendency of many arts and humanities teachers, researchers and practitioners to distance themselves from the useful industrial arts of design, engineering, extraction, manufacturing and construction. In the UK, design is taught for industrial and related purposes to engineers and architects. It is also taught, separately, in art college or university arts faculties, with a generally and significantly less practical and more aesthetic (and at times anarchic or frivolous) emphasis (Hudson, 1978).

2. Socioeconomic development: culture; development; and sustainable development

These are included to help clarify some of the major background assumptions used in this thesis. The specific relevance of each is made apparent in each case.

Culture

According to Williams (1976), culture was the most complex English word. Traditionally it has been associated with intellectually and socially prestigious elite leisure pursuits, including the often expensive fine and performing arts, and their conspicuous consumption for predatory purposes, in the pursuit of status and [by men] women (Veblen, 1921). Since the 1960s, one interpretation of it has increasingly been employed as a category in the study of management, and management has increasingly been thought of and discussed in cross-cultural terms. Unfortunately many early comparisons of managers and management in different countries tended to be rather shallow and concerned with superficial attitudes and behaviour, and researchers often made things worse by inferring values from them (cf. Hofstede, 1980).

However Sorge (1982-83, 1985) explored the history of the term to help arrive at a comprehensive definition. He discussed the roots of the word in the Latin verb *colere*, which means to grow, in the context of living organisms. He argued that the culture of a human group or social institution is made up of everything that it consisted of, everything that characterised it, everything that the people involved were and are, and that the culture of any human group, social institutions or society had three equally important components: ideational, material and social. Culture was so all-embracing and its roots were so deep that appearance was often taken for substance, with attitudes and ways of behaving, only parts of culture, being thought of as all of it.

What Sorge implied was, as many others have stated since, was that countries do not 'have' cultures. They are them. The same point is often made about organizations. This all meant that, for Sorge (1982-83), the more one writes or talks about the culture of something, the more one glosses over its essence. It also means that it is unacceptable to 'explain' aspects of events that cannot be explained using familiar influences and logical reasoning by attributing them to 'culture'. So it is nonsensical to argue that while 80% of a society's economic difficulties can be explained in economic terms, the other 20% are 'rooted in its culture', because the economic features of societies are themselves components of their culture.

Further, human characteristics develop over many generations, subject to many influences. Most of this is of course unknown to the individuals concerned, and we only ever really understand our own culture to a limited extent, and the understanding of it that we do have is naturally and highly subjective.

What is the present relevance of these points? The main point is that Malaysia is unique, like all nations, and to try to convert the Malaysian economy to something like that of Germany or the USA, or another more ‘advanced’ one, is like trying to turn a Toyota Yaris into large Mercedes car by putting a Mercedes engine in it, or vice-versa.

Development

Development has traditionally meant increasing the capacity, potential and output of a national economy. It tends to concern the capacity of a nation to generate annual increases in its gross national product (GNP).

In the 1950s and 1960s, much thinking about economic development was focused on less developed countries (LDCs) and advocated rapid industrialization at the expense of rural development (Todaro, 1988). Yet living standards of most LDCs remained unchanged in the 1970s, and development came to be thought of more in terms of general economic growth and reduction of poverty, inequality, and unemployment. Newer definitions treat development as a multidimensional process involving changes in attitudes, institutions and structures, as well as economic growth, reduction of inequality and eradication of absolute poverty.

Apart from its uses covering general socioeconomic change and that of LDCs, the term is also used in sustainable development (qv) and research and development (qv). The word also has another meaning, which includes the second part of R and D, in within-firm technical development activities (also see below). Parker (1978) saw the development of innovative processes as lengthy sequences of focused technical activities through which original concepts are modified until ready for production and sale. Such concepts, and improved or new processes and products, could come from inventions or scientific discoveries (Cory, 1996).

Sustainable development

Sustainable development, as described by the Brundtland Report of 1987, meets the needs of the present without compromising the ability of future generations to meet their needs (World Commission on Environment and Development, 1987). According to Kuhlman and Edler (2003), national systems of innovation, and by implication, environmental protection, tend to reflect national political histories, structures and traditions. In France the innovation system is more centralized than in Germany and the USA. Developing countries can seem to be careless with their natural environments. Their politicians can have relatively more power and more ambition in their own countries than those in older, wealthier societies. Such points may have some relevance for Malaysia.

3. Academic: research and development; and discovery

Research and development

This rather vague notion is used to include many types of technical work, often of a quite routine nature, like maintenance. It assumes, against most research evidence, that technical change needs to be preceded by scientific research. Most industrial R and D appears to consist of development work. However university and directly government organized and funded R and D has grown and apparently become more important in developed and some developing countries in the last 50 years.

Discovery

Discoveries, meaning new knowledge about the natural world, are often ineptly confused with inventions, and vice-versa. Industries tend to be concerned only with design, production and development problems, ones of practice, and not ones of fact or principle. Technical knowledge, built up from experience, is usually sufficient. This is not scientific knowledge. Industry is far normally more involved with inventions than discoveries. But many discoveries are relevant, with some very important or vital.

4. Industrial: production; design; entrepreneurship; innovation; invention; management of change; performance; success

Production

Production includes all the activities involved in the physical transformation of artefacts. Lawrence (1980) emphasized how production is what defines manufacturing in general, so that the type of product and production involved in each manufacturing sector defines it. He emphasized how production is the most central function of any manufacturing organization, preceded by design, development, marketing and finance and followed by accounting and sales. In West Germany, production generally meant ‘the whole company minus sales and finance’, thus including design, technical development, purchasing and maintenance, unlike the situation in the UK a generation ago.

Design

Design is a private act, intuitive and specific to the individuals who undertake it, unlike the public nature of scientific work. Design is the main activity of many engineers, and more central to engineering than even production, but academics concerned with commercialization, technical change, and R and D, have tended to neglect it compared with them. It is the core activity of engineering (Fores, 1978b).

Entrepreneurship

Entrepreneurial action is needed for new knowledge and techniques to be made productive and commercially viable. According to Kuratko (2001), an ‘entrepreneur undertakes to organise, manage and assume the risks of business’. Entrepreneurial activity inside established businesses has been called intrapreneurship.

For present purposes, entrepreneurship is relevant in the research, design, engineering, management, finance and marketing that result in the commercialization of discoveries and inventions. Enterprise can be social as well as economic, and in political terminology, left-wing as well as right-wing (Keat and Abercombie, 1994). However research has indicated that governments cannot build geographical or other clusters of innovative firms, and that such clusters are generally products of ‘systems of innovation’ in which companies, universities, banks, and other sources of venture capital and other finance, and government agencies, facilitate, support and stimulate each other to generate innovation, rather than to locate, channel or control it (Saxenian, 1996; Feldman and Audretsch, 1998; Feldman 2003; Clark and Tracey, 2004). While these factors can all be present in LDCs, their roots tend to be shallower than in established industrial countries.

Innovation

Innovation consists of inventions first being used to commercial effect. Marquis (1982) argued that about a quarter of innovations required virtually no adaptation of readily obtainable relevant information, and that another third were modifications of existing products or processes. As just noted above, innovations tend to be more successful when they occur in contexts of systems of innovation.

Invention

This notion is discussed at more length in Appendix 3, but a few points must be made here. First, inventions are created by new syntheses of existing techniques and knowledge. They consist of new products or processes or component parts of them. Invention is not the aim of science. It is art, although science often contributes. Inventions occur through both scarcities and surpluses of resources, or without resource considerations being much significance. Inventors can tend to be more technically focused than innovators.

The management of change

Commercialization is a kind of organizational change. To be successful, any changes must be managed suitably. Such management needs, above all, to be holistic, with all necessary actions being taken, neither more nor fewer. More details of the management literature on organizational change and of how it relates to commercialization are to be found in Appendix 3.

Performance

Performance criteria are of several kinds, and operate at several interdependent levels: international, societal, sectoral, organizational, group and individual. Well-known performance criteria include product and service quality, process quality, quality and/or volume of employment and sales, return on investment, profit, ecological friendliness, market share, and corporate social responsibility (cf. Child, 1984). All relate to different interests in the survival and performance of organizations. The issue of the short versus long term for performance is also important, as are historical and societal contexts. It is reasonable to suggest that Anglo-American short-termism is, in at least one fundamental respect, as ‘long-termist’ as it is possible to be. By eschewing the collectivism of Continental European and Far Eastern societies, and in trusting individuals and individual firms to perform, Anglo-Americans assume that the pursuit of individual self-interest and the creative destruction of market forces will, in the long run, optimise societal outcomes (cf. Elias, 1978). To coin a phrase, short-termism is only short-term in the short run.

Success

Success is more than performance. It can be impossible to measure. Also, even when all possible contingencies are understood and catered and accounted for, achievement may still be impossible. According to Landes (1998), business or economic success is normally a product of two phenomena. These are hard and focussed effort, and eschewing vanity, meaning refusing to believe one's own propaganda. As regards technical change, successful inventions are generally those which increase or maintain profits and market share.

5. Linking universities and industries: commercialization; technical change; technological change; technology transfer

Commercialization

Commercialization seeks to make new scientific and technical knowledge and capabilities profitable. Government aims for commercialization in Malaysia are generally the same as those of other governments. Hughes (1985) suggested that commercialization may be a synonym for government over-control of innovation.

Technical change

Technical change affects products and processes (Bell and Hill, 1978, p. 226)., and consist of innovation and diffusion. Most technical change is piecemeal and small-scale, and hardly merits the use of the word innovation. Most changes use technical knowledge far more than scientific knowledge. Some does originate in scientific research, and some of this is of considerable use to industry and this is the kind that most discussions of commercialization are concerned with.

Technological change

The successes of organizations depend on the effective use of technology (Joynt, 2001). Unfortunately however, technological change is rarely distinguished clearly or openly from technical change. It is useful to distinguish it in a relatively open and formal way by regarding it as a special case of technical change, in which, unlike the case with the latter, new scientific knowledge may combine with new and old techniques to help generate, not only improved or new processes and products, but new and often generic technologies with systemic implications.

Technology transfer

According to Brooks (1966), technology transfer occurs whenever scientific or other useful knowledge developed by one person, group or institution is used by another person, group or other institution to do whatever it wants it for. In practice, technology transfer means the transfer of technical knowledge, practical know-how, and not just scientific knowledge, but the relative importance of the latter is often exaggerated in the relevant literature.

The seven most salient concepts, regarded as those most relevant to the concerns of the thesis, are discussed further in Appendix 3.

SOME RECENT DISCUSSIONS OF TECHNOLOGY TRANSFER

The literature on technology transfer concerns collaboration between universities and industry. A general discussion of university-industry collaboration is in the report of the American Council on Education (American Council of Education 2001). This suggested that indirect costs, conflicts of interest and disputes about intellectual property and findings could threaten the practical use of research.

Bottom-up and top-down approaches to university-industry-government relations have been compared. On the former, the ‘micro strength’ of university-industry relations was described by Sutz (2000). However the institutional design of university-industry–government relations used the latter, being centred on the roles of institutions. Examples of the bottom-up approach included a successful enterprise that had established a ‘knowledge relationship’ with a ‘technological tailor’. One university research unit was a set-up agency designed to ensure that university researchers met company needs as effectively as possible. A criticism of the bottom-up approach concerned its need for careful management to keep collaboration focused and effective (Sutz, p. 283). The top-down approach often failed to involve firms in relevant decision-making, especially that concerned with in their dealings with universities. Relationships between firms and universities were generally weak and often unbalanced.

A seemingly better approach to planning stages of innovation from discovery/invention to commercialization was used by Moncada-Paternò-Castello et al (2003). Their case study of the technology portfolio of a European public research organization suggested that its type of technology-push was very successful for commercialising its technologies. The main success factor was the balancing of the power and interests of the participants, who included university scientists and commercial company managers. The authors stressed the importance of research administrators establishing early links with industry to prevent technology suppliers developing unrealistic technical and commercial expectations.

Foreign multinationals operating in Malaysia has rarely engaged in R and D there. Most R and D in newer and emerging technologies such as advanced materials, ICT and biotechnology in Malaysia is done by Malaysian university and other researchers (Azmi and Alavi, 2001). Working with university researchers can be difficult for Malaysian companies and venture capitalists. Universities too often expect to apply unsuitable one-size fits-all concepts. University expectations are generally different from other organizations'. Academics believe in and practise open publication of results, and oppose commercial secrecy. Universities publish their discoveries for all to see and use, unlike the position in companies where individuals register their patents for their own use. Universities need to accommodate businesses' and venture capitalists' needs without sacrificing their principles and long-term scientific objectives. Joint ventures and spin-off companies are effective by creating wealth for the universities and providing opportunities for venture capital companies and the businesses that they support by commercialising R and D and its funding. Scientists can publish their research as usual while spin-off companies use their findings in business, separately from universities. Scientists can be rewarded financially for working for spin-off companies if they do so separately from their university research. Goto (2000) argued that closer, more transparent, university-industry links and approaches to university patenting were needed.

The bottom-up approach of Sutz (2000) generally seems more likely to be suited to Malaysia than his top-down one. The former should better encourage creative relationships between researchers and companies by emphasizing enabling and supportive roles for institutions rather than more directive, controlling and rigid ones. It tends to favour rather than stifle the diversity and flexibility that economic and intellectual life thrive on. It encourages innovation without trying to plan and control it. It seems more likely to favour development of 'Triple Helix' relationships between governments, industries and university and other researchers that value sectoral, organizational, national and local kinds of embedded specificity (Etzkowitz and Leydesdorff, 2000). Industrial policies for LDCs have often ignored their needs for such kinds of tailor-made, apolitical, rooted and grounded industrial nurturing (Stiglitz, 2002). Yet while accepting that all such policies should be country-specific, and sector-specific and company-specific, it also seems sensible to agree with Mathias (1991, p. 28-29) that putting discoveries and inventions to use usually involves similar kinds of costs and problems of translation from laboratory and engineering techniques to factory production, from largely or partly non-commercial contexts and the motive of the pursuit of knowledge or technical excellence to profitability as a condition of existence, and to growth of market share as an aid to longer-term survival.

EIGHT MODELS OF COMMERCIALIZATION AND TECHNOLOGY TRANSFER

Some of the most relevant theories or models of commercialization and technology transfer are introduced below. These were produced by Cornwell (1998), Hindle and Yecken (2003), Jolly (1997), Lee and Gaertner (1994), Rothwell (1992), Etzkowitz and Leydesdorff (2000), Lowe (1993), and Siegel, Waldman, Atwater and Link (2004). From these eight, Lee and Gaertner's University Model appears to be the most thorough and realistic for present purposes, because it includes the actions of all those directly involved in technology transfer and commercialization, while also being world-open by taking most relevant external influences well into account. However all have something to offer the present study. Rothwell's is, however, more an account of the development of theories over time than a single theory. All eight are discussed again in chapters 6 and 8.

1. The University Model

This model (Lee and Gaertner 1994: 384) assumes that innovation moves in an iterative or repetitive, more than in a sequential way, under the influence of competitive market forces. Four stages in the model are assumed, nevertheless. They are basic research, technology development, technology commercialization, and marketing by industry. The stages are connected through a continuous feedback loop. The model assumes that some new scientific advances can be used to stimulate invention and technology creation and to lead to commercialization. The first step in innovation involves scientists with the help of commercial and financial, and especially technical, experts, considering their findings to decide whether they are commercially promising. If so, the next task is to consider more specific potential development and market needs. Commercial, that is economic and technical, feasibility, needs to be taken into account before decisions about initiating design, development and focused market research are made.

In this model, technical change uses scientific discoveries, which are engineered into processes and products. If a problem arises the search may go back as far as the original scientific research and be solved through references to relevant knowledge. The process is also evaluated and re-evaluated for possible demand shifts, other relevant discoveries and inventions, and unexpected setbacks. Commercialization consists of design and construction of processes and plant for market-oriented production. It involves start-up, evaluation and technical problem-solving. It identifies businesses potentially interested in adopting and adapting the new technology. It tests relevant markets, and works towards market entry. Universities have several alternatives if they have something to sell. One is to find an entrepreneur with a small or medium-sized firm that is interested in commercialising their new discoveries and/or technologies, and in using and licensing them and in paying royalties.

Another is to encourage researchers who have developed new technologies to start their own firms. Commercialization is seen as always including the finishing, 'business' phases of the university technology transfer process. This model is quite comprehensive and simple. It is also focused on actual people and events. While it tends to be compatible with the *Technik* model of technical change, it nonetheless allows use of relevant elements of the STH one.

2. The Integrative Model

Hindle and Yencken (2004) developed a model that described the various inputs to the spinning-off and development of new technology-based firms (NTBFs). They took into account the processes, events and resource inputs that could be expected to be involved in the construction of NTBFs. Researchers generated new knowledge. This led to ideas being converted into opportunities using technology development, moving on to proof of concept and to the first 'exit point', when, typically, venture capitalists or other investors might be interested. This model is more or less a simple linear one, but with various knowledge, information and expertise inputs reinforced and influenced by border scanning. Border scanning included company awareness of external economic and regulatory factors and being commercially informed about sources of new ideas and opportunities. The importance of access to entrepreneurial capacity at various phases of business development is emphasized. This model is simpler than the already quite simple University one. Its greater emphasis on external inputs is very helpful.

3. The Commercialization Map

Jolly (1997) posited five stages of commercializing technologies. These were imaging, incubating, demonstrating, promoting and sustaining. Imaging consisted of reviewing competing discoveries in the field, including patenting by others and the readiness of peers to endorse one's own discovery. Incubating involved using application-specific time windows for testing the technology, accepting the time scales of the firms expected to use the technology, selection of firms by universities as the resource providers and filing patents to consolidate positions. Demonstrating included assessment of competing products or processes for the function-targeted availability of complementary technology. Promoting involved assessing and encouraging the readiness of other market constituents to support commercialization and that of end users to adopt products or processes. The last stage was sustaining, which involved responding to or otherwise coping with launches of more cost-effective products or processes by competitors.

Each stage, except the last, had a definable 'transfer gap'. The transfer gaps were interest, technology transfer, market transfer and diffusion. The time windows of commercialization included all those typically seen as leading up to the acceptance of products in relevant markets. These are the stages through which the technology must pass if it is to be commercialised. The stages involve finding solutions to a variety of technical, production, and marketing problems and the bridges between the stages involve the mobilizing of resources to deal with them. Jolly called this process 'closing the circle of commercialization'. Closing the circle was about effective management of each stage (p. 329).

The last of the four gaps was diffusion. If the research had originated in a public sector institution, then this usually represented the end of its involvement. Dodgson (2000) argued that this model demonstrated a few important principles. Commercialization could fail at any one of the stages or gaps in the process. Effective commercialization processes tended to be continuous. They did not end when products reached the markets. Products could be improved, and markets could change. Long-term income streams depended not only on careful market entry strategies, but also on continuing market development activities. For Jolly (1997), the greater the value demonstrated in one stage of the commercialization process, the easier it was to build a bridge to one next to it. But because the intermediate values were mainly based on expectations, they tended to be subjective. This ultimately made bridging gaps a partly political act. This model is similar to the University one. Although more complicated, and also distinctly 'linear', it nonetheless adds several interesting detailed insights to the University and other models.

4. Quick Look

This model focused on the first stage of 'imagining' new products (Cornwell, 1998). It has been used at the National Mid-Continent Technology Transfer Centre (NMCTTC) of the USA's National Aeronautics and Space Administration (NASA) to provide a preliminary assessment of the commercial potential of new technologies. A Quick Look investigation provides a snapshot of the market's receptiveness towards an invention or discovery. Quick Look is an example of a structured preliminary examination of the potential of a new technology. It has three advantages. It is quick, relative to other approaches, and does not involve detailed market surveys, but collects information about the potential of the market systematically. Second, it focuses on the inventors of the technology and people who use similar technologies in potential markets. Third, it is used for comparisons, so that funding decisions can be made between competing projects (Cornwell, 1998).

Why do some technologies fail to meet their markets? Some are incorporated in products for which the anticipated demand does not materialise, some are never incorporated into any product; some products do not live up to their promised capabilities; and others simply do not attract enough interest (Jolly, 1997).

5. Rothwell's Five Generations of Models of Innovation

Rothwell (1992) described how five models of innovation processes were developed after the 1940s. The first, prevalent in the 1950s and 1960s, was the Science-Push Approach. Innovation was a linear process, beginning with scientific discoveries, passing through invention, engineering, and manufacturing activities, and ending with the marketing of a new process or product. At this time, university and government laboratories in the USA were being supported largely through supply-side policies for new product development (Rothwell, 1994, Strambach, 2002). It stressed the apparent relevance of R and D but, simplistically, there was little or no interaction or feedback between or among the stages, and no overlapping processes. The model was rapidly shown to apply only to relatively simple kinds of process and product.

From the early to mid-1960s, a second linear model of innovation, emphasizing demand-side factors, the Demand-Pull (or need-pull) Model, was more popular. Innovations resulted from perceived demand, which influenced directions and rate of innovation. Markets were major sources of ideas.

The third, the Coupling Model, integrated both supply-push and demand-pull, centring on an interaction process where innovation was regarded as a logical and sequential, although not necessarily a continuous, process. The series of stages and functions were ideas generation, research, design and development, prototype production, manufacturing, marketing and sales, with marketplaces the ultimate destinations. There were feedback loops between new ideas and new technology, needs of society and of markets, and states of the arts of technology and production. Technological capabilities and market needs are the main frameworks of this model. Communication was emphasized, be it intra-or extra-organizational, for linking the stages together (Rothwell, 1994, p. 10). This is more *Technik*-like and less linear or STH-like than the first two models.

The fourth was the Integrated Model. Japan, successful as a powerful source of innovation since the 1970s, was a major consideration in the development of the fourth-generation innovation model of the early 1980s and to the early 1990s. The high performance of Japanese companies had been based on more than a combination of technology imitation, just-in-time relationships with suppliers and efficient and quality-oriented production. The ability of Japanese companies to innovate was also caused by their superior within-sector and cross-sector integration and the parallel development of technologies. Design to manufacture helped innovative Japanese firms and sectors to succeed. It emphasized, above all, parallel development of technologies with integrated development teams. It has strong upstream links with suppliers and strong coupling with main customers with powerful effects on the integration with R and D and manufacturing. This is not the same as the Integrative Model of Hindle and Yencken (2004: see above). It is probably too complex an approach to be used in this study for Malaysian industry, with its shorter history and smaller scale than Japanese industry.

Rothwell's fifth generation and final model was the System Integration and Networking (SIN) one. It had fully integrated parallel development with the use of expert systems and simulation modelling in R and D. It had strong links with main customers. It featured strategic integration with primary suppliers, including co-development of new products and linked CAD systems. It had horizontal links including joint ventures, collaborative research groupings, and collaborative marketing management. It also emphasised corporate flexibility and speed of development. The model also had a very strong focus on quality and other non-price factors. Like the fourth of Rothwell's models, it is useful for thinking about some of the directions that Malaysia and other countries and their governments and companies may wish to take.

6. The Triple Helix model

This, produced by Etzkowitz and Leydesdorff (2000), seeks to account for and explore new configurations of institutional forces emerging from national innovation systems, especially from relationships between governments, industries and universities. It seeks to transcend previous models of institutional relationships, whether laissez-faire or socialist, in which either the economic or the political predominated, with the so-called knowledge sector, meaning universities and university and other researchers, playing a subsidiary role. The model is a generally bottom-up one that emphasizes the value of nurturing industries and involving university and other researchers and government departments and public officials and agencies in ways suited to the particular characteristics and creative satisfaction of embedded firm-specific, sector-specific and country-specific needs (cf. Stiglitz 2002). This broad model with its long-term concerns, has great relevance for Malaysia, although of a more general and background kind than the University Model.

7. The Industry and Technology Life Cycle Model

Lowe (1993) compared industry life cycles with technology life cycles to help search for optimal routes to success in the development, commercialization and exploitation of technology. He also compared relationships between the two types of life cycle in mature and emerging industries. In emerging industries, where technological trajectories were still evolving and where innovation was radical, use of spin-off companies was the most likely option. In mature industries, and when innovations tended to be less radical, licensing and/or self–start consultancy firms might be the only options. Thus Lowe pointed to the maturity of industries and the progressiveness of technology as being important factors in decisions about the nature of commercialization. Clearly, this strong focus on two particularly important influences on commercialization processes is very relevant for the present study, if only part of the story.

8. The General Linear Flow Model of University-Industry-Technology Transfer (UITT)

Siegel, Waldman, Atwater and Link (2004), had argued that the key UITT stakeholders are university scientists, who discover new technologies, university technology managers and administrators, who liaise between academic scientists and manage their universities' intellectual property, and companies, who commercialised university-based technologies, and the government, which funds research projects.

The general linear flow model of UITT reflects the conventional wisdom among academic administrators regarding how technologies are transferred. The process is presumed to begin with a discovery by a state-funded scientist in a university laboratory. In the USA such an academic is required by law to file an invention disclosure with the USA's Federal Government's Technology Transfer Office (TTO). Their university must then decide whether it has to patent the innovation, which was one of the mechanisms for protecting intellectual property. Any interest by industry partner could provide enough justification for a filing a patent. The next stage involved companies negotiating licensing agreements. The agreement could include benefits to universities such as royalties or an equity stake in a start-up. In the final stage, the technology is converted into a commercialised product.

In Chapter 2 relevant features of the Malaysian economy are discussed in detail and in Chapter 4 the above models are discussed in a little more depth, with their specific relevance for this study explored in more detail. A brief overview of their relevance follows.

The University Model appears to be the most helpful because of its simplicity, breadth, relative lack of emphasis on linear assumptions, and for its stress on entrepreneurs as the key agents in the diffusion of new technology. The entrepreneur is normally the key figure in capitalist economies for bringing innovations to market. The Integrative Model is not as detailed but it has a useful emphasis on external inputs to commercialization. The Commercialization Map is rather linear in emphasis, and is perhaps unnecessarily complicated, but it does offer a number of useful principles and specific inputs in the present context. Its perhaps inappropriate neatness is compensated for partly by its comprehensiveness. Quick Look is useful for thinking about the main reasons for success and failure of attempts at commercialization. Rothwell's five generations of models cover almost all relevant eventualities and show how thinking about innovation and commercialisation has evolved since the 1950s. His third model, the coupling one, is probably the most directly relevant to the position of Malaysia, but his fourth and fifth are also useful aids to thinking about how Malaysia's national innovation system should and should not develop. The Triple Helix Model also has clear kinds of implication for Malaysia, especially for the development of deeply embedded creative networks between companies, researchers and governments. Finally, the Industry and Technology Life Cycle Model is helpful for comparing the different market situations and technology levels of different sectors and companies with their needs for less or more adventurous modes of commercialization.

The least relevant elements of some of the above theories in the present context include over-emphasis on the new technology-based firm (NTBF) for the commercialisation of technology, on the various gaps in the technology transfer process, and undue concentration at times on specific processes and products. All these are relevant to the present study and are taken into account as necessary, but the interests, values, attitudes, roles, actions and behaviour of the main actors comprise, together, its central focus.

SOME PRECONCEPTIONS OF THE RESEARCHER

After speaking to a small number of entrepreneurs and university researchers in Malaysia, before conducting the main interview program, it seemed that the country has faced several problems with attempts to achieve effective commercialization. These included culture clashes between the worlds of science, business, administration and government, administrative and managerial inflexibility of several kinds, poorly designed reward systems for researchers and other relevant parties, and in particular, ineffective management of university technology transfer offices. As there appeared to be little systematic and widely appreciated understanding of organizational practices in the management of university intellectual property, the study sought answers to questions about various straightforward points including ones concerning definitions of technology transfer, measurement of performance in technology transfer, impediments to successful technology transfer, how to improve the process, and the characteristics of relationships with university commercialization, technology transfer and/or industrial liaison offices.

The answers to such questions might concern lack of mutual understanding of administrative, corporate, scientific and university norms as pervasive barriers to effective technology transfer to entrepreneurs and firms. Others answers may be about lack of marketing expertise, social skills and industrial awareness on the part of research administrators and other technology transfer-related staff, inadequate recognition of and rewards for university researchers, and managerialism and general inflexibility on the part of university administrators. Most of these weaknesses were themes of respondents' answers when the main interview program was conducted.

THE RESEARCH QUESTIONS

There are main two research questions. One concerns the problem of low uptake of potentially profitable discoveries and inventions, of low rates of commercialisation or innovation. This is addressed through asking questions of the above kinds about the attitudes and behaviour of the responsible parties.

The other concerns the underlying and often far from conscious reasons for the relevant attitudes and behaviour. They concern questions about values, interests and control. The four main parties, namely scientific researchers and engineers, business managers and entrepreneurs, research administrators and civil servants, and politicians, bring different backgrounds, experiences, attitudes and values to discussion and decision-making about commercialisation. In some respects, they are programmed to misunderstand and mistrust each other.

An extensive Anglo-American literature on such matters that dates back to the 1920s (see for example Currie and Glover 1999; Cotgrove and Box, 1970). Many writers on professionals and management are thus concerned with the different interests of the parties, be they scientific publication and reputation, professional achievement, prestige and status, financial reward, profit, market share, administrative resources and authority and managerial power and influence, political power, reputation and achievement, and so on (Child 1981; Glover and Hughes 2000). In some respects, control is a larger concern in the present context than values or interests, insofar as assumptions underpinning and directing commercialisation efforts in Malaysia may be unduly concerned with it. Such assumptions may be paternalistically culture-bound insofar as they embody rather arms'-length 'one size fits all' assumptions of policies designed by products of Anglo-American and in many respects neo-colonial and patrician educational and scientific traditions, employed by major international economic, financial and political institutions like the International Monetary Fund, the World Bank and the Organisation for Economic Co-operation and Development (cf. Stiglitz 2002).

Much thinking about strategic management, about technical change and innovation and about national and organizational culture and management has become more reflexively self-critical since the 1960s. Regarding the last of these, we have seen in the discussion of culture, above, the naïveté of attempts to impose 'solutions' from one society or economic activity sector as remedies for the problems of others. This fact, and that of the limitations of the STH model of technical change, are accepted widely amongst the more sophisticated, interdisciplinary and critical students of strategic management and technical change and innovation.

One factor that does appear to remain fairly constant throughout sectors, across the world and over time, is the combination of integrity and ability characteristic of able innovators. Sometimes the integrity is very focused and limited to the tasks in hand or thereabouts and it is at times unaccompanied by management of others with an eye to the long term. However, technical and scientific and other sustained creative achievements do require strong concern for facts and truth, as well as considerable persistence, and these are all admirable human characteristics (Groen and Hampden-Turner, 2005). Florida (2003) reinforced this view in his study of innovative regions of the USA, in which diversity of all kinds, social, political, and ethnic, as well as economic and technical, appears to be the fertile soil in which skills, knowledge and incomes have grown faster than in virtually all other regions of that country.

Saxenian (1994) compared sources of regional advantage in two such regions in the USA, Silicon Valley and Route 128 in Massachusetts. The former had prospered while the latter declined, because the former's industrial system was decentralized and co-operative, whereas the latter was dominated by self-sufficient independent corporations. Teece (2000) emphasised 'dynamic capabilities' of firms in the strategic management of technology, suggesting among other things how SMEs in LDCs could profit from innovations that had originated elsewhere. Because manufacturing competitiveness in advanced industrial countries had declined, with vertical integration often breaking up, firms in LDCs were able to rely less on imitating the products of the former than in the past, and more able to complement the efforts, often in sophisticated ways, of newer companies in the advanced industrial countries, which were filling important market niches. Such efforts to take advantage of spillover effects were often very profitable for the LDC's SMEs.

Teece's (2003) emphasis on the internally-generated activities of firms has acted as a critique of the more external, market-focused strategic theses and recipes of Michael Porter (1990). However Teece (2005), like Porter, does also take context into account, seeing it as constituting some of the resources available to SMEs and other firms, along with their own abilities, dynamism and other resources. Teece's thinking sits well with both the bottom-up emphasis for innovation management and strategy of Sutz (2000) and the demotic and creative emphasis of the *Technik* model of technical change.

All of this also relates well to the thesis of Stiglitz (2002) about 'Western', very often USA Ivy League university-educated, economists at the World Bank and in other major international institutions like the OECD, seeking to impose ‘one best way’ to organize economic activity across the world. Like Porter (1990), they sought to persuade governments, including those of LDCs, to build clusters of innovation from the bottom up, but with top-down government direction, through programmatic devices like Malaysia’s Intensification of Research in Priority Areas, but without enough of the conditions in which they could develop, such as relevant markets, industries, qualified people, venture capital, contacts and so on, being in place beforehand. Stiglitz and Teece were both keen to emphasize the importance of social institutions and conditions for effective innovation. If trust levels between individuals and institutions were low, for example, innovation was inhibited. Organic organization structures were of course preferable in many sectors to mechanistic ones, but it was also helpful for modes of interorganizational governance to be clearly structured as well as co-operative, as they often are in the USA. In editing a special issue of *Industrial and Corporate Change*, Breschi and Malerba (2001) criticised, after reviewing considerable evidence, the ‘ineffectiveness of public policies attempting to direct the formation of new clusters through top-down interventions, such as technopoles, science parks and firm incubators’. Instead they argued that governments should help clusters to develop by ‘accommodating new firms, investment in education and the provision of support infrastructures’.

CONCLUSION

In this chapter some of the issues regarding the perceived low uptake by Malaysian firms of commercialisation initiatives have been considered. The problems of learning from a ‘West’ that is not homogeneous were discussed by comparing and accounting for and exploring some ramifications of two master, contrasting and competing, sets of assumptions about the nature of technical change that have long been influential in Europe, North America and elsewhere. A number of concepts used to discuss technical change, innovation and commercialization were examined to illustrate the complexity and variety of interpretations and assumptions used in writings on the subject of this thesis. From these a smaller number of the most central concepts have been selected and these were explored at greater length as in Appendix 3.

Eight theories of commercialization and technology transfer were outlined and their different kinds of present relevance explained. Next, some preconceptions of the researcher about the perceived low rates of commercialisation of discoveries and inventions in Malaysia were outlined, as were the two research questions: the need for a rigorous explanation of this supposedly low uptake, and the need to explain the assumptions, interests and values and so on that helped to create the problem or problems in the first place, and which sustain its existence.

These preconceptions and the research questions are discussed at much greater length in Chapter 4. Chapter 4 also concerned with the kinds of issue discussed above, with Malaysian industrial and technology policy and strategies, but in more depth. Chapter 5 is the methodology one: It reminds the reader of the main hypotheses and research questions of this study, which were first spelt out in Chapter I. Even so, it is worth spelling them out here also, to end this chapter neatly and to help keep the thesis focused.

The main hypotheses deal with the two research questions, identified in Chapter I and the previous section, which are as follows. The first question concerned the reasons for the perceived low uptake of commercialisation efforts in Malaysia. The hypotheses for this are primarily concerned with apparent mutual misunderstanding between, and apparent resistance to change from, the main parties concerned. The second question concerns the broader and deeper reasons for the low uptake, for the misunderstanding, and for the resistance to change. The hypotheses in this context will concern Malaysia’s industrial and technology policies and practices in relation to its political and economic historical experience.

CHAPTER 4

COMMERCIALIZATION AND TECHNICAL CHANGE IN MALAYSIA

INTRODUCTION

This chapter describes and discusses commercialization and technical change in Malaysia. In the first section, the contributions of commercialisation and innovation to economic development are briefly described and explored. Relevant comparisons of commercialization in developing and developed countries are made. The institutions and people involved, that is companies, government departments, universities, government research institutes, banks and their staff, and venture capitalists are also identified. In the second section, inputs to commercialization in the form of discoveries and inventions from universities and government research institutes (GRIs) are described. In the third, the roles of the institutions, firms and people identified in the first section are discussed.

In the fourth, attention turns to the processes and results of commercialization in Malaysia, to try to develop an overview of achievement and lack of it in the commercialization of university and GRI discoveries and inventions in Malaysia. The fifth section turns to the two master models of technical change discussed in Chapter 3 and considers their relevance to the evidence discussed in the present chapter and vice-versa. The main point addressed here is the extent to which scientific discoveries do, and can, influence manufacturing and other relevant commercial and organizational processes. The sixth section turns to my own Model of Commercialization for Malaysia, with regards to the most appropriate flow of commercialization or The Commercialization Loop (Abu Talib, 2007). The final section considers the kinds of question that each type of respondent should be asked in the light of all of the foregoing and the contents of Chapters 1 to 3, meaning in the light of the research questions and existing evidence and information. The conclusion summarizes the chapter.

DEVELOPMENT, INNOVATION AND COMMERCIALIZATION

Commercialization of new knowledge is widely felt to be essential to economic growth. In Malaysia, in other developing countries, the problems of commercialization are felt to be inadequate infrastructure, lack of market research, and inexperience on the part of venture capitalists (Utusan Malaysia, 2003). Also, there are poor links between universities and firms, there is little market awareness and commercial motivation on the part of staff R and D. Further, seed-level development funding and business angel investments are two gaps faced by local entrepreneurs, and there are fewer than 150 business angel investors in Malaysia. Gan (2003) argued that working with university researchers can be challenging for firms and venture capitalists, as one should understand those universities' policies and or expectations are different from theirs insofar as most universities in Malaysia practise open publication of their research results, as opposed to firms' practices of keeping results and findings of their investigations commercially secret. Also, universities themselves hold patents of all their inventions, unlike firms, whereas individuals and companies usually register their patents.

University-industry knowledge transfer is a significant research subject in economics and management studies, as well a major feature of science and technology policy agendas in many countries (Balconi, Breschi and Lissoni, 2004). Using evidence from Latin American countries, Arocena and Sutz (2001) argued that it is harder for developing countries to innovate and commercialise are because of the low importance given to endogenous knowledge production and the low involvement of industry with R and D. Some Latin American universities were elitist and focused on self-defined research agendas, and international in outlook rather than focused on their intended roles of commercially-useful knowledge production and promoting of innovation.

In Japan, it has long been recognised that although expectations are placed on the potential of universities, Japanese universities are not making contributions to Japan's economy and society that match their potential. For example about 36% of research in Japan was in universities, but patents originating in universities at that time represented only 0.04% of total patents (Fujisue, 1998). Archibald and Finifter (2003) argued that in an era of reinventing government and performance measurement, if research centres started to shift resources towards specific projects to try to maximise commercial success, they might sensibly reduce the proportion of basic research. Muent (1999) studied the problems of commercialization for SMEs in Poland. He found that networks of relations between companies and technical universities and research institutes were often deficient.

Some American and Far Eastern researchers have recognised that about half of all university patents are never licensed, and that licensing activity is not randomly distributed across patents (Jensen and Thursby, 2001; Hsu and Bernstein, 1997). Shane (2002) argued that when patents are not an effective mechanism for appropriating the returns to innovation, university technology is likely to be licensed back to inventors, because commercialization by inventors mitigated the adverse solutions, moral hazards, and hold-up problems that plagued markets for knowledge. Jensen, Thursby and Thursby (2003) showed that university technology in the USA was more likely to be licensed if it was at relatively late stages of development.

Other examples include India. Sikka (1997) argued that the reasons why many technologies developed in Indian laboratories have remained unexploited were that they were not proven on adequate prototype or pilot plant scales. Kumar and Jain (2003), also in India, identified influences on decisions to commercialize new technologies. The more important ones included the status of technologies, sources of technology, market potential for end products, company business philosophies, financial statuses of industrial firms, tie-ups or technical back-up support, and patentability. Other influences included entrepreneurial experience of proposal, educational backgrounds of entrepreneurs, import-export policies, fiscal policies, the capacities of companies to expand, the geographical locations of companies, and the sizes of industrial firms. Some factors likely to enhance the chances of success of new technology firms were timely availability of required funds, no-repayment during gestation periods, nil or low interest rates during such periods, optimisation of technology at pilot plants and in-advance completion of plant engineering and design, including instrumentation.

One problem with universities in the USA as regards commercialization was that faculty members had little incentive to become involved with firms located in universities' incubators (Mian, 1994). It appeared that technology incubators in the USA university have not focused on technology transfer and commercialization of university research. Among the reasons for this is were legal impediments to licensing university research for commercialization. A few managers reported that existing legal structures at their universities impeded the ability to transfer or commercialize university-based research. Another reason was conflicts of interest which prohibited faculty members from having more than minority interests in companies located in incubators. Another reason was the proportion of royalty payments retained by universities. If such percentages were high, negotiations for technology transfer with firms could stall or be cancelled altogether (Phillips, 2002). Kumar and Jain (2003) argued that, in India, the parameters that influenced decisions about commercialization of new technology and the success of new technology ventures, included the efficacy of existing financing/support mechanism required by stakeholder agencies, that is those in industry, technology institutions, financial institutions and government for further development of commercialization of new technologies for India.

Most scholars have argued that economic development is mainly about two things: increases in efficiency, meaning achieving more output with the same levels of input, usually through technical change; or increases in the levels of inputs, that is by accumulating more and more capital. However, one of the major arguments about what is driving growth, centred on differences between countries in terms of initial conditions, for example in wealth distribution and education; in macroeconomic environments, for example inflation or savings rates; and in industrial policies, for examples inwards versus outwards orientation (von Tunzelman, 1995). Veloso and Soto (2001) argued that incentives, infrastructure, and institutions are relevant for understanding differences in technical development and industrial trajectories between countries, because they shape government policies and firm strategies in terms of exports, subcontracting, and technology acquisition, among others.

Commercialization can clearly enhance the abilities of local industries in Malaysia and elsewhere to gain competitive advantages for their product lines and to advance processes. Beyond engineering achievements and abilities in manufacturing and production, industries of all kinds should have scientific capabilities. In Malaysia, and based on government reports, about 300 R and D projects had been commercialised by the government research institutes and universities. These achievements includes ones in food production, wildlife conservation, diagnostic kit, environmental protection, smart cards, disease control, industrial products, biotechnology, engineering equipment, construction materials, waste treatment, information technology, multimedia, and e-business. As universities are seen as sources of technology development that may be useful to entrepreneurial activities, the government has emphasised increasing the flow of scientific knowledge to the industry. Successful commercialization of discoveries, it felt could bring many direct and indirect benefits to Malaysia. The formation of spin–off companies, starts ups, new enterprises, and entrepreneurship in technology development and technology licensing were among the benefits of successful commercialization. Ownership of intellectual property rights can support, the government thinks, an innovative culture, R and D excellence, and economic spill-over.

INPUTS TO COMMERCIALIZATION

Inputs to commercialization concern discoveries and inventions from the universities and GRIs in Malaysia. Under the IRPA many successful projects have been recognized as award-winning innovations. Examples include the production of high quality oysters of the species *crassostrea iredalei* by Universiti Sains Malaysia (USM); Malaysia tea tree oil, a joint project between Perlis Essentials Oil Sdn Bhd and the Malaysian Agricultural Research and Development Institutes (MARDI); the development of MARDI of a new variety of padi

MR220 capable of producing more than 10.5 tonnes per hectare; the development of the stone matrix Asphalt (SMA) with Cellulose Oil Palm Fibre for road surfacing by Universiti Putra Malaysia (UPM); and the development of by SIRIM of the e-Jari Access Control System, an intelligent Biometric (finger-print) access control system.

Others includes, by SIRIM, the Solar Powered Auto-Ventilator System (SPAVS) for cars. This was a joint project undertaken by SIRIM with Agreevest Sdn Bhd. There have also been pitcher plants by the Forest Research Institute of Malaysia (FRIM); the production of Oriented Strand Boards and Panels using rubber wood waste under the collaborative between FRIM and the Hevea Wood Industry Sdn Bhd. These collaborative projects were funded by the Industry R and D Grants Scheme (IGS). Another grant scheme under the government is Multimedia Super Corridor R and D Grant Scheme (MGS). This successful collaboration includes the Universiti Teknologi Malaysia and Airstar (M) Sdn. Bhd in producing wireless point-to-point link of high efficiency; lighter and smaller transceivers for easy installation; a new antenna design; the design and development of high-end artificial intelligent Made-in-Malaysia printing technology resulting in enhanced machine capabilities that matching those of imported models; development of Malaysian-made SF6 GIS incorporating vacuum interruption technology; design and development of specialised mobile oil palm tree shredder and cutter machine capable of disintegrating whole oil palm fronds and branches; development of low voltage and high voltage HRC fuse; and finally the development of mechanised equipment to harvest water weed (water hyacinth) in Malaysian lakes and ponds.

In the field of environmental technologies, the universities and GRIs have also developed a solid gasification/thermal oxidation plant for the treatment of unsorted municipal solid waste; designed and developed a zone outdoor air purifier that can provide filtered and cleaner air for outdoor structures; designed and developed a mobile modular incinerator system for the mass destruction of animal carcasses; and designed and developed a remediation process for closed and existing landfills using an advanced waste compositing technology.

There are also resourced-based technologies that include the development of machinery to produce empty fruit bunch fibres for the manufacture of medium density fibre board; and production of oil palm fibre/thermoplastic composite pellets for extrusion and moulding and development of Natural Oil Polyol (NOP), a low cost and environmentally friendly Polyol and polyuthane system manufactured from Malaysian oils. In advanced materials there is the development of RAM battery with a new mechanical sealing system; in aquaculture/marine culture technology, there are new automated high density poly culture systems for the production of freshwater fish and propagation and commercialization of corals.

Under the Ministry of International Trade and Industry, the programme of the Commercialization of R and D Fund (CRDF) offers examples of the inputs to commercialization from its machinery and equipment group. They include commercialization of a hydrogen generator based on electrolysis. This joint collaboration is between the Universiti Malaya and the Gas Generator (M) Sdn Bhd. It produced a dryer system for use in the animal feed industry by FRIM and KD Technology Sdn Bhd. This dryer is called the Radiant Modular Kin Drying (KD) system. It is an efficient industrial dryer for many products from timber to spices, from composite boards to fertilizer and from animal feed and to seafood. MARDI and UPM have developed a lever-operated Knapsack Sprayer. This product was being developed further by Metraplas Industries Sdn Bhd. It product is a lightweight plastic dispenser for applying chemical, fertilizer and pesticide in farms and plantations. Harta Semarak Sdn Bhd has taken the commercialization of a new process for waste water and drinking water from the Universiti Kebangsaan Malaysia (UKM). The company has modelled a prototype water and waste water treatment facility, which is able to treat water more efficiently. The Zeo-Tech has also been introduced to prawn farming, both as an odour absorption agent and growth stimulator. The introduction of Zeo-Tech to aquaculture ponds has been found to stimulate the growth of phytoplankton as a natural food for prawn.

Under the Chemical Industry Group, inputs to commercialization include the commercialization of a process to produce larvicide from *Bacillus thuringgiensis*. This is a joint collaboration between Inbiotech Sdn Bhd and the Institute of Medical Research (IMR). The bacterium is a Malaysian isolate of the Bacillus thuringgiensis that was first discovered in Europe. It was isolated by researchers at the Entomology Department of the IMR during studies to find a local species of the bacterium. The bacterium was recommended highly by the World Health Organization (WHO) for the control of disease-carrying mosquitoes. Another CRDF project is the commercialization of Mychorriza as a crop enhancer. This project involves joint collaboration between Malaysian Agri-Tech Sdn Bhd and UPM. This company has developed, for commercial application, a group of special underground agents called the Arbuscular mycorrhiza fungi (AMF). They can strengthen tree roots and provide a defence against pathogens. Malaysian Vaccines and Pharmaceuticals Sdn Bhd is company that has undertaken the production of animal vaccines formulated during R and D work at the Veterinary Research Institute (VRI) of the Department of Veterinary Service. Then the company was approved CRDF to conduct research into commercialization of animal vaccines with University of Putra Malaysia (UPM). The design of an advanced thymidine kinase gene-deletion process is different from that developed in some Western countries. The technique enables the microbiologist to develop a ‘designer’ virus unique in characteristics and for processing limited capabilities for causing damage to animal cells.

As mentioned above, the Malaysia tea tree oil project, a joint one between Perlis Essentials Oil (PEO) Sdn Bhd and the Malaysian Agricultural Research and Development Institutes (MARDI), is also funded under the CRDF. The grant was allocated for the setting up of a pilot plant at the MARDI Bukit Tinggi research station. The tea tree oil had been commercialized since early 1999, albeit on a smaller scale compared to when it was given MITI's funds for further R and D work.

In the electrical and electronic group, another form of commercialization is a portable card acceptance device with a biometric capability. It is a joint collaboration between SIRIM, MIMOS and EPNCR (M) Sdn Bhd. This device is consists of several key components, namely a microprocessor, a smart card interface module, a cryptographic module, a memory chip and a liquid crystal display panel. The product incorporates a large database management capability to handle the large amount of information that will be stored in its memory.

INSTITUTIONS AND FIRMS

The University-Industry Commercialization Collaboration Forum (UICCF), hosted bi-monthly, tries to encourage universities to transform their research into business ventures and to facilitate links between universities, industry and venture capitalists. UICCF acts as platform to allow researchers to showcase their projects to funding bodies, and at the same time, to ensure that their research projects meet industry/market needs.

The main source of research funding in Malaysia is the Intensification of Research in Priority Areas (IRPA) program. The IRPA is there to support R and D in the public sector in areas which address the need of Malaysian industry so as to enhance the national economy. The main purpose of the IRPA program is to focus on R and D activities which are in line with the national R and D Priority Areas.

Government support for university research comes from the Malaysian Technology Development Corporation (MTDC) which has links with companies, engineers, researchers and financial institutions, and which provides venture capital for commercialization of university research projects. Several high technology parks have been purpose-built close to key universities to enable both academia and industry to optimise available resources and capabilities. The MTDC is offering CRDF to SMEs to encourage firms to commercialize indigenous technologies developed by local universities and research institutions. In 2001, RM3millions was approved compared to RM9 million in 2002 under the CRDF fund by MTDC. Technology research funding which has a connection to public research is the CRDF. This fund provides partial grants, ranging from 50% to 70%, to most Malaysian-owned companies incorporated under the Companies Act 1965, to help them to commercialize research results. Approved activities for funding include market surveys and research, product/process design and development, standards and regulations compliance, intellectual property protection, and demonstrations of technology. Examples of smart partnerships between universities and industry include the University-Industry Technology Advancement Programme (UNITAP) of Universiti Teknologi Malaysia.

The IRPA Management Information Systems (IRPA-MIS) program has a design prescription system for the automation of the processes by which the general and financial management of the IRPA's R and D are controlled and monitored. It functions to provide financial administration for budgeting, for commitment from researchers and disbursement of IRPA funds, for monitoring and an assessment of R and D, for its database research-related policy, and for management support information. One of the venture capitalists in Malaysia is

Malaysia Venture Capital management Bhd, which work as the manager of the Cradle Investment Programme. The programme helps to promote early stages of commercialization, for example by producing market surveys and business plans.

The Universiti Putra Malaysia (UPM) has established the University Business Centre (UBC) as its investment arm. It introduces activities for commercialising technology and helping its academics in moving technology, capabilities and expertise into industry. It is also forming R and D partnerships designed to accelerate the introduction of discoveries and inventions into commercial use. It offers help to firms, entrepreneurs, educators, economic development officers and counsellors. UBC also offers services for the commercialization of research, contract research, consultancy services, training and venture partner in multimedia. UPM also offers industry-responsive R and D Centres such as those for Advanced Materials (CAM), Animal Production, and its Centre for Biological Control of Tropical Pests. The UPM also offers incubation centres and a Technology Park.

PROCESSES AND RESULTS OF COMMERCIALIZATION

Out of 3,707 research projects conducted under the Seventh Malaysia Plans, only 527 or 5 percent have been commercialized. Synergies between government, universities and industries are very relevant for shaping technical development in Malaysia. Thus, a study by Universiti Sains Malaysia (USM) under Research, Development and commercialization nexus has analysed the critical factors for successful commercialization. Problems includes the largely ‘pure’ research culture of doing research among academic staff. Thus an acculturation process has been introduced to educate researchers about the need to undertake research that ‘eventually’ leads commercialization (Mohd. Sadullah, 2005).

Most universities and GRIs have their own Business Units and Research Management Center (RMCs). An example of processes of commercialization in USM, is the way in which researchers get the support systems and acculturation based on their industrial inputs, under the supervision of the Research and Creative Management Division. After research findings are reported, the challenge is to create effective partnerships with industry. Three important steps are taken for this in USM. First, there is the pre-evaluation form, assessing the utility of technologies and focusing areas for funding. Second there is the patenting strategy, where the researchers get advice on strategies for protecting their intellectual property. Third, there is the first right of refusal, where USAINS Private Limited, the USM holding company set up to expedite the negotiation process with potential commercial partners. Their problems of commercialization include the gap between producing research findings and getting commercial partners. Others include the lack of pre-seed finance beyond the ‘proof of concept’ stage that precludes smooth translation of potential research findings into tangible commercial outputs (BDU, 2003).

Commercialization processes in Malaysia take place in many ways. Many benefits can be obtained from the spinning out R and D results. They include returns on R and D investment in bad and good times; greater satisfaction for and the retention of good researchers; economic gains for the outside community/world; and at universities, spin-off can sharpen a professor’s perspective and create jobs for graduates. In the survey done MOSTE, in 2003, four different stages of commercialization were examined in terms of their intensity. The stages were filing patents, purchasing of technologies, company formation and licensing of patents. Based on their findings, licensing of patent is not very prominent, as the quality of the research is not amenable to licensing and licensing strategies are not well understood. As R and D expenditure increases, the government is concerned about the research results that are untapped by the industry.

Reasons for this include the fact that laboratory priorities shift by the time technology is developed, the laboratory's parent has left a sector or market by the time technology is developed, researchers focus on research and not on technology commercialization, and researchers who discover something that they were not looking for are likely to focus back on their original goals at the expense of the new technology (MOSTE, 2003). In terms of spinning-off, the problems, from the survey, were that most researchers do not have the entrepreneurial drive to make a spin-off work, too few researchers tested their products among potential customers during the technology development phase, and many universities lacked the capabilities of technology transfer offices. However, the research done under the existing set-up is not effective, and the awareness and outreach programmes are poorly executed, resulting in lack of knowledge of their services.

In Universiti Malaya (UM) the problems of commercialization go beyond staffing and headcounts to start-up the needs and skill sets required to take the start-ups to the next stage of development. In Universiti Putra Malaysia (UPM), their process of commercializing research results is started by their researchers, using their findings and the university's Commercialization Business Units. UPM Holdings gives UPM's researchers consultancy, training and commercialization advisory services. In spite of no less than 20 successful technologies, UPM lacks the services of patent lawyer. The Standard Institutions and Research Innovation Malaysia (SIRIM), which does industrial research development faces problems of shortages of funds for 'up-scaling activities'. Then are also problems of fair values on technologies at hand, and in valuing those to be commercialised.

On behalf of venture capitalists, Malaysian Venture Capitalist (MAVCAP), in the Business Development Unit (BDU) of MOSTE report of their study, found that Malaysia was lacking in business-building competence. Yet this was very important to every start-up company as a necessary complement to the technical knowledge of researchers. Researchers were not willing to move to employment with commercialized ventures, as they did not want to risk their academic careers for risky ventures. Researchers were also so engrossed in their research that they ignored the commercial potential of their findings (MOSTE, 2003).

It is helpful to discuss the practices of the Malaysian Palm Oil Board as an example of a publicly funded government research institution, where five of the interviews for this study took place. Its institutional processes had recently been changed for it to help companies better in their implementation of commercialization processes and stages. The Malaysian Palm Oil Board was established in May 2000 as part of the restructuring of Palm Oil Research Institutes Malaysia (PORIM) and the Palm Oil Registration and Licensing Authority (PORLA). Commercialization processes start from and end in markets (Basiron and Soon, 2004). They cover research project formulation and evaluation, and project implementation and completion as well as commercialization itself. At the evaluation stage, there is Intra-Institutional or internal committee on research evaluation and also includes the presentation of new proposal to a Programme Advisory Committee (PAC) which recommends the MPOB Board to the acceptance or rejection of new projects and proposals. This committee comprises experts in their respective fields from universities and industries. A pre-screening procedure is used where the management of MPOB has an opportunity to question the usefulness, and the potential economic and potential technical viability of a proposal, and to make suggestions to strengthen it. An extra-institutional mechanism is used to help to determine the market-relevance and technical soundness of new proposals. This mechanism consists of the MPOB-Industry Committees. On the first implementation of research projects, MPOB introduced the PORIM Research Notebook in 1999. This recording system ensures that there are official records of research work being carried out, in particular of those lead seen as likely to lead to inventions.

MPOB also has an IPR policy, which is accordance with Civil Service Department of Malaysia's circular about such policies. The MPOB policy lays down the processes for identifying the owners and the creators of inventions, determining the scope and types of intellectual property protection to be effected, and the rewards to be given to the inventors in the event of successful commercialization. The researcher has his or her completed research projects vetted by the Viva Committee of the MPOB. Only projects accepted by the committee can be considered as completed. The committee then recommend or endorse follow-up actions for obtaining partners for commercialization, and to obtain funding for pilot or semi-industrial plants. Documentation of technology is part of the follow-up processes of firming-up the technology and the know-how in-house before offering it to third parties for commercialization. All future retirees of MPOB have to document their technologies before they are allowed to retire. On publicity and promotion, the MPOB organised a Transfer of Technology Seminars and Exhibitions annually since 2000. They allow interested parties to have a closer look at the technologies and to discuss them with potential investors. MPOB also holds an annual Technology Demonstration Month after the Technology Transfer Seminar. This month-long events enable interested investors to explore the nature and the potential of inventions in detail.

Based on MPOB's experience in commercialization of its technologies, the problems usually encountered stem from lack of expertise in the organizations that might be capable of managing intellectual property and of formulating deals with outside parties. Since 1995, 253 technologies have been launched and up to 2004 about 30 percent of them have been commercialized. MPOB has been involved in contract research and negotiations, technology licensing, consultancy, collaborative research, confidential disclosure, secrecy, and materials transfer. Other problems that it has experienced include making approval processes clear as this bureaucratic process takes time. To get funding for pilot plants and semi-industrial area facilities is also often a problem. Regarding selection of commercialization parties, the MPOB has only o little chances of few companies to choose from. Licensing is the best mode of commercialization used so far by the MPOB, as it does not involve its direct involvement in business ventures through equity investment. Such direct involvement can involve problems with key contract terms, technical support, consultancy, royalties, and rewarding research scientists. Three success factors for commercialization in MPOB are the quality of the technology, that of the entrepreneur and that of the R and D support from the research institutions (Basiron and Soon, 2004). In the face of such problems the MPOB has achieved 253 technologies, with about 30 percent of them being commercialized. Among the technologies and products are the continuous sterilisation milling technology, the Smart Balance edible oil formulation, red palm oil, palm vitamin E, a mechanical grabber for loading fresh fruit bunches, an aluminium harvesting pole, a palm-based cosmetic and personal care formulations, oil palm fibre, a thermoformable plastic composite for car components, oil palm plywood and many others.

As scientific knowledge and technical innovation are repeatedly advocated as very relevant for the economic growth, Malaysians should expect that practically useful research can come from many disciplines, including biology, chemistry, computer science, engineering of many kinds, mathematics and physics. In Malaysia, as is also true in many other countries, as discussed above, the commercialization of science and technical engineering work remains very difficult. Despite considerable investment in R and D, turning research findings into money-making business processes or products is still often very difficult. There was a definite significant increase in the number of researchers and R and D personnel in the period 1998 to 2000, greater than that for compared to 1996 to 1998, and an increase of R and D expenditure from 0.39% of GDP in 1998 to 0.5% in 2000. Expenditure (include salary and emolument) per researcher personal increased from £3300 in 1998 to £10250.

In 2003 the Universiti Teknologi Malaysia (UTM), reported a study of government agencies, universities, GRIs, financial companies and other private institutions that were involved in research and commercialization, in which it listed various problems. These included lack of critical mass and quality of R and D outputs of researchers; lack of knowledge in evaluating potential intellectual property assets and of how to protect them; lack of expertise in developing viable commercialization strategies; lack of IP awareness and support service for IPR protection; lack of private sector participation in R and D activities; and lack of an effective frameworks, and mechanism for successful commercialization of good quality and marketable R and D. There was also a need to make technology commercialization offices in universities and research institutions more effective; a need to establish a permanent and flexible networks for R and D commercialization; a need for greater incentives for owners of IPRs; a need to improves the funding mechanisms and for increased financial support for R and D commercialization in universities and research institutions; a need for policies to address any problems R and D commercialization investment versus financial return; a need to provide greater rewards and incentives for researchers who perform well; a need for human resource development in specific R and D areas, particularly in IPR management and in entrepreneurship; a need to enhance the competence of Technology Commercialization Offices (TCOs), and a need for more international networking, affiliations, and technology commercialization expertise.

The detailed of commercialization in Malaysia is further discussed in Appendix 4.

THE TWO MODELS OF TECHNICAL CHANGE

In Chapter 3, the two models of technical change used in this study were described quite thoroughly, from their origins to the differences in using both in industry. The *Technik* model was thought of mainly in terms of art and skill; and it mainly emphasised the technical aspects of technical change which was seen as spreading into and across industries through absorption plus modification. However, the STH model put its emphasis on the use of scientific discoveries leading, in industry to 'revolutionary' development which consisted mainly of 'basic' innovations. The two models link to this research, in that Malaysia failed to realize the possible importance of technical change and/or 'R and D' in the 1950s and 60s For example, South Korea and Taiwan were sending students in large numbers to universities in the USA especially to tap their scientific and technical resources and expertise. These students returned to their home countries and began developing indigenous products and other innovations. But in Malaysia, the master plan for technological development was only influential after the late 1980s and early 1990s as Malaysia started the creation of local technologies such as those needed to make its indigenous car, the Proton. Skills and knowledge remain the most important aspect of Malaysian industrialization process. The development of human resources requires substantial investment and inputs from various sectors. As in Europe and in Japan and some other countries, relevant systems of education and training were not always perfectly conceived well organized. As noted in Chapter 2, Malaysia followed the British system of education in the early part of its educational development and planning, so that technical change in Malaysia tends to be discussed using the STH model. However, the question has arisen as how far the discoveries, inventions and innovation produced in Malaysia have supported the development of manufacturing and industries? In the 1970s, Malaysia was largely only involved with assembly production and with manufacturing lower technology goods, such as the most basic wires and cables.

Nevertheless, the three decades after, the manufacturing of advanced chips and electronic products has been achieved.

The development of indigenous processes and products has been emphasised as benefiting greatly from having the natural resources in the country. Funk (2004) found that technological change was a major driver for the formulations of new industries. The development of a new industry did not drive growth nearly as much as advances in existing industries. A classic example of this was the technology trajectory for vacuum tubes, which was initially developed for radios but then helped to spawn television and mainframe computers. From the point of view of economic history, however, as reported by Bauer (1995), such a decentralized market outcome seems to be a poor descriptor of many technological breakthroughs. This is not to say that economic convenience is irrelevant, but rather, as argued by Mokyr (1998) that ‘there usually is, at some level, a non-market institution that has to approve, license or provide some other *imprimatur* without which firms cannot change their production methods’.

The market test by itself is not always enough. The reason is the very nature of technological change that leads almost invariably to an improvement in the welfare of some and to deterioration in that of others. Thus, as envisaged by Olson (1982), the decision whether to adopt a new technology is likely to be resisted by losers through some kind of activism aimed at influencing the decision by the relevant institutions. Malaysian companies have been referred to as consumer products exporters, as this is would refer only as a downstream segment of the industry. Thus the decisions in influencing Malaysian industry not only depend on its markets, but also on recognizing the fundamental institutional arrangements in the country.

Following the above discussion, of development, innovation and commercialization, and of inputs to, processes and results of commercialization, we can conclude that technical change in Malaysia is more based on the technical ingenuity of people then on new scientific knowledge. The preferred theory of technical change is the *Technik* rather than the STH one. This conclusion follows study of the types of discovery and invention made in Malaysia, especially of those from the universities and the GRIs. The researchers both from universities and GRIs mostly made discoveries and innovations by using their experience, skills and scientific and technical knowledge, together known as expertise or 'know-how'. Their ability to work out problems and having sometimes improved on processes and products was more like that of engineers than that of scientists.

THE COMMERCIALIZATION LOOP MODEL

In Chapter 3, eight models of Commercialization and Technology Transfer (CTT) were been presented. From the eight, Lee and Gartner's University Model appeared to be the most relevant to the Malaysian approaches to commercialization of university and government research findings. It assumes that basic research, technology development, technology commercialization and marketing by industry are linked by a feedback loop. The loop plays an important bridging communication and motivational role for the parties involved. The model identified entrepreneurs as agents of change, for diffusion of new technologies. A prominent feature of capitalist economies is that entrepreneurs have played and continue to play catalytic roles in bringing technical innovations to markets. However, the Triple Helix Model by Etzkowitz and Leydesdorff (2000) supported institutions such as government, industries and universities in a bottom-up model. They focus on the specific tasks of those institutions.

Using the above two models, and thoughts stimulated by other six and the data from the present study, a new model is presented here. The Commercialization Loop Model (Abu Talib, 2007) is intended to be quite broadly applicable and indicates who contributes to commercialization of university and GRIs research findings. As noted earlier, Malaysia has provided various funds to develop systematic process of CTT of research findings. In this new model, we identify who contributes to CTT. There is the government as a major stakeholder, and also scientists from universities and GRIs, senior research administrators from both universities and GRIs, the technology transfer officers from universities and GRIs, owner-managers, directors and managers and professionals from companies and managers and professionals from companies and banks and ventures capitalists. There are also the citizens and taxpayers whose work funds much university and GRI research and other activities, and related government work, but they are very relevant in an independent way in the present context. Analyzing the functioning of various parties involves examining the ways in which they parties interact in given national entities. Successful CTT can be said to happen when each party is co-operating and working productively.

With this new model, scientists are thought of the main contributors towards discoveries of new scientific knowledge and/or inventions done in universities and GRI laboratories. New scientific knowledge and/or inventions are made available to companies through academic papers, seminars, conferences, and exhibitions. Interested companies buy the discoveries through licensing, buy-outs, patents and consultancy. Financing the explorations of the new scientific knowledge is either through their own resources or through funding by investors or venture capitalists. Government acting partly as regulators, then create subsidies and taxes to help the match the needs of companies and to facilitate the movement of relevant scientific knowledge from universities and GRIs to them. These are the main elements of the processes of CTT. Networks or other forms of interaction between scientists, technology transfer offices, senior research administrators of universities, company managers and professionals, and banks and venture capitalists should be conceived as bargaining arenas in which the parties operate in hierarchies of interdependence. There may be gaps between them, which may create more complex outcomes. The gaps between the parties may be kinds of serious hindrances or impediments to potential technical developments from new scientific discoveries from scientists. For example, scientists can help in early identification of new technologies, increasing awareness, providing testing facilities and training programs, thereby significantly speeding up CTT. Varying degrees of integration between the parties is required in the processes of CTT.

Numerous factors can improve or damage the processes of CTT. One important critical factor in Malaysia appears to be too much top-down and arm's lengths management of and structures for the industrial use of discoveries and inventions from scientists from universities and GRIs. Factors that can improve the processes of CTT, based on thinking about this new model and the findings of the study, include better understanding of business by universities, wider and greater financial resources for both scientists and companies, better communication between the parties, better rewards for scientists and their discoveries, better government funding and more investment in near-to-market research findings, and more suitably educated and skilled and more TTO officers. Other factors that damage the processes include the slow speed, and expensive of negotiation of technology transfer between universities and companies. Financing technology transfer deals between companies and venture capitalists is often unsatisfactory. Each party seeks to satisfy its stakeholders, which can include governments. Scientists and universities also have often found it hard to identify companies wishing to acquire research findings, which have relevant interests and which willing to invest in to take up for commercialization. There are also often, specifically social attitudinal and control issues that affect the processes of CTT. Finally, the parties can lack the established contacts that they need to pursue CTT effectively.

This study of the commercialization of discoveries and inventions from Malaysian universities and GRIs by Malaysian manufacturing companies needs to be mainly qualitative, with the use of questions must be selective, partly subjective and historically grounded rather than too overly scientific or quantitative. It is, after the perceptions of respondents that suggest what their behaviour will be. As the aim of this thesis is to try to investigate, describe and explore from a standpoint that considers the historical, political, economic and social influences, it seemed sensible to ask respondents what appear at first to be some simple and direct questions about the roles of engineering and of science in technical change, and the relevance of research findings to companies and the approaches to CTT involved.

It may, at first sight, seem strange that this study should have been undertaken by an investigator without training in science or engineering and thereby largely dependent upon second-hand knowledge in fields intricate enough to deter the novice. So the fundamental question concerns the roles of engineering and of science in technical change. The study seeks to help get closer to the truth about the models of technical change used here taking into account the backgrounds and potential biases of the respondents in the process. The researcher has asked more detailed questions for example, on the value of the efforts of the government to increase the flow of new scientific knowledge to industry; on how the processes of CTT have changed over time at relevant universities and GRIs, on the importance of the commercial use, actual and potential, of the research findings compared with its other efficiency-seeking inputs. Finally, it is important to analyse relevant problems, strength and weaknesses of CTT processes.

CONCLUSION

In this chapter, the importance of CTT to the economy of Malaysia been discussed. Malaysia has already put much effort into stimulating potentially productive interaction between universities, GRIs, companies and relevant financial players. Policy makers such as politicians see university-industry links as a major feature of Malaysia's science and technology policy agenda. The nature and the roles of the parties involved in CTT in Malaysia have also been discussed. Various inputs to commercialization in the form of discoveries and inventions have been identified. We have focused on the roles, problems and issues of success and other factors in commercialization. The two master models of technical change discussed in Chapter 3 and elsewhere previously have been linked to the nature of technology development in Malaysia to help consider how technical change can contribute to its economic development. A new model of CTT was presented.

In the next chapter, the focus is on the qualitative research methods used to gather data involving 60 interviews conducted over three months in Malaysian companies, universities, GRIs and other institutions. The chapter has briefly explained the epistemological and ontological positions adopted by the researcher.

CHAPTER 5

RESEARCH METHODS

INTRODUCTION

This chapter described and attempts to justify the research methods used this study. They were qualitative ones, namely semi-structured interviews and to a much smaller extent, documentary analysis. It does the same for the sampling and for the methods chosen for the analysis of the data.

THE PHILOSOPHY OF RESEARCH DESIGN

A discussion of the philosophy behind the approach to research design can help clarify the choices and uses of research methods used in any research projects. Explaining choices of research design can often show us why an understanding of relevant philosophical issues is very useful in research (Esterby-Smith, Thorpe and Lowe, 2005). Philosophical orientation, research methods, experience and established knowledge and researcher competence ultimately determine the quality of research. What constitutes legitimate and accepted knowledge is greatly influenced by philosophical attitudes from time to time by communities of scholars (Chia, 2002).

Positivism (quantitative methods) and social constructionism (qualitative methods) are two contrasting traditional view of views of how social science research should be conducted. The social constructionist approach focuses how people make sense of the world, especially by language (Esterby-Smith, Thorpe and Lowe, 2005). In this study, the epistemological position adopted serves as an initial basis the conscious and unconscious questions, assumptions and beliefs that the researcher brings to her research endeavour. It informs all aspects of the research process. Thus research methodology is informed by what we know philosophically and its use affects what we come to know by doing research. However, if the epistemological basis of a study is weak, then progress in developing a specialised knowledge base for a study and for the practiced use of its findings also will be weak (Smyth and Morris, 2007). On the importance of epistemology in management research, it has been argued that 'how we come to ask particular questions, how we assesses the relevance and value of different research methodologies so that we can investigate those questions, how we evaluate the research findings, all… vary according to our underlying epistemological commitments' (Johnson and Duberly, 2000, p.61).

When comparing positivism and social constructionism, it can be seen than the latter, unlike the former includes the observer as part of what is being observed, regards human interests as among the main drivers of science, uses explanations to increase general understanding of phenomena, argues that research progresses through gathering rich data from which ideas are induced, under that concepts should incorporate stakeholder perspectives, and that units of analysis may include the complexity of ‘whole’ situations, that generalization comes through theoretical abstraction, that sampling may only requires small numbers of cases chosen for specific reasons. From a positivism standpoint, on the other hand, the observer must be independent, human interests should be irrelevant, explanations must demonstrate causality, research progresses through hypotheses and deductions, concepts need to be operationalized so that they can be measured, units of analysis should be reduced to simplest terms, and that generalization through statistical probability and sampling requires large numbers selected randomly These features constitute the differences between the qualitative and quantitative research methods (Easterby-Smith, Thorpe and Lowe, 2005).

On the links between epistemological and ontological positions that Easterby-Smith, Thorpe and Lowe (2005, p. 30) discuss, they summarize the links in ways that are useful for this study. As regards ontology in social science, truths depend on who ‘establish’ them, and facts are all best understood as fallible human creations. Here, the epistemological position is that of social constructionism. The acceptance of any particular epistemology usually leads a researcher to adopt methods that are characteristic of their position. Thus in this study, which generally relies on social constructionism, the methods used include having an aim of invention of theory or explanation, the starting points are with meanings and concepts, research design embodies reflexivity, the main techniques is conversation, the analysis/interpretation sense-making and the outcomes consists of enhanced or changed understanding.

Ontology concerns assumptions that we make about the nature of reality, while epistemology is about general sets of assumptions about different ways of inquiring into the nature of the world. Whenever a piece of research is carried out, researchers make assumptions about how the world is (ontology) and how we can come to know it (epistemology). While philosophy may never provide definitive answers about existence, it can ask relevant questions and provides some guidance and justification for certain courses of investigation and action. Hence the philosophy of critical realism used in this study asserts a view that the most affective kind of analysis is looking at ‘reality with reality eyes’. Discussions should focus on reality with the hope that the world can be changed and improved. Critical realism has influenced the concerns and methods of management research. It takes the view that science is not mainly about discovering universal laws; rather, it is concerned with explanation, understanding and interpretation (Fleetwood and Ackroyd, 2004). It wants science, especially social science, to be transformative.

Given the fact that this study focuses on the perspectives of scientists, companies, universities, government research institutes and other parties about perceived low industrial uptake of researchers’ discoveries and inventions of Malaysia universities and GRIs, may often subjective, and usually untidy and varied views competing for attention and support, a social constructivist epistemology and an approach to ontology that uses largely qualitative methods seems appropriate. The reasons for using qualitative methods are discussed in a little detail below.

METHODS

Methods include strategies and techniques employed to acquire knowledge and categorise to study, and manipulate data (Jary and Jary, 2000). Qualitative methods have been used for this study. According to Bryman and Burgess (1999), a qualitative method displays a preference for the interpretation of social phenomena from the point of view of the meanings employed by the people being studied; for the use of natural rather than artificial settings for the collection of data; and for generating data and theories rather than for simply testing the latter. Qualitative approaches generally provide a means for wider and more subjective views of the respondents towards the subject being studied than qualitative ones do. Weber's notion of v*erstehen* (understanding) implies that it is necessary to take people's subjective interpretations of phenomena into account to develop empathetic understanding of their social behaviour (Bryman and Burgess, 1999). Schultz (Bryman and Burgess, 1999) similarly emphasised the importance of developing an 'interpretative' understanding of the social world. Qualitative research methods provide means for people to express their views in wider ways rather than those allowed by confining them to rigid answers to closed questions of the kinds used with quantitative methods.

Many writers since the 1950s have stressed the value in social science of using qualitative methods (Denzin and Lincoln, 2002; Denzin, Norman, and Lincoln, 2000; Baker, 1986). Morse (1995) summarized such views by arguing that those qualitative methods are typically used to explore new or little known, and previously unconceptualized or inadequately understood, phenomena, or when an investigator suspects bias in existing interpretations. Qualitative methods were especially appropriate for looking at phenomena from everyday but also unbiased perspectives of non-experimenters or non-observers. As a result qualitative research was usually conducted in natural settings rather than in controlled laboratory ones. In the course of qualitative research, hypotheses and theories emerge from data, either while data collection is in process or in the course of data analysis.

The study of innovation has been considerable and varied. Many actors and institutions are involved in innovation, often over long periods. Its study often demands a flexible and processical orientation; an adaptive and developing methodological framework which can also change with the demands of the research over time; and an action research orientation, in which feedback and modification of information and interpretations are very important (Lyall, Bruce, Firn, Firn and Tait, 2004). Many innovations and commercialization processes are unique in themselves, and in their institutional, sectoral, market and national contexts, and it is easy to generalise too much about them.

Measuring the effects of research is difficult and can demand shifts in organizational mindsets and performance indicators (Lyall, Bruce, Firn, Firn and Tait 2004). Therefore commercialization can need to be set in wider contextual frameworks which consider the business environment, the dynamics of relevant processes, the different factors and elements involved and so on. However, it is clear that approaching the phenomenon from such angles is not easy. As Nasbeth and Ray (1974, p. 20) commented, '…the difficulty is that these micro level studies have to based on company data, which are always difficult to come by, with the further impediment that any result must usually be published in such a way that information about individual companies is not disclosed. Indeed, this dual difficulty with the data is probably the main reason why such reports and monographs are scarce compared with the more theoretical macro studies'.

In 1988 the UK's Department of Health and Social Security (DHSS) commissioned a report on how to improve and assess the use and dissemination of research that it funded (Richardson, Jackson and Sykes, 1990). The study used for the report adopted a largely exploratory qualitative approach and sought to collect ideas about problems and possible solutions rather than to collect more quantitative and factual data about research use and dissemination. Lyall, Bruce, Firn, Firn and Tait (2004), discussed research methods used in government to assess the end-users relevance of public sector research. They argued that the needs of end-user were diverse and often hard to quantify, and that there was often much ambiguity and many new things to learn from each process of evaluation. Their own methods reflected their respect for diversity, ambiguity and the idea of ongoing development process of evaluation. Thus in their own study they used desk and on-line research, personal and telephone interviews with senior managers and researchers, a series of focus groups conducted with selected end-users, a large postal survey of end-users, and telephone calls to a sample of respondents who had completed questionnaires. Jensen, Thursby and Thursby (2003), who investigated the disclosure and licensing of university inventions, used questionnaires that they sent to 62 research universities in the USA. They examined the interplay of the three major types of university actor in technology transfer from universities to industry: faculties, technology transfer offices (TTOs) and university central administrators. They found that TTOs reported that licensing objectives were influenced by the views of academics and administrators, supporting the assumptions that TTOs are dual agents who try, and sometimes fail, to agree with academics and central administrations as well as private sector companies.

SOURCES OF DATA

Research designs vary, depending on the needs of multi-focus or single-focus cases and process inquiries. Different sampling issues arise in each situation. These needs and issues also vary according to the paradigms that are being employed. Every instance of a case or process bears the stamp of the general class of phenomena to which it belongs. However, any given instance is likely to be particular and unique. Thus, for example, any given classroom is like all classrooms, but no two classrooms are the same (Mason, 2002).

For these reasons, many post-positivists, constructionists, and critical theory-centred qualitative researchers employ theoretical and purposive, and not random, sampling models.

They seek out groups, settings, and individuals where and with whom the processes being studied are most likely to occur. At the same time, a process of constant comparison of groups, concepts, and observations is necessary, as the researcher seeks to develop an understanding that encompasses all instances of processes or cases under investigation. A focus on negative cases is a key feature of this process (Denzin and Lincoln, 2000).

In designing this study I obviously to ask what I needed to know. In part, my study concerns an assumption that it is worth looking for immediate and practical and organizational reasons for the low uptake of researchers' discoveries and inventions in Malaysia universities and GRIs. I am therefore interested in a suspicion that the parties in government and administration, universities and research institutes, and manufacturing companies, lack experience of commercialization and technology transfer, and of knowledge of each others' aims and ways of working, and that the parties mistrust each other. The second hypothesis concerns the underlying and long-term reasons why there is apparently low uptake, and why there may be lack of relevant knowledge and experience, misunderstanding and mistrust. Malaysia was a British colony, and there exists a suspicion that it is operating with a partly post-colonial mentality in a partly neo-colonial socio-political and economic context. Malaysia is also still a developing country in some significant respects, and its political leaders, civil servants, academics and industrial companies lack experience of indigenous industrial innovation, with many of the resources needed to develop clusters of dynamic industrial capabilities only beginning to germinate. When reading relevant literature about all these issues, and through discussions with my supervisors and others, I have come to believe that better understanding of the strengths and potential of its economy and society, and of the opportunities available to it could eventually help Malaysia to develop its industries faster and more effectively than it has been, and with greater self-confidence and confidence in the future.

I chose interviews and used relevant university, government and company documents as the most appropriate methods for my research. I was very aware of how I needed to establish trust, rapport and authentic communication patterns with the interviewees. As my primary data were from the interviews, I sought as much direct evidence as possible about the supposed low uptake of researchers' discoveries and inventions in Malaysian universities and GRIs. Interviewing is the most commonly recognised kind of qualitative research method. Interviewing was chosen because this study aims to identify the respondents' knowledge, values, attitudes, interests, understanding, behaviour and experiences that are relevant to the commercialization and transfer of technology. Second, interviews are legitimate and meaningful ways of generating data by talking with respondents. Third, qualitative research perspectives assume that knowledge is situational, and because the interview is just as much as a social situation as any other interaction, interviewing is a natural and 'honest' way of gathering data. Also processes of commercialization and technology transfer deal with institutional knowledge.

Further, I wanted to develop social explanations and arguments from interview data rather than to produce a shallower analysis of surface comparability between relatively simple responses taken from larger numbers of people. I wanted to understand the variety, complexity and depth of the low uptake of scientific research findings by companies in Malaysia, rather than to draft a broad 'understanding' from surface patterns. I sought to use a distinctive approach to comparisons, to analysing data and to the construction of arguments, and maybe to the generation of detailed cross-contextual interpretations of the data and the problem studied. To do this, the semi-structured interview schedule was constructed so as to make it heavily dependent on the respondents' abilities and efforts to verbalise, interact, conceptualise and remember. The seven interview schedules do not all ask the same questions, because the respondents perform different roles, and I assumed that different questions were needed to generate data which were comparable across key areas. I also assumed that all my interviewees would be given more freedom in and control of the interview situation than is usually permitted (Mason, 2002) with the structured approach of mail survey questions, partly because they were generally very creative and highly qualified, intelligent and mature people.

Studies do try to get close to the internal complexities of commercialization processes can throw up the problem of making generalizations about commercialization. This is not to say that it is impossible to draw out some useful general lessons and guidelines from commercialization research, but the research should reflect some idea of the variety, of relevant problems in the real world, of its content and its contexts. This is an old problem associated with the study of management and organization. There are the approaches which seek to develop and extend theoretical knowledge and conceptual frameworks, but they may not be easily related to the everyday and broader concerns and experiences of the research subjects. If some of the underlying theory and its assumptions are mistaken, the research subjects' interest may be harmed.

GENERATING PRIMARY AND SECONDARY DATA

The evidence comes from 60 interviews and the study of a disappointingly limited number of organizational documents. The interview findings were meant to be supported or challenged by an examination of documentary secondary data. The documents sought included government, university and company reports, working papers, books, manuals, and newspapers, magazines and websites. Such documents can be very meaningful for research by constituting a form of expression or representation of relevant elements of situations or process that we can read or trace (Mason, 2002). In practice the documents that I was able to obtain were not of great use. This is obviously that some company document were typically bland company documents and have few grieves specific facts. The documents were only used for marketing information and its contents were not relevance to this study.

I chose to interview seven groups of respondents, because they were the main parties involved in commercialization and technology transfer (Kumar and Jain, 2003). Technical change and the idea of commercialization have attracted policy makers, who have been persuaded them to get involved with decisions-making about new technology and collaborative ventures (Walsh and Le Roux, 2004; Kumar and Jain, 2003).

The 60 interviews took a total of 55 days and involved nearly 4,000 miles of travelling in West Malaysia. Only one interview was conducted by telephone. All the others were conducted face-to-face. To gain access to interviewees, I first chose four universities and three GRIs. Malaysia has 68 public and private universities and colleges. The four universities chosen were the University Technology Malaysia (UTM), University Putra Malaysia (UPM), the National University of Malaysia (UKM) and the Science University of Malaysia (USM). The three GRIs are the Malaysian Agriculture Research and Development Institute (MARDI), the Malaysian Institute for Nuclear Technology Research (MINT), and the Malaysian Palm Oil Board (MPOB). I chose these universities and GRIs for being among the most active universities and institutes in developing technologies and in trying to commercialise them. The interviewees were the top research administrators, for example Deputy Vice-Chancellors (Research) of universities or Directors of GRIs and in companies, entrepreneurs and directors, managers and professionals. They also included researchers in the universities and GRIs and Technology Transfer Officers TTOs) venture capitalists, two journalists, a politician.

Those people are chosen as examples of real-life participants in technical change. They represent, or speak for, many other such people and they have access to the appropriate contextual and situated knowledge for the purpose of the research. The choice of the group and of the numbers and types of respondent is based on a classification of real-life or common-sense categories. As the researcher is using a purposive sampling strategy, it is not a major concern if the sample is big enough to be statistically representative of a total population. This small, but hardly absurdly small, qualitative sample is practical considering the time and money available for generating and analyzing qualitative data. The researcher has hopefully chosen respondents who provided access to enough data, with the right kinds of focus on the research questions.

The final sample size was 60, as noted earlier. It was made up of eight university researchers, nine GRI researchers, eight administrators in university technology transfer offices and GRIs, six top university research administrators (Deputy Vice Chancellors (Research) of their universities and the GRI's administrators (Directors' General), three venture capitalists, one politician, two journalists and 23 managers or entrepreneurs. The actual numbers in each category being interviewed were affected by the limitations of cost and time of the research. What was most important was to get enough in each category to gather enough data on what people of each type tended to think. Thus precisely correct numbers of respondents were not vital for this research, as the researcher is mainly interested in getting a reasonably varied and representative range of views and a number of interesting and possibly individual 'angles'. Interestingly 'wrong' answers may be much more illuminating and productive than typical ones, although, ultimately, both kinds are vital for research to be effective. Therefore the researcher did not make many very definite sampling decisions in advance. She was influenced by four factors in this. One was the uncertainty just discussed. The second was the need to get a reasonable number of respondents of each type. The third were her own cost and time restrictions. The fourth was the willingness of people to grant interviews.

By using the distinction between actors and the rules that are most related to the system failures, a systems failure framework can be used that reorganised the classifications and definitions of failures exclude one another (Woolthuis, Lankhuizen, and Gilsing, 2004). This categorization process is intended to be a practical tool for both researchers and policy makers. Thus when a system failure occurs, they ask, for example, what kinds of failure have occurred, and what actions or interaction between them are hindered? So, system innovation-based policy choices focus on the evaluations of government policies and their failures. It is important to ask whether they address the right failures/actors or whether there are other or more important ones that may stem from bottlenecks in the system or even the system having the wrong aims before it was designed. Woolthuis, Lankhuizen, and Gilsing (2004) categorise the actors, such as customers, firms, policy departments, research institutes, consultants and so on that act and thereby co-create not only products and technologies but also the institutional frameworks in which they functions. Rules/system failures that is the conditions that are either specifically created by the actors, or have evolved spontaneously, not only influence the functioning of individual actors, but also systems as wholes.

The evidence of this research is based on the interview findings and the few useful documents presented. Errors might have arisen in the interviews because the researcher and the questions had been misunderstood. Thus a concern with reliability of data stresses a concern with variance of interviews to the researcher and the data to the respondents' perceptions and interpretations of the interviewer and the questions asked (Cicourel, 1964). In this case the researcher added some questions to give more freedom to interviewees to release insights and further information. The question-wording and research design were intended to anticipate situations of 'deeper meaning' and 'difficult rapport' (Cicourel, 1964). The researcher also made on the spot decisions about the content, style, scope and sequencing of questions whenever it seemed appropriate to pursuing the research aims. She tried to make decisions and to act quickly in pursuing the research strategy, rather than in an *ad hoc* and idiosyncratic fashion (Mason, 2003). Even so, the journalist respondent, and several company and researcher respondents, about nine in total, did not answer several questions because they focused, instead, on other questions that interested them more.

DATA ANALYSIS

Because of the nature of the study and the data gathering, it was clear that content analysis was the appropriate method for data analysis. Content analysis is the method accepted to investigate texts such as interviews and discussion (Silverman, 2001). It is a research tool used to detect the presence of certain words or concepts in texts or sets of texts (Writing @ CSU: Writing Guide, 2004). This method allowed the researcher to classify and analyse the presence, meanings and relationships of significant words and concepts, and then to make inferences about the messages in the texts. There are two general categories of content analysis: conceptual and relational. Conceptual analysis can be thought of as establishing the existence and frequency of concepts most often represented by words of phrases in a text. Relational analysis on the other hand, goes one step further by examining the relationships among concepts in a text (Writing @ CSU: Writing Guide, 2004). Since the emphasis of my research was towards both interrelatedness establishing the existence and frequency of concepts and examining their interrelationships, it was appropriate for the researcher to use both categories.

However, the problem for users of content analysis is to employ the theory which is precise enough to enable the researcher to specify in advance what she should look for in some datasets, how she is to identify and extract the material, how she must code it, and finally, how its significance is to be decided (Cicourel, 1968). Therefore, the researcher must relate the categories to theories of technical change and commercialization (among others), and show how she came to develop the categories and the rules whereby material was coded into the categories.

Compared to the users of quantitative methods, who are more comfortable with conventional measures of reliability where standard instruments of measurement are used, the users of qualitative methods are unable to perform simple reliability tests (Mason, 2002). The reliability of this study is based on the precision of discussion and rigorousness of explanation in the next Chapters. Validity of data generated in the interviews reflected not only on how effective interviewing or documentary analysis were as strategies in this research, but also on how illuminating interviews were for the study of technical change, commercialization and transfer of technology. So the interview schedule was designed for semi-structured interviews, which as explained in the sections too had the capacity to perform these tasks. Cicourel (1964, p. 79) suggested that a well-conceived interview, complex as it may be, must have its roots in the categories of common-sense thinking, for without a knowledge of such roots the interviewer could not establish the necessary community for conducting the research. While that is also any view, Miller and Fredericks (2003) argued that the process by which data become evidence can be dubious because the relative significance of different kinds of data is hard to calculate.

CONCLUSION

In this chapter, the researcher has described and explained her reasons for choosing a qualitative approach to the topic, and semi-structured interviews and documentary materials as her main form of data. The philosophical bases of research design were discussed and the adoptions of the specific epistemological and ontological positions used in the study were explained. The sampling and the sampling process have also been described and discussed, as has the use of content analysis to classify the data. Finally, it should be noted that the data are analysed in a discursive and historical fashion in the following chapters, relating them to relevant economic, social and political developments and issues, rather than by employing statistical techniques and prescribing results in detail. Some quotations are used but they are kept deliberately short and focussed, so that what is written is a mixture of more or less factual description and the author's interpretations of the phenomena described and the views expressed by the respondents.

In the next chapters, the findings are presented and the interpretations of the data are made using conceptual and relational analysis. This analysis is used to help establish the context of commercialization and technology transfer in Malaysia and their problems.

CHAPTER 6

COMPANY PERSPECTIVES

INTRODUCTION

This chapter is concerned with the perspectives of the respondents who worked in industry. We have seen, in Appendix 1 how their companies were often trying to develop their own ways of producing or adopting technical change. In the latter case this was generally through either risk-averse use of partners, or by adopting foreign technology. Some companies had sub-units concerned with technical improvement. In general, there was a feeling amongst these respondents that university and GRI research findings were not relevant enough to the worth of their companies, nor even, sometimes, genuinely new. This chapter discusses the main assumptions of the respondents about technical change, commercialization and so on, their views about processes of commercialization and technology transfer in Malaysia, and those on the role of Malaysia's government in helping to effect them.

The values and interests of respondents, and their abilities to control events are important factors to bear in mind in considering such data (Child, 1981). The term value covers the major assumptions, emotions and goals of the respondents. Their interests are related to their material, psychological and social concerns, and they need an ability to control events to achieve things in accordance with their values and interests. For example, an engineer trying to improve a product is likely to consider his or her beliefs about the wider purposes and the possible results of his or her work, in philosophical, political or social terms, as well as in technical, economic and scientific ones. They will also be concerned with their continuing employment, their career prospects, and with how others, especially significant ones like their bosses, regard their contributions in the short and long term. They will also consider the motives and behaviour of colleagues and subordinates in their own workgroups, and those of bosses and colleagues outside them, and about the resources of all kinds available to them, so that they control events as far as possible, rather than being controlled by them.

The two main research questions of this study concern the apparent failure of Malaysian companies to use discoveries, ideas, inventions and knowledge produced by their country's universities and GRIs, and the apparent failure of the latter two kinds of institution to persuade companies to use their findings. Company respondents suggested that most scientific research was too academic or sometimes too expensive for them to use. They were mainly interested in whether existing things and limited improvements to them worked and whether they were profitable. Different values, philosophies, interests and structures of power were involved.

In Appendix 1 we saw that the company respondents often felt that government and university procedures to be too complicated and time-consuming. They also found that many researchers did not seem able to be to understand their needs or to be persuasive communicators. In theory, companies wanted to benefit from new discoveries and knowledge, and to work with scientists who genuinely wanted to help them, but in practice it was very often unnecessary or very hard to do so.

As noted previously, the company interviewees came from various sectors. They were most often engineers by profession, who had degrees in civil, chemical, electrical, electronic and mechanical engineering. The rest were degree holders in such subjects as business, computing, marketing, medicine and pharmacology. They were either owners, partners or managers in their companies. They worked for companies in construction, mechanical engineering, chemical engineering and pharmaceuticals, electronic and information technology, biomedical engineering, biotechnology and food technology, and in a technology transfer one.

The next section of this chapter discusses the respondents' assumptions about technical change, and commercialization and technology transfer (CTT). It draws on the relevant literature and on their answers to interview schedule questions 1, 2, 3, 4, 5 and 13. In the third section, their perspectives on the processes of CTT in Malaysia are considered. The models of CTT discussed in chapter 4 and the findings from the interview questions 2, 3, 4, 5 again, and 6, 7, 8, 9, 10 and 11, are used here.

The respondents' views on the role of government in CTT are discussed in the fourth section. This uses the findings from questions 6, 7 and 12. It also considers respondents' views on the nature of relevant supranational, national and company policies concerned with commercialization, doing so in relation to the ideas of such critical writers as Stiglitz (2002, 2006). The fifth and last main section, before the Conclusion discusses how far the company respondents' views help to answer the research questions. This discussion includes the practical relevance of the models of CTT that were described in chapter 4.

ASSUMPTIONS ABOUT TECHNICAL CHANGE, COMMERCIALIZATION AND TECHNOLOGY TRANSFER

In chapter 2 we saw that the government of Malaysia has been trying to upgrade Malaysian industry since the 1980s. It had followed a philosophy of economic and industrial development taken from some of the world's most powerful nations and from institutions such as the World Bank and the International Monetary Fund (IMF).

The backgrounds of the 23 company respondents were those of engineers, business people and scientists and they tended to be in their early forties, with their ages ranging from 35 to 45 and to be employed in senior management and professional roles. They tended to focus on their companies staying profitable and not to be very critical of conventional ways of thinking about technical change and authority structures.

In chapter 3 some problems about how university scientists and other researchers in the English-speaking world and/or former British Empire countries perceive industry and technical change are discussed. They tended to exaggerate the practical role of science, in spite of considerable evidence over many years, at least since 1950s, that most technical change builds on previous technical change, and that it usually originates from companies and engineers rather than from universities and scientists. Some recent research had suggested, also, that companies saw possible development costs as likely to be too high, partly because relevant findings were often too new or novel to be commercialised

(Markman, Gianiodis, Phan and Balkin, 2005; Schilling, 1998), and that company managers and professionals found university and government researchers hard to communicate with (Siegel, Waldman, Atwater and Link, 2004; Thursby, Jensen and Thursby, 2001).

Technical change, as noted earlier, involves the creation, design, production, use, and diffusion of new products, processes or systems. The outcomes of technical change are unpredictable in that no one can predict results of decisions to innovate. However, in Malaysia, the government encourages ‘scientific and technological’ advances without, often, any real interest on the parts of individual companies.

Several studies have been conducted, in different parts of the world, on synergies between industries, government and universities. Vuola and Hameri (2006) found that research organizations, states and industries had different expectations of collaboration. They saw it as potentially beneficial to all concerned, but most companies were not often interested in scientific discoveries, as they did not lead directly to new processes and products. ‘Big science’ and industry cooperation did, however, generate social interaction and inputs into industrial innovation and new business creation (Vuola and Hameri, 2006). However, they argued that some companies were not much interested in the big science-related as their own markets were small, often specific and narrow, and lacked potential economies of scale. Langrish, Gibbons, Evans and Jevons (1972), all very experienced researchers into and writers on such issue, argued that a new branch of science tended only to be useful to industry in its early days. For example, the early days of astronomy were linked with economically important attempts at improving navigation, but it had rarely been useful since then. (Since the 1970s it has become useful navigation again). According to Fores (1974), once a new area or industrial sector has been established, the aim of science is to understand it and the aim of technology is to make it work, and industry had been successful at making things work without too much reliance on understanding. Scientific knowledge and scientific methods were used at times in executive work in industry and business, but this type of work was inevitably much more often concerned with practical, much of it about people, detail than with general principles.

It was a challenge for government to stimulate new industries out of new technologies (Hung and Chu, 2006). They argued that there must be mechanisms to encourage partnerships for commercialization, entrepreneurship and venture initiatives. There needed to be encouragement of partnerships, a speeding up transition processes and the promotion of entrepreneurship, and ways of sustaining commercialization processes and new companies creation. Hung and Chu also advocated fostering R and D ventures and entrepreneurial capacities, establishing public support mechanisms targeted at sources of innovation and market failure, mobilizing public support, and policies for stimulating technology transfer. Most of the tasks discussed by them do need performing by someone, but their approach is a rather top-down, government-oriented one.

It has been argued that, companies with high sales performance have a strong emphasis on strategic orientation, operating environments and the use of e-commerce (O'regan, Ghobadian and Gallear, 2006). Many small companies experienced difficulties converting R and D outputs into profitable innovation. However, O'regan, Ghobadian and Gallear (2006) suggested that innovation did always not high growth performance of manufacturing companies. A sales orientation tended to be more profitable than innovation one. In developing countries, most SME performance is associated with appropriate learning capabilities, levels of technology, knowledge, skills ands experience. Informal learning was most effective and dominant way form of mastering new technologies (Oyelaran-Oyeyinka and Lal, 2006). Lack of understanding of their own needs was the reason why many SMEs failed to convert R and D into innovation (Kim and Mauborgne, 2000). Storey (1998) argued that most SME research focused on factors, such as financing that contributed to their survival, rather than to growth and the achievement of sustainable competitive advantage (Storey, 1994).

Technical change

The 23 respondents were asked (question 13) about ‘the roles of engineering, and of science, in technical change’. Five of them chose not to answer the question, in one way or another. One (7) dominated the interview almost completely (he was very informative) and then needed to return to his work before the question could be asked. Two others (23 and 1) were also knowledgeable but seemed to feel that it was insulting to them to ask the question, although they clearly regarded both engineering and science as vital for industry, and seemed slightly more sympathetic to the *Technik* model than the STH one. A fourth (14) was simply too busy to conduct a full interview with, and the researcher chose to focus on other points. The fifth, a researcher in a pharmaceuticals company (16), felt unable, for reasons not fully stated to consider the question.

Respondent 7 was a senior manager in his company. He did not answer the question as he felt that there was not much research done in universities that was relevant to his industrial sector. Although he was a production engineer, the company that he worked for was a multi-national, and a local company. The company used imported machines, and so no technical changes occurred in production. Respondents 23 and 1 were both senior partners of their companies. Respondent 23 was a chemical engineer and his company a consultant company in patent registration, technology licensing and market research and had experience of working with a Malaysian venture capitalist company. His attitude to the development of research findings from universities and GRIs was fairly positive. He did not answer the question directly, but he had an interest in the commercialization of scientific discoveries. Respondent 1 had been a scientific researcher before joining his construction company. He also did not answer the question, but he was more in favour of the STH model. He had been involved in research in natural rubber. He claimed that this had led to technical change in the natural rubber industry. Respondent 14 was a veterinary surgeon had experience of working with scientists from universities. He believed, like Fores (1976), that in the world of the scientist, the main aim is to test and put forward and test ideas. Respondent 16 held a doctorate in pharmaceutical technology. She was a senior researcher in her company. Although she had worked as a scientist, her views on technical change did not show understanding of how technical development might be related to engineering work. Therefore she did not answer question 13.

Of the remaining 18, six favoured the *Technik* model, four the STH one, with six feeling that they were both commercially relevant. The final two respondents out of the 23 gave other answers. The variety of the kinds of answer given to this question suggests that much confusion exists, even among people with relevant experience, about the relevant facts and issues. The arguments used by the seven favouring the *Technik* model tended to focus on the creativity and practicality of engineering and the way in which science was more distant from the actions of companies, although sometimes very directly, and usually potentially relevant, if only slightly so. They also tended to stress the great responsibilities borne by many professional engineers.

Of the six respondents who preferred the *Technik* model, three of them were engineers (3, 6 and 8). Respondents 12, 10, and 19 had degrees or certificates in human resources, auditing and computing. The engineers tend to have more understanding of the role of engineering work and of how it produces technical change. They undiscovered technological development and often did not depend university or government research, and of how their on ways of working led to it. Respondent 6, who was a scientist himself, and in his 40s, felt that the role of engineers was ‘to look at the problem; if he cannot solve it and then he has to go to the science people who maybe can solve it’. Therefore engineers and scientists had to talk to each other in order for technical change to succeed. Respondent 3, who ran an engineering company, emphasized how engineers affected everyday lives.

Respondent 8, who was in her 40s, argued that scientific knowledge was very general, and that it was engineers who worked the technical know-why of industrial processes and products. Respondents 12 who had degree in human resources management believed in communicating with university scientists and government researchers. He also believed that engineering was important for technical change, and that engineers were there ‘to solve technological problems in production’. Engineers were more concerned with improving processes than with knowledge. Respondent 12 said that ‘we ask engineers, to keep and improving things …we always ask them to be more creative’. According to the *Technik* model of technical change technical work is autonomous or separate cultural area, *Technik* or engineering and not part of, or dependent on science (Sorge and Hartman, 1980). Respondent 12 felt that ‘… science can be made useful along with engineering innovation in general, science can be an element of achievement connected with engineering contributions’. Respondents 10 and 19 who were senior managers said that their company appreciated engineers who work on improving process. Respondent 19 argued that scientific knowledge was about ideas mainly and hard to make useful in industry and difficult to drive into it. However engineers, with science-based engineering degrees, did work on solving engineering problems.

The four favouring the STH model argued that scientific knowledge was crucial to technical change. The four respondents were 9, 17, 18 and 21. Respondent 9 who had a degree in marketing, argued that as scientists create more knowledge, in form of scientific publications and sometimes patents, either in life and non-life sciences, it is the role of engineers form the knowledge into products. Obviously, the adoption of scientific knowledge or the applied of scientific knowledge is said to seeks to ascertain the possibility of practical use of knowledge discovered through basic research.

Respondents 17 argued that scientists had originated knowledge from the Stone Age. Engineers were applied scientific knowledge in industry. He suggested that '…theoretically, science creates impetus, you have a new invention, and engineering takes over, to make into products'. Respondent 21 regarded science as turning revolutionary inventions into products. Scientists were more concerned developing knowledge, and engineers were more interested in producing things.

Respondents 4, 5, 13, 15, 20 and 22 believed that both engineering and science were important in technical change. They spoke of an 'opportunistic' approach, using arguments that engineering and science were both important if needed by their companies. Respondents 4, 5, 15 and 22 felt that both the practical knowledge of engineering and the ideas of science could and did benefit industry. Respondent 13 said that both engineering and science should work together for the success of any technical change. Respondent 13 went on to argue that '…if you want to develop an engineering product alone, you cannot develop it on its own. It needs scientific support, actually. If you need detail facts from science, you still need engineering support'. Respondent 5 felt that engineering and science could not be separated. To him, a scientist with core scientific knowledge also needed to appreciate the engineering or technical parts of technical change. An engineer must also do the same.

Although respondent 20 argued that both engineering and science were important to industry, technical change in Malaysia had yet to come out with a ‘platform technology’ or something totally new, or novel, to progress faster. We can argue that experimental development in this context is the use of such knowledge to develop new materials, equipment, systems or processes. Unfortunately, however, much lay and public use of the term then tends to regard science as the source of all or almost all technical change, such as when politicians speak about ‘getting ideas out of laboratories and into production’ (Rosenberg, 1990). This in itself may be seen as evidence that most companies prefer re-engineering to make scientific research, or to create relatively simple improvements to their products or processes either through their partner or parent companies. Scientific knowledge might not really help them dramatically in their manufacturing or in most technical improvements that they make.

The last two respondents, 2 and 11 offered other answers about the roles of engineering and science in technical change. Respondent 2, who was a senior manager in his company, said that he was quite a pessimistic because his company did not have much interest in thinking about the roles in engineering and science as contributors to technical change. Although his company might have an option to improve its manufacturing methods, for example, by using welding robots or CNC machines, it was not relevant to it as he said, ‘we don’t go for [the] latest development, it’s not so relevant for us to fabricate and to put all fashion systems on the welding’. This was because the company was a small one, and unwilling to risk major investment in new technology. The respondent preferred its established hardware and technical knowledge. Respondent 11, who held more critical views, said that Germany had more advanced knowledge of engineering and science and that Malaysians should learn from it. This respondent preferred German machines for their its company’s production lines, as they were more reliable, even though more costly, compared with Japan ones.

Commercialization and Technology Transfer (CTT)

Many universities and GRIs have developed expertise in patenting the findings and inventions of their scientists, with the hope that the patents will yield products and return capital to them. Commercialization means the commercial use of such findings and inventions. Technology transfer means the dissemination of knowledge and techniques across universities, GRIs and industrial companies and sectors (industry links). The links involve the commercial uses of research finding, through the adaptation and adoption of new scientific knowledge, products and processes. Commercialization and technology transfer (CTT) thus create relationships between all or most of the parties involved.

Eleven of the 23 respondents said that discoveries made in universities and GRIs were not relevant to their companies' work or to the sectors that their companies worked in. The sectors thus referred to included chemicals, construction, food technology, mechanical engineering and pharmaceuticals. This is rather surprising list of sectors since, apart perhaps from constructions, they usually stand to benefit significantly from scientific research. However, the relevant scientific findings need not come from, or from collaborations with, university or GRIs located in Malaysia. The respondents who made this claim were 1, 2, 4, 5, 8, 10, 11, 12, 13, 15, and 22. All respondents spoke quite reluctantly on questions 2 and 3 which were about the relevance of discoveries made in universities and GRIs to their companies' work. They argued that they did not have any relationship with universities or GRIs about the discoveries made by these institutions. Their technology was either from their own parent companies or their partners. Therefore, there was no engagement either through consultation, licensing, patenting, external investment, prototype development, incubator, spin-off and even dissemination through scientific journals and books. Where respondents gave examples of real concern with the relevance of research findings, they generally related them to information about research findings or communication between scientists and companies. Companies were generally devoted to the needs of customers and their markets, in seeking for more profits.

Generally, these companies had no interest in scientific discoveries and CTT. They argued that they never been approach by any of these institutions, they had not been invited to promotions by universities or GRIs, and/or their research findings were not suitable to their needs. However, these reasons also had much to do with managerial decisions about processes of taking up any research findings from universities and GRIs. Respondents stressed the lengthy nature of processes of technology transfer from universities and GRIs. They felt that universities and GRIs took too long to make decisions about technology transfer.

The study found that generally companies agreed with the principle of adoption of new scientific discoveries made in universities and GRIs, but that it did not, take place. The engineer and manager respondents argued that most of the research findings were not very new, and some managers were keen to seek other sources of new technology. They found that some research institutes were quite discouraging. Scientists' understanding was most focused on knowledge. One respondent said that 'they carry out research, and they get good findings, they prepare papers and they prepare for conferences and seminars'. These activities gave scientists more satisfaction than trying to commercialize their findings into processes or products.

It seemed that nearly half of the total respondents supported and took part in the use of research findings from universities and GRIs. These companies had generally worked well with universities and GRIs. They were respondents 6, 9, 14, 16, 17, 18, 19, 20, 21, and 23.

They were from the sectors of electrical engineering (energy), chemicals, pharmaceuticals, electronic and information technology, biomedical science, biotechnology, food technology and technology transfer, all ones which benefit greatly from scientific knowledge. They appreciated research findings made at universities and GRIs and one of them said that, ‘it is quite relevant, because not many people exploit the resources within the universities’. Other respondent said that, ‘my company’s product actually is from the university. We are working closely together with scientists, since they didn’t have any knowledge about market needs and they are not business people’. Moreover, there were companies from pharmaceuticals that employed university scientists as consultants. These scientists experienced their research findings being commercialized by the companies. One respondent said that, ‘… because he is the consultant to the company, we found it was a very productive relationship, and we were able to come out of it with a lot of products’. However, one respondent said another reason ‘Just to commercialize without technology transfer, is not possible, right now. Therefore, what you have to do is you have to get all the agreements (?) right’. The respondent argued that transferor and transferee ‘must be able to work hand in hand in order to make commercialization a success’.

Where difficulties were reported, the respondents, 7 and 14, from two companies did not answer either question 2 or 3. These companies tended to focus on the availabilities of their own technology to make profit. The respondents said that their companies lacked the money to take any relevant research findings. They argued that they could rely on their existing technology and their own resources of other kinds.

On the relationship between the findings and its CTT [questions 1 and 4] it was thought by most respondents that CTT did not really take place much in Malaysia. Companies were reluctant to work with scientists from universities and GRIs. A respondent said that ‘any research involves a lot of money, time and all that, so right now, no company is ready to waste their time and money taking something that they are going to get within 5 or 10 years. Everyone wants to get profit immediately … it is easy to buy or do re-engineering products or processes'. The study tended to confirm the idea that some universities' research findings were regarded as too academic and unsuited to companies' needs, and in some ways, the *Technik* model of technical change. Another respondent said that 'if the product is functional, it is OK for me. There must be nice packaging and good display'. Difficulties in CTT also involved the nature of the invention of new processes or products. A respondent said that 'most university and GRI research findings are duplications of research findings from the West and made applicable to Malaysian environment'. Another respondent who was asked said '… yes, but not new processes but new products using existing technology. Malaysians did not have what we called "platform technology". They were all from the West'.

However, and along lines like those discussed by Okubo and Sjöberg (2000) regarding Sweden, private companies in Malaysia are increasingly being integrated into national and international academic networks and collaborate with many more players than in the past. Swedish university researchers were being motivated to be more socially-oriented and to seek more collaboration with industry. In Malaysia, even though some scientists produce some useful research findings, a respondent said that 'I think the market perspective is wide enough. If the market is saturated, and everybody is doing it, and yours is not any better than anybody in the world, and therefore, Malaysian scientists lack suitable resources, they are probably are still playing catch up with those in other countries'. Respondents reported that most of the prototypes might be good in laboratories and might look good. However, without necessary improvements in design and availability, the research findings may not be useful or commercial, and therefore technology transfer will not happen'.

THE PROCESSES OF COMMERCIALIZATION AND TECHNOLOGY TRANSFER (CTT)

In chapter 4, some sources of inputs to CTT in Malaysia were discussed. They included Ministries, universities, industries, and financial institutions such as banks and venture capitalists. The IRPA, as the main source of financial help for R and D in universities and GRIs, has been linked to their efforts in CTT. Uddin (2006) argued that entrepreneurs were the main parties who transformed indigenous innovations into products. In a study of rural industries in Bangladesh, it was found that innovation and diffusion should not be considered as different aspects of technical development process. Rather they were interlinked, since the technologies are adapted, meaning modified, adjusted and improved in the processes of their diffusion. However, company performance was highly associated with learning capabilities, levels of technology, and levels of knowledge, skills and experience (Oyeralan-Oyeyinka and Lal, 2006). Many SMEs had difficulties in achieving successful commercialization, despite having significant investments in R and D. Factors that affected this lay within the contexts of strategy, organizational culture and leadership style (O'regan, Ghobadian and Sims, 2006). According to those latter authors managers and professionals were agreed that, in general, investment in R and D, the numbers of new products introduced, needs to met technical changes in both processes and products, and the importance of prototype development, were the most important attributes of innovation in manufacturing SMEs (O'regan, Ghobadian and Gallear, 2006).

Regarding CTT, evidence of the 11 company respondents claimed that there no CTT had taken place in or around their companies. They were respondents 1, 2, 8, 10, 12, 13, 15, 17, 18, 21 and 22. There was much evidence to suggest that most companies simply did not know about the possibilities of CTT from universities and GRIs. Respondent 12 said that, 'we never know about their inventions or … their knowledge. Actually, we don't know what happen in the universities'. Respondent 2 argued that his company was a low profile one. It had tried to collaborate with a GRI, but had failed. The failure affected perceptions of the company so that people believed that it was not impressed with research findings from universities and GRIs. Therefore some companies preferred their own projects and developments rather than taking up CTT from scientists. Respondents 17 and 13 said that financial capabilities were their own problems with CTT. Respondent 13 preferred re-engineering products to using CTT from universities and GRIs. The company worked with a university for its testing requirements under the government rules. Thus they only used the university's testing facilities.

Therefore most of these manager and professional respondents felt that ideas from universities and GRIs lacked real potential for technical development through from research findings processes and products. Respondent 1 said that the research findings were often not good and attractive enough and therefore discouraged companies. Respondent 18 had discussed the possibilities of CTT with parties involved such as scientists, TTO officers and venture capitalists. He spoke of his frustration with his experience of the slow speed of CTT. Venture capitalists, in particular lacked confidence in CTT. The slow speed of CTT did not stimulate interest in it in his company. The data discussed so far suggest that there is a wide gap in understanding between the pursuit of knowledge by scientists and that of profit by companies and venture capitalists. Respondent 6 felt that although research by scientists could be critical to manufacturing, CTT was not easy. Most scientists were rarely often heard to disseminate knowledge to wider audiences or to inform companies directly about it as they did not have 'the business skills and capabilities, and therefore they need to be trained'.

The respondents who were usefully involved with CTT were 4, 9, 14, 16, 19, 20 and 23. Two were from bio-medical companies that engaged university scientists as consultants. CTT in these companies meant using the scientists' research findings and their downstream products. They spoke of working 'hand in hand' with them. Apart from of understanding the processes of CTT better, companies found that more interactive relationships with scientists often led to the development of new techniques and technologies. Sometimes companies focused on quality and other problems posed in production and design or customer feedback. Respondent 19, from the ICT sector, argued that sometimes scientists did not have any knowledge of the specific need of industries, and that, therefore, companies studied them and got feedback from customers and which they discussed with scientists. The CTT often emerged from flows of thinking between managers and scientists. Cohen, Nelson and Walsh (2002) suggested that technology transfer for innovation emerged from complicated processes where 'fundamental research need not play an initiating role, or at times, any roles'.

On the related question of companies' contacts with various parties about CTT, most companies seemed to have negative perceptions of those involved. The parties concerned were the Ministry of Science, Technology and Innovation (MOSTI), the Ministry of International Trade and Industry (MITI), venture capitalists, universities, GRIs, and banks. Companies which had positive views MOSTI or MITI and *vice- versa* were recipients of grants and funds for CTT.

The only politician in this study said that 'research findings from universities and GRIs were often not likely to be taken up by companies'. Government policies were merely 'top-down management and arms'-length' structures. Many research grants did not actually reach the companies that needed them. Respondent 9 argued that 'they give funds to people who do not justify their requirement but, [instead give funding] based on politically- related criteria'. Respondent 2 added that funds and grants for CTT all tended to involve IT and other complicated technology. He claimed that his company's technology was very basic, and that it was foreign-controlled as well. However, the company did contribute to technical development in the national context. The respondent argued that the Malaysian government should offer broader financial help for CTT. Respondent 3 argued that although his company had made many efforts to commercialise GRI research findings in mechanical engineering, the MITI, had ignored them and had taken more interest in IT companies for CTT. This suggest that the government may not understand how mechanical engineering deepening, although one of the longest-established kinds of engineering, is often just as any other kind.

MITI, on the other hand, was regarded as the main Ministry for helping companies with their trade promotions for international markets. Most of the present respondents said that MITI was good at assisting and consulting companies in international markets, especially with their trade missions and exhibitions. MOSTI had facilitated CTT with the Industrial Research and Development Grants Scheme (IGS), and in other similar ways. However, about small companies, respondent 14 said that 'A company has to top up a grant with matching funds and they cannot afford them. The cost of development of research findings includes testing equipment and analytical equipment which can be very costly to a company'. Respondent 17 argued that, with some grants, companies had to have the financial capabilities to take up any grants given to them. He said that a 'company has to produce necessary invoices. It means that they have to incur the financial cost and then get reimbursed by the grant provider. So, a company with financial constraints would not be able to apply for any grant'. Respondent 17 also said that 'to come out with the money first, and to claim it later, is not easy. They always put a damper in our activities. When we have to claim, the process is worst'. So, he preferred to go to a bank for financial assistance with his CTT.

Venture capitalists (VCs) were seen as risk-averse in Malaysia. Most respondents had negative perceptions of ways in which VCs assess companies for CTT and help them with it. Respondent 6 argued that Malaysian venture capitalists were very negative. They did not work as they should. In his experience, scientists and company managers and professionals all had negative thoughts about venture capitalists. The companies claimed that VCs sought an 80 percent level of confidence for profit, but that it was about 50 percent in the USA. Respondent 19 said that 'normally the whole process of CTT is taken over by them, and your company is controlled by them. So this is something that we don't like'. Respondent 23 said that a VC was someone who had funds, and 'he might have a deep knowledge of how to make money out of a project that is presented to him'. However, he argued that in Malaysia, there rarely were successful venturing models that had both incentives and rewards for both VCs and companies. These differences in perspective thus showed how wide some of the gaps between the various parties can be.

Despite the apparent problem, some respondents argued that their companies had strong financial capabilities and did not need assistance from VCs and banks. Respondent 12 claimed that his company had strong financial capabilities, as they were under foreign-control and that states were among their stakeholders. However, respondent 9 argued that that VC functions should act more like banks. They should have enough funds to support CTT. Respondent 8's company did not engage with banks, as it was small company and did not have any collateral to offer against loans for CTT.

Banks were regarded as normal profit-seeking organizations. Respondent 18 said that 'I think the bank's understanding of commercialization process is [that it is] very slow and they [feel that they] cannot wait afford to wait for five years for any product [to go] from scientists out to market'. Banks were seen as normal financial service providers, as in other countries. It seemed that most companies' contacts with banks were at a minimal level. Respondent 6 said that 'Malaysian banks have a certain image. They do not practice "performance loan" as some other developed countries. That facility could certainly help most companies. So the companies have to accept the banks' role and cannot argue much [about it]'. Generally, the company respondents in this study claimed that most banks preferred any research findings to have yielded market share. They were not really interested in new research findings, as they wanted to see the 'track record of the product'. However respondent 14 praised the role of the Malaysian Development Bank. It had assisted his company to build plants and to develop its operations under CTT. As the Bank was government-funded, these roles were normal for it.

The company respondents gave mixed answers to questions 9 and 10 about their contacts with universities and GRIs for CTT. These two questions were regarded as fundamental by them, and related to the research question 1, about why companies were reluctant to take up research findings from universities and GRIs. The answers to questions 9 and 10 were related to the new model of CTT where, this was the point of contact and informed between the various parties at the first level loop. Scientists were expected to support companies in their technical development when using their new scientific knowledge. But most of company respondents felt that universities and GRIs did not have any significant contributions to offer to their technical development, of processes or of products.

There was much evidence from this study that companies had minimal or no contacts with universities and GRIs. Respondents 1, 2, 4, 5, 7, 8, 10, 11, 12, 13, 15, 16, 19, 21 and 22 all made points along these lines. However respondents 3, 6, 9, 14, 17, 18, 19 and 23 had good contacts with universities and GRIs. We look first at the first group of these respondents. Obviously, most respondents have neutral perspectives on universities and GRIs. Most have had minimal contacts with universities as most of their companies provide and/or support industrial training for students and graduates at their plants or other premises. In Malaysia, industrial training is part and parcel of the qualifying requirements for universities graduates of many kinds and it is a form of almost unpaid labour for companies. For most companies, the industrial training is the only service that most universities can offer.

Respondent 12 said that his company did not have contacts with universities, as it was felt that university research findings did not meet its requirements. The company relied on its own chemists or production engineers to improve its processes and products. He said that most universities did not produce graduates with any detailed knowledge of what his company did. Respondents 13 and 10 had contacts with universities, but only to use their testing facilities. Respondent 21 said that 'We don't really encounter with any real attractive research findings for us to look at'. Respondent 1 claimed that his company did not have contacts with universities and GRIs because the technology in building houses were already available in national and international markets and it did not need to spend anything for any research. Furthermore, university scientists or their administrators had never approached it. The company also did not want to take any risk of taking research findings into the construction sector, or of acting as a testing bed for new scientific knowledge from universities or GRIs. Respondent 14 said that any contacts with university and GRI people, especially their scientists were based on friendship connections only. He could communicate well with scientists, or administrators because he knew them and they were among his friends, and any relevant research findings might be useful for CTT in such circumstance. Respondent 22 claimed that his company's contacts with one GRI were 'not on a formal basis and it did not have any memorandum of understanding to work with it'. The company's contact with the GRI was based on its common interest in technical development in mechanical engineering, but it remained informal. This does not, of course, that the contact was not useful to the company, and if informal contacts between companies and researchers are growing in Malaysia that is probably a good sign for the future.

When contracts existed between companies and universities or GRIs they seem to have worked well. Respondent 9 claimed that it was in his company's interest to work with universities and GRIs. This chemical engineering company had found that universities and GRIs had many research findings that were potentially practicable and commercially viable. Since his academic background was in marketing, he argued that he had the capabilities to develop and use strategic business and marketing plans for CTT. Respondent 19 said that his company had close contacts and collaboration with one of the universities the northern part of West Malaysia. The company premises were located at the university's incubator plant. Company staff met scientists regularly to implement CTT. Company managers felt that the location factor did speed up and help successful CTT. He claimed that his company had the business skills and knowledge for CTT that scientists often lacked. The company fully accepted that scientists can produce new knowledge and discoveries and it was the role of any interested company to pursue this with CTT. Respondent 23, who managed a technology transfer consultancy, commented on the role of university scientists based on his various close contacts. He said that 'University scientists themselves are responsible and they have to drive it. There is nothing else. If a scientist is passionate about his project, he has to push people around'. In short, respondent felt that scientists and university research administrators had to search the business community actively for financial resources as government funds for exploration and development of research findings were often non-existent or very limited.

We have noted and discussed the perspectives of company managers and professionals on the contributions of new scientific knowledge to technical development in companies through CTT. Past evidence and thinking about CTT had suggested that managers and professionals perceived CTT to be quite a fragmented set of processes. The present data show that company managers and professionals in Malaysia felt that universities and GRIs lack technology inputs to cater for industrial needs. Better mechanisms for information flows between industry and universities and GRIs may need to be developed by all parties. Companies may have failed to make use of relevant discoveries, inventions and knowledge produced by universities and GRIs because they are often very dependent on imported technologies through licensing or joint-venture agreements, and concentrate mainly on low to medium value-added operations. Companies also argued that the speed of negotiation of technology transfer between universities and GRIs and companies was too slow. This was expensive in terms of companies' money and time.

Only a few companies seem to need make contacts with universities and GRIs or want to enhance their strategy and technical capabilities. Therefore, CTT of research findings contributes only marginally to the development of the overall technical capability of Malaysian industry. This creates a circle in which some national companies try to overcome the technology dependency syndrome by developing their capabilities to select, acquire, assimilate and adapt imported technologies and thereafter innovate themselves. Although investment in any technical change is generally risky, long-term, and costly, the average returns on such investment can be substantial for companies, and even for the economy as a whole. Managers and professionals and scientists can seem to have different values, interests and ways of controlling their activities, although, as Tagiuri (1965) suggested these are easily exaggerated. Even so, they often did not seem to trust each other fully.

THE ROLE OF GOVERNMENT

The flow of scientific knowledge to at least some industrial sectors is clearly a problem for Malaysia's government. Changes of policies and roles of different institutions for supporting commercialization have had varied outcomes. The formation of spin–off and start up companies, entrepreneurship in technology development, and technology licensing are all more likely to produce useful technical change because they are active processes that commit and involve top managers and professionals directly. Yet as R and D expenditure apparently increases, the government is increasingly concerned about research results that are untapped by companies. Company respondents were asked detailed questions about, for example, the effectiveness of specific efforts of the government to increase the flow of new scientific knowledge to industry. The factors that support or retard processes of CTT and how they have changed over time have been described. In the context of the new model of CTT proposed (Abu Talib, 2007), companies were often unaware of CTT processes and when they were or became aware, of them, thought of them as costly in terms of development and new investment. Respondents also argued that conflicts of interests were experienced during CTT. For example, universities often had protective mechanisms that did not allowed scientists to get such rewards from successful CTT as cash royalties. In France, government – employed scientific researchers have expressed anger at reductions in research funds. The government felt unable to support some laboratories. Although it tried to strengthen the innovative capacities of firms, the researcher were very discontent (Vavakova, 2006).

Despite the variety and subtlety of much of the data drawn from the company respondents, as discussed in Appendix 1 and this one, it is clear that a gap exists between the expectations of the Malaysian government about the commercial potential of scientific research conducted in Malaysia and those of companies, some of which are non-existent.

The nature of this gap suggests that some politicians, civil servants and academics, while wanting to help industry to become more innovative and profitable, lack experience and understanding of it. At the same time, many of them want to be seen to be doing something, partly to maintain their own positions, or to strengthen them. This may make them too active and too keen to impose 'solutions' from above. So instead of simply ensuring that relevant knowledge and expertise are available to companies, along with competent sources of finance, they may create structures, institutions and procedures for stimulating, channelling, managing and controlling innovation, and starts to discourage, and even to stifle, it (Webb, 1992).

Therefore the freedom and ability of firms to invest and adapt new products or processes can be reduced. Such tendencies would disappoint. Etzkowitz and Leydesdorff (2000) whose Triple Helix Model favoured the creative potential of institutions such as government, companies and universities in their bottom-up model. Marques, Caraça and Diz (2006) supported the Triple Helix Model, arguing that it has been effective promoting regional innovation and entrepreneurship. They argued that the creation and development of technology-based firms have helped CTT given the least governments' role. It has been argued, too that in most cases the most sensible path towards solutions to lack of innovation in industry is to ensure that the relevant professionals, managers, technicians, skilled operatives and so on, are innovative people who are able to use their own colleagues, relevant sources of finance and universities and scientific researchers, as and when necessary. Wheelon (2004) argued that a combination of technical information collection systems and scientific analysis contributed decisively to the solution of three important Cold War problems. This was done through the collaboration of engineers and scientists with the intelligence community.

The Evidence

Having given some attention to company respondents' view on the flow of new scientific knowledge to industry and the processes of CTT, and on the various ways in which government might attempt to influence it, we now consider the respondents' answers on their government's role in such events. Respondents 16, 18 and 21 did not answer the question: they focused or in details of CTT processes and on the work of their own companies. Respondents 2, 3, 5, 6, 7, 9, 10, 13 and 21 and were worried about the weaknesses of the efforts of the government to increase the flow of new scientific knowledge from universities and GRIs. One would expect that, it appeared that some of the governments' effort only benefited few sectors of industries. Respondent 2, whose company made agriculture equipment argued that companies did not expect any new scientific knowledge from universities and GRIs. Further researches in companies had been simplified and the role of marketing people had become more important. He claimed that any product might often have 'zero value, zero efficiency' but marketing effect made them become saleable and become profited. He suggested that instead of product research, market research have been helping a lot for any successful companies. Some of the efforts were not relevant to the company, as some companies found that government tended to focus on more advanced technologies.

Similar controversies have marked the efforts of the government, with most universities' business centres being managed by scientists. Respondent 5 argued that 'Scientists are not good in managing business, especially when they are negotiating on their research findings. It is the government's weakness that some scientists being given research funds to prolong their research. Government often seemed unaware that some research is not relevant to companies. It's the government view that some "real research is being stifled" when some scientists are not given opportunities and funds. Respondent 5 said that some politicians did 'not have any real interest or knowledge in the technical development of industry. They should encourage scientists to do research in areas that "tries to go beyond what other people use or have"'. The main complaints of most companies centred around their efforts to get freedom of necessary new scientific knowledge or discoveries as there were information about it. Respondent 6 had been shocked knowing that under Sixth Malaysia Plan, covering 2001 to 2005, most industrially-relevant research findings had been left idle in the form of reports sent to MOSTI. Yet the government had allocated more IRPA funds under the next Plan, the situation might be happened will be 'nobody will read the report, and the research findings were ignored by the government itself'.

Respondent 17 said that although the government had made some effort, 'industry is rather reluctant to really pursue serious R and D… because they would like to see ready-made products, ready to be sold immediately, without them [needing] to do any more work on it'. Often scientists thought, wrongly, that their raw research findings are ready to be used and marketed by companies. There were gaps in understanding and ability between companies and scientists. Numerous obstacles to the development of research findings could be identified. Most concerned funding, incentives, rewards, incubation, patenting, and licensing, and a fear that government did not appreciate the practical details of CTT. Respondent 17 felt that most start-ups that were meant commercialise new scientific findings were doomed from the outset. Respondent 3 argued that most universities and GRIs had many problems with their applied research. Co-ordination between scientists and their administrators was poor, and both parties lacked power. In universities and GRIs there was some complacency and lack of real commitment to contributing to technical innovation. There was a widespread lack of links between researchers in different groups and institutions. Respondent 3 said that 'the research organizations need to get their house in order. If they cannot get their house in order, how can the government promote CTT?' Most government research premises were equipped well and indeed they had excess facilities, which were often seen as left idling.

Nevertheless, respondents were not generally against a role for government in trying to increase the flow of new scientific knowledge to industry. They tended to regard it as a catalyst for technical development and as consisting of a more committed and systematic approach than Malaysia had used previously. Respondents 1, 8, 11, 12, 14, 15, 18, 19, 20, 22 and 23 spoke along these lines. Most agreed that the government's approaches had real potential but they often feared undesirable consequences. Different respondents said that university research findings were not often applicable to companies, were not marketable, were technically not practical, not acceptable for up-scaling, and too academic in terms of their purposes. However, respondents 1 and 11 both argued that 'companies have the role of pursuing the development phase of research findings, as the government has given some funding'. Respondents 1 and 8 felt that the government ought to take a new approach to CTT. Respondent 8 argued that the 'government should encourage more inventors to come to market, and graduates from overseas should be brought back to Malaysia'.

Respondent 22 said that although the government's role should be broader and directed at more companies, the government should also improve specific ways of managing research funds. Respondent 19 argued that 'earlier on, some research funding was focused on ICT, but the focus has now changed to biotechnology and agriculture. Thus it affects the capability of the "ICT industry"'. This was because at the national level companies would not support any research in ICT and relevant Malaysian markets are so small. Other respondents argued that more recognition should be given to scientists. Respondents 1 and 5 felt that if more recognition and rewards were given to scientists, they would contribute strongly to a new surge of CTT. It was thought widely in Malaysia that scientists in the West produced good research findings as they 'loved their jobs, were highly capable and dedicated to their research' (respondent 23). In Malaysia 'differences in the strategic management of research funding … [were experienced] there were often inefficiencies in policy and bureaucracy'. Respondent 18 argued that 'the government was good at publicity, but actually getting companies involved is not easy. What the government says they want to do is another part of story'. He said that companies had different interests and resources from those of researchers and the government. Their bottom line concerns were financial capital and time, and speed of achieving CTT in terms of the processes and management of it were sometimes 'non-existent'.

The general perceptions of flows of scientific knowledge and their effects on companies was that they were or at least could be beneficial to them. However, most company respondents thought that there were seldom signs of positive incremental change in the technical development of companies. Companies' perceptions the roles of government in the attempts to increase the flow of scientific knowledge to industry included some very varied views. Some company respondents said that the role of government could be improved and that its approaches could be developed over time. Many respondents expected or wanted to see the freedom of companies to invest in and adopt new processes or products become an essential feature of the competitive manufacturing processes in Malaysia. Arms'-length and 'one size fits all' approaches by the government were not likely to increase, or even to help start, flows of new scientific knowledge from universities and GRIs to industry. Some companies were worried by proliferation of government controls and regulations, which could take up management time and effort. Such control and regulations, could, some felt, divert managements from pursuit of more urgent and fundamental company goals and lead to more defensive actions on their part.

DISCUSSION

In this section the research questions spelt out in Chapters I and Appendix 1 are restated briefly and readers are reminded of the main elements of the models of commercialization that were described in Chapter 3. The contents of the three previous sections are then related to each research question and to each more relevant model of commercialization, to help try to explain what the latter tell us about the former.

The apparent failure of Malaysian companies to use discoveries, ideas, inventions and knowledge produced by their country's universities and GRIs, and the apparent failure of the latter two kinds of institution to persuade companies to use their findings are the foci of the two main research questions. The questions suggest to, and remind, us that the respondents did not anticipate any impressive change of attitude, control and power for CTT to become more effective. It was widely thought that technical change and CTT would be advantageous to them, but there was little widespread evidence of a move towards any significant acceleration in technical development from a mixture of research findings and efforts from the government. Scientists were seen as the main factor in the development of intellectual property and in the encouragement and/or the establishment of companies to exploit research findings were seen as part of a natural process of university and GRI functions. However, companies were discouraged and marginalised by the drawbacks of time compression for cost, product quality, licensed technology, patent policies, property rights of inventors, and their collaboration with universities and GRIs. These activities need trust, support, and adaptation to increase the main philosophical of the models of commercialization of innovation between of the all parties involved.

The main elements in the various models of commercialization were engineering and scientific work. Relevant advanced engineering that was stimulated by the discoveries, inventions and creativity of engineers and scientists became diffused towards the construction of new processes and products, with economic and technical feasibility in terms of design and development generally regarded as important. The others were the universities and government laboratories and serious and constructive and feedback with administrators, and suppliers of finance from the government and the private sector, and managers and professionals in companies. Companies' capabilities were often influenced by the degree of their mature and radical perspectives on technical change. Their values were associated with types and sources of technical change. Companies' 'failure' to put profitable use discoveries, ideas, inventions and knowledge produced by their country's universities and GRIs were often related to the significance and interest or lack of them, of the research findings. Companies in the pharmaceuticals and biomedical science sectors often gained more benefits of technical change and from CTT compared to companies in other sectors.

In Chapter 3, eight models of commercialization, and [in Chapter 4] a new one of the author's (Abu Talib 2007), were described and discussed. The University Model had four stages of CTT, including basic research, technology development, technology commercialization and marketing (Lee and Gaertner, 1994). CTT started with the selection of scientific knowledge for the design and construction of processes or products. The Integrative Model regarded the formation of new technology-based firms, where scientists discovered new knowledge and proofs of concept were taken up by new firms and venture capitalists, was more of a linear model of CTT, where knowledge, information and expertise inputs were very important (Hindle and Yencken, 2004). Five stages of CTT constituted the Commercialization Map (Jolly, 1997). The stages were imaging, incubating, demonstrating, promoting and sustaining. The stages were linked by interest, technology transfer, market transfer and diffusion. It could be a 'failure model' due to a variety of technical, production and marketing problems. The Quick Look Model only emphasised short term actions associated with the market receptiveness of processes and products. Information on potential market was an important element in this model (Cornwell, 1998).

The Five Generation Models was really a conceptualisation of five different types of model (Rothwell, 1992). They were said to have started with the Science-Push Approach where CTT and innovation were linear processes. Scientific discoveries passed through inventors, engineering and manufacturing and ended with marketing. The market was the major element of source of ideas for R and D in the Demand-Pull Approach, the 'Second Generation Model'. The Coupling Model, the third one, combined the two previous generation models with a supply approach to innovation and it's CTT. The main elements in this model were ideas generation, research, design and development, prototype production, manufacturing, marketing and sales. Technology capabilities and market needs were often supported. The fourth and fifth generation models were the Integrated Model and the System Integration and Networking (SIN) ones. The former had elements of integration within its sector, across sectors and could take the form of parallel development. The important success factor with this model was 'design to manufacture'. The latter is seen as a successful tool for Japan's innovations in the 1990s and later. This model had full integration with parallel development, with the use of expert systems, where primary suppliers link with joint ventures, and collaborative research and marketing groups.

The Triple Helix Model's main element was companies (Etzkowitz and Leydesdorff, 2000). Universities and scientists were subsidiary elements. This model configured institutional forces from government, companies and universities. It depicted a generally bottom-up approach, emphasising the nurturing of companies. The seventh model, the Industry and Technology Life Cycle one, has as its main elements the maturity of industries and the progressiveness of technology (Etzkowitz and Leydesdorff, 2000). These factors contributed to decision making about the nature of commercialization. The eighth model was the General Linear Flow Model where the main elements were universities, industries and technology transfer (UITT) (Siegel, Waldman, Atwater and Link (2004). Scientists often began with new discoveries from their research. The role of universities was to make decisions on patenting and licensing to interested companies.

Abu Talib's Commercialization Loop Model, the new model proposed in conjunction with this study, prefers to stress the elements of loops and communication in and between governments, scientists, senior research administrators, technology transfer officers, managers and professionals from companies, banks and ventures capitalists. The use of loops between the actors or parties involved was perceived as a bargaining arena needed for successful CTT. Benefits of this model included greater understanding of business by universities and GRIs, greater financial capabilities, and better relationships and communications. However, the elements of the model also act to control them. Thus any defensive move by any of the actors involved can damage the process of CTT. The activities of CTT must be devised, evaluated and created to forestall this. Uncoordinated loops can have serious implications and effects such as loss of intellectual property, problems with licensing, and reduced independence and autonomy of one or more actors or parties.

Generally, companies did not use new discoveries and other kinds of new knowledge from universities because it was assumed that most universities do research that are not relevant to their own approaches to CTT. Universities seem to be beginning to learn about their mistakes and to recognise the importance of developing policies and practices to protect themselves during CTT. In this study, the companies tended to prefer a separate form or s structure or a not-for-profit organization to administer some or all aspects of CTT. This might usefully be a bank or a venture capitalist company. Further, some university research findings had not resulted in companies gaining financially from them. If universities and GRIs made more efforts to help companies to get more out of CTT by focusing more, with companies, on company financial objectivities, and adjust their own priorities accordingly, CTT could be more effective.

From the first section of this Chapter, we can conclude that companies generally favour the *Technik* model. Their managers and professionals tended to believe that the creativity and practicality of engineering were central to technical change. They argued that scientists aimed to discover and test new knowledge as their major contribution. Scientific knowledge was relevant and useful but usually either in very broad, general, background ways, or in very specialised and specific ones that tended to be unique. Companies preferred that their engineers try to solve technical problems. They did not normally expect to use scientists from universities or GRIs to do so. They argued that their engineers mainly improved processes or products, rather than dealing with scientific theories of facts. Engineers did sometimes use new and other knowledge to improve processes and products, of course. Universities and GRIs often failed to persuade companies to use their research findings, because the findings were presented in the form of scientific knowledge, and not in ways designed to show how the knowledge could be used.

However, a minority of managers and professionals did prefer the STH model. Most of them had worked or were working with scientists from universities and GRIs because their research was relevant to their companies. These respondents argued that scientists could use the impetus from new knowledge to help invent, design and develop new processes or products. Their companies had been working well with scientists as they had the same drive and interest in technical development. Some of them preferred working closely with scientists rather than with their administrators.

A third group of respondents thought that scientific knowledge and engineering were both important in technical change. They argued that both the practical knowledge of engineering and the ideas of science were of benefit to companies. However, not all of their companies worked well with universities and GRIs as they preferred to do re-engineering in their production, either through collaborations or with more established partners. Yet they did understand how some scientists understood, appreciated and could contribute to the work of engineers and *vice-versa*.

On the process of CTT, some company respondents argued that their companies did not use any research findings from universities and GRIs. They preferred to generate their own improvements. They had their own financial capabilities and used them to re-engineer processes and products. They used and regarded university and GRI laboratories simply as testing-hubs. Companies did not use their research findings because they were not good enough for or attractive enough to them. Such respondents also argued that argued that venture capitalists did not seem serious in investing in new ventures, as they seemed to lack confidence both in managers and professionals in companies and in scientists themselves, and they had accused all parties as not having the capabilities to manage spin-offs or new ventures. The company respondents also argued that universities and GRIs had failed to persuade them to their use research findings because CTT took too long. Government research laboratories, in particulars had to obey the rules and regulations of bureaucracy. Companies found that there were gaps in terms of interests, support, trust and confidence. Scientists were said to have more interest in pursuing knowledge and companies were profit-led.

Some of the more negative company respondents also felt that scientists and their administrators did not have the business knowledge and abilities to work them. Yet more positive ones favoured the work of scientists and enjoyed working with them. The companies concerned in such instances were located either in university or GRI incubator plants or a university business premises. However, most companies did focus their technical development either through opportunities created by prior development or through buyers and feedback from them. The complicated processes of CTT could, respondents claimed, become a hindrance to companies wanting to use research findings from universities and GRIs. A respondent employed by a foreign-controlled company argued that the company did nevertheless contribute to the development of Malaysia by producing and generating sales. Some company respondents argued that the failure of its GRIs and their research administrators to get companies involved in CTT happened because they were focusing too much on biotechnology and ICT sectors.

Regarding companies' contacts with universities, GRIs, MITI, MOSTI, banks and venture capitalists, there was more evidence on the apparent failure of companies to use knowledge. Most companies did not have contacts with most of these in connection with CTT. However, they did have contacts with some of them on the basis of the requirements of government agencies. These relationships were quite formal basis and did not affect any initiatives of companies to do with technical change and CTT. Some companies did receive R and D funds from the government, but some respondents argued that the recipients did not use the funding fully, that they abused it, or used political connection to get funds, and that there were elements of bribery on top of that. More often, politicians' decisions on innovation seemed to be evidence that research findings were 'left on the shelves' without further design, development or marketing. The negative perspective towards the parties also included the process of applying for grants involving disbursement of money from the MITI or the MOSTI. Small companies with limited financial capital found that the process was a hindrance for them in their pursuit of and attempts to use research findings from universities and GRIs, as they had to design, develop and market them as profitable products or processes, while continuing to be profitable and while also trying to innovate and be diplomatic with those whose help they were seeking.

The company respondents were generally quite critical about venture capitalists and banks. They regarded the former as risk-averse about investing new ventures designed to exploit research findings. Knowledge about venture capitalists among companies was quite new to them, and successful models of venturing were rare in Malaysia. Most banks and venture capitalists in Malaysia were not interested in research findings that companies have taken, or might take, into the product market. Since universities and GRIs were unable to collaborate with banks or venture capitalists, companies were inhibited from getting into venturing. Banks and venture capitalists appeared to be much less active in supporting research-based development of companies than they are in some developed countries. When Malaysian venture capitalists did take any interest in companies that wanted to commercialise research findings they were very emphatic about the need for business plans to be prepared.

When universities and GRIs did not have significant and relevant research findings that interested companies, the relevant companies had minimal or no contacts with them. They argued that their in-house engineers or scientists were capable of improving products or processes based on demand or prior customer contact. The central point in this argument was that university research administrators and their technology transfer officers had no business skills and seldom learnt about them from companies. New scientific knowledge from universities and GRIs was biased towards presentations in seminars and conferences, and in academic papers. Yet the government complained about companies not using knowledge from universities and GRIs, MITI or MOSTI and its agencies did not ensure that research findings were presented attractively or early. Technology transfer offices and university and GRI administrators often took too long to negotiate with companies and to make decision about CTT. There were increasingly negative perceptions of companies towards some scientists and university administrators about negotiations on the ownership of intellectual property. Universities and technology transfer offices often showed little trust in transferring knowledge and ideas to companies. Yet there were companies that were actively involved with scientific research and the uses of its findings. They were often located near or in universities. Companies located close to universities tend to be those that collaborated with them the most, commercially and in publishing joint academic papers (Mueller, 2006).

A major conclusion of this study that companies failed to use discoveries, ideas and inventions produced by universities and GRIs, and that these institutions fail to persuade companies to use their findings mainly because of gaps in interaction between relevant companies, scientists, universities, GRIs, and Ministries. The interview data suggest that the government wanted to control the freedom of scientists, its administrators in research offices, of technology transfer officers, other senior research or university administrators, and company managers and professionals. The problem appears to start whenever the government wants to exploit research findings commercially. The ability or inability of scientists and administrators to produce, identify and exploit commercially relevant knowledge depends partly on the state of existing research knowledge and also on the absorptive capacity of managers and professionals. Generally companies did not expect much from university and GRI research findings, as they claimed that they had own technological capabilities, either through partners, research alliances with other firms, contracted out research, or by recruiting researchers and scientists for their firms. However, some companies focused on improving existing processes and products and did not do research, using their own engineers and technicians. Obviously, companies do not want to take risks in adopting new processes or products. They might as well focus on exploiting the profit possibilities of their given product programs, rather than in searching for new opportunities and realizing the potential of new discoveries, ideas, inventions and knowledge produced by universities and GRIs, which could divert them away from their main area of strength.

The Malaysian government's apparent failure to persuade companies to use research findings was based partly, according to some respondents, on the funding of most scientific research in universities and GRIs. Companies were angered that some scientists were given responsibilities for managing university business units or their technology transfer offices. They argued that the government should understand that most scientists did not have business skills. The government seemed to ignore the facts that these scientists and companies need further financial assistance because the practical use of some research findings might have been substantially delayed. Companies were often reluctant to pursue research findings, because they 'would like to see ready-made products'. Not surprisingly, public research only very rarely results in ready-to-produce innovation (Arundel and Geuna, 2004). However Mueller (2006) has found that 'firms are most likely to draw from university research if they follow specific innovation strategies'. In very successful once-developing countries in Far East, such as Japan in the 1960s and the Republic of Korea in the 1980s, industrial firms, especially, large conglomerates, had stronger research capacities than their national universities. However, universities in developing countries often devote their resources to undergraduate education that mostly use the knowledge imported from developed countries, or to applied research that can adopted easily by national industrial firms (Eun, Keun and Guisheng, 2006).

Further to this argument, the fact that most of respondents agreed that although the government had a great deal in the form of resources and funds, the problem arises, as one of the respondents said, ‘How cheap is that technology and how good is it?’ He meant that any research finding could have industrial potential but it is can be costly to small companies. Small companies usually have very limited financial resources. For the purposes of managing the research funds, some respondents argued the responsibility of the people who were involved in managing the government funds and projects. They clearly agreed that some IRPA projects failed and some succeeded. It was difficult to facilitate them. One of the respondents said, ‘getting things done is another part of the story’. The expected rate of return may exceed what the government wanted it to be, in time of 2, 3 or 10 years. However, they found that some universities’ scientists were preferred consultancy work rather than presenting research findings to be transferred to companies. Companies, as business entities, often ‘look at the bottom line, at how much money they can get and everything’. Therefore, to facilitate more, the government should produce a manual outlining its steps towards communications and publication for CTT.

As noted above, the role of government varies in the eight models of commercialization. There were insignificant roles for the government in the University Model, the Integrated Model, the Quick Look Model and the Industry and Technology Life Cycle Model. For example, the University Model emphasizes the influence of market forces. As the stages of commercialization were linked and connected through feedback loops, scientists often get creative freedom and with the help of commercial and financial people. The Integrated Model stresses the formation of new technology-based firms. Even though the model is a rather linear one, external economic and regulatory factors were taken into consideration as the capacities and achievement of entrepreneurs. The Quick Look Model was a simple one that emphasised the potential commercial uses of new processes or products.

On the other hand, the Commercialization Map, Rothwell's Five Generations of Models of Innovation Model, the Triple Helix, the General Linear Flow of University-Industry-Technology Transfer Model and The Commercialization Loop Models (Abu Talib, 2007) all have significant roles for government. The most significant of them is the Triple Helix Model. A triple helix of relations between university-industry-government transcends the earlier models of institutional relations, both the more liberal (laissez-faire) and the socialist ones (Marques, Caraça and Diz, 2006). In the former, the economy and markets' predominated, while in the second, interest was focused primarily on politics and the actions of government. While in the Commercialization Map Model, the ultimate expectations came from government. The Commercialization Loop Model has the same feature, where the intervention of government was one of the main influences. In most countries scientific research is government-funded, and most governments have some interest in commercialization, so it would be surprising if models of commercialization did not include some role for government action.

In the above discussion, two assumptions about creativity and resources have been relied upon. On creativity, the respondents felt that the role of government was to provide controls and to act as a sort of 'gate-keeper'. The choices and independence of companies to use discoveries, ideas, inventions and knowledge produced by their countries' universities and GRIs seemed to be weak. The company respondents generally felt that universities and GRIs seemed to keep a distance from business people or to become entrepreneurial to take part in the functions of business. There was also a problem with the absorptive capacities of business people, and with the existence of intermediary institutions like politicians, ministries, media, banks and venture capitalists. Although some respondents argued that some universities and GRIs do have the propensity to persuade companies to use their findings, but these institutions had problems of inadequate human and financial resources.

Technology transfer offices and the actions of senior research administrators in both universities and GRIs often failed because of inexperienced or having the wrong kinds of experience. However, when we realise the likely problems faced by companies trying to use discoveries, inventions and knowledge produced by their country's universities and GRIs, none of the relevant difficulties and failures seem surprising. Innovation and other ways of improving competitiveness amongst companies are seen as economic multipliers in both industrial and developing countries. The innovative capabilities of companies depend on their organizational and institutional arrangements, entrepreneurial behaviour, economic opportunities, organizational learning and technical capabilities, and all of these are complex and varied in themselves as well as being parts of very complicated and ever-changing systems.

CONCLUSION

This chapter has described and evaluated the data gathered from the interviews with the company respondents. The data largely concerned the failure of Malaysian companies to use discoveries, inventions and knowledge produced by their country's universities and GRIs, and the apparent failure of the latter two kinds of institution to persuade companies to use their findings. It has been suggested that major assumptions about technical change and CTT form profound parts of the context of relevant processes. Most respondents felt that engineering was more important than science in technical change. They tended to favour the *Technik* model and to regard scientists' research findings as being mainly irrelevant to their companies' needs and demands. Another important perspective was the processes of CTT. The respondents often suspected that CTT was favoured by the government as an idea that could be used to help it to control what companies did, especially as regards innovation and development. The creativity and technological capabilities of companies largely depended, however on their engineers who preferred to adapt technology to develop their processes and products, rather than to apply university and GRI research findings.

The data suggested those important aspects of eight existing models of commercialization and one new one have genuine and varied and relevance to many different individual sectors. However, universities and GRIs with limited financial and human resources and poor business skills had weakened the propensity of companies to pursue CTT. The relatively poor response from banks and venture capitalists to CTT has trapped companies in situations in which companies generally did not want to contact and work with them as sources of finances. The role of government in developing CTT had not usually had significant effects. The respondents argued that many research findings only seemed suitable in laboratory environments and that developing them into commercial processes and products was often far too expensive in terms of time and money. Of course, government should be able to help companies to enhance their absorptive capacities in their respective sectors. The data gathered from scientists, research administrators and other representatives of government and public interests are discussed in the next chapter. The discussion and the evaluations of them are presented in an equivalent manner to that of this chapter.

CHAPTER 7

SCIENTISTS' AND PUBLIC PERSPECTIVES

INTRODUCTION

This chapter is concerned with the views of 17 practising scientists and 14 technology transfer officers and senior research administrators from universities and GRIs and also with those of three venture capitalists, two journalists and a politician. Various details and interpretations of the interview data taken from these people are drawn together to explore the relations between them and the research questions.

The most interesting facet of this chapter concerns the flaws in the system or the management of innovation by and with the Malaysian government. The data from the scientists and the other university and GRI staff seem to suggest that government and the GRIs tend to be too controlling and demanding in their management of relevant research. Low rates of use in business, of discoveries and inventions made in universities and GRIs, are responsibility of politicians and government and university research administrators, as well as of business people. All of these parties tend to blame each other for low uptake, and each does appear to be partly responsible, at least to some degree.

The first section summarises the ideas and literature from chapters 2, 3 and 4, with other recent literature related to the study. It addresses the main arguments of the thesis. Data on the assumptions about technical change, commercialization and technology transfer (CTT) from 37 respondents, number 24 to 60, are described in detail in this section. Chapter 6 has described 23 company managers' and professionals' assumptions of these kinds. In this chapter, the data considered are from 17 scientists (respondents 24 to 40), 8 technology transfer officers (respondents 41 to 48), and 6 senior research staff (respondents 49 to 54) from universities and GRIs respectively. Three venture capitalists (respondents 55 to 57), two journalists (respondents 58 and 59) and a politician (respondent 60). The relevant answers were questions 11, 1, 2, 3 and 6 for the scientists, questions 1, 2, 3, and 4 for the technology transfer staff; questions 4, 1, 2, 4, and 12 for the senior research staff; questions 1, 3 and 4 for the venture capitalists; questions 5, 1, 2, and 3 for the journalists, and questions 5, 2 and 3 for the politician.

The next section discusses the respondents' views about and experiences of processes of commercialization and technology transfer (CTT). It draws on relevant literature and on their answers to the related interview schedule questions, which are numbers 4 to 10 for the scientists; questions 2 to 7 for the technology transfer staff; questions 3 to 12 for senior research administrators; question 2 for the venture capitalists and journalists; questions 2, 3, 4 and 6 for the politician. In this section, the eight models of commercialization and the new model will be discussed in relation to the data from the interviews.

The third section, apart from this Introduction, concerns the role of the government in trying to increase the flow of new scientific knowledge to industries, which are discussed in the fourth section. The involvement of government in industry, previously discussed in Chapter 4, has been increasing because much new scientific knowledge is potentially usable by companies. However, the involvement of scientists in policy formulation and implementation can be problematic because scientists vary in their understanding and companies vary in their understanding of science. This section uses the answers to question 10 for the scientists; 3 and 4 for the technology transfer staff; 2, 6, 7, and 13 for the senior research staff, 2d and 2e for the venture capitalists; 1, 2 and 3 for the journalist; and 2f and 2 g for the politician. The fifth and the last main section before the brief summarizing Conclusion discuss how and why the respondents' answer the research questions. This discussion includes some understanding the practical relevance of the models of CTT that were presented and described in Chapter 3.

ASSUMPTIONS ABOUT TECHNICAL CHANGE, COMMERCIALIZATION AND TECHNOLOGY TRANSFER

In chapter 2, the launching of the Industrial Master Plan (IMP) in 1986 was noted. It reflected the Malaysian government's concern at that time with the state of industrial development, and more importantly, the future role of manufacturing. The latter was expected to become a major catalyst towards Malaysia becoming a fully industrial country. However, with both then and now, Malaysia's domestic industries tend to lack sophisticated technical and commercial expertise. Although Malaysian companies have experiences of technology transfer, continuing the development of indigenous technology remain an issue. Not only in Malaysia, and rightly or wrongly, this is often felt to be the one of the critical issues in science and technology policy formulation and implementation, which relates to the depth of technical knowledge required in a country's various manufacturing activities at any stage of industrialization. Data from manufacturing firms in Argentina, suggested that in spite of low R and D expenditures in Argentina's manufacturing industries, managers considered R and D activities as part of their routines (Chudnovsky, Lopez and Pupato, 2006). Generally, Malaysian public R and D expenditure is largely generated through government budgetary allocations. Most of Malaysia's R and D budget was spent on engineering sciences, information and communication technology and agricultural science (Stads, Tawang and Beintema, 2005).

In chapter 3, we considered the idea of that manufacturing consists the application of science, or is part of science. The argument that this is not the case was supported by the Byatt and Cohen approach (Jevons, 1976). Jevons argued that there had been virtually no identifiable curiosity-oriented research inputs that led into industrial innovation. There were only two genuine examples that satisfied the idea that curiosity-oriented research leads to major industrial innovation: nuclear power and silicon. Jevons argued that, normally innovations proceeds continuously in firms and those inventions are made as technical problems arise that need solutions. Mayr (1976) suggested that there were various dimensions of science and technology; as different bodies of knowledge, or different types of work, or according to motives of the people who do the work. Therefore, engineering was shown not generally to be thought of as part of, nor as the 'mere' application of science. This was discussed in Chapter 3. The *Technik* model of technical change sometimes considered most useful for describing situations in which engineering successes consists solely of, and are solely informed by improvements to products or processes. However, education and perhaps research in science seems an important precondition for the economic advancement of less developed countries (Bernardes and Albuquerque, 2003). These authors argued that the presence of science and scientists helps to initiate and sustain positive interaction with technical development. This seems arguments relevant to any country's absorptive capability, whether the country be less developed or developed.

Ali (1992) argued that developing countries like Malaysia offer little evidence to show that technology transfer regulations have been used nationally to screen processes for more 'appropriate technologies', partly because technology transfer is evaluated by administrators lacking the necessary educational and industrial backgrounds. Malaysia's technological 'base' has been relatively underdeveloped. Therefore it needs to be less dependent on upon imported technologies, while ways and means ought to be found to improve the capabilities of domestic industries. The role of technology transfer offices in universities and GRIs appears to be important in such a context. Lee and Win (2004) conducted a study of Singaporean research centres and industries, and argued that the ideal technology transfer mode seemed to be joint projects among research centres and companies in which relevant facilities and expertise complemented each other. The research centres in Singapore helped domestic companies through licensing and contract research programs. Reducing risk through such collaboration encouraged use of technology transfer as a motivational mechanism for industries and universities. Financial risk was the critical factor to be considered in technology transfer and it could be decreased by sharing R and D costs and facilities.

Technical change

In the interviews, scientists and others except technology transfer officers were asked about their perspectives on the roles of engineering and science in technical change. Out of 29 respondents, seven preferred *Technik* model, six preferred the STH one, 10 had sympathies with elements of both, and six others did not answer the question. The six respondents who did not answer the question were respondents 27, 33, 40, 53, 55 and 58. Respondents 27, 33 and 40 were scientists. Respondent 53 was a senior research administrator, 55 was a venture capitalist and 58 was the journalist. The scientists from the universities and GRIs had at least masters' degrees in their fields. Generally, the scientists from universities had PhD degrees. The scientists who preferred the *Technik* model were respondents 24, 25, 29 and 32. Others were respondents 49, 51 and 54. Respondent 24 was a university lecturer and a consultant to a company, and he argued that scientific knowledge in chemistry did help him to produce producing fertilizer-relevant research outputs that had helped agriculture in Malaysia. But engineering knowledge was the basis for the production and improvement of fertilizers. Respondent 25, who had wide experience of the commercialization of research findings in telecommunications, argued that Malaysia 'cannot focus on science'. He said that Korea and Taiwan had emerged as newly industrial countries in the 1990s by focusing on engineering. He preferred to help companies to solve their engineering problems and he supported the *Technik* model. Respondent 29 also supported the *Technik* model. He found that many of his students did not have strong knowledge of sciences. They excelled in their engineering classes. However he believed that wide scientific knowledge was the foundation of good engineering and that its availability helped companies. Respondent 32 said that engineers worked on problem solving and that they needed basic scientific knowledge to do so. However, most companies that were interested in quality products were not interested in university and GRI new scientific knowledge for its own sake.

Respondents 49, 51 and 54 who were senior university and GRI research administrators also supported the *Technik* model. Respondent 49 said that 'physics is the father of knowledge, and chemistry is the mother of science. Therefore engineers rely on scientific knowledge for the underlying principles to help them understand their work'. He gave an example of

Korean engineers who had been involved in construction of the Penang Bridge. They sought help from the University of Science Malaysia's scientists in their attempt to get cement to set fast in water. Scientists did the necessary work 'backward' as relevant theories had been developed previously. The engineers needed to build pillars to the bridge and they also needed support from scientists in this work. Respondent 51 argued that the roles of engineering and science in technical change should be separated. He said that 'both have different functions, depending on the nature of the problem'. Therefore, in his university, there were separate faculties for engineering and science. Respondent 54 argued that engineering helped to ensure precision in any particular technical change. Even though engineers might have done good research to help to create something new, they still needed scientists' knowledge to enhance the quality of their work. His institute had built a successful prototype machine for food mechanization. However, the products did not gain any market advantages. Companies did not seem have any interest in them, as the market was not big enough.

Respondents 30, 31, 36, 50, 59 and 60 were the six who supported the STH model. Respondent 30 said that 'scientists who are the ones who develop research findings or a small scale and then the scientists will pass the technical part to engineers for the engineering work. Engineers will use the larger part of the research findings. However, engineers can also help industry to solve their technical problems, and work together with scientists'. Respondent 31 argued the same, as she felt that research findings starts with science. Engineering was then applied to it. Respondent 36 argued that engineering cannot exist without science and that engineering was a part of science. His research work involved a lot of scientific knowledge and had a wider scope than engineering. He said that 'science covers all and engineering originates from science'. Respondents 50 and 59, who did not have either science or engineering degree backgrounds, argued that engineering can be considered as the application of science or that it is applied science. Scientific knowledge was the basic knowledge for engineering work. However, although respondent 60 was a scientist, he argued that 'there are differences between science and engineering. Engineering is more practical and science is more academic'. Yet he went on to say: 'Science is still basic to engineering'.

The largest group of respondents discussed in this chapter tended to support the idea that both engineering and science had important roles in technical change. They gave varied perceptions of this. Respondents 31, 34 and 35 who were scientists, said that for their research findings to be relevant to industry, it needed to use both engineering and science. They had been involved in commercializing their research findings and found that without the help of engineers and engineering knowledge, their scientific discoveries could not be turned into products or processes. For example, respondent 35 said that 'when I want to scale up my process, I leave it to the engineers to design the whole thing. I called relevant engineers to get involved in my project'. Respondent 34 said that 'engineers must work together with the science people, because people…lack knowledge about machinery and design, so they have to work [together] to get better products'. Interestingly, respondent 38 noted that the roles of engineering and science need to be interrelated for technical change to occur. He gave an example of the use of his research findings with one of the national car production companies. He said, 'we started with science, analysing concepts by formulating the right method, analysing raw materials and so on, and then followed up by using engineering principles in developing actual processes'. As a senior research administrator, respondent 55 noted that 'I think science cannot stand alone, and engineering cannot stand alone. They have to be combined to solve problems for technical change [to happen]'.

Commercialization and Technology Transfer (CTT)

Debackere and Veugelers (2005) studied the context, structure and the processes that universities can use to become active in the scientific knowledge market, managing and applying academic science, technology and innovation. They described about the advantages of decentralized organization and incentives that helped active involvement of scientists with commercialization with support from technology transfer offices (TTOs). TTOs became mediating institutions for improving links between scientists and industry. Lee and Win (2004), argued that 'the higher the commitment in motivating industry to participate in technology transfer projects, the more successful the technology transfer practices become'. Reasons for why industrial collaboration with university research centres experienced problems were included lack of in-house R and D, companies shortening product life cycles, cutbacks in R and D budgets, and the changing nature of research priorities.

In this study, there is evidence that all scientists, both from universities and GRIs, are likely to perceive that their research findings are industrially relevant, and that many expect that they will be used in the future. However, scientists were nevertheless not always satisfied about the way of their research findings are commercialized and transferred to industry. Respondent 24 said that 'it was very relevant, as we work directly with the farmers. I got the research problem from the farmers'. He also trusted the company that took up his research findings. He claimed that the company had profited well from them. Respondent 25 said that 'our research was…problem- oriented. We identified the problem first, and then we solved it. Since this was an engineering problem, not a scientific one, we could do it fast. Therefore we set a target of less than four months'. He also said that his findings would be used widely as the work was an application, one that could solve problems in telecommunication.

Respondent 28 said that, ‘this finding [is] very relevant to the industry in the sense that latex waste that they produce, they do not have to throw it away any more, as it can be converted into something useful’. He admitted that his research has taken a long period to perfect. He took eight years to come to the stage of commercialization. Respondent 30 said that ‘my product is 100 percent relevant to industry. Some scientists do fundamental research. Mine was not fundamental research, although it was applied research. I think applied research is more relevant to industry than fundamental research’. Respondent 33 said that his research findings were always tailor-made towards industry’s needs. Respondent 34 was very committed with her research findings in such a way, and said that ‘my product was relevant because at the moment all artificial dressings are imported. So we started using starch, the indigenous material. Then we were trying to convert cytosine derivatives that will be produced by local manufacturers into dressing. I believe that our dressings will latter replace those imported ones’. Respondent 35 said that his research findings in rubber vulcanisation were relevant to users, as they suitable to their requirements, and were user-friendly products, especially to the environment. It took him five years to complete his research findings and start to commercialize and become involved with technology transfer. Respondent 39 said that his research findings were relevant to traditional food processing, as no other machine was being used. The machine had helped to improve traditional food-making.

Most, about 13 or 14, of the scientists were not satisfied with the ways in which their research findings were being commercialised. Respondent 26 said that his research findings did not attract any business people. He said ‘there is no taker for the time being. That’s why to make sure that the thing is not wasted, I sell it myself, and so people can still benefit from my invention’. Respondent 25 was quite upset on some about some companies’ resistance towards university research findings. He said, ‘they don’t care about how big scientists you are, they don’t care about your findings’. He gave his opinion that ‘scientists in Malaysia themselves have to go out and do necessary things in order to commercialise their products. That [is] the existing way, which nobody likes to do … because it interferes with other job functions. It is very hectic thing to do, but there is no better way out at this time.' He suggested that university administrators need other people to do marketing, to identify potential industry partners, to make contact, and to do product demonstrations or presentations. He then implied that university administrators should understand how to do business with industry people. Respondent 27 spoke about her frustration of the way in which her research findings were being commercialised. She was upset about from the poor responses from various government people especially policy makers. She noted that some of them did not appreciate scientists' work. Although she had made every effort to present and demonstrate her research and to train people using her accounting software, it had not helped her. Respondent 28 spoke about problems with giving his research findings a 'price'. He said 'well, we can transfer the findings. We can sell the findings but … we need to put the price on the findings. That is the hardest part, you know'.

Another point noted in this study was the weakness of university technology transfer offices (TTOs). Respondent 29 spoke about scientists' efforts to get research findings commercialised. He said 'It's [because of] the effort of the lecturers. They have to do the research, and then when they found something, the TTO in the University will take a certain portion of their profit. On top of that, they will take from our personal income another 10% above ten thousand. But they don't really bother whether the lecturer can sell or not. Because although there were some programs being organized by them from time from time, but they have got limited resources, and they may get very good research findings about 20 to 30 in numbers, but they can not really market them all. It's just like trying to be Jack of all trades, and master of none. I cannot blame them'.

There was a range of perspective from the 20 respondents who were not scientists. The eight TTO officers often suggested that licensing was the best method for commercialization of research findings. Respondent 41 said ‘Commercialization can be successful in more developed countries because universities are getting funding from industries for them to solve specific problems. In Malaysia, 90 to 95 percent of the research funds for universities come from the government. Therefore there is another hurdle for universities. They have to find a business entity that have confidence in their findings and commercialise them, which it is not an easy one to overcome’. His university had failed once with a joint venture project, because the university took more time to find a reliable business partner than it had. Respondent 42 spoke about the function of TTOs. He stressed that university scientists should focus on and continue their research. There should be a mechanism established to commercialize research findings, to transfer them to business people. It would benefit all the parties involved. However, he noted that with commercialization, 90 percent of the work consisted of upscaling, prototyping, market survey work, assessing cost effectiveness, packaging and so on. He commented on some scientists’ attitudes and beliefs regarding commercialization. He felt that scientists were very proud people and not very open to suggestions. He felt that scientists should have open minds, a will to listen and more openness to and less contempt for comment and advice. Some scientists put a high tag value on their research findings even though they still needed further improvements. He also found that generally scientists refused to give out everything they know to business people, as they were very afraid to be cheated or ‘taken for ride by the business people’.

Respondent 43 said that commercialization and technology transfer were two different things. Technology transfer ‘is transporting the technology’. It transfers knowledge and know-how to the third parties. University research findings and technology are transferred to business people through licensing, patenting or outright sale. Technology transfer also involved training. Commercialisation was more focused on money matters. He said that 'If the findings do not generate profit there is no commercialisation … You can see or not? There are many research products that will not be able to be commercialised because they doesn't have any value to industry. However, university research findings do not create interest [in] industry. Maybe one of the examples, is that the product is good and innovative but they are [industry is] not ready. Or the product is good and innovative, but it is too costly'. Respondent 44 made the same point. CTT is 'ideally translating the R and D results into a business model, and that model is has some market orientation or market relevance so that people will want to buy the idea, formula, products or services. This is strictly dollar and cents'. Respondent 46, who consists of two persons, argued that there was not any official approval proper to commercialized government activities in the government system. They described commercialization and technology transfer differently. Technology transfer was transferring research findings to business people, which they 'use or apply'. They considered that with commercialization 'you [have] got to get [the] money that you invest'.

Respondent 49, from the senior research administrators' group of six respondents, argued that commercialization activities were important to his university, apart from the basic research and teaching that were its main function. Respondent 50 described research findings are very significant as they reflect a university's own achievements. Their production was in line with one of a university's two core functions. He spoke of the importance of research findings in terms of the budget allocated to his university by the government. His university received a level among the highest funding for university R and D. However, the respondent gave a different perception of CTT. He said that 'Commercialization is a bonus. This is because commercialization is not the main aim of R and D for a university lecturer'. He argued that any scientist who reached the stage of commercializing his research findings successfully, could be treated having reached the full cycle from idea conceptualization to product commercialization. His university's scientists had three main functions. One was to teach, another is to do research and the third is professional extension either through training and in other ways. He argued that the three functions support each other. He said 'To be a good teacher, he or she must be a good researcher, and they should go hand in hand'. Respondent 53 and 54 came from different GRIs. Since the main function of a GRI is to support public people as a social obligation, respondent 53 said that 'Since the palm oil industries are paying us money, we must be able to turn all research findings into commercial use so that the industry gets benefits. To get funding for research, every scientist in his office has to apply and pass its assessment. Respondent 60 noted that his office had only started to commercialize research findings in the past ten years. His office had taken every measure to make sure that its scientists' research findings had commercial value right from the beginning of the early stage of conducting research or even at the proposal level.

Comparisons between points made in previous literature discussed in this study and the evidence have suggested that scientists claim that they have made contributions towards Malaysian economic development. They spoke of their contribution towards patenting, consultancy, licensing, training, spin-off companies and other methods of commercializing their findings. However, it can be seen from the study that even though scientists argued that they had research findings relevant for business people, they were not satisfied with the ways in which their findings were being (were not) commercialized. About two thirds of the 17 scientists interviewed preferred doing research that had helped solving industrial problems. Lee and Win (2004) noted that research centres in Singapore mainly conducted applied research, not basic research, as their main objectives include helping local industry. This was in line with the claim of Charlton (2007), that although people often suggested that a scientist should have a specific personality, usually conscientious and self-critical, it was not always necessary for this to be followed. He argued that past scientists usually worked alone and depended on conscientiousness and self-criticism for the validity of their research. He also argued that generally scientists tended to be shy, introverted and highly-focused. In this study, respondent 42 (a TTO officer) and respondent 6 (a company interviewee) claimed the same. However, scientists should have three different stances towards their research (Drenth, 2001). First, they emphasize the search for truth, which requires an attitude of openness and collaboration; second, they can provide evidence and information that can settle differences of opinion or reduce intellectual tensions, and third, they can offer independent and unbiased advice on policy matters that involve scientific information or requires a scientific foundation. Commercialization efforts are made to facilitate the work of scientists with adequate links and openness and trust between the various parties.

THE PROCESSES OF COMMERCIALIZATION AND TECHNOLOGY TRANSFER (CTT)

Ali (1992: 110-111) argued that there was a problem of perceptions on all sides about the ability of each to create permanent links with the other. The GRIs are perceived by industry to be lacking in market orientation. The industrial sectors are perceived by GRIs to be in forging necessary links. In Malaysia the tendency for larger companies to undertake their own research, while small companies are unlikely to do any research (Lee, 2004), is similar to that in more developed economies, but probably more pronounced. Closer links between universities, GRIs and companies that encourage CTT would very probably be useful. Universities are regarded as major, insufficiently exploited, repositories of knowledge (Langford, Hall, Josty, Matos and Jacobson, 2006). There are major differences between industrial and academic incentives. Industry seeks competitive advantage, which generally accepted being derived from unique, valuable and difficult to imitate assets and capabilities (Barney, 1991). Heterogeneity and appropriability are important with the goal of increasing shareholder value (Teece, 1997). On the other hand, academics seek peer recognition, and thus may lack interest in appropriability. This claim is in line with at least some of the evidence from this study.

Mostly scientists spoke about their involvement with CTT, their relationships other in organizing commercialization and various their further points about commercialization. Most of the involvement was based on individual effort. Scientists with relevant research findings found that training was the best way of transferring knowledge to business people. All the training was done either by themselves as consultants or through their universities or departments. Respondent 25 argued that some national companies were reluctant to use university or GRIs research findings that supported their production or processing lines. Therefore he claimed that he should be involved in the commercialization process. Respondent 28 argued that the government had funded research through the IRPA, and that it did not support companies with its development fund. He said that ‘we don’t have time to go around and do the promotion. So that’s the problem. The government gave us the money to do the research. We came out with a product and we need mechanism actually to transfer our findings to the private sector. That kind of link is missing’.

Respondent 29 felt that he had the responsibility to train the buyers of research finding, so as to help to disseminate the knowledge to them. Respondent 30 felt that he had to get totally involved in CTT as to assist technology transfer officers. He claimed that through exhibitions and competitions, he got chances to meet business people and to know their demands for technical development. Respondent 33 said ‘Training is a continuous process, it is not just one off one’. He felt that through training, seminars, discussions and workshops he had helped companies to fabricate machines that business people needed. His task was technical specification and to design. Respondent 31 saw licensing as the best method for commercializing research findings. She said ‘I think a more pragmatic approach is licensing. That’s why I said, if you have the IP, it is a ticket for you to negotiate on the licensing’. She added that in developed countries ‘The private sector participates in research and then they get the first right of refusal to commercialize. That’s more efficient, rather than through IRPA. We have very broad-based research and you know you have to focus back and tailor to the market. So that’s what we are trying to do now, we have to tailor back to the market’. Respondent 32 pointed out those senior managers of any company are important in making commercialization decisions. Eventually they made decisions on technical development that could be good for them to become more competitive compared with their competitors. So it [commercialization] is to help them and it is better for them’.

The group respondents of eight technology transfer officers (TTO) mostly spoke about three main subjects. They were first, about scientists’ attitudes towards CTT, second about TTOs’ role in transferring research findings to business people, and finally, how the processes of technology transfer and commercialization changed over time. Markman, Gianiodis, Phan and Balkin (2005) evaluated university technology transfer in the USA as ‘innovation speed related to time’. They claimed that accelerating the use of any research findings by business people is subjected to various problems, such as confusion due to knowledge spillover, competitors’ replication of processes, and operational and technical obsolescence. Hence the TTO’s role has affected the universities’ aim to maximize the return to Intellectual Property (IP) through licensing, joint ventures or spin-off companies. Locket and Wright (2005) stressed their view that TT officers should be equipped with business skills as one of the universities’ resources and capabilities for CTT.

Respondent 41 argued that scientists should be allowed to continue their research and not be made responsible for asking any company to take theirs up. However, respondent 42 said that ‘Scientists should not only pursue their knowledge through publishing in scientific journals. They should also have an interest in starting to commercialize their research findings’. Respondent 43 argued that in the past, before 1995, scientists never made any activities of CTT known. Therefore, scientists more often said ‘I like to do my research because it is my interest and my research domain’, since then they did not have direct contacts with business people or work experience in the commercial world. However, although his university had made many research findings, few had been commercialized successfully and few had generated returns to his university. Respondent 44 noted that some scientists had higher chances of helping business people if their research findings had novelty, and were demonstrable, and technically and economically viable. However, he was upset that there were scientists who had negative attitudes, what he called ‘What Is In It For Me? (WIIIFM). He meant that some scientists were more focused on to the return of money from their research findings that been commercialized by business people. Respondent 48 argued that although the government preferred scientists to tailor their research findings to helping companies, scientists should be given the freedom to remain scientists and discover things.

About their roles of transferring research findings to companies, respondents 44 and 46 spoke of details of the most important characteristics of successful CTT, the most and least effective aspects of relationship with companies, and the most and least satisfying aspects GRI’s interaction with companies. However, the other TTO officers also managed to respond well to related questions. Respondent 44 stressed that scientists at his institution did research that had helped companies and that they had gained experienced in CTT. The main factor leading to lag in Malaysian CTT of research findings was market size. He argued that although government had its five-year development planning, its implementation had suffered. He commented that there had been series of meetings, discussions and committees on many issues, especially on education, but that their value had been questionable. The IRPA funds that did not support development funding were another issue. He said that 'Companies won't want to go and jump into the puddle just like that. Therefore development funds that go beyond IRPA should be managed'. He felt that scientists did not understand how businesses were run and how companies made complicated decision over the IP ownership and licensing. Often, and often irrelevantly, some scientists wanted to get involved directly in the management of companies or to become CEOs. He also quoted the problem of control by fund management of the IRPA. Because of the inadequate funds from IRPA, he argued that the IRPA food and agriculture research area should be treated fairly although the research area was quite saturated. Some scientists' proposals for research were neglected or not given enough funds to be completes within a particular period of time. The management also often said that 'You cannot do this, you cannot do that, after that you have to follow the national code of sharing this and that, and share skill, expertise and so on'. This statement then will hamper scientists' enthusiasm to do research and to innovate. Thus the situation had made scientists' attitudes towards compete each other for funds and research areas, and for recognition that based on individual achievement, more strongly than they ideally should. Scientists in Malaysia seldom wanted to share funds and interests, although the government wanted them to. This problem made collaboration in research between universities and GRIs difficult. The respondent argued that from his experience, several types commercialization were regarded as being at high and low satisfactory levels in his institution. The types of commercialization of research findings were joint ventures, licensing, consultancy and client-specified problems. From these types of commercialization, joint ventures and consultancy bore the highest risks, while licensing and client-specified problems had the lowest risks. In terms of success rates, consultancy and client-specified projects had highest rates, and the other two had lower rates. Client-specified projects had the highest rates among the four types of commercialization.

Apart from the types of commercialization and their levels of risk, success and satisfaction with results, he spoke of companies' attitudes, interest and enthusiasm. He said that some companies were not serious about CTT and had no relevant knowledge at all. These people he called 'opportunists'. They were business people who always wanted quick money. He also gave an example of people who acted as 'introducers' or 'brokers' who took on other person's advantages. He felt that these people were not real professionals and therefore, that their involvement in commercialization of research findings was a problem.

Respondent 45 also spoke about his problems with commercialization of research findings. He asked whether commercialization of research findings started from scientists or business people. It could be from either. He felt that, generally scientists' findings did not have 'commercial interfaces'. If they had the commercial interfaces, the processes of commercialization could be easily done. He also spoke about companies that took up research findings. Their main targets and purposes were always to get higher growth rates. As stated before, companies would always want profits from their businesses.

Respondent 46, who, as noted before consisted of two interviewees, argued that at present, Malaysian SMEs did not understand the importance of research findings. So often, such companies did not have funds for their R and D. Therefore, some companies would request help from their institution, asking about any research findings that could help them to remain competitive. However, they said that 'Their scientists often did not seem to know what products do they have to produce, because they don't understand the market. So a gap existed'. Therefore, the best thing they could do was to work together with companies in order for the two sides to understand each other. The institution had a program of gathering companies and venture capitalists either from the private or the public sector, to come together to discuss their interests in research findings and their commercialization. Again, they spoke about the different cultures of business and government people. With the pressure to have lower costs and higher profits, some companies impatient with the bureaucratic system of government. The working system of the government was not integrated well with how companies worked. The government wanted efficiency in management. The government regarded ‘one way communication’ as normal and held its own strong views on companies wanting work done quickly. Generally companies saw ‘time’ as their main priority because if innovation was slow, profits tended to be less. Scientists tended to seek long-term and permanent answers to problems, but companies sought improvements that worked quickly and were profitable. If CTT made a company slow to innovate, it could lose market share. Therefore their roles as TTOs were to make firm decisions as soon as possible on whether research findings were commercially viable. They said that ‘our role in [the] TTO is to pick things up and match [ourselves] with business people, and the research still goes on’.

How the processes of CTT change over time in universities and GRIs depends on government requirements for research and its findings. For example, in one of the GRIs, the institution had changed its technique of finding a good research area. Initially, choices were based on ‘market push’. It meant that, the researchers developed processes or products and then looked at their features. If the features solved relevant problems, they pushed the processes or products or replaced others. Previously, they were trying to make processes or products using a ‘market pull’ approach.

Generally, senior research administrators focused on four subject areas in their interviews responses. First, they discussed their university's/institute's strategy for CTT. Second, they discussed critical factors and weaknesses in commercialization. Third, they considered their contacts with various parties involved in commercialization, such as the Ministry of Science, Technology and Innovation (MOSTI), the Ministry of International Trade and Industry (MITI), venture capitalists, banks, universities and GRIs. Finally, they explained how the processes of CTT changed over time.

Respondent 49 spoke about his university's strategy of appointing a consultancy company to draw their 'Innovation System' up for them. The system meant that the university helped to find business partners for viable research findings of their scientists to be commercialized, chosen, first, through investing in pilot plants and production plants. The system also proposed research parks or incubator parks that eventually helped scientists to pursue their findings and improve them. He also argued that some scientists might be interested in being entrepreneurs and in getting involved in commercialization of their own findings. However, the present procedures did not give any help to or have any flexibility for scientists. He said that 'If a scientist is able to go outside to do his production and join a company, we should not ask him to resign. At least if he has some fall-back station, when he doesn't make it or even if he does make it, after the product has been fully developed, he sometimes wants to go back to the lab. So we let him come back to the lab as a professor but the company flourishes'. On their weaknesses, this respondent argued that from hundreds of research findings that his university had produced, there were none that had made significant contributions towards his university. The Nokia mobile telephone from Sweden had been good bench mark of innovation. He then suggested a reward system for scientists that might motivate them to stay in universities and continue to contribute to their work. On their relationship with various parties, respondent 49 argued that generally the relationship was as well maintained as it was supposed to be. However, his role was more about getting funds for research at his university. He had made close contacts with business people to gain funds for research collaboration. Respondents in this group often argued that they had minimal relationships with venture capitalists. Companies were responsible for getting involved with venture capitalists. Generally, MOSTI and MITI supported universities and GRIs with research and CTT funds, respectively.

Respondent 51 spoke about his university's main strengths and weaknesses regarding the commercialization of its research findings. Some scientists did not have much awareness of market needs. He said that 'Scientists conduct research in the university. Their main aim is not to come out with a product. Our main aim is to extend knowledge'. He argued that MOSTI had recently stated in Eighth Malaysia Plan (for 2001 to 2005) that 'commercialization is the end thing'. Therefore scientists could not stop their research in the middle of a planning period, but this new statement had attracted scientists to CTT through collaboration. Respondent 54 spoke about how his institution's strategy for CTT was restructuring his organization since 2000. With its new structure, the institute had a special task unit for R and D and CTT. The new unit's aim was designed to have links with business people for CTT. It also has units that support CTT, the TT and Promotion and Development Centre. The others are the Centre for Economy and Technology Management and the Technical Services Centre. However, only about 30 percent of his institute's scientists are engaged in CTT activities at any time. This figure had changed from previously only a few percent doing CTT. A study of British industry-university collaboration (Laursen and Salter, 2004) found that there was an over-estimation of universities as direct source of innovation. They claimed that the interaction between universities and industrial firms remained largely subtle and complex (p. 212).

The three venture capitalist respondents spoke about the abilities of various parties involved in commercialization and their relationships with them. Respondent 55 argued that venture capitalists did not run any businesses, and that they depended on business people to do that. However, venture capitalists did not invest in research findings to be commercialized unless they were identified and taken up by business people. Respondent 56 discussed the gaps between scientists and business people. Generally universities in Malaysia had their own TTOs. But their functions were harder to perform because they were headed by academics. Although the scientists' ideas or concepts were good and special, they often took too long to commercialise, and venture capitalists often had to pull out as they became short of funds. He said that 'some scientists may take 10 years and thus the venturing options [were] not good'. Respondent 57 spoke about his experience of helping companies to fund commercialization. He said that 'some research is being done by lecturers and students, and so you can see that there is a lack of an entrepreneurial environment'. He argued that university scientists' research findings often only offered an improvement to or an enhancement of processes or products. However, companies looked at the competitive advantage of any new processes or products. He also spoke of the issue of the time taken for research findings to be commercialized. Some universities' administrations took more time to make decisions about doing so. New software products could be outdated after six months. Although research findings might have potential benefits, there could no be demand from users, or companies might not have a 'track record'. Business people often did not want to take any risk of losing capital on pilot plants that might need excessive investment. Most venture capitalists had minimal contacts and relationships with MOSTI and MITI as regards CTT of university and GRI research findings.

Both of the journalist respondents spoke about there being different interests with regards to processes of CTT. Respondent 58 argued that although Malaysia had many competent scientists in agriculture, often they tended to have little knowledge about commercialization of their findings. The low uptake by business people was because some of the findings were not very likely help them improve their businesses. Since agriculture is a big sector, he suggested that scientists should do research to help increase food production. He also argued that some scientists had negative attitudes towards business people who might be interested in their findings, and might say to them, ‘Who are you to ask?’ He suggested the formation of a clearing house for research findings to act as coordinator and support for research and its commercialization. As many companies seemed unable or unwilling to put new scientific knowledge to use, he suggested that the problem was that there was no comparability of research. Companies had different interests and the government had others. He said: ‘the industry is going one way, the government is going another way’. Some politicians made reckless statements about a revolutionised agricultural sector. He also argued that the education policy had a bad effect on the main purposes of education. Education can stifle originality, and he suggested a revamping of educational policies. He claimed that the best idea was to produce holistic students who excelled in academic work and who were also creative. He then discussed the American management ideas that he thought best to adapt to. However respondent 59 thought otherwise. He argued that Malaysia had been influenced by American management rather than the Far East management. The Americans often emphasised such concepts as the ‘short term’ and ‘quarterly horizons’ and the idea of the ‘technopreneur’. He argued that the word technopreneur did not exist as it is had two different and rather opposed meanings, for ‘technology’ and ‘entrepreneur’.

The only politician in this study spoke mostly about his Ministry’s role in facilitating the process of CTT. MOSTI had put a different emphasis on commercialization of scientific knowledge in two different Malaysian Plans. He suggested that Seventh Malaysia Plan’s motives for R and D were about ‘capacity building’. Later, at the end of the Eighth Malaysia

Plan and at the beginning of the Ninth Plan, commercialization had become the main focus of R and D in universities and GRIs. He argued that both scientists and its administrators had less experience in business than they ought to have and said that ‘they did not have the [a] remote view of how to market the products … by university researchers and know how to file patents’. He said that ‘University administrators must follow what the government wanted and was hoping for. This also goes for GRIs’. The respondent spoke about the idea of producing more and more ‘relevant’ graduates and other qualified people for industry and made the argument of basic education plus hard heads and crafty hands, producing industrial success. He noted how the Malaysian education system had followed the British system for many years. However, when compared to the German and French systems, they had *Fachhochschule* and *Grandes Ecoles* respectively, and these systems apparently emphasised competencies and skills. However, the Malaysian education system has changed when more vocational and technical schools were given priority to give hands’-on skills for technical change.

Based on the evidence above, the various parties tended to believe that the low uptake of research findings was to blame purely on the system or on the management of it, but most of them did not have very wide-ranging or long-term historical perspectives. The views of scientists and its administrators have been described and discussed. Generally scientists claimed that the process of CTT was new to them. Individual scientists tried to pursue CTT and their efforts were partly in their own interests and/or for patronage from their university’s or GRI TTOs or senior administrators. They revealed that some policies were against their aspirations for commercialization, especially towards their incentives and rewards. Only by looking to their companies’ intentions and objectives, scientists should strive to achieve, and by then they should be guided in setting priorities between research and development. Companies’ profit motives had to be understood by the others in this study. In this sense, technical change and CTT are best promoted in a system where all the parties involved trust each other. Large companies were often first to adapt new inventions compared to small companies, as the former have substantial resources while the latter have much more limited ones. The uptake of research findings of universities and GRIs should show the ability of both big and small companies to adapt. TTOs and senior research administrators have shown that in this study that they have limited abilities. Clearly the ability to cope with government regulations tends to deter the process of CTT. Government regulations on budgeting processes and spending sometimes take much time that could be spent more usefully on technical development work. There were a number of aspects to this: first, the mere existence of regulations is especially burdensome to scientists who are looking for research funds; second, the cost of compliance to can be prohibitively high to them; third, scientists and the administrators might not possess the technical or legal expertise to cope with legally and technically complex compliance problems in CTT. Lockett and Wright (2005) suggested that university and other senior administrators needed to devote attention to the training and recruitment of officers with broad bases of business skills. Markman, Gianiodis, Phan, and Balkin (2005) found that the 'faster' TTOs can commercialise research findings that are protected by patents, the greater the returns to the university and the higher the rate of start-up formation. These authors reported that there were three key influences on speed: TTO resources, competency in identifying licensing processes, and participation of faculty inventors in the licensing process. On the roles of venture capitalists in the process of CTT, they prefer to invest after the seed stage (Wright, Locket, Clarysse and Binks, 2006).

THE ROLE OF GOVERNMENT

A critical aspiration that governments of developing countries such as Malaysia should satisfy in managing technology development is fostering technology efforts that lead to the most efficient use of the available domestic resources (Ali, 1992). The role of government in promoting and guiding the flow of scientific knowledge from universities and GRIs to industry is significant and was discussed in Chapter 6. The government has created funds to foster the enabling research findings to be used to help create new processes and products. Wright, Locket, Clarysse and Binks (2006) studied the role of several governments, including Malaysia's, in supporting CTT and found that TTOs have major problems in developing prototypes, conducting initial market research and developing business plans, because of shortages of proof of concept funding. A lack of adequate staff is also indicated with respect to their availability to identify, assess and exploit intellectual property. Incentives and rewards for such staff also appear to pose problems.

The Evidence

The data suggest that most scientists were not satisfied with the process of CTT and its incentives and rewards. Respondent 27 argued that the government should give more help to scientists who trying hard to get their research findings commercialised. There should be one government coordinating agency to be a link between scientists, business people and government. Various existing committees intended to act as links between them did not actually help. She said that 'if the research findings can be used by the government agencies, we do make sure that government agencies buy from them'. Business people and venture capitalists should then come into action, after any improved development of those research findings. However, she felt that her suggestions would most probably be difficult to implement. She said that sometimes the government gave the reason of there being a lack of enough finance to help scientists and business people.

Respondent 28 reported on the attitudes of TTO officers, when he referred to his interest in CTT. He said ‘because I thought I just gave them my idea, this is my product then they find the suitable partner for me. No reply. I mean they are there. I’m not sure how many lecturers, how many university researchers actually benefited from the exercise. I don’t know. They still want to see the business plan, the research feature or customers and all those things. It is really ridiculous you know. As a scientist you don’t have time actually to do the market survey. I only can give my input from my knowledge or my experience in the laboratory. This is my product and this is what my product can do. So they should be the ones that try to match me with someone else’. Respondent 29 argued that university research administrators did not have suitable knowledge about CTT and their functions. University administrators did help scientists to participate in conferences, but ‘after the exhibition, nothing happens and [there is] no help’. Therefore, he suggested that if ‘any scientists go for promotion, they should published papers more. Research findings did not contribute anything: they want to see how many papers you have written’. Respondent 31 recommended that ‘scientists should be allowed to be directors, but not managing directors until they ask the university for leave, temporarily leave of absence’. It would appear that scientists are helping companies to improve research findings and to develop them. Respondent 34 said that ‘scientists are just like water. They can be coloured’. She also said ‘but we guide them. If we want them to do things, we then assist them. If not they will go wild’. Therefore, without a proper guide in terms of the flow and process of commercially driven research, it could not succeed.

Respondent 40 said that the problem of the government in supporting CTT was that CTT was hindered by the non-understanding of many business people. They regarded research findings as able to be commercialized and taken up without them paying any costs. She argued that sometimes her Institute had to charge money to small companies. Therefore, companies thought it better to buy from overseas, because they felt more confident doing so, and they did not believe in Malaysian technology. She pointed out that 'when [the] government wanted us to sort out and fund our own research, it's difficult you know, because we cannot depend solely on commercialization. We still need the government funding to some extent, like the IRPA'.

From the TTO group, respondent 43 spoke about a significant share of IRPA funds and government infrastructure being ready for CTT. He cited the case of Japan. In Japan, research findings took about eight to thirteen years to be developed. It then took about the same number of years to enter their market in the form of developed products. Therefore, the Malaysian government should realise that 'if you have got something today, don't expect that tomorrow or within a year it will be in the market. It will not happen'. Therefore, any research findings obtained during the period of the present Malaysian plan, will only be developed the product or processes in the period of the next Malaysian plan. He argued that his office should not be responsible for any incubating and nurturing product development, which is meant for business people. His and other TTO offices should be supported with financial assistance to provide infrastructure for incubations and nurturing. However, he found that some business people misused CTT funds from government. Indeed, respondent 46 argued that the government should contribute to the 'push-type market research'. They claimed that some companies needed to be 'pushed' to use relevant research findings from GRIs. By having a government regulatory framework, it will create demand from business people. They argued that being a government department, it has a different culture and can act as a different source of pressure. Many companies regarded time as their main constraint and some government departments ignored or forgot this. Normal government rules and regulations wore down the motivation of business people. However the respondent agreed that government regulations did help to increase efficiency, but not to increase profit. He emphasised his view that the government was trying to be fair to all of the parties. But the barriers between government, scientists and industries were not being reduced.

Respondent 49 argued that both MOSTI and the Ministry of Education (MOE) had good communication with his university regarding its scientists and their research. Their contacts were mainly about research policy and management. His university also obtained research funds from other Ministries with the help of MOSTI. Therefore, his Office had helped scientists to get more research funding from the government. However, respondent 51 said that 'his university felt that commercialization is a new interest even in the case of MOSTI. MOSTI's previous interest was to encourage R and D. So our link with them is more about monitoring, ensuring that research gets its funding and that it gets implemented as per proposal'. Therefore, his university had regular meetings with MOSTI about funds for R and D. This respondent stressed his view that some companies preferred to engage scientists as consultants, rather than taking research findings and commercializing them. The government had facilitated CTT with matching funds but some companies preferred the freedom of getting research findings ready or nearly ready to be used. He said 'they engaged the researchers as consultants. That's all. Some researchers are happy with that. This is because as I said [the] university's job is not to make money. But the university's job is to disseminate knowledge. Some universities stress [this] at the early stage, sometimes maybe you want to allow some freedom for the researchers'. He gave praise to the government initiatives of the IRPA. Through the IRPA, his institutes got extra funds and collaborated with universities. He argued that CTT initiatives were new to SMEs in Malaysia. He said, ‘their *modus operandi* is maybe a little bit too early for [the] majority of our SMEs’. He suggested that the government should give direct support in terms of soft loans or direct subsidies.

Venture capitalists (VC) gave different perspectives on the role of the government. Respondent 55 argued that his company did not have much contact with the Ministry involved in CTT, as they only focused on the ‘findings due not only from national companies but also other countries, like India, Singapore and Thailand’. Respondent 56 held similar views. He argued that his company did not work with government departments or government servants. They worked well with companies. Although his companies were involved in CTT, he found that it was a high risk thing. One of companies that he been investing in failed in an attempt at commercialization. The failure happened because companies that he been investing were still on a scale. Since the findings took longer to be developed, his company stopped the investment, although they thought that the product might be excellent and extraordinary. He also argued that most research findings remained on shelves as the government was not benefiting obviously from innovations and inventions from universities and GRIs. He suggested that the government should give more incentives to scientists and change its policy on the investments of venture capitalists. The government should support industry as a whole.

Only respondent 58, one of the journalist respondents, offered his particular argument about the role of the government. He suggested that the government should play an active role and take more initiative for example, by setting up research universities and commercialization centres. His suggestion came about as there seemed to be no proper links between the demands of the industry and the supply of scientific knowledge from universities and GRIs.

As a politician, and member of the government, respondent 60 argued that the government had made many changes to its policies for CTT.

Clearly, most of the respondents frequently cited in this chapter argued that government, university and GRIs bureaucracy and inflexibility were barriers to the use of scientific knowledge in industry. They believed that although the government was trying to fund industrially relevant research and to help companies to use it, there was evidence of inability on the government's part to support the practical development of research findings, and of inability on the part of their staff to help university and other researchers and companies to deliver the process efficiently. The respondents felt that there were some particularly rigid procedures in universities, GRIs and various government ministries and other agencies that very clearly did not fit some specific, and often important, situation.

DISCUSSION

The evidence in this chapter is well linked with that discussed in Chapter 6. So far, in this Chapter and in the previous one, there is a considerable mix of more or less objectives, perspectives on technical change, CTT and its processes and the role of government in trying to increase the flow of new scientific knowledge to industry. We found that most of the respondents' various kinds of interests, values, understandings, and skills influenced the apparent failure of Malaysian companies to use such knowledge, and the apparent failure of the latter two kinds of institution to persuade companies to use their findings.

More specifically scientists wishing to pursue their research findings with companies found that they needed to be mindful of various organizational and managerial factors. Most scientists argued that their research findings were relevant to their intended industries. They clearly wished to foster CTT and thus to help industry. We also found that some other scientists would prefer to help companies to contribute to their technical development. This study has also shown that most scientists' had various, and varying, understandings of the role of engineering and of science in technical change. This was because most of the scientist respondents applied research, conducted feasibility studies or undertook prototype development. The Scientists who preferred *Technik* model of technical change tended to work in environments that helped companies with feasibility studies and prototype development. The scientists who mainly did applied research argued that it started from scientific knowledge and they generally believed the STH model. However, in Chapter 6 we found that the understandings of business people of the roles of engineering and science in technical change to be almost the same. Most of the respondents from companies had quite liberal and flexible views about the nature and the processes of technical change.

Beyond this, changes in the environment of technical change and how people respond to it depend on the 'rules' of the market place. Both scientists and business people argued that the government should play a role in influencing relevant aspects of markets. Scientists, especially, wanted the government to create regulations and procedures that might help scientists to participate more effectively in CTT. For example, respondent 27 (a scientist) argued that the government does not have the political will to ensure that its scientists get proper incentives and assistance with research and CTT. The delaying of decision making by the government, by both its administrators and politicians weakened the motivation of many scientists. Stiglitz (2006, 122-123) argued that, in spite of the rhetoric about intellectual property providing incentives, the incentives have not been translated into action. Respondent 31 claimed in line with Stiglitz, that she had involved in research and CTT for 10 years and she realized that the lack of sufficient incentives had hampered most scientists. Generally scientists and business people who were involved in CTT wanted heavy involvement of the government to create demand, particularly in the market segments where major customers belonged. The government was not, apparently, capable of rational and even-handed decision making.

There were also various uncertainties in government policies and procedures that affected scientists, university and GRI administrators that hampered the flow of scientific knowledge. In Chapter 6 we saw that most business respondents also blamed the system of government management and its bureaucracy that sometimes slowed CTT. They also found that there was a lack of coordination between scientists, its administrators and business people that might have been designed to harmonise and bring together their motives for CTT. Both administrators and scientists respondents indicated that they should be given incentives and rewards. Most scientists and administrators argued that that although the IRPA was meant to help nurture R and D in universities and GRIs, the intentions of commercialization was only been realized to any degree in 2002 (during the mid-term review of the start of the Eighth Malaysia Plan). Therefore, CTT had not been given strong support from the various parties. Most scientists and research administrators claimed that ‘having’ to pursue CTT was a sort of ‘bonus’. However, they were not only worried about companies’ systems for managing R and D, but also with responses of business people who largely had limited technical and financial capabilities.

Most of the company-based respondents preferred scientists to become their companies’ consultants to give them advice for technical development. The government wants another mode of CTT, such as the use joint ventures, start-ups, licensing, patenting and spin-off. Respondents 46 and 52, who were a TTO and a senior research administrator from the same GRI, also mentioned their Institute’s success rate of CTT in terms of their establishment of a Trust Fund and their contributions towards CTT. They argued that the government had put an emphasis on numbers of patents, licenses and of the formation of joint ventures as indicators of the likely success of CTT. However the company respondents had different grounds for their involvement. These included, first, the idea that technical change is the best source of growth for a company, although small companies preferred adaptations of more radical innovations or to become imitators. However, many SMEs in Malaysia tended to enjoy the comparative advantage of being near the end of relevant innovation cycles. This evidence of variety of needs reinforces the idea that the role of the government should be to decide on the most appropriate measures in each case, and generally to act as a supporter and facilitator of companies.

The study also shows that the role of TTOs and senior research administrators in CTT should come from a strategic perspective. The data also suggest that there need for more flexible university and GRI management of commercialization, for improving business skills of TT Officers and for the more effective financial support from the government for design and prototyping. The study shows, too, that any CTT mechanisms, such as licensing, start-up and sponsored research, should always be given adequate resources.

Relationships between university and GRI scientist and administrators on the one hand and venture capitalists on the other need to be improved, with the culture gap between them being bridged through the processes of setting up and monitoring commercialization agreements. Venture capitalists need to prove to themselves that new scientific knowledge is commercially relevant.

CONCLUSION

In this chapter, interview evidence on the apparent failures of companies to engage themselves in successful CTT, and of scientists, TTO staff and university and GRI senior research administrators to persuade relevant companies to use research findings from their universities and GRIs has been reported and discussed. The main data considered here came from 17 scientists, eight TTO staff, six senior research officers from universities and GRIs, three venture capitalists, two journalists and a politician. The data from the venture capitalists, the journalists, and a politician were sometimes about different things, but in general they supported the most significant views expressed by the other main groups of respondents in this study.

It has been suggested in earlier Chapters that opposed and mixed assumptions about the roles of engineering and of science in technical change are widespread in Malaysia and elsewhere. Generally, the survey respondents with engineering academic backgrounds understood that engineering is not an application of science. However, they appreciated the often vital role of science in engineering and its usefulness in explaining technical change. Respondents who had scientific academic backgrounds tended to favour the STH model more, and to emphasise their view that their research findings were relevant to the need of relevant companies. Their assumptions were based on their experience and their interest in research and its advancement of knowledge of their domain areas. However, the TTOs and senior research administrators argued that while scientists did generally work well on and through their research, companies did not often like the long-term nature of scientific research, or the time taken in universities and GRIs to organize commercialization agreements. The apparently very detailed control by the government in terms of IRPA and grants for CTT was not much liked by either the scientists or the company respondents.

In the next Chapter, Chapter 8, the findings that have been described and discussed in this one are summarised briefly and discussed, before considering some more general ideas relevant to the use of knowledge and innovation in industry, and the relevance of everything discussed up to that point to policies for CTT in Malaysia.

CHAPTER 8

DISCUSSION: A MALAYSIAN WAY?

INTRODUCTION

The purposes of this chapter are to discuss the research questions and the findings together in the context of some broader considerations, and to consider the relevance of the study to policy makers in Malaysia. The first section summarises and, in some respects, contextualises, the arguments and evidence of the study. The second approaches the question of whether there can and should be a specifically Malaysian route to economic development, and if so, what it might be like. The third section explores some issues related to this question, ones to do with namely industrialization and development. The fourth performs a similar function, but focuses on innovation and CTT, and on features of management and organization, and also the role of government that affect them. Finally, the fifth section draws the foregoing together to help produce an idea what a Malaysian route to economic development should be like.

THE STORY SO FAR

The main research questions concern with apparent failure by Malaysia companies to use research findings from universities and GRIs through the processes of CTT, and with the apparent failure of the government and scientists and others in universities and GRIs to persuade companies to engage in CTT. The two secondary research questions concern, together, the possibility of specifically a Malaysian approach to economic development and CTT, at all levels of policy-making. It is a concern of the whole of this chapter.

The first main research question, low up-take by companies, was attributed to several factors by respondents. This included lack of finance from companies or the government; zero or poor communication of relevant research findings; companies preferring their own ideas and knowledge to those of external researchers; foreign-owned holding companies or partners supplying new technology or preferring reverse engineering; inflexible and time-consuming government, GRI and university regulations and procedures; the long-term and/or ‘blue sky’ nature of research; and lack of CTT-related knowledge and skills among administrators in GRIs and universities.

The second main one, failure to persuade companies to commercialize new knowledge by the government, GRIs and universities, was attributed to scientists being largely concerned with advancing knowledge and with publications rather than with the profits of the companies that they may help; to the procedures and regulations referred to above; to CTT processes taking too long to satisfy market needs; to research administrators not understanding how CTT happens or how to make it happen; and to research administrators not knowing how to motivate and how to give time to researchers so that they involve themselves in CTT.

On the idea of a specifically Malaysian approach, a few respondents made comments about researchers and universities and GRI authorities needing clearer and stronger policies from the government on how to help companies with CTT. But apart from that, the respondents tended to be rather passive in their thinking. This appears to be because their responsibilities and the structures and procedures that they operate with constrain their time and imaginations.

Also relevant here is the fact that in Chapter 3, eight models of CTT were reviewed, and in general it was thought that they tended to be too complicated. Before the data were obtained, a simple relatively Double Loop Model was proposed (Abu Talib 2007), in chapter 4. This criticism and the act of replacing them were based on study of these other models and on their relevance and problems, and not on any empirical work. However the interview data did support the emphasis of the Double Loop Model on the overwhelming importance of communication between scientists, university or GRI technology transfer offices and companies, and also, in many cases, on funding from the government and companies.

On relevant contextual factors, facts and issues that stand out as particularly important concern the general nature and background of Malaysia as an economy and society, the present social and political context of Malaysia's economy, the beliefs about economic and social and social phenomena held by Malaysia's elite and their relationship with Malaysia's provision for CTT, and relevant educational and related matters.

On Malaysia's economic and social characteristics and as we have seen in Chapter 2, it is a middle-income developing country with a democratic, if in some less formal respects imperfect, system of government, with a mixed but mainly privately-owned economy, and effective public services of varying but improving effectiveness. There was a colonial presence in Malaya/Malaysia from the fifteen century to 1957, and during it the economy evolved from a simple agrarian one to one with a developing infrastructure and public services, extensive and often exploited commodity production and some basic manufacturing. The ethnic composition of the society changed under British rule, which lasted from the early-to-mid nineteenth century to 1957. By the end of this period, the result was that 30 percent of the population was (and is now) Chinese, about 10 percent Indian and about 60 percent Bumiputera. The Chinese tend to be more entrepreneurial than the Bumiputera or the Indians, and this has meant that there has been a need for the Bumiputera and the Indians to become more economically and politically dynamic in the last 50 years, to keep up with them.

As a participant in the world's economy Malaysia remains a large scale producer of natural rubber and oil and other commodities. But now about a third of employment is in industry. Employment in services is increasing faster than in other sectors, but most such employment is in such goods-related jobs as those in retailing. Manufacturing jobs are changing from assembly type branch factory ones under foreign control to more sophisticated ones in Malaysian or partly Malaysian-owned companies, especially in more advanced industrial sectors. Foreign direct investment and joint ventures with foreign companies are growing and more Malaysian companies are becoming more expert commercially, financially and technically. Exports have been changing in kind as well as growing in number and value, and import substitution continues. The economy is increasingly diverse, balanced and entrepreneurial. More companies are specialised, especially in ICT and biotechnology, but also in many other sectors. The balance of payments has generally been in surplus since the mid-1980s and the typical annual surplus has been growing. In general terms Malaysia is quite a successful economy. It is not a victim of the world economy in any sense. It is not a poor developing country. It is relatively industrial and it does not borrow from the

International Monetary Fund, for example the IMF-managed 'bail-out' in 1997 of Thailand, Indonesia and South Korea.

However Malaysia's leaders, while normally acting in quite dynamic and independent ways, are still to some extent influenced by Western managerial thinking. The educational backgrounds of ministers, industrialists and professional specialists are still often North American and British and similar, and Western education remains prestigious and influential in elite circles. The MBA, for example is very popular among senior managers of companies, and the concepts and the language of English-speaking business and management education, and also those of its higher scientific and technical education, pervade discussions of technical change and CTT.

Malaysian provision for CTT is an important part of the work of the government. For example, six out of 34 Ministers are responsible for Ministries which are involved with CTT either directly or indirectly: MOSTI, MITI, the Ministry of Human Resources, the Ministry of Education, the Ministry of Entrepreneurial Development and the Ministry of Higher Education. The IRPA has been operative for over 20 years and government discussions of the need for commercialization began around 30 years ago. IRPA started in the Fifth Malaysia Plan (1986 to 1990) and it has continued to expand since. The government changed and gave large emphasis to such important areas of research as biotechnology, ICT, advanced manufacturing, advanced materials, aerospace-related technology, and nanotechnology, whereas previously agriculture and its related industries were emphasised more. The number of IRPA grants that have been approved to areas of research has changed from time to time with agro-industry changing from 33.9% in 1996 to 2000, to 19.7% in 2001 to 2005. This is because the government reduced the priority and put emphasis research on engineering and science in universities, from 19.5% to 26.9% in the same period, when the emphasis on manufacturing grew from 8.7% to 14.5%. The amount spent on IRPA research grants in 1996 to 2000 was £102 million. In 2001 to 2005 it was £132 million and the amount allocated for 2006 to 2010 is £225 million. The amount spend on CTT was £29 million in 1996 to 2000, £38 million between 2001 to 2005, and for 2006 to 2010 it will be £263 million. The number of researchers was 15,022 in 2002, 17,790 in 2002 and 27,500 people (estimated number) for 2005 (EPU, 2006).

Finally on these contextual factors, there is an apparent tendency in Malaysia that is referred to in Chapter 3, for considerable faith to be put into vocational education as a source of wealth (Illich, 1971; Dore, 1976). Such faith can be questioned for the kinds of reasons explored by Illich and Dore, insofar as modern schooling and the pursuit of credentials often seem to exist for the sake of social control and personal and institutional ambition rather than to give people genuinely useful knowledge and skills.

Education that is very instrumental and focused can help to produce people with weak values and distorted priorities, whereas education that is genuinely independent and thoughtful can be the most effective basis for practical learning and action. For example, the UK, before, during and after the Second World War, has been criticised strongly for being led by graduates in the classics and the humanities, whereas Germany tended to have a more technocratic elite (Barnett, 1972). Surprisingly perhaps, the UK, with about two thirds of Germany's population, and no slave labour to supplement it, produced significantly more military aircraft than Germany in the Second World War, many more naval ships, and more tanks and artillery pieces per head of population (Ellis, 1993).

TOWARDS A MALAYSIAN WAY

According to Sorge (1985, p. 244) ‘the appropriate way of transferring experience and recipies from one culture to another… does not involve imitation but ingenious and judicious tinkering’. This means that work and employment are always organized, and people experience them, in ways that are always full of conflict between extremes, with ambiguous processes and change and instability always present. Similarly, choices can always be made, but they are always constrained. Simply to imitate something attractive in another country, or industry or other social institutions can be unsubtle and even dangerous. Different institutions and practices in different societies are, after all, different institutions to different societies. The culture of a human society or social institution is everything that it consists of. It is the sum total of all of its material artefacts, all its the historical experience and all of its ways of life. It has three components: the material ones include its climate and geography, the bodies of its people and or the artefacts that its people construct. The social ones consist of all the institutions of a society, for example, families, friendships, companies, government departments, public associations and so on. The ideational ones consist of its members’ beliefs, attitudes, opinions, values and ways of acting and behaving (Sorge, 1982; 1985).

If a society tries to impose its institutions on another it is likely to experience serious difficulties (see for example, Sorge, 1985, and Locke, 1996). After the Second World War the USA tried to impose some aspects of American management on Germany (Sorge) and Japan (Locke on both countries). However, each country had its own strong and distinctive approach to management, which in both cases was engineering-based and specialised. Companies in both countries tended to copy superficial aspects of American management while, in general, carrying on as before. Sorge (1978) reported how a firm of American management consultants produced a report in 1973 saying that Germany had a ‘management gap'. In other words, it did not have general managers with non-relevant or business administration first degrees and MBAs. Sorge (1979) and Calori and de Woot (1994) both argued that any given independent country had developed its own way of organizing and managing work. This was always a product of its history and was deeply embedded in the society along, for example, with its systems of education, kinship, production and consumption.

Numerous writers including Locke (1996) and Locke and Schőne (2004) have argued that there is a fundamental difference between continental European and North American and other former British empire countries approaches to management (see also Glover and Hughes, 1996). Glover and Hughes called them the *Technik* and (later, Business) Management approaches. The former tends to emphasize the value of production, process, the long term, management *in* specialist activities, and more positive side of the state's role in economic life. The latter, the neo-American or the (Business) Management Model, stresses consumption, outcome, the short term, management *of* specialist activities, and the more negative side of the state's role, Glover and Hughes (1996: 5). Later, Locke and Shöne (2004) explained how use of the generally more effective *Technik* approach in the USA could be successful in a country widely regarded as the home of the opposed Business Management one.

Different countries have different needs and priorities. Often the priorities are flawed and sometimes even badly mistaken. More generally, capitalist societies take many forms. Some provide more social welfare than others, and some are run by technocrats whereas others are run more democratically. There is great variation in levels and kinds of regulation by governments. Some countries tend to ignore the rules and wishes of regional and global supra-national organization like Association of South East Asian Nations (ASEAN) and the World Trade Organization (WTO), and others do not.

There are also conflicts and trade-off between values and economic rationality. When a country has a comparative advantage in the production and sale of some good or service, it may dominate markets at the expense of the values of those who buy the products. In other cases, countries will spend more on things that they value than they actually need to. The development of a given economy and society is not simply matter of economic growth. Growth can take many directions. For example, the environment may be seen as something that deserves the utmost respect, or something that can be damaged but perhaps eventually repaired. Similar arguments can be applied to people. They may be employed like commodities simply to help an economy grow exist or they may be strongly valued and developed as individuals. Cairncross (1995, p. 66) argued that growth of populations and incomes meant that the world's resources are being used on a larger scale than ever. There have been shortages of energy and food in individual countries and regions of the world since industrialization began. But in the most recent decades they have contributed to pressures on population and on other resources. Growth that does not respect the environment tends to reduce the quality of life and to affect poorer people more than richer ones, with the former being much more numerous. As populations have become richer they tend to become more environmentally concerned, but possibly more because they have damaged the environment in the process, than because their wealth has enlightened them.

According to Stiglitz (2006), much post-1945 economic decision making by the most powerful countries has damaged the weakest ones. This has meant that processes of successful development have not always been well understood. Today, according to Stiglitz, some of the factors that favour successful development are economic growth and stability, lack of poverty and of severe income inequality, full employment, sound balances between governments and markets, democracy, efficiency that is not completely due to self-interest and market forces, reasonable economic equity, and social consensus, at least some serious concern for the environment and at least some support for basic research, reasonable consumer protection, and the existence and tolerance of social and cultural diversity. These things are, in fact, when taken together, successful development.

Economic development also requires lack of serious vulnerability to damaging external forces and good internal financial management. High levels of debt tend to handicap development. Innovation should be facilitated by liberal and fair intellectual property laws, by government support that both rewards and punishes companies as appropriate, by understanding financial institutions, by investment in both engineering and scientific education and research, and by companies that value positive change.

Barney (1991) argued that any firm had three kinds of resource or asset. Physical resources meant hardware, plant and equipment, access to raw materials, and geographical location. Human resources consist of such things as experience, training, intelligence, judgment, relationships and individual insight. Organizational resources consist of such things as formal structure, formal and informal system of planning, controlling and coordinating; and informal relations inside and outside the firm. Some resources made firms more viable and competitive than others. Such resources needed to be valuable, rare and impossible to substitute and difficult to imitate. Barney's statement of the Resource Based Theory of Firm was used by Pringle and Kroll (1997), who argued, as we saw in Chapter 5, that the British had defeated large and stronger French and Spanish fleets at the Battle of Trafalgar (in 1805) because they had superior skills and seamanship and gunnery and a much longer seafaring and naval tradition. According to Pringle and Kroll the biggest assets of the Royal Navy were the human and organizational resources of its seafaring heritage, a winning tradition and the ‘superlative leadership of Horatio Nelson’. The British naval tradition was arguably 1000 years old. At the time of Trafalgar it was highly innovative, co-operative, creative, confident, skilled, aggressive and motivated. Its strongest traditions were arguably adaptability and innovativeness.

If Malaysia is thought in terms of having physical human and organizational resources, some of which have the attributes of key ones (being valuable, rare, unsubstituable and very hard to imitate), they might be described as follows. The physical resources include plentiful resources of energy and minerals, more than adequate housing, a modern transport and communications infrastructure, and a strong agricultural sector. The human resources are increasingly well educated with expanding numbers of state and private schools and colleges, and 46 universities for a population of 23 million. Literacy is quite high and total educational provision is expanding. Technical education needs to expand, but it is doing so. On the organizational resources, there is a lively system of economic planning with state support for the expansion of firms, in the generally being economic integration. Provision for health, education and welfare, both public and private, is generally sound and expanding. Much state-supported economic expansion since the 1980s has been concerned with ICT, but since the late 1990s the focus has been shifting to biotechnology, partly because this matches the country’s natural resource endowments.

Some brief further indicators of what a Malaysian way might look like can be gleaned from the following arguments. On economic development, Salih (2005) compared it in South East Asia (Malaysia, Taiwan and Singapore) and South West Asia (Iraq), against a background of the experiences of various other countries. Salih argued that for a developing country to develop successfully it needed to invest in human resources, science, and technologies that are aimed at the future; agri-industrial capacity and links; and the spirit of entrepreneurship. Ismail and Yussof (2003), on labour market competitiveness and foreign direct investment (FDI) in Malaysia, Thailand and the Philiphines, found that varied labour market characteristics tended to affect FDI inflows differently. For example, Malaysia had allowed many foreign workers to enter the country, and this had curbed wage increases. Also Malaysia encouraged foreign companies to export what they produced in Malaysia so that their product policies did not need to be strongly Malaysia-centred. There was also evidence that the growing number of Malaysia's professional employees tended to work for Malaysian and not foreign companies, probably strengthening the former at the expense of the latter. Further, when Malaysia spent more on R and D, FDI inflows tended to fall because Malaysia seemed to be getting less reliant on foreign technology. The main conclusions were that Malaysia's wage levels, interest rates and levels of employee qualification were low enough to keep the country attractive for FDI for some time to come, without FDI being a threat in any serious way to economic growth and development. On environmental policy in Malaysia, Hezri and Hasan (2006) discussed what they saw as its four phases of development since 1971. They did so in the contexts of changing environmental concerns and concepts, and of Malaysia's changing, meaning largely expanding and improving, relationships with the rest of the world.

On relevant educational and related economic issues, Lai and Yap (2004) argued that 'the availability of skilled human capital in Malaysia is not sufficient for technological development to progress'. They compared the availability of the 'strategic resources of' human capital, R and D, S and T [science and technology] parks, foreign technology transfer and GRIs' in Malaysia with the same in the Republic of Korea, Singapore and Taiwan. The data in this article are significant for policy, and are discussed at greater length below, as are the arguments of two other articles, by Neville (1998), and Sohail, Daud (2006), on managerial changes in Malaysian higher education.

Public management reforms in Malaysia are dealt with by Siddique (2006). This is discussed below. It is relevant because CTT depends partly on competent public sector management. Finally, the concept of psychic distance, a mixture of geographical distance and culture, (see, for example Child, Ng and Wong, 2002; Hassel and Cunningham 2006), is also relevant and is also useful for thinking, for example, about whether Anglo-Saxon culture likely to influence that of Malaysia for much longer.

INDUSTRIALIZATION AND DEVELOPMENT

So far in this and earlier Chapters we have been seen that the ‘failures’ of companies to commercialize scientific outputs and of scientists to persuade companies to use their work are attributable from such factor overly high expectations of the industrial potential of science through to practical problems of making it commercially useful to sometimes trivial organizational deficiencies and personal inadequacies. We have seen how Malaysia has the resources to become a dynamic advanced industrial economy and that it is using them with ever greater confidence and ability. We have, however, also expressed numerous doubts as to whether all aspects of modern thinking about industrial innovation and management are squally relevant to Malaysia’s needs, or indeed, to everyone’s.

Some of the arguments of this section have already been made in some detail in Chapter 2 and in some other chapters, and when this is the case they are generally spelt out quite briefly here. They concerned, in Chapter 2, with the continuing and indeed growing importance of industrialization as the world's major kind of and force for change, and the organizations of contemporary advanced or partly advanced industrial /industrializing economies under alliance capitalism. They concerned the contemporary tendency to overrate globalization as a force and as a master trend, and the tendency to exaggerate the impossible of formal education as a provider of useful knowledge and skills.

The industrialization that Malaysia, along with many other countries, past, present and no doubt, future, is pursuing is important as a force in the world for many reasons. One of the most persuasive is the fact that in about 50 years after the Second World War, world industrial production grew sevenfold, when the world's population 'merely' doubled (Cairncross, 1995). Another concerns the way in which manufacturing, which so often replaces employees with machines, nevertheless generates many millions of goods-related job in services, upstream (for example in design, investment analysis, market research and extraction sectors) downstream of factories (for example in retailing and the maintenance and repair of goods). Another example is that there has been a long-term tendency to replace personal services with various machines, as when computers and voice recognition software replace typists or audiovisual equipment replaces live entertainment. Goods are thus used by us to provide services for ourselves, replacing services provided by others as our employees or as employees of others. Further to, and also suggested by all above three reasons, is the one that development of manufacturing, and of industry defined more broadly, to include energy and construction for example, tends to precede and underpin many other kinds of innovation, in services and manufacturing, and outside places of work as well (Tagiuri, 1965).

Finally, and all taken together, these forces and changes mean that we inhabit, in the developed world at least a very technically sophisticated highly goods-dependent economy and society in which divisions of labour are unexpectedly complex and interdependent, with most employment in industry being services types and with most employment in services being viable only when reliant on the use of sophisticated and often expensive hardware.

The process of industrialization arguably began in the late Middle Ages with the beginning of industrialized warfare headed by the widespread use of gunpowder, and with modern forms of communication facilitated by the invention and use of moveable type of printing and the magnetic compass for navigation (Glover and Walker, 2007). However, mechanization, the first of four phases of industrialization proper, began with the invention of the steam engine, the archetypal machine of this phase, and loosely associated changes in energy supply, in large and small scale metalworking, and in mechanical engineering more generally. The second phase, starting in the second half of the nineteenth century, had two major components and has thus been called electrochemicalisation. The two components are the discovery and use of electrical power and the development of the chemicals industry, and later in many respects the pharmaceuticals one. The archetypal machines of this phase were and are the electric motor and the chemical plant. The third phase belongs to the second half of the twentieth century and to a lesser extent, the opening decade or two of the present one and it is infotechnologization, with its archetypal machine being the computer, or more precisely, the personal computer. The fourth one, biotechnologization, is currently accelerating into major prominence and dominance, although its early origins go back thousands of years, to beer-brewing and viticulture for example. The archetypal machine of biotechnologization is the android, combining use of mechanics, electricity, electronics and biology with important and major attributes of all preceding technologies.

Many other technologies and machines have been invented those are as old as these just referred to, and nuclear and renewable sources of energy have not even been alluded to.

However, virtually all past, current or projected technologies and machines are related, or relatable, to at least one of the above. Whether they are in a process of exhausting all possible technologies and machines is probably unknowable, but Leonardo da Vinci and H. G. Wells, among others have shown how it is possible to imagine future ones, including some that are invented several decades or even centuries after the idea of their existence was first spelt out for posterity. Glover and Walker (2007) estimate that the pace of technical change will be very much slower than it is now by around 2300, but admit that this is a fairly wild guess. However, it does still seem fair to agree with the stance taken by Ackroyd, Glover, Currie and Bull (2000) nearly ten years ago, that technical change is unlikely ever to be as significant, fast and dramatic as it was in the half century around 1900.

The context of a developing economy like that of Malaysia is made up, therefore, in a large part by the industrialization that Malaysian government has embraced for over a generation. It is important, as claimed earlier in this thesis, that economic growth does not neglect the natural environment or treat it brutally (Cairncross, 1995). Growth that takes more from the Earth than it returns to it, and which thus degrades it, has quantifiable economic costs. Permanent or long-lasting damage to soil, to forest, to sources of water and seafood may produce high short-term gains for the few and some benefits for the many, but they are normally outweight by the cost to all, even in the very short term. Pollution and poverty have long gone hand-in hand, but serious and effective efforts to end them tend to do the same, so that a clean environment with high environmental standard and a wealthy and healthy society also tend to go together. This lesson needs to be learnt or a world level and applied using principles of equity and appropriate economic incentives, with poorer countries paid fair prices for their labour and natural resources, with much more serious attraction being given to overpopulation than has been apparent to date, and with international political and economic institutions, governments and large international companies encouraged or forced to behave more co-operatively, democratically and responsibly (Stiglitz, 2006). In Malaysia, public, government-ordained environmental controls have been opposed by industries, which have padoxically been encouraged to do so by the government policy of highly valuing rapid economic growth (Nor, 1991; also see Aiken and Leigh, 1988:; and Visvanathan and Tiong, 1999).

In Chapter 2 attention was drawn to the highly and apparently ever-increasingly complex and interdependent nature of economic divisions of labour between and within firms and between and within countries (Ackroyd, 2002; Glover, 2003). This direction of change is reflected well in international trade theories, which increasingly take account, beyond different national resource endowments and the value of interdependence, the growing tendency for multinational and transnational firms to trade with themselves and the pursue competitive advantage by operating within complex networks of firms in and across relevant sectors (Daniels, Redebaugh and Sullivan, 2004). The same theme is tackled from another angle in theories and accounts of the industrialization of firms, where the development and nature of theorising shows clearly that while big business remains big business, it is more complex and fragmented, but more interdependent and less monolithic than in the past.

One of the most recent approaches, the network one, explains how the more intentionally experienced a firm gets the bolder it seems to become. It becomes keener to get involved with other companies in various ways, often changing its own shape in processes like internationalization, alliance-building and off shoring. It masters diverse location, no longer being overawed by them. Its reputation and capabilities help it to increase the capital available to it, and to overcome deficiencies in its desired level and pattern of ownership. In recent decades in the developed and developing worlds, whole national industrial sectors have internationalized. This is because of intersectoral, interdependencies, between networks of suppliers of capital, ideas, information, materials and parts, assemblers, producers, distributors, sellers, users, repairers and maintainers, hirers and so on. Competition and technical change often disrupt such networks and often encourage involvement of foreign companies. This all means that firms increasingly work in internationally integrated activities and networks. The higher the degrees of industrialization become, the stronger the international networks become. Such networks typically involve SMEs and/or subcontractors as well as larger and more dominant companies (Ghaury, 2000). Malaysia's economy contains a high proportion of SMEs, and levels of FDI are high at increasing and these characteristics are increasingly representative of it.

ASEAN is important to Malaysia because its members receive a high proportion of Malaysian exports, because its members' economies have grown and are growing fast, and because its roles, economic, environmental and political, are expanding, although there is some disagreement among its members about the directions that these roles have been taking and are to take in the future. Malaysia is a member of the World Trade Organization (WTO) and its economic policies are affected, as are those of most countries, between its loyalty to its fellow members of ASEAN, a free trade area, and its commitment to the wider aims of the WTO.

In general communal and economic relationship between Malaysia's Bumiputera, Chinese and Indian populations are good. Bumiputera people do not identify with any other ethnic or national group apart from themselves. Constituting some 60% of the population, they have considerable freedom to develop socially, economically, educationally and politically in several directions, or none apart from their own. They also have no great need to pursue fashionably 'high-tech' routes industrially, at least not at the expense of other that could be more congenial and/or profitable. But they do need education that will suit whatever return of alliance, or possibly other, capitalism, they choose to develop. At present the education system is inherited from the British with growing element of US-style management education for graduates. Increasingly, however, vocational education for business and management is bearing more country-specific.

The disadvantages and problems of industrialization have been, and are considerable. Two World and numerous other Wars since the 1850s have arguably been encouraged and fed by the availability of ever-more destructive, novel and sophisticated forms of hardware. Old ways of life have been disrupted and diseases spread by it and by preceding but related changes like ones in navigation, transport, warfare and agriculture since the fifteenth country. Last, but far from least, there is now accelerating environmental pollution and global warming.

INNOVATION, MANAGEMENT AND THE ROLE OF GOVERNMENT

In Chapter 3 a fundamental issue concerning CTT was raised. Industry is the main home of engineering, which uses, or 'applies' scientific knowledge, but this is a very different activity from scientific research. This suggest' that the commercialization of new scientific discoveries is not likely to be an easy task for industry, except perhaps when certain sectors, like chemical and pharmaceuticals, constantly employ significant numbers of staff with scientific qualifications. However very large segments of the education of engineers are in scientific subjects, and a scientific, meaning analytical and curious, cost of mind is an asset in most situations, not least those in which scientific knowledge is routinely used as a resource, for important or vital information. Both engineering and science demand analytical, disciplined and linear thinking and more intuitive, unconventional and divergent types or inputs. There are, therefore, at least intuitive grounds for assuming that the presence of scientists and scientific thinking around engineers, often of people with diverse disciplinary backgrounds, will enhance the intellectual and creative work of the former. Moreover, the evidence and arguments of Tagiuri (1965) reinforce this assumption about thinking styles with some points about educational and social backgrounds and individual values. Tagiuri was interested in a tradition of social research into presumed contexts of values between engineers and/or scientists and managers working in industry. Managers, many felt, would value commercial, financial and economic achievements, whereas engineers would value the capabilities, quality and at times the aesthetic features of the products that they designed and made, and whereas scientists would value the quality and beauty of their intellectual efforts and solutions. In the past studies, researchers had asked members of each group what frustrated and pleased them in their dealings with the others.

Not surprisingly, perhaps, each group had spoken of managers interfering with their desire to be creative, swamping them with 'bureaucracy' closing excellent projects down for short-term financial reasons, and treating them like children in other ways, and so on (see for example, Cotgrove and Box, 1970). Tagiuri felt that the researchers who had reported a number of American and British studies of scientists or engineers versus managers in industry had asked their respondents leading questions like 'Do you feel that you lack autonomy in your job?, which had elicited spurious replies. In other words the industrial engineers or scientist would say "yes", the management never leave us alone' or anything similar in order to get sympathy from the researcher and whoever would later read their report. This was an example of 'socially respectable' responses or of the famous 'Hawthorne Effect' in industrial sociology, when the very act of doing research creates certain 'results' or 'thinking' that would never have 'existed' otherwise.

The relevance of this to the presence study, in which managers and professionals on the one hand, and scientists on the other, gave answers of very much different kinds that might have been predicted from knowledge of their backgrounds, the questions asked, and their situations. In my opinion, their answers seemed were perfectly valid on the whole, although they seemed to be a few examples of socially respectable and specious answers. In particular, some of the senior research administrators seemed to be trying to gave me an impression of effort and ability on their part which the content of other interviews of various kinds seemed to cast doubt on. However, Taguiri's main point was based on his own research. He got samples of managers, engineers and scientists to complete a questionnaire that asked them to supply information from which he could work out the degrees to which their personal values were aesthetic, economic, political, theoretical, religious or social. Engineers might tend to be aesthetic and economic, businessmen economic and political or social, scientists theoretical, and so on. What Tagiuri actually found was that all three types similar values, ones typically of white Anglo-Saxon American managers and professionals, who had happened to have chosen one from three different occupations to belong to.

The respondents tended on the whole to realise that industrial companies were mainly do engineering, and that science is only relevant occasionally and usually only shows itself when they think that scientific knowledge can be used to help increase profits. However, they tended to believed that it could often do so, and they also felt that scientists could be very useful people to employ in engineering contexts. They could often offer different and original perspectives and help to trigger off and to pursue view and profitable lines of thinking.

The real danger to innovative work in Malaysian industry may not come from any of those employed in it, except perhaps from some of those employed it the highest levels.

Researchers and writers on management and management work like Geneen (1986), Jackal (1982) and Kolter (1982) have noted how egoism and selfishness can limit the potential and achievement of managers. Geneen attributed failed careers to 'egotism, not alcoholism'; Jackal explored managerial careerism, presentationism and politics in some depth; and Kolter described how most managers began new jobs with 'an agenda' a desire to 'make a mark on the organization' through a mixture of achievement and networking. This kind of behaviour was linked to managerialism by Enteman (1993), who argued that efficiency was the main target of present-day managers, whose ambitious consisted of running organizations for themselves and themselves only, with other managers the only people whom they wished to please.

According to Glover (2003) the values and beliefs of managers, especially young graduate ones, and of business and management education were as follows. The pace of change in the world is accelerating, as competition and as a new phenomenon globalization. Technologies and cultures are growing ever more able across the world. Services are growing, and manufacturing declining, in influencing as sources of employment and wealth. To get staff to work effectively, it is vital to manage culture, or 'the way we do things round here'. Bureaucracy is bad and decreasing in importance and organic organization is the opposite. Service and technology are replacing engineering in the new knowledge and information and post-industrial-economy and society, in which more and more employees are knowledge workers. Innovative methods and systems are increasingly effective, replacing older ones, in business and management. They are best used by a new elite of dynamic young managers which is needed to engineer and manage the business processes, and the economies and societies of the globe. With their help and under their management, the economies and the societies of the globe should eventually converge into one global economy and society.

This sub belief is embodied in many English-language management textbooks. It is taught to many students from their mid-late teens onward. The beliefs are largely mistaken: apart from points already made about globalization, competition, the pace of change, manufacturing and services, engineering and service and the uses of knowledge, human societies or cultures normally converge and diverge at the same time, and bureaucracy is about efficiency and fairness, whereas organic organization is often inefficient, stressful and political, and a nursery for bullies. What most distinguishes Anglo-Saxon, or Anglo-American, managerialism is its selfish and aggressive ageism. Its appeal is to be sweep whatever is older to one side (Glover and Branine, 1997). There may be some in newly industrial countries like Malaysia who might usefully be aware of this, and who may have distanced themselves, them thinking and their policies, too high above the realities of technical work in industry.

There may, in fact, be a deep problem with the whole idea of managing innovation. Webb (1992) hinted at this in her report of her study of medium-size company in the UK components industry. The management claimed to run the company as a permissive, high-discretion, high-trust workplace but 'innovative was undermined by fear of failure at the top management levels (p. 490), resulting in defensive management, lowered performance and job losses including one at professional and management levels. In Malaysia the relevant contrast may not be anything like as stark as those depicted here, but the more government erects structures around those given creative tasks to perform and the longer it fails to get the balance between control and autonomy right in they day to day work, to greater the danger that long-term damage will institutionalised in relevant habits, expectations and structures.

DISCUSSION: A MALAYSIAN WAY

Malaysia is a newly developed, newly industrial country, a little inexperienced in all of the complexities of international economies and politics. On the other hand its leaders and its people are more likely than counterparts in more experienced but cynical settings to look on the outside world with clear, unjaundiced and unbiased eyes. Malaysia also has the advantage of being an indigenously wealthy country with plentiful natural resources, some offshore, that include ones that can attract tourist in large numbers. These points suggest that while Malaysia should not be slow to consider its national security, it can rationally afford to indulge in 'satisfying', less than fully economically rational, behaviour (March and Simon, 1958). This means that it does not need to strive to assert itself against or over others or to prove itself to itself in any way, so as to maximise all or most of its outcomes. It means that it can opt for sustainable development rather than for development or any price.

The above point also leads to the suggestion, about education, and along similar to those presented in the previous section, to be creative with education by indulging itself with a certain amount of experimentation. It can afford liberal vocationalism, producing citizen with principles, open minds and useful knowledge and skills, people who combine the graduates of the philosopher-king and the true, meaning broadly educated, general as well as specialist, technocrat. It can follow Illich (1971) by explicitly trying to avoid 'schooling' young people to conform and follow authoritarian principles, while actively helping them to obey those whom they respect and work with disciplined ways while starting to achieve self-disciplined.

Education should be valued to its own sake. There should be no contempt-rather the reverse-for the practical and for the intellectual. An ideal of source should be uncalculated, but it should stand in a mutual and synergistic scholarship with enlightened self-interest. Pride in all of the positive features of Malaysia, its history and its people should be valued and when appropriate rewarded. The notion of civil surely should be principally concerned with including habits and expectations of self-government, with the state explicitly in the service of the people. Membership of supranatural organizations like the WTO and ASEAN should be assertive, benevolent and active. Economic management has, however, already been discussed, as how relevant environmental points.

Lai and Yap (2004) make a number of recommendations to technology development in Malaysia. They emphasise on producing service as opposed to arts graduates, more education and training involving the private sector, more liberal immigration policies, more collaborative involving foreign companies in R and D, more active and efficient management of science and technology parks, more FDI abroad and more technically sophisticated SMEs and more and more sector-focused GRIs are all advocated. These are logical recommendations on the basis of relevant evidence, but the mixture of top-down leadership and self-sustaining business activity is arguably slightly biased in favour of the former.

To sum up, a truly Malaysian way would play more often to the existing strengths of Malaysia and its people, and be somewhat less tidy, structured and imposed from above. It would accept the strong probability that most Malaysian want to be wealthier and to inhibit a technically sophisticated society, but it would also seek explicitly to build on the strength offered by Islam, Confusion and other religious and philosophical traditions; it would seek to define and pursue appropriate kinds of technology for the Malaysian contexts; and in line with pursuing sustainability, it would generally refrain from pursuing aggressively wasteful growth. It would accept, further, the inexperience of the relevant parties with CTT and generally encourage those involved to develop their own forms of them and methods for pursuing them. This would, at time, involve the government acting proactively, but the word proactively should be accepted as one that can mean very different things in different sectoral and other context.

CONCLUSION

This chapter has emphasised a need for ‘softer’ aspects of CTT to be pursued in Malaysia, including an approach that understands and develops without its own limitations. It has sought to think about CTT in a broader and more subtle and thoughtful way than has usually been the case in the past. More specific ideas and recommendations follow in the last and final chapter.

CHAPTER 9

CONCLUSIONS

INTRODUCTION

First, in this final chapter, the aims, research questions and methods of the study are restated and followed by a summary of the thesis. Then, the study's main focus, the preconceptions, and some key findings and their implications are discussed briefly. The theoretical contributions of the thesis are considered next. The limitations of the research and the thesis are then noted, partly to underpin the arguments of final three sections, which consist of some general policy implications of the study, some specific recommendations for policy, and recommendation for further research, which include methodological ones.

SUMMARY OF THE RESEARCH AND THE THESIS

The aim of this study has been to describe, investigate and explain the perceived the low rate of adoption and commercialization of inventions and knowledge in Malaysian manufacturing companies. The topic was chosen partly because Malaysia is a developing country, with GDP per capita of about £2,970.00 in 2006 and a generally high rate of economic growth. Other reasons for interest in the topic included certain differences in management language and assumptions involving use of rhetoric about globalization, the presumption of accelerating economic and social change, an apparently growing belief in the notions that science is the main source of technical change, and that advanced economies are 'knowledge' ones. The social and educational backgrounds of Malaysian leaders, professionals and managers, which have been influenced by Western, especially British, approaches to learning and human resource development, appeared to be potentially important influences on their actions and values. Therefore the work began in search of answers to the suggestion that Malaysia may have particular strengths and weaknesses in its attempts to commercialise scientific knowledge from universities and GRIs. The respondents in the present study that used 60 semi-structured interviews of seven types of interested party were: managers and professionals from companies; scientists, technology transfer staff (Technology Transfer Officers: TTOs), senior research administrators, all from universities and GRIs; venture capitalists, a journalist and a politician.

The aim of this study was pursued by seeking answers to two main and two supporting research questions, by administering seven differently-worded interview schedules to the seven groups of respondents. The main research questions were concerned with why many Malaysian firms do not appear to make use of scientific knowledge produced by Malaysian universities and government research institutes, and with why university and government research institute researchers, whose work is funded by the government and intended to be commercialised by Malaysian industry, apparently failed to persuade many companies to use their knowledge. The supporting research questions concerned the notion of the possibility of a uniquely 'Malaysian way' to enhance the technical and scientific sophistication of industry, and with the actual relevance to industry of the scientific knowledge aimed at it by Malaysia's university and GRI scientists.

Eight chapters follow this. Chapter 2 discusses the nature and the potential of Malaysia's economy. The main foci are economic policies and the development of manufacturing. It also offers a discussion of the importance of understanding industrialization to the thesis. Industrialization, and not globalization, is thought of as the master change of the present era. The assumption that effective HRM, including formal vocational education, was vital to innovation was also, like that of globalisation, criticised. There were also preliminary evaluations of the Malaysian economy based on PEST and SWOT analyses, the Boston Consultancy Group's Matrix, and the Dynamic Capabilities version of Resource-Based Theory. These evaluations suggested that there are several kinds of policy-maker with varied values and objectives influencing the Malaysian economy. Chapter 3 reviewed some of the main assumptions, concepts, and influences on them, that are used in studying problems of CTT in Malaysia. Key foci included the backgrounds of researchers who have written influentially about technical change. It presented two models of technical change based on different assumptions about human nature, knowledge, skills, and the use of knowledge for practical ends. Key concepts were classified in ways that divided them into five main headings. Another aim of Chapter 3 was to focus on the seven most salient concepts used from 25 concepts for this study that was discussed as Appendix 3. The seven were commercialization, entrepreneurship, innovation, invention, the management of change, research and development and technology transfer. It also goes on to discuss eight extant models of CTT, which generally assumed that the main parties involved in it were scientists and entrepreneurs. The author also offered her own Double Loop Commercialization Model, which stressed the importance of demand, supply and effective communication in CTT. A brief constructive critique of the values and interests of, and of the mental models of control of events used by, most of the various parties involved was also made.

In Chapter 4, an overview of Malaysian commercialization and technical change policies and practices was presented. It was seen that the contributions of CTT to Malaysian economic development tended to be lag behind politicians’ expectations. However, it was noteworthy that the institutions and people involved proved to be important in the processes of CTT. This chapter also provided descriptions of the roles of the master models of technical change for understanding CTT in Malaysia. It appeared that technical change in Malaysia was more based on the technical ingenuity of business people, so that the *Technik* model of technical change was more realistic than the STH one. Various types of discovery and invention from Malaysian universities and GRIs were considered in the course of this discussion. This chapter ended with the presentation of the author’s new model of commercialization, the Commercialization Loop Model, which appeared to be quite broadly applicable, and to help indicate which kinds of people contributes most to CTT in Malaysia (Abu Talib, 2007).

Research methods were discussed in Chapter 5. The method for gathering data for this qualitative study was interviewing. The interviews were semi-structured and used relatively open-ended questions. Each group of respondents had its own partly different interview schedule. Appendix 1 (Research Participants) documented all the interview findings in some detail and reviews a little of documentary evidence taken from the companies and other organizations that supplied by the interviewees. Data from companies and scientists and other respondents were dealt with separately. The most powerful findings concerned many companies seeing CTT as not relevant to them, and making criticisms of the qualities and procedures of the administrators of CTT in universities and GRIs. Venture capitalists were also criticised, for lacking interest in working with scientists.

Chapters 6 and 7 discussed data from the company managers and professionals, and from the scientists and other public parties. These two chapters were mainly focused on the respondents' assumptions about technical change and CTT; the processes of CTT; and the role of government in trying to foster it. In Chapter 6 it was seen that some company managers and professionals regarded many research findings as irrelevant to them, but that others did find them to be relevant. The latter tended to work well with universities and GRIs, and tended to take up grants provided for CTT. The main elements of successful CTT included scientists' involvement in the process and the establishment of companies near universities' and GRIs' premises, including the use of incubators or technology parks. Most company respondents considered that any involvement in CTT could be expensive in terms of time and money. Companies preferred relevant research findings that profited their companies. Although some companies did try to meet the requirements of getting grants for CTT, the processes sometimes discouraged them. Further, they believed the attitudes of some scientists who refused to share all their knowledge were blurring the missions of successful CTT.

Some scientists felt that involvement with CTT tended to pressurise them. Scientists could and did work well with companies, sometimes as consultants. TTOs, however, often lacked necessary skills and resources. Venture capitalists argued that they would prefer to work with companies rather than with scientists. Differences in culture and poor understanding of policies and practices sometimes did contribute to the failure of companies to take up research findings, and to the failures of scientists and their administrators to get them to do so.

In Chapter 8, the author briefly discussed how a 'Malaysian way' towards successful economic development and CTT, might be found, in a theoretical and practical context in which, as Sorge (1985) argued, choices can always be made, but always in ways constrained by resource and other limitations. Different institutions and practices in different societies are different institutions to different societies, and, therefore, each country's ambitions, ways of achieving them, and achievements, are always unique. The culture of a human society or social institution is everything that it used to be and which it now consists of. For Malaysia, in its present context, the higher the degree of industrialization becomes, the stronger the international networks become. Malaysia's economy contains a high proportion of SMEs, and levels of FDI are high and increasing, and these characteristics are highly representative of it. .The other main focus of discussion was a specifically Malaysian route to economic development. It was partly about education and inculcation of liberal thinking, producing citizens with principles, open-minds, and with useful knowledge and skills, people who combine the qualities of the philosopher-king and the true, meaning broadly educated, general as well as specialist, technocrat.

In the contexts of respondents' arguments on government policies, companies' managers and professionals spoke of being concerned about a lack of readiness on the part of government venture capitalists to invest in companies. This was also referred as lack of commitment by government policy-makers to look on university research as being a fully respectable part of the government's agenda. They also felt that most government-funded inventions and discoveries were not publicised enough to companies and businesses. Companies argued that they had advanced knowledge of technology and production but did not try hard enough to disseminate it widely.. Further, TTOs emphasised their view that their organizations did not have many CTT-expert staff. They felt that there should be a flexible process of CTT that could help it become more successful. Almost all of the respondents omitted to mention the importance of the role of regional economic differences in CTT. Although the government had launched a new regional development policy, the role of management in CTT was not regarded as an essential element of government policy. Most of the scientist respondents made remarks about difficulties involved in working with companies. They had experienced them in their roles in selling ideas, in design and in manufacturing. Companies appreciated foreign technology more than domestic kinds. However, university staff believed in the importance of using pilot plants to convince companies of the usefulness of their findings. Finally, they felt that elements of trust and commitment from the various parties involved, especially between scientists and companies, should be among the main features of CTT.

THE MAIN FOCUS OF THE STUDY, THE PRECONCEPTIONS, AND SOME KEY FINDINGS AND PRACTICAL IMPLICATIONS

The main focus of this study was the perceived failure of manufacturing companies in Malaysia to use university and GRI research findings, and the failure of scientists to persuade companies to use them. Many people in industry in Malaysia seemed to think that scientists, in their own country at least, did not always do industrially relevant research. This is the case in most countries, of course, but in Malaysia this commonplace fact seemed to surprise industrial managers more than it might in countries with older traditions of modern manufacturing. Companies often used reverse engineering or help from foreign-owned parents instead of using research from Malaysian universities. In some sectors, of course, there was little research from anywhere for companies to use. This is also common across the industrial world, but in Malaysia the degrees to which university and GRI TTOs lacked relevant skills, experience and procedures needed to make CTT work seemed particularly noticeable. Some industry sectors did, however, enjoy experiential advantages in using research findings, and to be sophisticated by any standards, for example ones in chemicals, pharmaceuticals, biotechnology, and mechanical engineering.

Government industrial policies have focused on the government-business relationship, and this study suggests that business climate influences, sometimes dramatically, relationships between scientists, their administrators and companies. A key element of the findings was the importance of effective communication between the various parties for success with CTT. As university and GRI scientists become, rightly or wrongly, the main focus of models of CTT, it is relevant to focus on their business and technical knowledge and skills, or on their lack of them, and their need to become more involved with processes of invention and innovation in companies. In future alliances between companies, scientists, TTOs and research administrators it seems that it will be helpful to develop the currently often very poor links and methods of communication between them. Therefore the preconception of this study, those differences in values, attitudes and ways of initiating, prosecuting and controlling activities matter greatly as influences on actual low uptake by companies, has been validated. Given the efforts to promote CTT and to supply funds for it by the government, the success rates of CTT are still questionable. Some restructuring of funds and grants could also help to increase the volume of effective support for research and its successful development.

THE THEORETICAL CONTRIBUTION OF THE THESIS

This study makes some contributions to theory. The idea of commercialization as a useful input to economic life is partly dubious, as explained and discussed in several ways in previous chapters, but sometimes it is very or partly relevant and useful. The study offers some evidence for evaluating and considering further the two very wide-ranging and general models and theories of technical change, the *Technik* and the STH ones. The practical problems of CTT can, as we have seen, be understood better by looking at them from these two theoretical perspectives. This is because the hopes for CTT are expressed from the STH perspective and criticised from the *Technik* one. Malaysia has its own specific industrial and other technical needs, priorities and resources, of course, and the models and the contrasts between them are also useful for helping us to understand what they are.

This study has offered original data that demonstrate that there are genuine problems with CTT. We have seen how CTT are advocated for political and economic purposes by politicians and their allies and employees in business and government, apparently without achieving a great deal, although some scientists and companies, in some sectors, have built and used links successfully. Some companies have pursued technical development largely by relying on their unique capabilities and resources.

University and GRI scientists tended to be rather passive in their thinking and responses. Their backgrounds, responsibilities and the structures and procedures that they operate with constrain their time and imaginations. D'Este and Patel (2007, p.1309) concluded that interaction between universities and industry in the UK was most effective when it used a variety of channels. These included the creation of new physical processes, consultancy and contract research, joint research, training, and meetings and conferences. The individual characteristics of the people involved had stronger effects on the variety and frequency of interaction between industry and academic researchers than the characteristics of the latter's departments, disciplines or universities,. D'Este and Patel (2007) also questioned two aspects of government policies directed at university-industry interaction, namely the concerns of governments with measurement of rates of patenting and of spin-off activities. For the present study, their findings suggest that the Malaysian government and universities may be putting too much pressure on academic researchers to interact formally with companies through existing university channels, and to do so with goals and targets that are too highly specified and quantifiable. Researchers who interacted well with companies, according to them, and in several ways suggested by the present findings, often did use the formal university channels but several others too, formal and informal, and in both their universities and in the companies that they helped.

The results of this study are relevant in a more general sense, because it is widely accepted that CTT is a very, perhaps the single most, important tool of a so-called knowledge-based strategy for growth (Wong, Ho, and Singh, 2007; Etzkowitz, Webster, Gebhart and Terra, 2000). Wong, Ho and Singh (2007) built a model to help plan knowledge-based economic development for the National University of Singapore. However, the Commercialization Loop Model created by the present writer is not as ambitious because it was designed for a different, narrower or more focused, purpose, to respond to the perceived problem of low uptake of research from universities and GRIs. Universities in Malaysia have succeeded in being granted funding from government initiatives for economic development in various years of Malaysian Development Plans, and Malaysian governments have now been looking to universities for knowledge and innovation to help stimulate economic growth for a number of decades. As the experience and the challenges facing scientists and companies in Malaysia continue to develop, and if as the most general conclusions of this study suggest they should, relevant government and related policies become more based on the *Technik* as opposed to the STH model of technical change, and therefore more focused and sector-specific and company-centred, they should become more practical and effective.

The present study also presents some discussion of parts of the historical, political and intellectual background of CTT. In chapter 3, comparisons were made between academics, who were grouped into cosmopolitan intellectuals, provincial academics and technical college teachers. The backgrounds of all those involved with CTT can be compared with theirs, so as to suggest that certain types of experience and outlook, in industry, government and universities alike, will tend to be associated with specific kinds of attitude to CTT. Thus some academic researchers tend to have fairly narrow outlooks and tend not to understand the wider possibilities, and the relevance and the limitations of their own work: they tend to be provincial academics. Cosmopolitan intellectuals, on the other hand, who do tend to understand the wider issues, tend to be the more able and successful kinds of academic or government minister or official, or manager or professional in more technically sophisticated sectors like pharmaceuticals or aerospace.

In the same context, university administrators and TTO officers have been criticised for lacking relevant, or for having inadequately sophisticated, experience and capabilities (Wong, Ho, and Singh, 2007; Debackere and Veugelers, 2005). They have also been criticised for lack of subtlety, understanding and administrative and communicative ability when acting on behalf of university managers to encourage and support researchers (Debackere and Veugelers, 2005; Inzelt, 2004). On the other hand, they are likely to be criticised by researchers for whatever they do, because of the administrative and managerial nature of their roles, and many of them have distinguished backgrounds themselves, often as former researchers with genuine desires to support currently active ones. These are important practical as well as theoretically relevant findings of this study.

Another interesting theoretical contribution of this thesis concerns how the terms engineering and science are understood by different kinds of people who are involved in or with them in Malaysia, The interview data and the present writer's general experiences suggest that the English language meanings of these words are very influential, and that the STH model of technical change is widely assumed to be broadly correct in Malaysia. This, it is suggested, makes Malaysian governments and other Malaysian institutions expect too much, too soon, from CTT, and to make them think of it as a much more rational and sequential or linear set of processes than it is in reality, or if the *Technik* model of technical change had been more influential in Malaysia.

THE LIMITATIONS OF THE STUDY

The limitations of this study were discussed briefly in Chapter 5. Cost and time considerations had limited the number of respondents. Thus the findings cannot be generalised directly to the larger populations being considered. Some respondents tended to express their answers and views in 'socially respectable' ways, and seemed reluctant to present themselves did not present themselves and their universities, GRIs, and companies or other organizations negatively. The group of respondents that appeared to do this most were the TTOs and senior research administrators. This was perhaps not surprising as they usually held promoted positions in non-traditional, non-mainstream, in some respects marginal, units of their organizations, and it must also usually be tempting for them to paint the most favourable pictures possible of the science and scientists that they represent. Another reason was probably the ages of these respondents. Generally they were in their late 40s and early 50s, in a country in which people tend to retire at 55. They were senior managers, senior lecturers, senior officers and senior administrators who, being in mid-career, would be unlikely to feel very free to be critical of their own and related employing organizations.

A further, partly separate, limitation lay in the use of the qualitative data-gathering method of interviewing. The quality of interview data is depends on the skills of the interviewer, how rigorously the data are understood and analyzed, and on the validity of the insights being discussed in the findings and interpretations of data that, in this case, are in Appendix 1, and in Chapters 6, 7 and 8.

SOME GENERAL POLICY IMPLICATIONS

The discussion of the data from company and scientists' and public sector perspectives presented in Chapters 6, 7 and 8 suggest some useful implications for policy. Regarding CTT, we have seen how scientists were thought of as the main factors in the production of new intellectual property and the encouragement of companies to exploit research findings. However, companies' thinking and efforts were often discouraged and marginalised by constraints of time, cost, product quality considerations, technology licensing, patenting processes, inventors' intellectual property rights, and the organization and character of their collaboration with universities and GRIs. Inzelt (2004) showed how, in Hungary, a very different country from Malaysia in many ways but one at a not dissimilar stage of economic development, the proportion of industrial companies involved with public scientific researchers and government agencies concerned with CTT and supporting it with incentives and encouragement is low, as is also the case in Malaysia. Evidence from this study suggests that support for the R and D objectives of universities and GRIs is different from that given or not given in companies for innovation. The former consists of dissemination of research through journals and publication. The latter is sensitive to a large degree to companies' technical, financial and commercial disciplines and their direct encouragement or otherwise of CTT and innovation. Therefore, government policies during the Eighth Plan period (2001-2005) that have made companies contribute towards the expansion of their own research and development activities can be questioned.

Effective CTT needs mutual trust and support and adaptability from all the parties. Building up business partnerships between universities and companies in the long term is more than a question of providing financial resources. In any case the financial resources and capabilities of the Malaysian government have definite limits. On the other hand, Malaysia has plenty of natural resources. The politician interviewee admitted that the initial motives of the government as regards CTT were focused on building human capabilities. Interaction and links between universities and companies were, he accurately pointed out, becoming more regular. Relevant government policies for higher education, research and CTT were becoming more ambitious and strategic in practice, whereas in the past they only tended to be so in theory. Policies and incentives were now more focused on supporting strategic links between scientists and companies. Thinking about regional economic development and science-industry collaboration has become both more practical, and also more theoretically developed in Malaysia, as elsewhere, drawing on new growth theory, transaction cost and resource-based value theory, and evolutionary economics (Juniper, 2002).

The data contain many potentially useful points, general and specific, about how the companies' capabilities were very often influenced by the sectors that they occupied and their familiarity with technical change and scientific knowledge. The government is concerned with indigenous capacity building particularly in such areas as ICT, biotechnology, advanced manufacturing, advanced materials, and aerospace-related technologies. Companies involved in and with these technologies are very prominent among those for whom CTT are relevant and likely to be useful. Yet the data suggest that, even for them, CTT are rarely simple and straightforward. For other companies, their relevance can range from minimal to surprisingly important. In most cases, uncertainty about research and development is normal.

RECOMMENDATIONS FOR POLICY

Evidence discussed above suggests that CTT can be burdens on pressurised scientists, TTOs and senior research officers who are expected to help companies to implement them.

Responsible company managers and professionals need to act in ways that satisfy their superiors. In making recommendation for policy, many influences and options need to be taken into account. How universities are organized to contribute to CTT is one key influence. In principle, university administrators have to change their policies on intellectual property ownership to allow scientists to enjoy greater shares of royalty income than was usually the case before CTT became a priority. They need to encourage their scientists to become directly involved with companies and to be more entrepreneurial and commercial.. Therefore, scientists might increasingly be allowed to form and own or part-own engineering or so-called technology-based companies. Universities might be encouraged to break some academic barriers and to get scientists to work more like engineers by aiming to conduct commercially relevant research from the outset. However, senior university staff should not put too much pressure on scientists to be narrowly relevant, because the most relevant and profitable research of all, and not only in the long run, is often the most broad in approach and fundamental in its concerns.

As noted before, the other main problem with CTT concerns financial capabilities of universities, GRIs and companies. The government might usefully give more substantial financial to help them to design, test and develop products and processes, using relevant research findings. It is well to remember that inadequate communication is too often another source of barriers between various parties involved in CTT. If communication and co-operation are organized and managed more competently, the spread of CTT from universities and GRIs into companies should be faster, more successful, and better integrated. Such improvements should start by developing common and clear overarching aims, and by emphasising the importance of experience and continuity in collaboration and communication.

It would also seem desirable for the Malaysian government to approach CTT and the development of Malaysia's industry and economy in a broader way, one that is more historical and comparative and more detached from day to day policy and management considerations. The key issue for this study concerned the abilities of the various parties involved to take appropriate measures to help to strengthen the market orientation of research. The thesis has pointed to the factors that have allowed the relatively low uptake of research findings by many Malaysian companies to persist for over a decade after the IRPA policy was implemented. It would be wrong to rule out the strong possibility, indeed the probability, that many companies need to gain competitive advantages by taking up research findings, whether or not they are aware of their needs for technical change, and whether or not such change is obviously likely to be profitable. Also, it is clear from the interview data that many scientists prefer their established approaches to their academic jobs to trying to engage in CTT. This tendency appears to include a defensive-minded preference on the part of some scientists to conceal their research findings from companies. The more general question then arises as to how far different groups in the scientific community are willing, over time, to share their knowledge and findings with businesses. Also how may the process of CTT help shape the directions of scientific research, the nature of relevant scientific knowledge, and co-operation between scientific and business communities? Such broad and partly comparative and historical questions need to be asked and answered by researchers before policies can be shaped with any confidence, or modified suitably in action.

Support for CTT can have different objectives and take a variety of forms. Therefore, policy objectives recommended to be pursued by the Malaysian government should involve technology forecasting, technology acquisition, exploitation/licensing, lead users and the financial institutions that specialise in funding technical change. Although such institutions and practices exist, their contributions are questionable, as they seem often seem to focus on profiting from the financing of politically fashionable or popular innovations. Continuous dialogue and regular discussion between the main parties, meaning scientists, companies, engineers, university administrators and TTOs is necessary for supporting CTT. Legislation on financing and education policies should be developed to increase relevant kinds of support for CTT.

The new regional development programmes in Malaysia such as those for the Northern Corridor Economic Region (NCER), the Iskandar Development Region (ISR) and East Coast Economic Region (ECER) mean that they are among the main new regional foci for CTT. Such 'new' areas and the Multimedia Super Corridor could complement each other and Malaysia's other areas or regions with their efforts, and their success, measurable partly by such indicators as patents awarded, depends partly on closing relevant so-called technology gaps through industry-science co-operation.

We have seen that since the Fifth Malaysian Plan, the government has increasingly promoted R and D and other kinds of innovation. As well as support for CTT/innovation by universities and companies, and regional financing/support, other relevant programmes and initiatives include electronic government, 'Smart Schools', telemedicine and R and D clusters. These have been promoted as flagship ways of promoting the use of new technologies. Tighter public budgets and growing interest in the natural environment seem likely to firm up evaluations of policies and their implementation.

Important policies for regional development include regulatory intervention, such as regulatory policies, technical norms and protective regulations; financial incentives for promotion of R and D and innovative projects in companies and universities, using with direct support or tax measures, and promotion of co-operation of companies with public institutions; and promotion of public demand for innovative products, involving procurement by the public sectors. However, the last suggestion could fail if, in the public sectors, managers prefer imports and, in effect, imported techniques, to indigenous products and techniques from Malaysia's universities and GRIs. Therefore, it is the responsibility of the federal government to intervene accordingly to help ensure the greater success of CTT across Malaysia's regions.

Other policy recommendations could include upgrading of the International Divisions under MOSTI that now provide links and nurture scientific collaboration with other countries, and a re-evaluation of the role of GRIs. There is a need for GRIs to respond faster to changing competitive environments, which probably requires more flexible use as well as planning of their work. Here, also, more interdisciplinarity is also needed, in both companies and amongst university and GRI scientists, to help cope with often large effects of complex systems of successful CTT, as well as use of more internal competition in GRIs, and possibly some restructuring of incentives for R and D and related staff. In the last of these cases it should be remembered that professionals like engineers and scientists and related GRI and university staff do not always react positively to incentives that are purely monetary, because many such people rightly regard themselves primarily as public servants with altruistic motives.

The above proposals are geared towards enhancing technical change and the development and internationalisation of business. Better long-term use and development of limited resources is sought. This means more selectivity as regards sectors, technology and location, although the government needs to be careful not to intervene too much in markets and in their self-regulating forces, or in the largely self-organized science system. Several of the interviewees made this point in different ways and from different standpoints.

RECOMMENDATIONS FOR FURTHER RESEARCH

A more historical, comparative and long-term approach to research into CTT is needed, rather than one focused on their day-to-day management and specific policies, however important the latter may be. The key question in this study was the ability of various parties involved to take appropriate measures to strengthen the use by Malaysian companies of more market-oriented scientific research findings. The factors that affect the low uptake of research findings by Malaysian companies, over two decades after IRPA was implemented (in 1986), have been noted. So too have the existence of positive attitudes and practices among many researchers and in some, mainly more advanced, industrial sectors, the lack of interest in science, some reasonable enough and some not, in many others; some rather defensive attitudes among some scientists; some rather inflexible approaches to the management of CTT in universities and GRIs; and the evolving nature of the relationships between government, researchers and companies and the relationships of all three major parties, individually and combined, with the outside world.

One methodological limitation of the study is a lack of case study materials to complement the interview data. The present study was, in some ways, a case study of some reasonably representative Malaysian universities and GRIs. However, the use of only two research tools, the interview and - to a very minor degree - documentary analysis, was a genuine weakness. To improve on this study, further research which uses other methods should be conducted. A case study is not so much a single data-gathering technique as a methodological approach that incorporates a number of data-gathering techniques (Hamel, Dufour and Fortin, 1993; Merriam, 2001; Yin, 1998). The case study approach can vary from an interview of a single individual or group to a general all-encompassing field study gathering and using many types and source of data. Thus a case study may focus on an individual, a group, or an entire organization or community, and may use a wide range of data-gathering tools such as life histories, documents, oral histories, interviews, postal surveys, and observation, direct and participant (Hagan, 2002: Yin, 1994). Case studies can be rather pointed in their focus or take a very broad view of life and society. For example, an investigator may confine his or her examination to a single aspect of an individual's life such as studying a medical student's action and behaviour in their medical school. Or an investigator might try to assess the whole life of the individual and their entire background, experiences, roles, and all of the motives that affect his or her behaviour as a student and in society, past, present and future. Very rich and detailed information can come from case studies. In contrast, often extensive large-scale survey research data may seem somewhat superficial in nature (Champion, 1993).

In the case of CTT in Malaysia, additional research is needed to fill out and/or to contradict elements of the sketchy picture drawn on the basis of the present data. More systematic coverage of more industries, sectors and/or companies is needed. An attempt is needed to use more detailed and comprehensive data to identify the features of the scientists who are engaged with companies in different sectors. By concentrating on single universities, GRIs, and on different sectors or industries, we may uncover the interaction of the more significant factors characteristic of CTT in their and other cases and some if not all of the reasons for them. We may be able to capture various nuances, patterns and thus some of the more latent elements that even the interview method might overlook (Gall, Borg and Gall, 1995; 1998). The case study has an ability to open the way for significant discoveries (Shaughnessy and Zeshmeister, 1999). It can serve as a breeding ground for insights and hypothesis to be pursued in subsequent work. For example, Wong, Ho and Singh (2007) conducted a case study of the National University of Singapore (NUS) as a kind of entrepreneurial university in the context of a Triple Helix kind of theoretical approach (Etzkowitz and Leydesdorff, 2000). A case study of an organization involves systematic gathering of enough information about it to allow the investigator serious insights into its life (Berg, 2004). The National University of Singapore was chosen because of its technology commercialization activities. Multi-case study work can include cross-case analysis. Thus Barnes, Pashby and Gibbons (2002) evaluated six collaborative research projects undertaken partly for the purpose of effective university-industry interaction. The collection of the data for this research was through interviews with participants in each of the projects, project documentation and direct observation of project meetings. The study could be regarded as broad and generic, but it has yielded findings useful for academic and industrial practitioners. Therefore, in future research for evidence of successful CTT in clusters, industries, regions or areas, universities and GRIs case studies are needed in order to develop deeper and more comprehensive evaluations.

Future research should also be longitudinal, also in the cause of better evaluation. Case studies tend to have longitudinal elements, often extensive ones, of course. The present study tended only to gather deep data from the respondents who were experienced scientists and members of companies, and partly because purposive sampling was used to find respondents with relevant interesting backgrounds and experiences. Longitudinal studies have obvious advantages over cross-sectional ones by providing data about events that take place over time. They usually ask and answer more ‘why questions’ than cross-sectional studies do. However, this advantage often comes at a heavy cost of time and money. Observations may have to be made at the times when events are occurring, and the methods of observation may require many researchers (Babbie, 2002). The present study was a sponsored one with time limits, although as a government-sponsored one by an academic from a very good Malaysian university with an obvious constructive interest in the work of the respondents, it was likely to be viewed favourably by them. Kjaergaard and Kautz

(2008) conducted a very useful longitudinal study on how to manage knowledge in organizations in Denmark from February 1999 until June 2000 which focused on events, organizational members, their contexts and interaction between all three factors over this relatively short period. The study nonetheless appears to make good sense of the perceptions, actions and behaviour of management, in clear and useful ways.

Longitudinal studies have has been used for exploring relationships between external technology acquisitions and firm performance. The method was used to control industry effects, firm effects and time effects, with analysis using data sets on 341 electronics manufacturing firms over the years 1998 to 2002 (Tsai and Wang, 2008). Further study of the present subject could compare the data from the present sample with evidence from a region with high absorptive capacity, rather than taking selected universities, GRIs and industries through longitudinal studies. Arguments about analytical and methodological issues concerning innovation systems have been considered by Carlsson, Jacobsson, Holmén and Rickne (2002). They argued that certain methodological aspects stood out as the most problematic ones. There were: level of analysis; system boundaries; and system performance. The phenomenon most in need of further research was performance measurement. Measuring performance of a technological system is not a straightforward, but requires a careful consideration of level analysis factors and the degree of maturity of the technological system studied.

Relevant future research in the Malaysian context needs, especially, to focus on regional innovation systems and clusters of industrial development. Innovation system is a concept widely dealt with in the literature on technical change and regional economies. The concept relates to two main bodies of theory and research. The first is innovation systems research; the second is regional economics, with its interest in explaining the locational distribution and policy effects of regional high technology industry, technology parks, innovation networks and innovation programmes (Cooke, Uranga and Extebarria, 1997). Here, these researchers considered the concepts of region, innovation and system and discussed the importance of financial capacity, institutionalised learning and productive culture to systematic innovation. They argued that regions had evolved along different trajectories though varied combinations of political, social and economic forces.

In Malaysia the Central Region includes Melaka, Negeri Sembilan, Selangor and Wilayah Persekutuan. It, and they, has enjoyed faster fastest growth of GDP compared to other regions which include the Northern, Southern and Eastern ones, and Sabah and Sarawak (EPU, 2006). Selected examples of comparative studies of regional innovation systems have included Regional Innovation Systems: Designing for the Future; the European Regional Innovation Survey; SME Policy and the Regional Dimension of Innovation; Nordic SMEs and Regional Innovation Systems; Regional Cluster-driven Innovation in Canada; and Regional Innovative Clusters (Doloreux and Parto, 2005). According to Doloreuex and Parto, the main objectives of these studies was to understand how regional innovation systems function, to specify factors and mechanisms that best promote competitiveness and innovation, and to assess relevant policy implications. Doloreuex and Parto attempted a state-of-the-art review of such studies, with a focus on conceptual clarification and the usefulness of research findings *vis-á-vis* regional innovation systems, and stressing the roles of different types of regional innovation system in different countries. They concluded that a regional innovation system is a normative and descriptive notion that tries to capture how technical development takes place in a country or other usefully identifiable territory. They argued that regional institutional arrangements and institutions needed to be as appropriate as possible in their different geographical contexts as factors that could help optimise the achievement of regional development and innovation.

Research in China on regional innovation systems located between Beijing and Shenzhen suggested that local officials played important roles in developing the evolutionary trajectories of their regions. In particular, they discussed how and why Beijing and Shenzhen had used different methods for developing their technology clusters (Chen and Kenney, 2007). Beijing had developed University/Research Institute (URI) links through spin-off companies and university science parks. Shenzhen had upgraded higher education institutions.

Cooke (2005) argued that the 'regional knowledge capabilities' approach proved superior in explaining how research, innovation and production actually function. The case of Basel and its bioscience firms evaluated using this approach is the result of much recent thinking by users of the regional innovation model about the nature of innovation. From capabilities rooted initially in 'open science' and subsequently in 'open innovation', 'spirals of growth nodes', operating through international networks, were set in motion. Conceição and Heitor (2007) suggested that many firms lacked even more incentives to perform their own R and D than was thought previously, and thus needed stronger interventions from the public sector. This might be particularly important for late industrializing countries, with relatively immature industries and education systems. Often these countries showed low levels of private commitment to technical development or R and D, with disproportionately high government expenditure on it.

Cabrer-Borrás and Serrano-Domingo (2007) analysed spatial patterns of innovation, their regional interdependencies and evolution, as well as its role in local innovation, in Spanish regions. They argued that while local capacity was very relevant for domestic innovation, so too were spatial innovation spillovers, which came mainly from higher education and public administration. A minimum level of regional development was required to improve the effectiveness of R and D policies. They indicated that it was necessary for R and D policies to be used in combination with others that were focused on improving socio-economic and structural influences on innovative performance. They concluded that to combine such general policies with other industrial, technological and scientific policies, both general and regional in scope, was to focus constructively on the improvement of the educational levels of populations, on the technical intensity of relevant sectors, and on the links between scientific research and the technical requirements of such sectors. These Such arguments were firmed up before by Rondé and Hussler (2005), who felt that the engine of regional innovativeness seemed to reside in the relationships developed between the actors in the given territory. The present study shows the significance of the effects of relational competences and confirms the idea that networking capability is a major enhancer of innovation.

Singh (2007) suggested, on the basis of his study, that innovative teams that achieve cross-regional knowledge integration emerge with innovations of significantly greater value than those that do not. Cross-regional knowledge integration did not only seem to have a direct effect on quality of innovation but it also appeared to have a moderating effect on the geographical distribution of R and D as an influence on innovation quality. The addresses of firms seemed to be linked to limitations on their patent counts, and Singh argued that location in a region was generally a useful indicator of both knowledge availability and innovative capacity. Mainwaring, Moore and Murphy's (2007) study and arguments are consistent with the Schumpeterian view that innovation increases with firm size, contrary to much of the recent empirical literature. The latter argued that firms outside their 'region' (Ireland) made little contributions to regional patent stocks and that patenting activity rose and increased with firm size. Similarly, the main arguments of Rutten and Boekema (2007) on differences in regional social capital also help to explain regional differences in economic development. They argued, as many other have since the 1990s, that regional social capital originates from the embeddedness of firms in regional webs of economic, political and social relations. The norms, values and customs of relevant networks facilitated collaboration for mutual benefit. To conclude, an innovative regional cluster is likely to have: firms with access to other firms in their sectors as customers, suppliers or partners, perhaps operating in formal or informal networks; and knowledge centres such as universities, research institutes, contract research organizations and technology-transfer agencies (Cooke, Uranga and Extebarria, 1997). It seems, therefore, important for strengthening regional capacities for promoting both systemic learning and interactive innovation for regions to manifest such characteristics.

From the findings, the topic of regional innovation systems was barely discussed by the interviewees. Only one scientist mentioned that their organization encountered other regional players such as ones in African countries in their commercialization of agricultural research output. These had engaged in the successful commercialization of scientific research. One senior university administrator reported how his university had to co-operate with several government departments, including Regional Development Authorities, to commercialize its scientific discoveries.

Very little research appears to be being or to have been conducted in Malaysia on the effects of regional innovation systems on the fate of CTT. Apart from the use of regional development organizations to monitor and co-ordinate activities and changes, innovative regional economic development appears to need sustained economic, financial, social and political support. It also needs to be in harmony with environmental developments. Further research should be used to explore the ramifications of this observation in different regions and sectors of Malaysia and its economy, and in other societies as well.

BIBLOGRAPHY

Abdullah, S.C. (2004) 'University should give priority to commercialized R and D product' in Utusan Malaysia, 10/8, Kuala Lumpur.

Abernathy, W. J., Clark, K.B. and Kantrow, A.M. (1983) Industrial Renaissance: Producing a Competitive Future for America, New York: Basic Books.

Abernathy, W. J. and Clark, K. B (1985), 'Innovation: Mapping the Winds of Creative Destruction', Research Policy,14, 3-22.

Abernathy, W. J. and Utterback, J. (1978), 'Patterns of Industrial Innovation'. Technology Review,80, 7, 40-47.

Abu Bakar, S.R. (2000), 'Metraplas Industries Sdn Bhd' in Technology Innovation in Malaysia, Ministry of International Trade and Industry Malaysia: Kuala Lumpur.

Ackers, P., Smith, C. and Smith, P. (eds.) (1996), The new workplace and trade unionism, London: Routledge.

Ackroyd, S. (2002), The Organization of Business, Oxford: OUP.

Ackroyd, S., Glover, I., Currie, W. and Bull, S. (2000) 'The Triumph of Hierarchies over Markets? Information Systems Specialists in the Current Context', 267-304 in I. A. Glover and M.D. Hughes (eds.) Professions at Bay: Control and Encouragement of Ingenuity in British Management, Aldershot: Ashgate.

Adnan, M.A., Ali, S. and Ali, A. (1996), 'Globalization Challenges and Competitiveness: the Role of the State and Private', Managerial Finance, 22, 5/6.

Afuah, A. (2003), Innovation Management: Strategies, Implementation and Profit. Oxford: OUP.

Aiken, S. R. and Leigh, C. H. (1988), 'Environment and the Federal Government in Malaysia', Applied Geography, 8, 4, 291-314.

Alam, G. and Langrish, J. (1984) 'Government research and its utilisation by industry: the case of industrial civil research in India', Research Policy, 13, 55-61.

Ali, A. (1992), Malaysia's Industrialization: The Quest for Technology, Singapore: OUP.

American Council of Education, (2001) 'Reports examines challenges facing research collaborations between industries and universities'.

Amsden, A. H. (1989) Asia's Next Giant: South Korea and Late Industrialization. Oxford: OUP.

Amsden, A. H. (1990), 'South Korea's record wage rates: Labour in late industrialization, Industrial Relations, 29, 1, 77-93.

Amsden, A. H. (1991), ‘Diffusion of Development: The Late-Industrialization Model and Greater East Asia’, AEA Papers and Proceeding. 81, 2, 282-6.

Archer, L. B. (1967) ‘Arts and Design’ in (eds.) G. Will and R. Yearsley. Handbook of Management Technology, London: Heinemann

Archibald, R. B. and Finifter, D. H. (2003), ‘Evaluating the NASA Small Business Innovation Research Program: Preliminary Evidence of a Trade-off between Commercialization and Basic Research’, Research Policy, 32, 605-19.

Ariff, M. and Ahmed, K. (2000) Liberation, growth and the Asian financial crisis-lessons for developing and transitional economies in Asia. London. Edward Elgar

Arocena, R and Sutz, J. (2001), ‘Changing knowledge production and Latin American universities’, Research Policy, 30, 1221-34.

Arundel, A., and Geuna, A. (2004), ‘Proximity and the use of public science by innovative Europeans firms. Economic of Innovation and New Technology. 13, 559-80.

Ashby, E. (1961) ‘On universities and the scientific revolution’ in A. H. Hasley, J. Floud and C.A. Anderson (eds.). Education, Economy and Society: a reader in the sociology education. Free Press.

Asian Development Bank, News Release No 137/97, US$40 Million ADB Loan to Strengthen Malaysian Technical Education.

Athukorala, Prema-chandra (2005) ‘Trade Policy in Malaysia: Liberation Process, Structure of Protection and Reform Agenda’. ASEAN Economic Bulletin. April, Vol. 22, No. 1.

Aton, M.A. (2005) ‘Looking Back to Step Forward’ in Nordin. N.A. (2005) Symbiosis. Technology Park Malaysia. Kuala Lumpur.

Azmi, I.M. and Alavi, R. (2001) ‘Trips, Patent, Technology Transfer, Foreign Direct Investment and the Pharmaceutical Industry in Malaysia’. The Journal of World Intellectual Property, 4, 6, 947-76.

Babbie, E.R. (2002). The Basic of Social Research. (2nd. ed.) CA: Wadsworth/Thomson Learning.

Badawi, Abdullah. (2003) ‘Equitable wealth distribution more challenging due to globalisation’, New Straits Times, Kuala Lumpur, Malaysia, 1.

Bajunid, Ibrahim Ahmad. (1996) An Assessment of Accountability Systems in Malaysian Education. Elsevier Science Ltd.

Baker, H. S. (1986) Doing Things Together. Evanston. Northwestern University Press.

Bank Negara Malaysia (1999) The Central Bank and the financial system in Malaysia, Bank Negara Malaysia. Kuala Lumpur.

Barnes, T., Pashby, I. and Gibbons, A. (2002), Effective University-Industry Interactions: A Multi-case Evaluation of Collaborative R and D Projects, European Management Journal, 20, 3, 272-285.

Barnett, C. (1972) The Collapse of British Power, London: Eyre Methuen

Barney, J. (1991) Firm Resources and Sustained Competitive Advantage. Journal of Management, 17, 1, 99-120.

Basiron, Y and Soon, L.W. (2004) Best Practices Processes For Research Commercialization: The Malaysian Palm Oil Board Experience (MPOB) Experience. Paper given to a conference at National Conference on Science, Technology and Society, 10-11 December, Kuala Lumpur.

Bell, E. (1993) 'some current issues in technology transfer and academic-industrial relations: a review'. Technology Analysis and Strategic Management. 5, 3, 307-21.

Bell, R.M. and Hill, S.C. (1978) 'Research on technology transfer and innovation' in F. Bradbury, P., R. Jervis, and A. Pearson (eds.). Transfer Processes in Technical Change Alphenaan den Rjin: Sijthoff and Noordhoff.

Bendix, R. (1956) Work and Authority in Industry: Ideologies of Management in the Course of Industrialization. New York. John Wiley.

Benneworth, P. (2001), 'Academic Entrepreneurship and Long-Term Business Relationships: Understanding 'Commercialization' Activities', Enterprise and Innovation Management Studies, 2, 3, 225-237.

Berg, B.L. (2004). Qualitative Research Methods for the Social Sciences (5th ed.). Allyn and Bacon: Boston.

Bernardes. A. T. and Albuquerque, E. (2003), 'Cross-over, Thresholds, and Interactions Between Science and Technology: Lessons for Less-developed Countries'. Research Policy. 32. 865-85.

Bessant, J. and Grunt, M. (1985), Management and manufacturing innovation in the United Kingdom and West Germany, Aldershot: Gower.

Bordogna, F. (2005), 'Scientific Personae in American Psychology: Three Case Studies', Studies in History and Philosophy of Biological and Biomedical Sciences. 36, 95-134.

Bose, J. (2001), 'Observer' No. 228, September.

Bowman, C. and Ambrosini, V. (2003) How Resource-base and Dynamic Capability views of the firm inform corporate-level strategy, British Journal of Management. 14, 289-303.

Bozeman, B (1994) 'Evaluating government technology transfer: early impact "Cooperative Technology Paradigm'. Public Policy Journal, 22, 2, 322 (16).

Bremer, H. W. (1990), 'The Impediments to Technology Transfer from the Higher Education Sector. The Education and Training Requirements for Their Removal, World Patent Information, 12, 3, 143-150

Breschi, S. and Malerba, F. (2001) 'The geography of innovation and economic clustering: some introductory notes' Industrial and Corporate Change, 10, 4, 817-33

Brooks (1966) 'National Science Policy and Technology Transfer' in Proceedings of a Conference on Technology Transfer and Innovation, N. S. F. 67-5, Washington D.C.

Brown, M. A., Berry L. G. and Goel, R. K. (1991) 'Guidelines for successful transferring government-sponsored innovations' Research Policy. 20, 2, 121-43.

Cabrer-Borrás, B. and Serrano-Domingo, G. (2007), Innovation and R and D Spillover Effects in Spanish Regions: A Spatial Approach, Research Policy, 36, 1357-1371.

Cairncross, F. (1995), Green, Inc. London: Earthscan

Calori, P. and de Woot, P. (ed), (1994), A European Model of Management Beyond Diversity, New York: Prentice Hall

Cantwell, J. (1998) 'Innovation as the principal source of growth in the global economy' in D. Archibugi, J. Howells, and J. Michie (eds.). Innovation in the Global Economy. Cambridge. CUP.

Cardwell, D.S.L. (1957) The organisation of science in England: a retrospect. London. William Heinemann.

Cardwell, D.S.L. (1971) From Watt to Clausius: the rise of thermodynamics in the early industrial age. London. Heinemann Educational.

Cardwell, D.S.L. (1972) Technology, science and history: a short study of the major developments in the history of Western mechanical technology and their relationships with science and other forms of knowledge. London. Heinemann Educational.

Carlsson, B., Jacobsson, S., Holmén, M. and Rickne, A. (2002), 'Innovation Systems: Analytical and Methodological Issues', Research Policy, 31, 233-245.

Carter, C. and Williams, B. (1957) Industry and Technical Progress. London. OUP.

Casson, M. (1982) The Entrepreneur: an Economic Theory. Oxford. Martin Robertson.

Cebon, P. and Newton, P. (1999) Innovation in Firms: Towards a Framework for Indicator Development. Melbourne Business School Working Paper 99-9.

Champion, D.J. (1993) Research Methods for Criminal Justice and Criminology. Englewood Cliff, NJ: Prentice Hall.

Charlton, B.G. (2007), ‘From Nutty Professor to Buddy Love – Personality Types in Modern Science’. Medical Hypotheses. 68, 243-44.

Chen, K. and Kenney, M. (2007), ‘Universities/Research Institutes and Regional Innovation Systems: The Cases of Beijing and Shenzhen’, World Development, 35, 6, 1056-1074.

Chen, M (2001) ‘International technology transfer’ pp. 3391- 3409 in M. Warner (ed.), International Encyclopaedia of Business and Management. London. Thornson International.

Chia, R. (2002), The Production of Management Knowledge: Philosophical Underpinnings of Research Design in (ed.), Partington, D. (2002) Essential Skills for Management Research, New York: Sage.

Child, J. (1969) British Management Thought. London. Allen and Unwin.

Child, J. (1978), ‘The non-productive component within the productive sector’, in M. Fores and I. Glover (eds). Manufacturing and Management. London. HMSO.

Child, J. (1981) ‘Professionals in the corporate world: Values, Interests and Control’ in D. Dunkerley and G. Salaman (eds.). The International Yearbook of Organization Studies. London. Routledge and Kegan Paul.

Child, J. (1982), ‘Professional in the Corporate World: Values, Interest and Control, in D. Dunkerley and G. Salaman (eds), International Yearbook of Organization Studies, London: Routledge and Kegan Paul.

Child, J. (1984) Organization: A Guide to Problems and Practice. New York. Harper and Row.

Child, J., Fores, M., Glover, L., and Lawrence, P. (1983) ‘A Price to Pay? Professionalism and Work Organization in Britain and West Germany’ Sociology. 17, 63-78.

Child, J., Ng, S. K. and Wong, C. (2002), ‘Psychic Distance and Internationalization’, International Studies of Management and Organization, 32, Spring, 36-56.

Christensen, C. (1997) The Innovator’s Dilemma. Cambridge, Mass. Harvard University Press.

Choo, K. E. (2002) Managing enterprise in the era of uncertainty: the recent Malaysian experience, Malaysian Management Review.

Chudnovsky, D., Lopez, A. and Pupato, G. (2006), ‘Innovation and Productivity in Developing Countries: A study of Argentina Manufacturing Firms’ Behaviour (1992-2001). Research Policy. 35, 226-88.

Chze, C.L. (2003) 'Reinventing manufacturing sector', New Straits Times, Kuala Lumpur, Malaysia, 12 May.

Cicourel, A. V. (1964) Methods and Measurement in Sociology. London. Collier-Macmillan.

Clark, G. L and Tracey, P. (2004) Global Competitiveness and Innovation. London. Palgrave Macmillan.

Cohen, W. M., Nelson, R.R. and Walsh, J.P. (2002) 'Links and Impacts: The influence of Public Research on industrial R and D'. Management Science. 48, 1, 1-23.

Cohen, S. S. and Zysman, J. (1987) Manufacturing Matters: The Myth of the Post-Industrial Economy. New York. Basic Books.

Colombo, M.G. and Delmastro, M. (2003) 'How effective are technology incubators? Evidence from Italy', Research Policy, 31, 1103-22.

Conceição, P., Heitor, M. and Oliveira, P. (1998) 'University-based technology licensing in the knowledge based economy', Technovation, 18, 10, 615-625.

Cooke, P., Uranga, M.G. and Extebarria, G. (1997), 'Regional Innovation Systems: Institutional and Organizational Dimensions', Research Policy, 26, 475-491.

Cooke, P. (2005), 'Regionally Asymmetric Knowledge Capabilities and Open Innovation; Exploring 'Globalization 2' – A new Model of Industry Organization, Research Policy, 34, 1128-1149.

Cornwell, B. (1998) 'Quicklook Commercialization Assessment'. R and D Enterprise – Asia Pacific. 1, 1, 7-9.

Cory, J.P. (1996) 'A business architecture for technology management' in Gaynor, G.H. (ed.). Handbook of Technology Management. New York. McGraw-Hill.

Cotgrove, S. and Box, S. (1970) Science, Industry and Society. London. Allen and Unwin.

Crook, S., Pakulski, J. and Waters, M. (1992) Postmodernization: Change in Advanced Society. London. Sage.

Currie, W.L. and Glover, I. A. (1999) 'Hybrid managers: an example of tunnel vision and regression in management research', in W.L. Currie and B. Galliers (eds.). Rethinking Management Information Systems. Oxford. OUP.

David, J. (1996) Industrial Economies and Organization: a European Perspective. McGraw-Hill. Berkshire.

Daniels J.D., Radebaugh, L.H. and Sullivan, D.P. (2004), International business: Environments and Operations, London: Pearson & Prentice Hall

Debackere, K. and Veugelers, R. (2005), 'The Role of Technology Transfer Organizations in Improving Industry Science Links'. Research Policy. 34, 321-42

Deeds, D., DeCarolis, D. and Coombs, J. (1999) Dynamic capabilities and new product development in high technology ventures: an empirical analysis of new biotechnology firms, Journal of Business Venturing. 15, 211-229.

D'Este, P. and Patel. P (2007), University-industry Linkages in the UK: What are the Factors Underlying the Variety of Interactions With Industry? Research Policy, 36, 1295-1313.

DeMarchi, N. (1976) 'Problems in the economist's conceptualisation of technological innovations', in N. Rosenberg, (ed.). Perspectives on Technology. Cambridge. University Press.

Denzin, N. (1970) The Research Act in Sociology. Chicago. Aldine.

Denzin, N. K. and Lincoln, Y. S. (2000), Handbook of Qualitative Research, 2nd Edition. London. Sage.

Department of Statistics, Malaysia (2003) Report on Population and Housing Census, Department of Statistics, Putra Jaya, Malaysia.

Department of Trade and Industry (2005) Internationalisation of R and D in the UK, A Review of the Evidence. Report of The Office of Science and Technology. London.

Dickens, P. (1998) Global shift: transforming the world economy. London. Paul Chapman.

Dicken, P. (2003) Global Shift: Reshaping the global economic Map in the 21st century. London. Sage.

Dodgson, M. (2000) The Management of Technological Innovation: An International and Strategic Approach. Oxford. OUP.

Dodgson, M. and Hinze, S. (2000) 'Indicators Used to Measure the Innovation Process: Defects and Possible Remedies' Research Evaluation, 8, 101-114.

Doloreux, D. and Parto, S. (2005), Regional Innovation Systems: Current Discourse and Unresolved Issues, Technology in Society, 27, 133-153.

Dore, R. (1975) British Factory-Japanese Factory London. Allen and Unwin.

Dore, R. (1976) The Diploma Disease: Education, Qualification and Development London. Allen and Unwin.

Dore, R. (1976) The Diploma Disease: Education, Qualifications and Development. London. Allen and Unwin.

Dosi, G. (1982) 'Technological Paradigms and Technological Trajectories: the Determinants and Directions of Technical Change and the Transformation of the Economy' Research Policy. 11, 3, 147-62.

Drabble, John H. (2000), An Economic History of Malaysia, c.1800-1990: the transition to modern economic growth. Basingstoke. Macmillan.

Drenth, P.J.D. (2001) ‘Scientific Academic in International Conflict Resolution’. Technology in Society. 23, 451-60

Easterby-Smith, M., Thorpe, R. and Lowe, A. (2002), Management Research, London: Sage.

Ecob, R., Glover, I. and Herriot, P. (1980) ‘Students’ intentions and job types – fit for an intellectual? Engineering undergraduates’ attitudes towards production and other functions of manufacturing units’. European Journal of Engineering Education. 5, 301-8.

Economic Planning Unit (EPU) (1996) The Seventh Malaysia Plan 1996-2000. Kuala Lumpur. Prime Minister’s Department.

Economic Planning Unit (EPU) (2001) The Eighth Malaysia Plan 2001-2005. Kuala Lumpur. Prime Minister’s Department.

Economic Planning Unit (EPU) (2006) The Ninth Malaysia Plan 2006-2010. Kuala Lumpur. Prime Minister’s Department.

Edgington, D. W. and Hayter, R. (2001) ‘Japanese electronics firms in Malaysia: after the financial crisis’ in N. Chris, W. Smith, R Smyth, and A. M. Vicziany (ed). Malaysian Business in the New Era. Cheltenham. Edward Elgar.

Elias, N. (1978) ‘The Civilising Process’ translated from German by Edmund Jephcott. ‘The History of Manners’. Oxford. Blackwell.

Ellis, J. (1993), The World War II Databook, London: Aurum

Engineering Council (2005), Engineering UK 2005, A Statistical Guide to Labour Supply and Demand in Engineering and Technology, Research Report, London. Engineering Council.

Enteman, W.J. (1993) Managerialism. The Emergence of a New Ideology. University of Wisconsin Press. Madison, Wisconsin.

Eun, J. H., Keun, L. and Guisheng, W. (2006), Explaining the ‘University-run enterprises’ in China: A theoretical framework for university-industry relationship in developing countries and its application to China, Research Policy. 35, 1329-46.

Etzkowitz, H. and Leydesdorff, L. (2000) ‘The dynamics of innovation from National Systems and ‘Mode 2’ to a Triple Helix of university-industry-government relations’, Research Policy. 29, 109-123.

Etzkowitz, H., Webster, A., Gebhart, C., and Terra, B. R. C. (2000) ‘The Future of University and the University of the Future: Evolution of Ivory Tower to Entrepreneurial Paradigm. Research Policy, 29 (2), 313-330.

Feldman, M.P. and Ronzio, C. R. (2001) 'Closing the innovation loop: moving from the laboratory to the shop floor in biotechnology manufacturing', Entrepreneurship & Regional Development, 13, 1-16.

Fleetwood, S. and Ackryod, S. (Eds.), (2004), Critical Realist Application in Organizations and Management Studies, London: Routledge.

Flick, U. (1998) An Introduction to Qualitative Research: Theory, Method and Application. London. Sage.

Fores, M. (1972) 'Engineering and the British economic problem'. Quest. 2, 21-3.

Fores, M. (1976) Note on the conversion process which engineers and industrial managers face. London. Department of Industry.

Fores, M. (1976), 'A Proper Use of Science', in Fores, M. and Glover, I. (eds.). Manufacturing and Management. London. The City University

Fores, M. (1977) Scientists on technology: a confusing saga Occasional Paper No. 571. London. Free University of Kensington.

Fores, M. and Sorge, A. (1978) 'The Rational Fallacy', Discussion paper, 78-84. Berlin: International Institutes of Management.

Fores, M. (1978a) Personal communication to I.A. Glover, 16 April

Fores, M. (1978b), 'A proper use of science' in M. Fores and I.A. Glover (eds.), Manufacturing and Management. London. HMSO.

Fores, M. (1979) 'Technical change and human skill: art lost in a Sea of Science', Discussion paper, 79-88. Berlin: International Institutes of Management.

Fores, M. (1979b) 'The myth of technology and industrial science', Discussion Paper 79-49 Berlin: International Institute of Management.

Fores, M. (1979c) 'The myth of a British industrial revolution', History (June), 181-98.

Fores, M. (1982a) 'Homo Faber and the American Disease', Cambridge Review, 241-47.

Fores, M. (1982b) "New information technology" as another "industrial revolution": teacher gets it wrong', Discussion Paper 82-6. Berlin: International Institute of Management.

Fores, M. and Glover. I.A. (1978) Manufacturing and Management. London.

Fores, M., Glover, I. and Lawrence, P. (1992) 'Management Thought, the American Identity and the Future of European Labour Processes in 1992' Tenth Annual International Labour Process Conference. Birmingham. University of Aston.

Fores, M. and Rey, L (1979d) 'The British disease: professionalism', Higher Education Review (Spring), Vol. 11.

Fores, M. and Sorge, A. (1981) 'The decline of management ethic'. Journal of General Management. 6, 3, 36-50.

Freeman, C. (1974) The Economic of Industrial Innovation. London. Printer.

Freeman, C. (1992) 'Formal scientific and technical institutions in the National System of Innovation' in B.A. Lunvall. (ed.) National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, London: Pinter.

Freeman, C. and Perez, C. (1998) Structural crises of adjustment, business cycles and investment behaviour, in G. Dosi, C. Freeman, R. Nelson, G. Silverberg and L. Soete (eds) Technical Change and Economic Theory. London. Pinter.

Funk, J. L. (2004) Creating and Succeeding in New Industry: Lesson from the Electronic Industries, on the web http://www.iir.hit.u.ac.jp/file/SMR-funk.pdf, cited on 19 January 2005.

Fujisue, K. (1998) Promotion of Academia-industry Cooperation in Japan: Establishing the Law of Promoting Technology Transfer from University to Industry in Japan, Technovation. 18, 6/7, 371-381.

Gambardella, A. (2002) 'Successes and Failures in the markets for technology' Oxford Review of Economy Policy, 18, 10, 52-62.

Galbraith, J.R. (1982), 'Designing the innovation organization', Organization Dynamics. 3-24.

Gall, M.G., Borg, W. R. and Gall, J. P. (1995). Educational Research and Introduction. New York: Longman.

Gall, M.G., Borg, W. R. and Gall, J. P. (1998), Applying Educational Research. New York: Longman.

Gannicot, K. and Blaug, M. (1969) 'Manpower forecasting since Robbins: a science lobby in action'. Higher Education Review. 2. 1, 56-74.

Geisler, E., Furino, A. and Kiresuk, T. (1990), 'Factors in the success or failure of industry-university cooperative centres'. Interfaces. 20. 6, 99-109.

Geneen, H. (1986), Managing, London: Grafton Books.

Ghaury, P (2000) 'Internationalization of the Firm', pp. 129-153 in ed. M. Tayeb, International Business: Theories, Policies and Practices, Harlow: Pearson.

Gispen, K. (1989) New Profession, Old Order: Engineers and German Society 1815-1914. Cambridge. CUP.

Glaser, B. and Strauss, A. (1968) The Discovery of Grounded Theory. London. Weidenfeld and Nicolson.

Gloria, L. L. and Smith, C. (1992) British engineers in context, in Gloria, L. L. and Smith, C. (eds.) Engineers and Management: International Comparisons. London. Routledge.

Glover, I. A. (1978) 'Executive Career Patterns: Britain, France, Germany and Sweden. In M. Fores and I. A. Glover (eds.) Manufacturing and Management. London. HSMO.

Glover, I. A. (1980) 'Social science, engineering and society', Higher Education Review. 12, 3, 27-42.

Glover, I. A. (1985) 'How the West was Lost? Decline of engineering and manufacturing in Britain and the United States'. Higher Education Review. 17, 3, 3-34.

Glover, I. A. and Kelly, M. P. (1987) Engineers in Britain: A Sociological Study of the Engineering Dimension, London. Allen and Unwin.

Glover, I.A. (1992) Wheels within wheels: predicting and accounting for fashionable alternatives to engineering in G.L Lee. and C. Smith (eds.). Engineers and Management-International Comparisons. London. Routledge.

Glover, I. A. and Kelly, M. (1993) 'Engineering Better Management', in Payne, G. and Cross, M. (eds.). Sociology in Action, Basingstoke. Macmillan.

Glover, I. and Hughes, M. (1996), 'British Management in the Pursuer Mode', in Glover, I. and Hughes, M. (eds.), The Managerial Professional-Managerial Class: Contemporary British Management in the Pursuer Mode, Aldershot: Avebery, 1-34

Glover, I.A. and Tracey, P. J. (1997) 'In Search of *Technik*: Will Engineering Outgrow Management?' Work, Employment and Society, 11, 4, 759-76.

Glover, I., Tracey, P. and Curries, W. (1998) 'Engineering our future again: Towards a long-term strategy for manufacturing and management in the United Kingdom' in R. Delbridge and J. Lowe (eds). Manufacturing in Transitions, 199-223. London. Routledge.

Glover, I. A. and Hughes, M. D. (2000) Professions at Bay: Control and Encouragement of Ingenuity in British Management Ashgate. Aldershot.

Glover, I.A. (2003) 'Adolescent Rebellion? The Problem of Managerialism in Time and Space', proceedings of the 18th Annual Conference of the Employment Research Unit, Cardiff Business School, University of Cardiff, September 2003.

Glover, I. A. and Branine, M. (1997), 'Ageism and the Labour Process: Towards a Research Agenda', Personnel Review, 26, 4, 274-292

Glover, I. A. and Walker, A.G. (2007), 'Age Relations: Problems, Policies and Prospects', mimeo, University of Stirling and Sheffield

Goldfarb, B. and Henrekson, M. (2002), 'Bottom-up versus top-down policies towards the commercialisation of university intellectual property', Research Policy, forthcoming.

Goto, A. (2000) 'Japan's National Innovations System; Current Status and Problems'. Oxford Review of Economic Policy.16, 2, 103-13.

Government of Malaysia (1996), Second Industrial Master Plan (IMP2), Kuala Lumpur: National Printing.

Government of Malaysia (2000) Population and Housing Census. Kuala Lumpur. National Publication.

Government of Malaysia (2002) Malaysia: Statistical. Kuala Lumpur. National Printing.
Government of Malaysia (2002) Ministry External Trade Development Corporation. Kuala Lumpur. National Printing.

Grindley, P. (1993) 'Firm strategy and successful technological change' in A. Cozijnsen, and W. Vrakking (eds.). Handbook of Innovation Management, London: Blackwell.

Groen, B. and Hampden-Turner, C. (2005) The Titans of Saturn: Leadership and Performance Lessons from the Casssini-Huyaens Missions. London. Cyan.

Haeffner, E.A. (1979) 'Innovation strategies for industrial corporations and for satisfying national needs' in M. J. Baker (ed.). Industrial Innovation: Technology, Policy, Diffusion. New York: Macmillan

Hagan, F.E. (2002), Research Method in Criminal Justice and Criminology: Boston: Allyn and Bacon.

Hall, P. and Soskice, D. (Eds) (2001) Varieties of capitalism: the institutional foundations of comparative advantage. Oxford. OUP.

Hamilton, W. F. and Singh, H. (1992) The evolution of corporate capabilities in emerging technologies, Interfaces, 22, 13-23.

Hamel, J. Dufour, S. and Fortin, D. (1993) Case Study Method. Thousand Oaks, CA: Sage.

Harzing, A.W. and Sorge, A. (2003) 'The Relative Impact of Country of Origin and Universal Contingencies on Strategies and Corporate Control in Multinationals Enterprises: World-Wide and European Perspectives'. Organization Studies, 24, 2, 187-214.

Hashim, K. and Mahajar, A. (2001) Exporting problems of Malaysian SMEs: A recent study, Malaysian Management Review, 2, 20-30.

Hassel, L.G. and Cunningham, G. M. (2004), 'Psychic Distance and Budget Control of Foreign Subsidiaries', Journal of International Accounting Research, 3, 2, 79-93.

Hawthorne, E.P. (1978) The Management of Technology, New York. McGraw-Hill.

Hayashi, T. (2003) ‘Effect of R&D programmes on the formation of university-industry-government networks: comparative analysis of Japanese R&D programmes’, Research Policy, 32, 1421-42.

Henderson, R., and Clark, K. (1990), ‘Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms’. Administrative Science Quarterly. 35, 1, 9-30.

Hindle, K. and Yencken, J. (2004) ‘Public Research Commercialisation, Entrepreneurship and New Technology Based Firms: an Integrated Model’. Technovation, 24, 10, 793-803

Hezri, A.A. and Hasan, M.N. (2006), ‘Towards Sustainable Development? The Evolution of Environmental Policy in Malaysia’, Natural Resources Forum, 30, 37-50

Hirst, P. and Thompson, G. (1996a) Globalization in Question: The International Economy and The Possibilities of Governance. Cambridge. Polity Press.

Hirst, P. and Thompson, G. (1999) Globalisation in Question: The International Summary and The Possibilities of Governance. Cambridge. Polity Press.

Hofstede, G. (1980) Culture’s Consequences, Beverley Hills, CA. Sage Publications.

Hudson, L. (1966) Contrary Imaginations: a Psychological Study of the English Schoolboy. London. Methuen.

Hudson, L (1978) ‘Making Things’, in M. Fores and I. A. Glover (eds.). Manufacturing and Management. London. HMSO.

Hughes, M. D. (1985) ‘De-bureaucratization and private interest government: the British state and economic development policy’, pp. 87-104 in eds. W. Streeck and P.C. Schmitter. Private Interest Government: Beyond Market and State. London. Sage.

Hung, S.H. and Chu, Y.Y. (2006) ‘Stimulating New Industries From Emerging Technologies: Challenges for Public Sector’. Technovation. 26, 104-10.

Huq, Atul Pramanik, (1994). Malaysia’s Economic Success. Kuala Lumpur. Pelanduk Publication (M) Sdn Bhd Malaysia.

Hutton, S. P. and Lawrence, P.A. (1981) Engineers in Germany. Oxford: OUP.

Hsu, D. and Bernstein, D. (1997) Managing the University Technology Licensing Process: Findings from Case Studies. Journal of the Association University Technology Managers. 9, 1-33.

Ibrahim, S. (1997) The role of university in promoting and developing technology: a case study of Universiti Teknologi Malaysia, Higher Education Policy. 10, 2, 121-126.

Illich, I. (1970) Deschooling Society. Harmondsworth. Penguin.

Illich, I. (1974) After Deschooling, What? London. Writers and Readers.

Illich, I. D. (1976) Deschooling Society Harmondsworth. Penguin.

Inglis, C (1979). Educational Policy and Occupational Structures in Peninsular Malaysia. Issues in Malaysian Development, Asian Studies Association of Australia.

Inkster, I. (1998) Technology and Industrialisation: Historical Case Studies and International Perspectives, Aldershot: Ashgate.

Inzelt, A. (2004), The Evolution of University-Industry-Government Relationships During Transitions. Research Policy. 33, 975-995.

Ismail, R. and Yusuf, I. (2003), 'Labour market Competitiveness and Foreign Direct Investment: the case of Malaysia, Thailand and the Philippines, Papers in Regional Science, 82, 389-402.

Itami, H. (1987), Mobilizing Invisible Assets. Cambridge, MA. Harvard University.

Jaafar, M.A (2004) 'Prime Minister did not satisfied with R and D Return' in Utusan Malaysia. 26 October, Kuala Lumpur.

Jackal, R. (1982), 'Moral Mazes: Inside the World of Corporate Managers, Oxford: OUP

Jacob, M., Lundqvist, M. and Hellsmark, H. (2003) 'Entrepreneurial transformations in the Swedish University system: the case of Chalmers University of Technology', Research Policy. 32, 1555-68.

Janesick, V. L. (2000) The Choreography of Qualitative Research Design, in Handbook of Qualitative Research, 2nd edition. London. Sage.

Jeffrey L. C. and Teng, B.S (2003) 'Transferring R and D knowledge: The key factors affecting knowledge transfer success' Journal of Engineering and Technology Management, 20, 39-68.

Jenkins, D (1997) Managing Empowerment. Management Books: London.

Jenkins, D (2005) Targetitis, the Current Organizational Disease. Management Books: London.

Jensen, R. and Thursby, M. (2001) Proofs and Prototypes for Sale: the Tale of University Licensing. American Economic Review. 91(1), 240-59.

Jensen, R. Thursby, J. and Thursby, M. (2003) Disclosure and licensing of University inventions: 'The best we can do with the s**t we get to work with' International Journal of Industrial Organization. 21, 9, 1271-300.

Jewkes, J., Sawers, D. and Stillerman, R. (1969) The Sources of Invention. London. Macmillan.

Jevons, F.R. (1976), 'The Interaction of Science and Technology Today, or is Science the Mother of Invention? Technology and Culture, 17, 4, 729-736.

Johari, E. (2006) 'MBDr Ready To Make Some Noise' in The Edge. 12 June. Kuala Lumpur.

Johnson, P. and Duberly, J. (2000), Understanding Management Research: An Introduction to Epistemology in Management Research, London: Sage.

Jolly, V. (1997) Commercialization new technologies: Getting from Mind to Market. Boston. Harvard Business School Press.

Jomo, K.S. (ed.). (1993) Industrializing Malaysia: Policy, Performance and Prospects. Routledge. London.

Jomo K. S. and Gomez E. T. (1999) Malaysia's Political Economy: Politic, Patronage and Profits, 2nd edition. Cambridge. Cambridge University Press.

Jones, M. (2002) Conflict and Confrontation in South East Asia, 1961-1965: Britain, the United States and the Creation of Malaysia. New York. Cambridge University Press.

Jospin, L. (1998) 'Towards the Factory of the Next Century, Innovation and Technology Transfer, 16-21.

Joynt, P. (2001) 'Technology Strategy, International' pp. 6397 - 6395 pp. 3049 – 3054 in M. Warner, International Encyclopaedia of Business and Management (ed.). London. Thornson International.

Juniper, J. (2002), Universities and Collaboration Within Complex, Uncertain Knowledge-Based Economics. Critical Perspectives on Accounting, 13, 747-778.

Kaufmann, A. and Tidtling, F. (2000) 'Systems of innovation in traditional industrial regions: the case of Syria in a comparative perspective'. Regional Studies. 34, 1, 29-40.

Kim, W.C. and Mauborgne, R. (2000), 'Knowing A Winning Business Idea When You See One'. Harvard Business Review. September-October, 129-37.

Kjaergaard, A. and Kautz, K. (2008), A Process Model of Establishing Knowledge Management: Insight from a Longitudinal Field Study, Omega, 36, 282-297.

Klevorick, A.K., Levin, R.C., Nelson, R. R. and Winter, S. G. (1993) On the sources and significance of inter industry differences in technological opportunities. Research Policy. 24, 185-205.

Kogurt, B. and Zander, U. (1992) Knowledge of the firm, combinative capabilities and replication of technology. Organization Science. 3, 383-96.

Koh, F.C.C., Koh, W.T.H. and Tschang, F.T. (2005), 'An Analytical Framework for Science Parks and Technology Districts with an Application to Singapore' Journal of Business Venturing 20, 2, 217-239.

Kotter, J. P. (1982), The General Managers, New York: Free Press.

Kuhlmann, S. and Edler, J. (2003) 'Scenarios of technology and innovation policies in Europe: investigating future governance'. Technological Forecasting and Social Change. 70, 7, 619-637.

Kuhn, T. S. (1962) The Structure of Scientific Revolutions, Chicago. University of Chicago Press.

Kumar, V. and Jain, P.K. (2003) 'Commercialization of New Technologies in India: an Empirical Study of Perceptions of Technology Institution'. Technovation. 23, 113-20.

Kuratko, D. F. (2001) 'Entrepreneurship' pp. 1763 – 69 in M. Warner (ed.) International Encyclopaedia of Business and Management, London. Thornson International.

Lai, M. and Yap, S. (2004), 'Technology Development in Malaysia and the Newly Industrializing Economies: A Comparative Analysis', Asia-Pacific Development Journal, 11, 2, 53-80.

Landes, D.S. (1998) Wealth and Poverty of Nations: Why Some are so Rich and Some so Poor. London. Little, Brown and Company.

Langford, C. H., Hall, J., Josty, P., Matos, S. and Jacobson, A. (2006). 'Indicators and Outcomes of Canadian University Research: Proxies Becoming Goal? Research Policy. 35, 1586-98.

Langrish, J. (1974) The Changing relationship between science and technology. Nature, 250, No. 5468.

Langrish, J., Gibbons, M., Evans, W.G., and Jevons, F.R. (1972) Wealth From Knowledge: A Study of Innovation in Industry. London. Macmillan.

Laursen, K., and Salter, A. (2004), 'Searching Low and High: What Types of Firms Use Universities as a source of innovation? Research Policy. 33, 1201-15.

Lawrence, P. (1992) Engineering and management in West Germany: a study in consistency? In G.L Lee and C. Smith (ed.). Engineers and Management-International Comparisons. London. Routledge.

Lawrence, P.A. (1980) Managers and Management in West Germany. London. Croom Helm.

Lee, C. (2004), 'The Determinants of Innovation in the Malaysian Manufacturing Sector: An Econometric Analysis at the Firm level'. ASEAN Economic Bulletin, 21, 3, 319-29.

Lee, G. and Smith, C. (1992) British engineers in context, in Gloria, L. L. and Smith, C. (eds.) Engineers and Management: International Comparisons. London. Routledge.

Lee, G.L. and Smith. C. (1992) Engineers and Management: International Comparisons (eds.) London. Routledge.

Lee, J. and Win, H.N. (2004), 'Technology Transfer Between University Research Centres and Industry in Singapore', Technovation, 24, 433-42.

Lee, Y and Gaertner, R. (1994) 'Technology transfer from university to industry: a large-scale experiment with technology development and commercialization'. Policy Studies Journal, 22, 2, 384 (16).

Lee, Y. S (1994) 'Technology transfer and public policy in an age of global economic competitions'. Public Policy Journal, 22, 2, 260 (7).

Lee, Y. S (1998) 'University –industry collaboration on technology transfer: views from the ivory tower', Public Policy Journal, 26, 1, 69 (16).

Leftwich, G. M. (2002) 'Science and the humanities: the case for state humanities councils', Technology in Society. 24, 523-30.

Legge, K. (1991) Human Resource Management: rhetoric and realities. Basingstoke. Macmillan.

Lehrer, M. and Asakawa, K. (2004) Rethinking the public sector: idiosyncrasies of biotechnology commercialization as motors of national R and D reform in Germany and Japan. Research Policy. 33, 921-38.

Levine, C. S. (1998) 'Reorienting for sustainable development: support for a National Science and Technology Policy'. Journal of International Affairs. 51, 2, 675-88.

Lim, (2004) Regulating the transfer of technology: an analysis of Malaysia's experience, Malaysian Institutes of Management, Kuala Lumpur.

Lim, C.P. (1994) 'Heavy Industrialization, A Second Round of Import Substitution in Japan and Malaysian Development' in Jomo K.S. (ed.) The Shadow Of The Rising Sun. London. Routledge.

Lim, D. (1992). 'The dynamics of economic policy-making: a study of Malaysian trade policies and performance', 94-114: in McIntyre, A.J. and Jayasuria, K. (eds.), The Dynamics of Economics Policy Reform in South-east Asia and South-west Pacific. Oxford. OUP.

Lim, P.L. and Ong, A. (2002) Malaysia case study of the use and impact of performance and requirement, paper prepared for UNTAD, Mimeo.

Ling, S.L.M. and Yong. Y.S. (1997) 'Malaysia: electronic, automobiles and the trade investment nexus', in W. Dobson and C.S. Yue, (eds), ASEAN-Japan Relations: Investment, Institute of South-East Asian Studies. Singapore.

Link, A. N. and Siegel, D. S. (2005) Generating Science-Based Growth: An Econometric Analysis of the Impact of Organizational Incentives on University-Industry Technology Transfer, The European Journal of Finance, 11, 3, 169-81.

Lister, I. (1974) Deschooling Revisited in I. Illich, After Deschooling, What? London. Writers and Readers.

Lloyd, P.J. (1996) The role of foreign investment in the success of Asian industrialization, Journal of Asian Economies, 7, 3, 407-33.

Locke, R.R. (1989) Management and higher education since 1940: the influence of America and Japan on West Germany, Great Britain and France. Cambridge. CUP.

Locke, R. R. (1996) The Collapse of the American Management Mystique. Oxford. OUP.

Locke, R.R. and Schöne, K. E. (2004), The Entrepreneurial Shift: Americanization in European High-Technology Management Education, Cambridge: CUP.

Lockett, A. and Wright, M. (2005), 'Resources, Capabilities, Risk-Capital and the Creation of University Spin-out Companies'. Research Policy. 34, 1043-57.

Loveridge, R. (2001)'Technology and Organizations', pp. 6375-86 in M. Warner, International Encyclopaedia of Business and Management (ed.). London. Thornson International.

Lucas, R. and Verry, D. (1999) Restructuring the Malaysian economy development and human resources, London. Macmillan.

Lukacs, G. (1923) History and Class Consciousness: Studies in Marxist Dialectics. London. Merlin.

Lundvall, B. (1985) Product Innovation and User-Producer Interaction, Aalborg. Aalborg University Press.

Lyall, C., Bruce, A, Firn,J., Firn, M, and Tait, J. (2004) 'Assessing end-use relevance of public sector research organizations' Research Policy, 33, 1, 73-87.

Macfarlane, A. (1978) The Origins of English Individualism: the Family, Property and Social Transition. Oxford. Blackwell.

Maddison, A. (1995) Monitoring the world economy 1820-1992. Paris. OECD.

Maddison, A., Roa, D. S. and Shepherd, W. (2002) The Asian economics in the twentieth century, (eds.). Cheltenham. Edward Elgar.

Mainwaring, L. Moore, N.J. and Murphy, P.D. (2007), A Regional Comparison of Enterprise Patent Holdings: A Study of British and Irish Data, Research Policy, 36, 1655-1665.

Maddison, A. (1983), Ideology, Wisconsin: University Wisconsin Press.

Malairaja, C. (2003), 'Learning from the Silicon Valley and implications for technological leapfrogging the experience of Malaysia**,** International Journal of Technology Management and Sustainable Development, 2, 73-95.

Malaysia (2001) Economic Report 2001/2002. Ministry of Finance. Kuala Lumpur.

Malaysia (2002) Year Book of Statistics. Department of Statistics. Kuala Lumpur.

Malaysia Government (2006) Science and Technology Policy, Economic Development Unit, Prime Minister Department. Putrajaya.

Malaysian Science and Technology Information Centre [MASTIC] (2000) National Survey of Innovation, Malaysian Science and Technology Information Centre, Putra Jaya, Malaysia.

Mansfield, E. (1986) 'Patents and innovation: an empirical study'. Management Science. 32, 2, 173-81.

Mant, A.D. (1977) The Rise and Fall of the British Manager. London. Macmillan.

March, J. G. and Simon, H.A. (1958), Organization, New York: Wiley

Marques, J.P.C., Caraça, J.M.G. and H. Diz. (2006) How can university-industry-government interactions change the innovation scenario in Portugal? – The case of the University of Cumbria. Technovation. 26, 534-42.

Mason, J. (2002) Qualitative Methods, 2nd Edition. London. Sage.

Mathias, P. (1991), 'Resources and technology', in P. Mathias, and J. A. Davis, (eds.), Innovation and Technology in Europe: From the Eighteenth Century to The Present Day, Cambridge. Blackwell.

Mathias, P. and Davis, J. A. (1991) Innovation and Technology in Europe: From the Eighteenth Century To the Present Day, Cambridge. Blackwell.

MATRADE- Ministry External Trade Development Corporation. (2002).

Mayr, O. (1976) 'The Science and Technology Relationship as a Historiographic Problem' Technology and Culture. 17, 4, 663-73.

Merriam, S.B. (2001), Qualitative Research and Case Study Application in Education. San Fransisco: Jossey-Bass.

Merton, R.K. (1957) Priorities in scientific discovery: a chapter in the sociological of science. American Sociological Review. 22, 635-39.

Merton, R. K. (1968) Social Theory and Social Structure, New York Free Press.

Mian, S. (1994) 'US university-sponsored Technology Incubators: an Overview of Management, Policies and Performance'. Technovation. 14, 8, 515-28.

Miller, D. and Garnsey, E. (2000) 'Entrepreneurs and technology diffusion. How diffusion research can benefit from greater understanding of entrepreneurship'. Technology in Society. 22, 445-65.

Miller, S. and Fredericks, M. (2003) The nature of 'Evidence' in Qualitative Research Methods. International Journal of Qualitative Methods, 2(1) Winter.

Milne, R.S. and Mauzy, D.K. (1978) Politics and government in Malaysia. Federal Publication. Singapore.

Ministry of Science, Technology and Environmental (MOSTE) Malaysia (2000) National Science and Technology Plan.

Ministry of Science, Technology and Environmental (MOSTE) Malaysia (2003a) Commercialization of R and D in the Public Sector. Unpublished Report.

Ministry of Science, Technology and Environmental (MOSTE) Malaysia (2003b) Paper Report, Commercialization of R and D in the Public Sector. Unpublished Report.

Mohd. Sadullah, A. F. (2005), Facing the Challenges: Universities and Technologies Development in Malaysia. Symbiosis, Malaysia.

Moncada-Paternò-Castello, P., Rojo, J., Bellido, F., Fiore, F. and Tübke, A. (2003) 'Early identification and marketing of innovative technologies: a case study of RTD result valorisation at the European Commission's Joint Research Centre'. Technovation. 23, 655-67.

Montalvo, C. (2006) What triggers change and innovation? Technovation. 26, 312-23.

Morrissey, O. and Filatotchev, I (2000), 'Globalization and Trade: The implications for exports from marginalised economics'. The Journal of Development Studies. London: December, 37, 2. Pg.1, 12 pgs.

Morse, J. M. (1995), 'Exploring the Theoretical Basis of Nursing Using Advanced Techniques of Concept Analysis' in Advances in Nursing Science, 17, 31-46.

Mueller, P. (2006) Exploring the knowledge filter: How entrepreneurship and university-industry relationships drive economic growth. Research Policy. 35, 1499-508.

Muhamad, Musa. (2003) 'Industrial sector not responding to commercialisation of university research'. New Straits Times, Kuala Lumpur, Malaysia, 10 May.

National Productivity Corporation (2003) Round table discussion (RTD) on bridging the gap between R and D and its commercialisation/adoption at the farm level on 29 May 2003 at National Productivity Corporation, Petaling Jaya. http://dominoapp.npc.org.my/ cited on 20 November 2003.

Nasbeth, L. and Ray, G. (1974) The Diffusion of New Industrial Processes: An International Study. Cambridge, CUP.

Neville, W. (1998), 'Restructuring Tertiary Education in Malaysia: the Nature and Implications of Policy Changes', Higher Education Policy, 11, 257-279

Nicholls, W. A. T. (1969) Ownership, Control and Ideology. London. Allen and Unwin.

Nor, Y. (1991), 'Problems and Perspectives in Malaysia', Environmental Impact Assessment Review, 11, 2, 129-142.

OECD. (1999) Managing National Innovation Systems. Paris. OECD

Okubo, Y. and Sjöberg, C. (2000), 'The Changing Pattern of Industrial Scientific research Collaboration in Sweden' Research Policy. 29, 81-98.

Onn, Fong Chan. (1986) Technological Leap: Malaysia Industry in Transition. Singapore. OUP.

O'regan, N., Ghobadian, A. and Sims, M. (2006) Fast tracking in manufacturing SMEs. Technovation. 26, 251-61.

Oyeralan-Oyeyinka, B. and Lal, K. (2006) Learning new technologies by small and medium enterprises in developing countries. Technovation. 26, 220-31.

Parker, J. E. S. (1978) The Economics of Innovation. London. Longman.

Pavitt, K. (1997) The social shaping of the National Science base, SPRU Electronic Working Paper Series 5, http://www.sussex.ac.uk/spru/ cited on 21 November 2003.

Payne, R. (1975) 'Truism in Organizational Behaviour', Interpersonal Development. 6, 202-222.

Penning, J. M. (2001) 'Innovation and Change' pp. 3031-47 in M. Warner, International Encyclopaedia of Business and Management (ed.), London. Thomson International.

Penrose, E. (1959) The theory of growth of the firm. Oxford. Blackwell.

Petraff, E. (1993) The cornerstone of competitive advantage: A resource-based view. Strategic Management Journal, 14, 3, 179-191.

Pettigrew, A. (1974) The Politics of Organizational Decision Making. London. Tavistock.

Phillips, R. (2002) 'Technology Business Incubators: How Effective as Technology Transfer Mechanisms?' Technology in Society. 24, 299-316.

Population Studies (1980), in Grebenik, E. A Journal of Demography, London: The Population Investigation Committee, Vol. 34, 3, 437.

Powers, J. B. and McDougall, P.P. (2005) University starts-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship, Journal of Business Venturing, 20, 3, 291-311.

Pringle, C. and Kroll. J. (1999), 'Why Trafalgar was won before it was fought: Lessons from Resource-based Theory', Academy of Management Executive, 11, 4, 73-89

Qin, Y. and Simon, A. (1990) 'Laboratory replication of scientific discovery process', Cognitive Science. 14, 2, 281-312.

Radice, H. (1997) The Question of Globalization, Review Article, Competition and Change, 2, 247-258.

Rahm, D. (1994) 'Academic perceptions of university-firm technology transfer'. Public Policy Journal. 2, 267 (13).

Rajah, R. and Ishak, S. (2001), 'Market, government and Malaysia's new economic policy', Cambridge Journal of Economics. 25, 57-78.

Rasiah, R. (1998) Policy recommendations: flexible and demand-driven, unpublished (Malaysia).

Rasiah, R. and Shari, I. (2001) Market, government and Malaysia's new economic policy, Cambridge Journal of Economics. 25, 57-78.

Rauch, W. (1998) 'Problems of decision making for a sustainable development', Water Science Technology. 33, 11, 31-42.

Richardson, A. Jackson, C. and Sykes, W. (1990) Taking Research Seriously, London: HMSO.

Rondé, P. and Hussler, C. (2005) 'Innovations in Regions: What Does Really Matter? Research Policy, 34, 1150-1172.

Rosenberg, N. (1992) Inside the Black Box: Technology and Economics. New York. CUP.

Rothwell, R. (1979) 'The relationship between technical change and economic performance in mechanical engineering: some evidence', in M.J. Baker, Industrial Innovation (ed.). London. Macmillan.

Rothwell, R. (1992), 'Successful industrial innovation: critical factors for the 1990s'. R & D Management. 22, 3, 221-39.

Rothwell, R (1994) 'Industrial Innovation: Success, Strategy, Trends', in M. Dodgson and R. Rothwell (eds.). The Handbook of Industrial Innovation. Aldershot. Edward Elgar.

Rothwell, R. and Freeman, C., Horlsey, A., Jervis, V.T.P., Robertson, A.B. and Townsend, J., (1974) 'Sappho undated- project Sappho phase 11', Research Policy. 3, 258-92.

Saad, M. and Zawdie, G. (2005) From Technology Transfer to the Emergence of a Triple Helix Culture: The Experience of Algeria in Innovation and Technological Capability Development, Technology Analysis and Strategic Management. 17, 1, 89-103.

Sadullah, A.F. (2002) 'Commercialization of Research Results: Issues and Challenges', University Sans Malaysia Frontiers: Bulletin for Research and Development, 1, 1, 10-11.

Salih, T.M. (2002) 'Lessons from Malaysian trade and development experiences, 1960-99', Competitiveness Review. 12, 1.

Salih, T.M. (2005), 'Economic Development and Geopolitics: a Tale of Two Regions', International Journal of Social Economics, 32, 10, 857-867.

Salleh, Meyanathan S. (1993) Malaysia, I: Growth, Equity and Structural Transformation, Occasional Paper Series. Washington, DC. World Bank.

Salmenkaita, J. and Salo, A. (2002) 'Rationales for government intervention in the commercialization of new technology'. Technology Analysis and Strategic Management. 14, 2, 183-200.

Schibany, A. and Schartinger, D. (2001) Interaction between university and enterprises in Austria: an empirical analysis at the micro and sector level, in Innovative Networks: Co-operation in National Innovation System. Paris. OECD Proceedings.

Schilling, M. (1998) Technological lockout: an integrative model of the economic and strategic factor driving technology success and failure. Academic of Management Review. 23, 267-84.

Schwarz, K.K. (1990) Design and Wealth Creation. London. Peter Peregrines.

Seah, C. M. (ed.) (1977) Asian Values and Modernization. Singapore University Press. Singapore.

Senker, J. (1996) 'National system of innovation, organizational learning and industrial biotechnology'. Technovation. 16, 5, 219-29.

Siddique, N. A. (2006) 'Public Management Reform in Malaysia: Recent Initiatives and Experiences', International Journal of Public Management, 19, 4, 339-358

Singh, J. (2007) 'Distributed R and D, Cross-Regional Knowledge Integration and Quality of Innovative Output', Research Policy, 37, 77-96.

Shane, S. (2002) 'Selling University technology Patterns from MIT' Management Science, 48, 1, 122-37.

Shane, S. and Venkataraman, S. (2003) 'Guest editors' Introduction to the special issue on technology entrepreneurship'. Research Policy. 32, 181-84.

Siegel, Waldman, Atwater and Link (2004) Towards a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. Journal of Engineering and Technology Management. 24, 115-34.

Sikka, P. (1997) 'Technology Support and Financing System for Development and Commercialization – perspectives in India'. Technovation. 17, (11/12), 707-14.

Simandjuntak, B. (1969) Malayan Federalism 1945-1963. Kuala Lumpur. OUP.

Shaughnessy, J.J. and Zeshmeister, E.B. (1999). Research Methods in Psychology (4th. Ed.). New York: McGraw-Hill.

Smith, C. (1987) Technical Workers: Class, Labour and Trade Unions. London. Macmillan.

Smith, H.J. and Morris, W.G. (2007), An Epistemological Evaluation of Research into Projects and Their Management: Methodological Issues, International Journal of Project Management, 25, 423-436.

Sohail, M. and Daud, S. (2006), 'Restructuring a Higher Education Institution: a case study from a developing country', International Journal of Educational Management, 20, 4, 279-290.

Sorge, A. (1978) 'The management tradition – a continental view', in M. Fores and I. Glover (eds.), Manufacturing and Management. London. HMSO.

Sorge, A. (1979), 'Engineers in Management: A Study of the British, German and French Traditions', Journal of General Management, 5, 45-57.
Sorge, A. (1982-83) 'Culture's Consequences'. P. Lawrence and K. Elliot (eds.) Introducing Management. Harmondsworth. Penguin Books.

Sorge, A. (1982-83) 'Cultured Organization'. International Studies of Management and Organization. 12, 106-38.

Sorge, A. and Hartmann, G. (1980) 'Technology and Markets', Discussion Paper No. 80/39, Berlin: International Institute of Management.

Sorge, A., Hartmann, G., Warner, M. and Nicholas, I. (1983) Microelectronics and Manpower in Manufacturing, Applications of Computer Numerical Control in Great Britain and West Germany. Aldershot. Gower.

Sorge, A. and Warner, M. (1986) Comparative Factory Management: an Anglo-German Comparison of Manufacturing Management and Manpower. Aldershot. Gower.

Srica, V. (2001) 'Innovation Management', pp. 3049-3054 in M. Warner (ed.). International Encyclopaedia of Business and Management. London. Thornson International.

Stads, G.J., Tawang, A. and Beintema, N. M. (2005) 'Malaysia'. Agricultural Science and Technology Indicators. 30.

Steinmueller, E. (1994) 'Basic research and innovation', in M. Dodgson and R. Rothwell (eds.). The Handbook of Industrial Innovation. Aldershot. Edward Elgar.

Stiglitz, J. (2002) Globalization and Its Discontent. London. Allen Lane Penguin Press.

Stiglitz, J. (2006), Making Globalization Work. London: Allen Lane

Stiglitz, J. E. and Wallsten, S. J. (1999) Public-Private Technology Partnerships. American Behavioral Scientist. 43, 1, 52-73.

Storey, D. (1994) Understanding the small business sector. London. Routledge.

Strambach, S. (2002), 'Change in the innovation process: new knowledge production and competitive cities-the case of Stuttgart'. European Planning Studies. 10, 2, 215-31.

Sulaiman, A. B. (2005) 'Paying the price for 'Ketuanan Melayu' folly, in Malaysiakini, 10 November 2005.

Sutz, J. (2000) 'The university-industry-government relations in Latin America', Research Policy. 29, 279-90.

Sweeney, G (1999) 'Sustainable regional development: new dimension in policy formulation' in ed. K. Cowling, Industrial Policy in Europe: Theoretical, Perspective and Practical Proposal. London. Routledge.

Tagiuri, R. (1965) 'Value Orientations and the Relationship of Managers and Scientists', Administrative Science Quarterly, 10, 39-51.

Teece, D.J., Pisano, G. and Shuen, A. (1992) Dynamic Capabilities and Strategic Management. Mimeo, Haas School of Business. Berkeley. University of California.

Teece, D., Pisano, G. and Shuen, A. (1997), 'Dynamic Capability and Strategic Management'. Strategic Management Journal. 18, 507-34.

Tejima, S. (1992) 'Japanese foreign direct investment in the 1980s, and its prospects for the 1990s', Exim Review, 11 (2), 25-51.

Teubal, M. (1990) 'On user needs and need determination: aspects of the theory of technological innovation' in M. J. Baker, (ed.). Industrial Innovation, Technology, Policy, Diffusion. London. Macmillan.

The Technical Change Centre (1984) Aspects of Japanese Commercial Innovation: Report. London. The Technical Change Centre.

Thursby, J.G., Jensen, R. and Thursby, M. C. (2001) Objectives, characteristics and outcomes of university licensing: a survey of major U. S. universities. Journal of Technology Transfer. 26, 59-72.

Todaro, M. P. (1989) Economic Development in the Third World. London. Longman

Tsai, K. and Wand J. (2008) External Technology Acquisitions and Firm Performance: A longitudinal Study, Journal of Business Venturing, 23, 91-112.

Turner, T. (2001) 'Development: Conventional Versus Critical Perspectives'. Humanomics. 17.

Tushman, M. and Anderson, P. (1986) 'Technological discontinuities and organizational environments', Administrative Science Quarterly. 3, 439-56.

Uddin, K. (2006) The role of diffusion of innovation for incremental development in small enterprises. Technovation. 26, 274-84.

Universiti Sains Malaysia (2002) Technical Report, Acculturation of Potential World Class Research Program at Universiti Sains Malaysia. Pulau Pinang Universiti Sains Malaysia. Unpublished Report.

Universiti Sains Malaysia (2003) The Innovation System–The USM Model. Pulau Pinang. Universiti Sains Malaysia. Unpublished Document.

Universiti Sains Malaysia (2004) Research at Universiti Sains Malaysia: Policy Studies and Consultancy Services. Pulau Pinang. Universiti Sains Malaysia.

USAINS Groups of Companies (2004) USAINS Briefing, (Short Briefing During Interview on 3 December 2004) Pulau Pinang. USAINS.

Utterback, J.M. (1982) "Innovation in Industry and the Diffusion of Technology," in M. L. Tushman and W. L. Moore. Readings in the Management of Technology. Ballinger. Cambridge, Massachusetts. 29-41. (Reprinted from *Science*)

Vavakova, B. (2006) Reconceptualizing innovation policy. The Case of France.Technovation. 26, 444-62.

Veblen, T. (1921) The Engineers and the Price System. New York. Viking.

Veloso, F. and Soto, J. M. (2001) 'Incentives, Infrastructure and Institutions: Perspectives on Industrialization and Technical Change in Late-Developing Nations', Technological Forecasting and Social Change. 66, 87-109.

Verhaeghe, A. and Kfir, R. (2002), 'Managing innovation in a knowledge intensive technology organization (KITO)'. R & D Management. 32. 5, 409-17.

Vicziany, M., Navaratnam, R., Wong, K.N. and Thornton, R. (2001) 'Australian business attitudes to Malaysia' in N. Chris, W. Smith, R Smyth, and A. M. Vicziany (ed.). Malaysian Business in the New Era. Cheltenham. Edward Elgar.

Visvanathan, C. and Tiong, T.K. (1999), 'Use of Economic Tools for Malaysian Environmental Management, Strategic Environmental Management, 1, 4, 333-350.

Von Tunzelman, G. N. (1995) Technology and Industrial Progress: The Foundation of Economic Growth. Aldershot. Edwards Elgar.

Vuola, O. and Hameri, A. P. (2006) Mutually benefiting joint innovation process between industry and big-science. Technovation. 26, 3-12.

Wah, L.Y. and Narayanan, S. (1997) The quest for technological competence via MNCs: A Malaysian case study, Asian Economic Journal. 41, 407-22.

Wallerstein, I. (1979) The capitalist world economy, Cambridge: Cambridge University Express.

Walsh, V. and Le Roux, M. (2004). 'Contingency in Innovation and the Role of National System: taxol and taxotere in the USA and France'. Research Policy. 33, 1307-27.

Warner (1987) Industrialization, management education and training systems: A comparative analysis, Journal of Management Studies, 24, 92-112.

Warner (1998) Book review article: German management, human resources and competitive advantage, The International Journal of Human Resource Management, 9, 1, 215-223.

Webb. J. (1992) The Mismanagement of Innovation, Sociology. 26, 3, 471-492.

Weiner, M. (1981) English Culture and the Decline of the Industrial Spirit 1850-1980. Cambridge. CUP.

Wheelon, A. D. (2004) Technology and intelligence. Technology in Society. 26, 245-55.

Wilson, P (2001) ‘Malaysian export competitiveness compared with the dynamic Asian economies: past performance and prospects for the next millennium’ in N. Chris, W. Smith, R Smyth, and A. M. Vicziany (ed.). Malaysian Business in the New Era. Cheltenham. Edward Elgar.

Winstedt, R. O. (1962) A History of Malaya. Singapore. Marican and Sons.

Wong, P. K., Ho, Y. O., and Singh. A. (2007), World Development, 35, 6, 941-958.

Woolthuis, R. K., Lankhuizen, M. and Gilsing, V. (2005) ‘A system failure framework for innovation policy design’. Technovation. 25, 609-619.

Wright, M., Locket, A., Clarysse, B. and Binks, M. (2006) ‘University Spin-out Companies and Venture Capital’. Research Policy. 35, 481-501

Yin, R. K. (1994), Case Study Research: Design and Methods (2nd ed.)Beverly Hills, CA: Sage.

Yin, R.K. (1998), The Abridged version of case study research: Design and method. In L. Bickman and D.J. Rog, Handbook of Applied Social Research Methods. Thousand Oaks, CA: Sage.

Ziegler, J. N. (1997) Governing ideas: strategies for innovation in France and Germany. Ithaca. Cornell University Press.

Ziman, J. (1968) Public Knowledge. Cambridge. Cambridge University Press.

Ziman, J. (2000) ‘Evolutionary models for technological change’, in idem, (ed.). Technological Innovation as an Evolutionary Process. Cambridge, 3-11.

Zysman, J. (1983) Government, markets and growth: financial systems and the politics of industrial change. Oxford. Martin Roberts.

APPENDIX 1:

RESEARCH PARTICIPANTS

INTRODUCTION

This appendix presents the interview findings in some detail and reviews a little of documentary evidence taken from the companies and other organizations that supplied the interviewees. The research questions are again presented in this appendix, in its first section. In the next section the results of the interviews that took place in companies are described. The following section records the findings of the interviews in universities and government research institutes. The fourth section records the findings of the interviews of other interested parties, meaning three venture capitalists, two journalists and a politician. In the fifth, the documentary evidence is described and discussed. In the sixth, some comparisons are made between the various findings and they are summarised in general. Finally, the appendix is briefly summarised.

THE RESEARCH QUESTIONS

The research findings that indicated in this appendix are supposed to answer the research questions. Two main questions underlying in this study were as follows. First, why have many Malaysian firms apparently failed to make use of relevant discoveries, inventions, ideas and knowledge produced by Malaysian government research institutes, universities and others?

Second, why do the government research institutes and the universities and other researchers, whose work is funded by government and intended to be commercialized by Malaysian industry, apparently fail to persuade many companies to use their discoveries, inventions, ideas and knowledge? Thus the two main themes were particularly concerned about the problems of company up take and the researchers' persuasiveness.

However, there were also two other secondary research questions underlying the two main ones. First, could there be a specifically Malaysian route to the commercialisation of inventions and knowledge? And if so, to what extent is the Malaysian government aware of this and able to use it? Second, do Malaysia's government and its research managers and specialists provide information about relevant inventions and knowledge to companies in appropriate and persuasive ways? These two secondary questions will be discussed in Chapter 6, 7 and 8 respectively.

THE COMPANY INTERVIEWS

These were 23 company interviews. The companies consisted of two from mechanical, five from electrical and four from chemical engineering, four from pharmaceuticals, two from electronics, and one each from five companies in construction, IT and software, biotechnology, food technology, and technology transfer.

The order of the interviews

The interview findings are described under eight headings, based on the sectors in which the respondents were employed, and generally on the historical periods when the sectors emerged.

The first sector is construction (one respondent), the second is mechanical engineering (three respondents), the third is electrical engineering and mixtures of electrical and mechanical engineering (five respondents), the fourth is chemicals and pharmaceuticals (eight respondents), the fifth is electronics and information technology (three respondents), the sixth is biomedical and biotechnology (two respondents) the seventh is food technology (one respondents) and the eighth is a technology transfer company.

Construction (one interviewee)

Interviewee 1

This respondent was 50. His background was in rubber-based technology, in which he had a PhD from an English university. He had 12 years' research experience in a government research institute. After that he worked as a political secretary for a Malaysia's foreign minister for three years. Then, in 2001, he became the managing director of his present company which builds houses and shops in satellite towns, and also other facilities that complete satellite towns.

He was asked about the commercialization of research. He spoke mainly about his research in rubber, because he regards construction technologies as more stable and established. He began by restating the problem of low commercialization of research findings to do with rubber. He spoke of there being a chicken and egg question with there being 'the usual difficulties with finance and technology'. Although relevant research was often quite advanced and sometimes very much so by the industry's standards the scientists did not know how companies should use it and companies lacked the staff and the money to do so themselves.

In universities and research institutes most scientists were motivated mainly by publication. In big foreign companies, technical improvements often did not need any fundamental research, but when it did, company employees could either do it themselves, or adapt recent university findings. In Malaysia however, companies tended only to be users rather than creators of technology. Even in newer sectors like information technology, Malaysian companies tended to use manufacturing techniques from abroad.

His own company in construction and property used designers of houses and other buildings but it hardly ever used any new scientific knowledge. In mechanical and electronic engineering and IT, most developments were of a craft and engineering type and they did not often use some scientific knowledge. Even companies that built very sophisticated buildings did not seem to rely on scientific research findings.

Mechanical engineering (two interviewees)

Interviewee 2

This interviewee was an Australian who looked and spoke as if he were about 60. His company made agricultural implements used for cutting vegetation and levelling land and roads. The company was originally an Australian one, which had come to Malaysia in 1976. It becomes partly Malaysian through a joint venture with a local company which had been created by Malaysia's National Farmers' Association. The company is still a joint venture, but the shares are now split 49:51 between the now wholly owned Malaysian one and a Danish company. It has about 30 employees and it exports about 30 percent of its output, mostly to Indonesia. Its technology has not changed much since the late 1980s, and there has been a little change in the company's market.

The respondent had worked with the company in Malaysia for 16 years. He had been to college but not university. His background was in marketing. The company had two technicians with diplomas, and no graduate engineers. It had a 'sort of' R and D department which involved three people in a small division or section in the production department. The innovative activities consisted of making improvement to products and processes on a part-time basis. Improvements or innovations that the managers thought would be useful were defined as projects, with some being more innovative than others. Usually one or two people from the R and D section would work alongside one or two production or marketing people from outside on a project. Usually three or four such projects were running at any given time.

The company's products consisted of powered and un-powered machines that were attached to tractors of different sizes. The company was very confident about its expertise with such machines. They had long been suppliers to their customers. They were no overseas inputs to technical change. The respondent said, that agricultural machinery is 'old technology' and 'a plough is a plough, was a plough 100 years ago, a plough today and it will be still a plough in 100 years time' Ploughs were wider than in the past and had been pulled by tractors for several decades, but they were still ploughs. The main source of innovation was customers, although most employees had great mastery of the products and had worked for the company for between 12 to 14 years. Some had been with the company for 25 years. They were almost all trained by the company rather than being academically qualified.

Interviewee 3

This interviewee, who was in his mid-40s, was a graduate in civil engineering of an English university. He was involved in building furnaces. Most of his employing company's sales in South East Asia, but recently the company has collaborated with the Dutch one to supply hospital incineration to several countries, especially like Costa Rica, Croatia, Iran and Libya.

The company's perspective on the process of technology transfer and commercialization was very broad. The prerequisite capabilities for any company to experience technology transfer are knowledge and understanding, minimum basic engineering concepts, ideas and abilities awareness of changes in relevant technology survive over time. Such characteristics helped interested companies to spend wisely on developing new technology. However, the company had no proper R and D department. Nevertheless, it did a set of R and D work by using its own resources, with definite ideas what it was going to do and about its preferred outcomes.

The company had experience of working with the Malaysian Institute of Nuclear Technology (MINT). They exchanged ideas and had the passion about the same technology, that of incineration and combustion. However working with a government department, it had to deal with its bureaucratic systems and procedures. This 'slows down' the company's desire research momentum. Despite working well on waste management products, it had never worked with the Ministry of Local Government and Housing. Generally, Malaysians and their government and their public or private sector organizations and 'the eyes of these people' did not see the company's potential and capability in the said technology. The syndrome 'where is your technology coming from?' makes the company find other strategies for marketing their product.

This was about people tending to appreciate more foreign products than local ones. They mistrusted Malaysian technology.

On the question of the differences between the roles of science and engineering in technical change, the respondent felt that the question was too general. As most people wanted more technical change, it was poignant that not many politicians had engineering or scientific backgrounds. In Malaysia engineers and scientists were not being valued enough for their devotion and the excellence of their work. There was a tendency in Malaysia for the 'the pride of being engineers or scientists already diminishing'.

Electrical, Electrical (Energy) and Electrical (Mechanical): (four interviewees)

Interviewee 4

The interviewee was in his early fifties. He has a degree in mechanical engineering. He had experience working for Brunei Shell as a maintenance engineer for 14 years on a contract basis. He left Shell and started doing his own research on refrigerators. He is the owner of his own company making refrigerators powered by batteries and air conditioner. The company was now supplying refrigerators, relying on demand from existing customers. The company had not reached a stage of large-scale production.

The company was very interested in new technology developed in government research institutes and universities. It visited many exhibitions and found that many research findings were applicable to its requirements and to improve its products. It felt that until the technology or product was being exhibited, only it would be directly useful to them. They could not risk adopting it, as these products or processes were 'very dynamic types of things', although it was true that 'we need to improve regularly'. Therefore, these tasks of improvement had to be done by the universities. The main reason was that, regarding 'most private companies, in Asia in general, and in Malaysia particularly, not many actually can spend money on research. We have not reached that kind of mentality yet to allocate a certain portion of profit back into research….very unfortunate'. The result is that all the profits are given back to the owners' pockets. Making prototypes was very costly and the company had spent a great deal of its own money. Regarding the banks, if the product was too innovative, they were not interested. This was because they are looking for 'a track record of the product'. If it was a new product, they were not very supportive. Further, a company must provide collateral even if the funding was already government-supported.

Interviewee 5

This interviewee was a senior engineer and in his mid-40s. The company manufactured cables since 1975. This joint venture company was formed from a government statutory body and the British cable manufacturer, British Insulated Callenders and Cables (BICC). Then, in 1978, it became a joint venture between the first one and an Italian one, that had been formerly known as Pirelli Energy Cables and Systems, then the largest cable manufacturer in the world. The company marketed its products both nationally and internationally.

He held a degree in electrical engineering from an English university. He argued that the materials, the principles, and the production characteristics of the electrical technology were basically the same since its beginning. A huge amount of investment was used by the technology, and it came from parent companies outside Malaysia. The owners of the technology will not disclose everything about it. They will then keep certain things secret. Much of the machinery used in Malaysia had now and then been disposed of by parent companies. They were exporting their ageing technologies to Malaysia.

On the extent of university and government research institutes roles in R and D, commercialization and technology transfer, he argued that there should be a change of focus and policy. Since many developing technologies were imported, it took Malaysians time to understand and use them fully. The universities and government research institutes (GRIs) should focus on home-grown products and technologies. Malaysia received very established technologies from outside that have been studied and developed many years. To the company, 'we are given the technology on a silver plate'. As the 'renaissance did not start here', the best way for Malaysia was to focus on new inventions or products that were pertinent to more or less all industries. The objective of this should be to have the capabilities to assist many industries.

On the question of the roles of engineering and science, the interviewee felt that the two cannot be separated. Both were vital for technical change. It was very important for children to learn about and know about these things so that they could focus on their careers or either engineering or science. The interviewee then gave the example of German education for engineers. Germans understood the importance of such things at the very beginning of their education.

Interviewee 6: Electrical Engineering (Energy)

The third interviewee was a university professor in his early fifties. He held a PhD in energy studies. He has also been the chief executive of a company owned by his university. The company is funded by the Ministry of Energy. Its function is to promote renewable and efficient energy products and services. It produces solar panels and battery storage units.

The company makes big efforts to commercialize its products. A few other companies have been interested in them. Although several products had been perfected over the last five years, the company still had problems in getting companies to make them, and in convincing financiers, like banks and venture capitalists, to help it. Some of its scientists had difficulties in selling ideas, products and projects to others. Venture capitalists were not very supportive. The respondent said that 'they were supposed to be investors' but they were not risk-takers as 'they can't afford to lose money'. Therefore most companies wanted, instead, to go to banks for finance.

On the roles of engineering and science in technical change, the interviewee felt that both should be harmonized and 'helping each other'. Engineers were people who solved the problems, but scientists might bring different views to the table. So 'they have to talk to each other' as without engineers, science could not be very significant.

Interviewee 7: Electrical (Mechanical)

This interviewee was a senior manager of a publishing company. He held a degree in electronic engineering from an English university. He was 51. He was one of the first Malaysians to be sent to the West to get higher technical education. He has had experience in a leading electronic company making integrated circuits for international markets. He then joined a major newspaper company in Malaysia as a senior engineer in charge of production and other technical functions. He was in influential senior manager with 20 years of knowledge in printing operations of newspapers. He described publishing activities as ‘perishable, [with] on time delivery and no holiday’. There is a daily cycle time. This sector is the first to be hit in recessions, because most of their income comes from advertisements. The interviewee and the company had a technical philosophy of self-reliance. He regards this as helping local people to gain knowledge and skills. In the printing sector, he contended that, publishing in Malaysia had a ‘very close and small market’

There was a lack of relevant research in Malaysia, both on technical aspects of printing and on journalism. However, some good research had been done abroad. Even though its results might not be applicable to the Malaysian scenario, ‘it is interesting to find and think about’. In his company the technical staff could only operate and maintain the printing machines. They could not design or upgrade them. There was also lack of suitable technical staff and knowledge in Malaysia. Human resource staff had real no ability to help his company in this way, yet someone needed to document the technical staff’s abilities and tasks. Otherwise, the company would lose centuries of knowledge and the expertise of its staff, many of whom were coming up to pension age, which is 56.

The interviewee concluded that although there were many changes in the technology of printing, ‘the change in science is not crucial’. For his company, the critical factors were is changes ‘in engineering science’.

Mechanical and Electrical (one interviewee)

Interviewee 8

The interviewee was 44, and an owner-manager of an engineering company. She held a degree in electrical engineering from former English polytechnic. The company provided various mechanical, electrical and telecommunication services to local companies. The company only employed technicians, but because the interviewee is an engineer herself, her expertise is used by her company. However, the company does often employ engineers on a freelance basis on projects.

Regarding technology transfer and commercialization, the interviewee said that most Western companies practised R and D all the time, whereas Malaysian ones usually imported new technology. Malaysians were not innovative or assertive enough in conducting R and D. Her company took note of different specialist technologies of various kinds, from other countries and help Malaysian ones to introduce them. It got involved in agency, distribution and dealership kinds of contract. It acted as a link between originator and user companies. If a company encountered problems in using a technology, eventually it could be referred back to the ‘one who originated it’.

Being a relatively small company, it mainly appeared to offer simple, standard and common services and consultations on non-specialised products. These products might come from China or India, to be made locally. Many specialised services originated with major foreign companies like Siemens or Toshiba. The interviewee had no contact with university or government researchers, which she regretted, because their work could be relevant to her. The government ought to support more Malaysian inventions. As many Malaysian students studied overseas, they should bring back the innovations they had achieved.

The interviewee discussed relationship with universities, GRIs, MOSTI, MITI, banks and venture capitalists. Research findings universities and government research institutes were not directly relevant to the company, and the former did not do much to publiase their research outputs. As a small company, they did not have any contact with MOSTI or MITI. She went to a trade exhibition in Singapore every year, which was quite useful to the telecommunications, broadcasting and IT or electronics parts of her business. The company was self-financed and did not rely on venture capitalists or banks. The government was right to help industry with knowledge of new inventions and discoveries. Science was mainly relevant to industry, but engineering know-how was always vital. It could be very simple but the need for it was fundamental.

Chemicals (four interviewees)

Interviewee 9

The interviewee was the managing director of a company specializing in polymer manufacturing. He was in his mid-40s and held a degree in marketing. He has been in the company since its formation in 1993. The company being funded by government funded venture capitalist called National Investment Private Limited Company (PUNB). This venture capitalist had ventured into many small-scale and medium-scale industries. The company also produced customised products like a wide range of plastic parts supplying to Japanese multinational companies such as Honda, Yamaha, Sony and Suzuki. They started as supplying to these companies under a vendor programme initiated the by government. They are subcontractors to Malaysian companies like Modenas, Perodua and Petronas. However it was important to own technology, to stay in business.

The respondent felt that national companies should obtain technologies from collaboration with any institution. It made companies liberated and self-reliant to develop their own products or by having ‘a complete product’. Furthermore, while the company depends on Multinational Companies (MNCs), the respondent argued that most Japanese companies would prefer to take their supplies from Japanese suppliers. So having the vendor programme, the government must make a policy that MNCs must distribute the market share of supplies to national companies in at least a proportion of 10 percent. At the same time, since MNCs are getting tax relief and duties from Malaysia government, it was then reasonable enough that national companies been given a chance to penetrate international markets through MNCs.

Finally, the company had secured good support from universities and GRIs. Following their involvement with them, the company been given a grant from the Small and Medium Industries Development Corporation (SMIDEC) to commercialize a product from the Malaysian Agriculture Research and Development Institute (MARDI). However, the company felt that venture capitalists should have enough money to fund working capital investment. If ‘venture capitalist’ cannot comprehend the need of companies, then companies will have to turn to banks’, and at the end, ‘the business will belong to the bank’.

Interviewee 10
The company is a chemical engineering one in Johor, in the south of Malaysia. The interviewee was its manager. He was in his late 40s. He was an auditing assistant without a degree, but he had learnt with the company and had some other accountancy training. The company employed about 300 people and made power transfusion belting for cars and other engineering companies. It was the only Malaysia company doing so. About 30% of its output was exported, mainly to South East Asian countries, China, also to Pakistan and India. The rest was sold in Malaysia. The company intended to diversify into rubber-based products. Most of its present sources of natural rubber were in Malaysia. Its synthetic rubber came from Japan. The company's techniques were very advanced.

Its experience in technology transfer was with a partner, a Japanese company. The innovations mainly concern production and quality control and are used to help broaden the product range. But the products and processes remained specialised and the company's expertise and that of its Japanese partner was high and so the company had never had sustained contact with universities, government research institutes or MOSTI. However the company did contact Malaysia's Rubber Research Institutes for some advice about rubber processes.

The interviewee argued that innovations and discoveries made in universities and government research institutes were not publicised enough to business people. He felt that more innovation could be feasible, but that it could need high levels of investment that could be too high for most companies. This was why they refused to take them for commercialization. On the roles of engineering and science in technical change, the interviewee believed that both were vital, 'where engineering is in the position of improving the process, and creating new design and new machinery. The science is more about knowledge'.

Interviewee 11
The interviewee is a Chinese marketing manager in his mid-30s working for a company that make plastics products for households and other companies. He held a degree in business administration and a diploma in industrial chemistry, both from Japanese institutions. He had worked for a Japanese company for 12 years after he finished his studies, and, he appreciated differences between Malaysian and Japanese technology. He said that water treatment research and development in Malaysia was about 30 years behind that of Japan.

Regarding technology transfer, the company used Japanese technology in production. However, it faced a problem of job-hopping by employees who wanted higher wages. He argued that Malaysia's government was wrong to claim that foreign companies did not transfer technology to their Malaysian subsidiaries and other counterparts. The company had various experiences involving technology transfer with foreign supplier companies. Also, because many Malaysian workers did not stay for long with one company, and new technologies that were being brought into Malaysia often soon found their ways into other Malaysian companies.

Concerning commercialization of knowledge and inventions from universities and government research institutes, the company felt that it was unlikely to work. Most universities were far behind the company in plastic moulding technology. The company did not get much information from university researchers, either. Most of its innovations came from their supplier in Japan.

Interviewee 12
The last respondent in this sector is a senior personnel manager for a rubber company in southern Malaysia. He was 35. He had a diploma in business studies, specialising in marketing, and had been working for ten and half years in HRM function. He had worked in Taiwanese company for four years in general management, for Matsushita Electronics for in 1998 for three years, and for American company for another four years. Then he joined his present company. This company makes parts of polymer and natural rubber products. Their product is used by companies making paints, resins and acids. Seventy percent of its shares are UK owned and the balance of 30 percent is state-owned. The company holds 70 of percent of Malaysia's market share for emulsion paint. It had its own plant for natural rubber and synthetic rubber, and catered for a different market, 70 percent locally and 30 percent for export. The company was not interested in commercialization and technology transfer, because it had its own R and D staff and felt that it needed no outside help. Half of its R and D staff were chemists.

On the roles of engineering and science in technical change, the respondent emphasised the vital role of engineers for the company. Their engineers kept improving production processes and innovating and solving problems. As 'sometimes the new requirements comes from customers, whose technical people pass them on to our engineers, and from our engineers there come a solution or a pilot plant'. Engineering know most about processes and solutions to practical problems, and science was more about intellectual standards and precision.

To conclude, this company felt that it had a very strong team of scientists especially chemists, and very competent engineers, and it was financially stable, and therefore it did not need any help from outside institutions, either private or public.

Pharmaceuticals (four interviewees)

Interviewee 13
The respondent was an Indian expatriate. He held a masters degree in chemical science and had been working in Malaysia for seven years for two different companies. He was in his 30s. He worked in R and D with other scientists, including three chemists and four laboratory assistants. The company made cosmetics, toiletries, skin care and other pharmaceutical products. The company undertook manufacturing contracts for about 40 other companies. The latter used to import products from overseas but they had found it cheaper to source nationally from own respondent's company. Some of its work involved reverse engineering.

On commercialization and technology transfer in Malaysia, the respondent argued that since research was expensive in terms of time and money, most companies chose simply to buy new technology. Yet universities and government research institutes did do useful research. Many of their R and D outputs were not commercialized because they did not lead to companies getting quick profits. The company had no contact with universities, government research institutes, MOSTI or MITI concerning commercialization and technology transfer. However it had been working with the University of Science of Malaysia on remote testing of its products.

Over the roles of engineering and science in technical change, the respondent said that 'even [with] simple food products, you need a lot of engineering'. Yet to develop virtually any product, at least some scientific knowledge was needed.

Interviewee 14

The next respondent was a company general manager. In his 40s, he was trained as a veterinary surgeon. He has working experience in the Malaysian Technology Development Corporation (MTDC), a national venture capital organization. He got his present job as a result of a restructuring exercise of one of the MTDC's venture investment companies. This company was established in 1992, and makes animal vaccines. It has collaborated with University Putra Malaysia (UPM) and the government's Veterinary Research Institute and has been funded with a grant from the Commercialization of R and D Fund (CRDF). It depends totally on the UPM as it only makes and markets its products. It had undertaken meticulous marketing to the Philippines, Indonesia, Thailand and China. However it was in the position of not meeting the market demand.

The respondent had noted that although universities had developed products with good added value, the products could not sold as the costs of production were so high, making the product unaffordable by most people. The company improved its products with the help of researchers. Most universities did not have enough money to develop the outputs of their researches. Many of their ideas were shelved and became redundant.

Interviewee 15

This respondent was a company director, and was previously a lecturer in Faculty of Medicine of University of Malaya. He was a graduate in medical science and in his 30s. His company was a contract research one in biotechnology and life sciences. It conducts bio-equivalent studies for about 50 other companies, both Malaysian and foreign. As someone with both academic and business experience, the respondent was a particularly intelligent one. As regards commercialization and technology transfer, they were two different phenomena. Commercialization was 'basically towards downstream' while technology transfer concerned as the technical requirements of two different organizations.

The respondent had experience of research with IRPA funding. He felt that research often had no commercial potential as the knowledge produced was more meant for academic, government and the national interest and for more national independence. The researchers and the authorities were 'not as serious as we are', when compared to company research that complied with international standards or was accredited through foreign regulations. The company had never had contacts with universities or government research institutes about their research.

As regards the efforts of the government to increase flows of scientific knowledge, he believed that despite the government initiatives to attract Malaysian researchers from overseas to come back to Malaysia, they were not strong enough. Malaysian scientists often worked abroad doing research that was several years ahead of what their counterparts based in Malaysia were doing. To return to Malaysia would be for them to take a step back in time. Malaysian policy makers knew all this, and resented t.

Interviewee 16

The last respondent in this sector was a 30-year-old pharmacist. She held a PhD in pharmaceutical technology. She worked for a pharmaceuticals company as a senior researcher. The company made various pharmaceutical and health supplement products. It had two sites; one is for R and D, and the other for manufacturing. The R and D staff, work closely with a local university, and develop products and processes. A lecturer from the university did research for it, and it used university equipment for testing work. The respondent argued that technology transfer from the university and from work done jointly with it was with genuine and successful.

Nevertheless, the respondent also claimed that the company also got important information from its marketing staff about market needs. It also studied its external environment so as to get to know market trends and the nature of new technology in pharmaceuticals. Finally, since the respondent was only responsible for company research, she felt that her ability to answer all the interview questions was limited.

Electronics and Information Technology (three interviewees)

Interviewee 17

The first respondent in this sector group was a general manager of a subsidiary company of a university. He was 50 and held a degree in communication engineering and digital communication, and a PhD in medical electronics. His company was established in 1998. It was a joint venture between a local university and an Australian one. The company had developed an electronic device from university research. However, despite the company's confidence in the potential of the product, market surveys suggested otherwise. So the company made other products.

This company was very dependent on collaboration with the university. Most research products were not ready to be marketed. So it was vital, for them to know 'how far the product can go and exactly what the market needs'. There were many things to be dealt with, such as investor support, sales people, design, after-sales services, support services, competitors, share market volume and the continuous of the products. Most business people were not very attracted by universities with prototypes. Any prototype could be shown to be well-designed, ergonomic and attractive. Product versions could involve through versions one, two, three and so on, before potential buyers became seriously interested in them.

The respondent stated that many university scientists embark on work in saturated research environments. Given that resources were often decreasing, scientists needed to have clear targets. The respondent had found that university administrators were not keen to promote their company products commercially. As for MOSTI's role in funding research, the respondent said that the process of getting money was very troublesome. The company had to use its out–of pocket money first and then be reimbursed by the MOSTI. But most companies had little money to put up. However, some were 'taking advantage of getting funds and building their factories'.

In general, venture capitalists were not ready to change their ways of evaluating potential investments. The respondent said that, 'I guess when they hold the money, and if their money is used, they want to have full control'. The company was interested in taking a bank loan, as banks could be willing to lend to them without any collateral.

Interviewee 18

The respondent in this sector group was in his 30s and the owner of an electronic company. He had a deep interest in computing and in working with scientists from a nearby university to commercialize their research. The company had been given some money under the 'cradle investment programme' of Malaysia Venture Capital Management (Mavcap). A business plan had been presented that included product potential, product application and product development. However, the business plan was not enough to convince a venture capitalist to invest in its manufacture. The respondent felt that venture capitalist's requirements in terms of rate of return on investment varied from one company to the other.

In discussing commercialization and technology transfer, the respondent claimed that the main problem between universities, and government research institutes and business people was communication. Business people are were ones who 'had money to invest'. If the two sides did not work hard together that would lead to no commercialization. The respondents also pointed out that scientists and business people had different views on products that came from laboratory research. Business people saw them as their main concern, but researchers saw the knowledge that went into them as more important. It was easy for business people and scientists to drift apart and for governments to lose interest in helping them. The respondent argued that a procedural manual for commercialization should be written, to help expedite the processes and minimize the 'calculated risks '.

Interviewee 19

The final respondent in this sector group was a senior manager of a software services company. The company worked with its local university. He was 30 and a graduate in computer science. The company had been working directly with the university on a project called the 'E-commerce Solution System'. It had been funded under Malaysia R and D Grant Scheme (MGS). The reasons why they worked closely with the university were to do with shared abilities, experience, knowledge and skill. The company helped the university commercialize software developments, the relevant processes were different from those in other sectors. Hence in terms of technology transfer it includes source codes, programme codes, and also documentation, and there was no easy way to do the research.

The respondent claimed that research in IT is 'so risky …we have the order of the market, which has to be followed'. Although IT research is often praised by companies, market size in Malaysia was small and markets were 'not ready'. Hence the company had to 'touch up' the output. Further, Malaysian university researchers were different from many overseas ones, as they are very 'market-centric' and they 'know something that the market needs'. The respondent argued that the barrier between the university and the IT sector was the lack of relevant knowledge and the different mind sets. So 'people lack enthusiasm to build'. University people could not easily set the prospects for new products. The universities needed to focus on and to understand market needs more.

Biomedical Science (one interviewee)

Interviewee 20

This respondent was in his 50s and held an Australian degree in pharmacy. He had worked for several pharmaceutical companies. He was the first executive director of his company when it was established in 1994. The company was owned by a Malaysian government corporation under its investment programme. The company made biomedical products developed from university research. Its products were mostly initiated in university laboratories, and the company relied on university researchers greatly as it did not have its own R and D department or scientists. It had improved its products following customer reactions and product failures.

The respondent spoke at length on problems of commercialization. The vital parts of the commercialization were the research findings and the researchers. Companies had to contend with the university researchers about any failures or improvements to the products, based on their ‘technology know-how agreement’. He argued that ‘commercialization and technology transfer should go hand in hand, in the Malaysian situation’. Both interested parties were obliged to spend large amounts because the ‘the cost acceleration is always there …before you can get results’. Since it was vital that the product continue to exist, it was the responsibility of both sides to work together along for successful commercialization.

Finally, the respondent argued that Malaysian venture capitalists ought to be different in their ways of investing their funds. In the West, venture capitalists did just not match the researchers with companies, but also provided seed capital. This was because they ‘were more able to see how good the technology is’.

Biotechnology (one interviewee)

Interviewee 21
This respondent was a lady in her 30s. She was an executive director of a biotechnology company producing crop enhancers and other agricultural products. She held a degree in business management, and had experience as a government fund manager before she joined her present company. The company had commercialized a university research output. Then the company did its own research too. When she had worked as a government fund manager, she had evaluated university research findings.

She was asked about her experience of commercialization and technology transfer from university and government research institutes. She argued that ‘every product, every technology has their unique problems’, so that every form of commercialization was relevant. Second, many scientists in universities lacked dedication to their research, and relied greatly on their assistants. They were too used to doing research for years and years. Ownership of intellectual property should be held by the government, since research was funded by them. To generate smooth processes of commercialization, offices of technology transfer should be headed by non-scientists and marketing people.

Food Technology (one interviewee)

Interviewee 22
The only respondent in this sector group was a university lecturer. He was in his 50s and was also a managing director of a company making wafers and sugar confectionery products. He had a PhD in marketing from an English university. He spoke mainly about the drawbacks of university research. Most of it was never really commercialized. It was often too theoretical, with marketability and return on investment rarely in the minds of researchers.

There was not much communication between industries and universities in Malaysia. University staff hardly ever dealt with front-line people in companies, with those who might understand and use their findings. Business people were indifferent about R and D spending. Most Malaysian companies did not appreciate the potential of R and D they only got involved with it when they needed to in the short term. They were not really interested in innovation as such.

Finally on the issue of the flow of scientific knowledge, the respondent argued universities and industry did not understand each other much. They did nor work closely together, as happened in the West, when there were 'good symbiotic linkages between them'.

Technology Transfer (one interviewee)

Interviewee 23
The only respondent in this sector group was a managing director of and a partner in a consulting company. The company's functions included intellectual property valuation, patent registration, technology licensing and market research. The respondent had worked as chemical engineer for Esso. He had worked for a government fund manager as a chief executive officer for 12 years. He had substantial experience in commercialization of research findings from universities and government research institutes. In his present company, he worked very closely with scientists from both kinds of institution, as he appreciated and had a passion for discoveries and innovations.

Mostly he spoke about his experience in managing funds for commercialization on behalf of the Malaysian government. Amongst the problems highlighted, he included the need to realise how much work had to be completed on commercialization as it 'starts from zero', skilled requirement, whether products were sellable or not, the need for a small pools of technology expertise 'to provide necessary inputs to make a production commercials, weaknesses in market research, too many scientists working largely on product improvement, the need for products to be good in the first place, commitment to research and knowledge among scientists, the complacency of many business people about technology, and a need for levels of research to be 'advanced enough to attract international parties'.

The respondent suggested a number of ways to make commercialization and technology transfer successful. Those included a need for universities to develop new technology more and to improve product less when working with companies, a need to develop useful models of commercialization, to be more focused and efficient in resource allocation, a need to avoid the 'not invented syndrome here', a need for firms to be good partners in terms of 'track records' with investment financial capital, the roles of technology brokers in helping out universities and GRIs, the use of venture capitalists by each university, and strategic thinking about research funding in the IRPA context.

THE UNIVERSITY AND GOVERNMENT RESEARCH INSTITUTE INTERVIEWS

Thirty-one interviews were conducted in four universities and three government research institutes. The respondents consisted of eight scientists from universities, nine scientists from GRIs, eight officers from technology transfer offices, and six top research administrators from universities and GRIs.

The order of interviews
The interviews of scientists consisted of four from the University of Putra of Malaysia, two from the University of Science of Malaysia and two from the University of Technology of Malaysia, five from the Malaysian Institute for Nuclear Technology (MINT), two from the Malaysian Palm Oil Board (MPOB) and two from the Malaysian Agricultural Research and Development Institute (MARDI). The three top research administrators (for example Deputy Vice-Chancellor (Research) were one each from each of the University of Putra of Malaysia, University of Science of Malaysia and University of Technology of Malaysia, and the three senior officers (for example Directors) from each of three GRIs, four officers of technology transfer offices from four universities, and four officers of technology transfer offices from the three GRIs.

Scientists (eight interviewees from universities)

Interviewee 24
This respondent held a first degree in agricultural science, a masters degree in soil science, and a PhD in soil and atmospheric sciences from the USA. He was deputy dean of his faculty, and 44 years old. His research findings were fertilizers for farmers especially for paddy farmers. His commercialization of the research findings was taken by a company. Previously it was undertaken by himself and one government agency. He was the consultant to the company and getting feedback from farmers and the company's staff. In transferring technology, he gave the company the formulae. He went directly to the users of the products and taught them. The vital element in commercialization was trust. He felt that scientists should not involve themselves in marketing research findings, and that they should concentrate on research. The company concerned managed to succeed in commercialization and plough back some profits into university research. The company did not rely on any government grant because of the hassle of going through the procedure of applying for grants.

The respondent argued that there were some restrictions or using research grants. For example, funds were for specific topics, there were no extra funds for extensions and on the time allowed to lapse between the application time and the start of the research as scientific knowledge changes over time. By the time the scientist receives their funding, they have to manage the differences between the intentions of the research and the changes that they have to make. He added that, '…I think scientists are honest people'. The government had put trust them.

Finally, the respondent proposed some improvements to the management of government research grants. There should be coordination between companies and universities on the use and benefits of research in terms of knowledge of products, and on grant management by the government for scientific research.

Interviewee 25
The respondent was a researcher for one of the telecommunications service providers in Malaysia. His present job was as university lecturer. He held a masters degree in electronics, and a PhD in electronic engineering. He was in his middle 40s. His specialization was in fibre optic communications. He was a head of a photonic laboratory in his university. He also taught, and in the laboratory, there were 11 staff and 23 research students. His contributions in innovation included fibre reflection module. The laboratory had produced 15 research findings. His objectives were to focus either on new knowledge or on the broadening of knowledge. He also wanted to help companies solve their problems in specific area. Apart of getting the

researches published internationally, his goal was also to produce many scientists, especially in the photonic area which was the priority area under IRPA.

On his success in research, he argued that some big companies were unwilling to support 'university people' as they thought that 'there is no business point to them'. He referred to his request to look at the technical system in the telecommunications company. Although the university had research findings ready, it could not market it as a 'university is not a production company'. The other problem was to influence the potential buyers for commercialization, in terms of 'functionality, capabilities, commercial value in after sales service, and manufacturability' However, through his experience working with companies before he joined his present job, and his contacts with colleagues, he managed to get some information and knows some of companies problems. In this respect, some national companies may be put off university research work because 'the mentality is to look on foreign products compared national products'. They seemed to have a perspective that foreign goods were superior to national one. This mentality was also present within some government corporate bodies.

Interviewee 26

He was 52 and deputy dean of his faculty. He has a masters degree and a PhD, both from an English university. His masters is in solid state physics and the PhD is in electronic and electrical engineering specializing in microwaves. His research findings led to the making an instrument called a latexometer microwave, used to measure moisture in latex. He makes his own product and sells it to other firms, since he patented it. He has improved the instrument, making it into a multipurpose use, for example with wood, grains and fruits. However the instrument is in competition with other kinds, for example, laser and ultrasonics ones, and hydrometers, which are more convenient to use for many rubber latex companies.

On the question of commercialization of the instrument, he said that most companies in Malaysia were keen to maximize profits 'as quickly as possible'. For that reason, research findings from universities that needed fine tuning and to be developed from a prototype stage onwards could be ignored by them. He argued that universities should try harder to match up companies and researchers, as there was only little response on his instruments from companies.

Interviewee 27

This respondent was 45 and a lecturer in accounting. She is also the dean of her faculty. She is a social scientist, and also has a degree in accounting, and a PhD in computerized accounting. She did her PhD part-time with an English university. Her research product is accounting software for education. She was very enthusiastic about it. Her software was said to be different from other industry packages as hers offered simulation. The simulation works based on accounting logic and is used in industry packages. It was different to a UK package that did some similar things.

She spoke about her own experience of the commercialization of her software, which began with her own initiative of getting schools in Malaysia to use it. She has won much recognition for her research at national as well as international levels. However, her inventiveness and entrepreneurship were hampered by various factors. First, there was lack of commitment from government policy makers, as they did not really look upon university research as fully a part of the 'government agenda'. Second, some of the public universities were quite reluctant to take up her software development in education on accounting because of their ignorance about its nature and potential. Third, educational authorities were not comfortable with change and innovation. Finally, the Ministry of Education was less keen to support and fund innovation that involved ‘soft’ social science, as opposed to ‘harder’ sciences and engineering. Given to the weakness of commercialization of research, she suggested that there should be a body to co-ordinate and fund all development processes.

Interviewee 28
This respondent was a lecturer at University of Science Malaysia. He was 45 and held a PhD in polymer technology, and he was specialized in plastic technology. He then came to concentrate on latex technology. His main contribution in research concerned recycling of waste latex in Malaysia. The research took him eight years under IRPA funding to create the method of making a special powder and later a product out of it. The product which has been improved since then, has attracted many potential buyers from oil and gas producers. Therefore he has a real intention to commercialize his research, but he insisted that ‘trying to commercialize it is more difficult than doing the research’. This was because it was hard to convince potential investors to finance an accessory product compared to a commodity.

The respondent then discussed commercialization of university research at length. Most scientists did not have the ability or time to do all the administrative, promotion and marketing needed. He argued that there should be a mechanism for transferring university research findings to companies. Universities’ technology transfer offices did give a little help in finding the right partners from the private sector. He accepted that most research findings were being from controlled laboratory environment. Most companies in Malaysia needed to see marketable products functioning. He then commented that the government ‘are saying something and they are doing another thing’, as he had found that many government policies often did not succeed in generating the potential benefits of research findings. He argued that most research funding should be given to basic research.

Interviewee 29
The respondent held a degree in civil engineering, a masters in structural engineering and a PhD in building technology. He had working experience in a Works Department for a year and a half, after graduating from an English university 1982. He then joined his university as a tutor and finished his MSc and PhD by 2000. His PhD research combined architecture and engineering. He studied building materials concentrating on cellular concrete. His clients were from Chile, Canada, Russia, South Korea, Mauritius and many other countries. He was the pioneer scientist in his university who had successfully commercialized his product before making the fact known to his university. As the machine he designed was a system by itself, the university did not sell it widely because ‘there will be competitors that will kill each other’. His system has been well received in the country by a big company developer and its contractor who wanted to lessen its costs.

On how his research findings had been commercialized, he had found that his university gave insignificant support. This was because they had limited resources and the staff involved had to try to be ‘Jacks of all trades and masters of none’. He felt that through use of good marketing strategies, almost any products could be commercialized successfully. Therefore he once recommended that his university’s technology transfer office should assign some funds for upgrading some potential products that had won prizes in an innovation exhibition. He called such a process the ‘second stage of commercialization or semi-commercialization’.

Interviewee 30
The respondent was in his 40s and a lecturer in a chemical engineering and natural resources faculty. He held a degree in chemical engineering. His MSc and PhD were in membrane separation. His main contribution in research was separating particles from liquid that had formerly been used for water treatment. All his work concerned product improvements. He had four patents, and was regarded as the most active researcher in his university. He had been in the limelight because of his success in his research and considered that his research was applied and 'more relevant to industry' than fundamental research. He did it to solve problems and to help companies to innovate.

He had experienced real problems in commercializing his research. All of it was done by him alone, and then adopted by his university's technology transfer office. He argued that no-one in his university had so far been referred as an expert at commercialization. Scientists should always get involved with companies that have expressed interest in research findings. As different products needed different approaches to commercialization, there should be a flexible process. Many links with companies had started with his participation in exhibitions. The respondent had employed his own consultant to help him with commercialization of his research findings.

Finally, the respondent noted that any successful commercialization needs study and understanding of different kinds of product and process. Most research findings were not ready for commercialization. Experts should be employed to support scientists involved in the commercialization of their findings. In his university, the technology transfer office had helped on a marginal basis.

Interviewee 31
The researcher was 45 and was the deputy dean of her faculty. Her PhD was on fibre-optic instrumentation and now she specialized in maritime hydraulics. Her main contribution to research and innovation concerned coastal protection and the apparatus and methods used for erosion control. Her innovation had been patented and was one of her university's successful commercialization products. She was planning to market her product internationally market as the Malaysian market was rather small. However, she needed staff to help her, and too few were available. As a scientist and administrator, she was unable to give enough commitment of time for marketing her own product.

She observed that 'any product from a university that is not investment-ready' would not be taken by companies. Most companies in Malaysia were hesitant in taking on more research and development. They were not risk takers and unwilling to do the later parts of upscaling research findings. Therefore university initiatives to give in seed funding to scientists 'to polish their products' were vital. Scientists needed help to produce business plans, and to make selling tools, for example brochures, videos and presentation materials.

Scientists (nine interviewees from GRIs)

Interviewee 32
The respondent, in his 40s, held a first degree in chemistry and a PhD in material engineering. He was a specialist in processing advanced materials and his innovations were mainly of a

problem-solving kind. He intended to produce more value-added products from local resources that would to relevant to many industries. He argued that sometimes businesses are considerably 'way behind the scientific communities in terms of knowledge'. He gave an example of the production of nano materials from local resources. But many companies were not innovative, commercially or technically. Some were only interested 'in how to produce a very cheap component'. Thus the interests of scientists and business people were often conflicting.

He then suggested that scientists, business people and venture capitalists needed to improve their communication and interaction. There was a general perception of research in Malaysia in the 'sense that we the scientific community at times as only thinking about our interests'.

Finally, the respondent emphasized that he could do research prioritizing without IRPA funds, as he could do his research freely to take his own way and do the prioritizing himself. His employers managed their own research funds and have budgets for conferences, and having IRPA status was an advantage to them.

Interviewee 33

This respondent was the head of one of the departments in his institute. He had a first degree in mechanical engineering and MSc in combustion and quality control. His PhD was in chemical engineering from an English university. After he finished his PhD, he was assigned to a management post, and became a leader of a research project. He claimed that since he became a manager, he became more interested in strategic thinking for his department and institute. His specialization was incineration. From his experience of working with companies, he had thought hard about how companies perceived the government in terms of their own benefits and purposes. One company was really committed to working closely with government departments or institutes. It put its effort into getting grants and pilot plants for adaptive research. From Malaysian companies' perspectives, bankers and other investors had a 'seeing is believing philosophy'. To have a pilot plant was essential for turning research findings into products. However, some companies were dishonest when working with the government. He claimed that some companies 'always want to have or to win everything and that they just ride on the back of the government'.

On the commercialization of research findings, the respondent emphasized that he was willing to work with any university or company. The nature of the collaborations was as important as any research finding to be commercialized. There needed to be bankability, viability and track record from the standpoints of banks. Universities lacked funding for development or pilot plants when compared to government research institutes.

Interviewee 34

This head of a department of her institute was 50. She held a first degree in biology and genetics and an MSc and a PhD in radiation biology. Since she finished her PhD in an English university in 1982, she had held an administrative role, mainly in R and D management. However, she claimed that 'management, at a certain level has become a routine job, and there's no challenge', compared to research. Therefore she came to lead a research group in food radiation data and help to develop Malaysia's national essence tissue and bone bank.

As regards the commercialization of her findings about hydro-gel, she found that the process took longer time than expected. It had 'sounded so nice, but yet it was not easy'. Although the relevant company had paid her licensing fee, and had been given space in her office to help with the building of a pilot plant, the company had failed to market her work. There were other problems for commercialization in the agricultural sector, especially for nurseries. Since most of them were relatively small, they could not afford to diversity as there was 'not much of market and no big market' for the products of agriculture.

Finally, she argued that researchers in Malaysia 'have to do everything'. Therefore special units with the right people had to be employed to help commercialization. The commercial partner had to be 'large scale' rather than the scientist. However, the research institutes should not spend too much on 'prototypes' as products might not be perceived well by markets.

Interviewee 35

This respondent was in his 40s, and he had specialized in radiation vulcanization on natural rubber. He had perfected an alternative technology for the mechanization of natural latex rubber. Apart of his work as a scientist and inventor he was also the leading organizer for national innovation competitions among universities and government research institutes. He was also the leader of the Malaysian scientists' delegations for the same competitions at international levels. He had his own pilot plant for his research findings. He spoke mostly about his ways of commercializing his research findings and of the problems involved.

The former included visits to companies and exhibitions, and attending conferences and seminars. Through his interaction with companies, he had managed to convince some of them about his research findings. To get through to companies he had needed 'sincerity, consistency and continuous interaction'. He gave companies samples and asked them to try them on. He perfected his findings using feedback from companies and developed 'mutual understanding' with them to get their confidence. He commented that most Malaysian based companies 'don't have much knowledge about scientific things'. They just had the finance for materials and facilities and for manufacturing and marketing. Their 'R and D' units were merely for quality control, when compared to what foreign-based companies had. Therefore it was the responsibility of scientists to educate them.

Finally, he argued that most researchers were reluctant to commercialize their research findings because of the hard work involved. Given a choice between working in their laboratories and meeting people for the other purposes the former usually came first.

Interviewee 36

This respondent is 51, and held a first degree in nuclear physics, a masters in nuclear technology and a PhD in materials engineering. All were from English universities. His specialization was on the industrial use of radioisotopes. He had become a United Nations expert in his area. He aimed his research towards the oil and gas industry. Most of his inventions were related to problem-solving. He had led his groups of researchers in many projects related to the industry. He spoke mostly of his own experiences in the commercialization of his research. He claimed that all his technologies had been commercialized. At very beginning of his work, he had undertaken many marketing activities like demonstrations, conferences, seminars and road shows to promote his research findings, which were to do with problematic areas of oil and gas. He had been accepted by all major foreign and national companies in the industry.

On problems of commercializing research, it depended ‘on the project, as there are some projects that you just license’. His projects give services to the customers involved with radiation products, and they needed recognition and approval from the authorities concerned. Generally Malaysian scientists were doing adaptive types of research, as they were fairly easy to do. He commented about his relationships with administrators who helped to organize commercialization: that the ‘relationship is not so good, and it can be better’. This was because they did not reward most researchers enough. Although there were many successful scientists in government research institutes, they were not getting enough support in terms of money and promotion. However, compared to scientists from universities, they were promoted more easily.

Interviewee 37

She was the head of a research division of a government research institute concerned with the palm oil sector, and she was in her 40s. Her degree was in chemical engineering and her masters in process chemical engineering. She claimed that her unit had been very successful at commercializing its research findings. Her research products were mainly in cosmetic formulations, cosmetic toiletries and detergent cleaning products. Cosmetics and personal care were the most successful. Her division had 20 memoranda of agreement, with mostly with small and medium-sized industries (SMIs). The collaborations were more about the use of palm-based materials. One company took pride in commercializing its products with the help of the institute. The company used the institute’s pilot plant and within two years of being assisted by the institute, the company had its own pilot plant. The company had done its strategic marketing and managed to sell its products to ASEAN countries.

She spoke positively about her successful commercialization and about how she had accomplished it. They had included ‘one stop centre for R and D cosmetics’, meaning complete facilities for formulating cosmetics. Her staff had been to Italy and gained knowledge through cosmetics courses and by attending seminars on cosmetics. Her institute did not charge any up-front fees to most of their collaborators as they were willing to be compensated by the successes of the companies. Once the companies succeeded, they would pay something to the institute. In the end, ‘the institute is very pleased that we have created a number of SMIs’.

Interviewee 38

This respondent was also in his 40s. He was a scientist in one of the government research institutes serving the palm oil industry. His research findings were widely used in motor vehicles. Elements of reverse engineering were used too. He worked directly with national car manufacturers as there was need to use and develop resources and materials. His worked helped Malaysian companies to ‘offer more competitive pricing than other car manufacturers in Asia’.

On the process of commercialization of GRI findings in Malaysia, he said that researchers and companies needed to ‘adapt reverse engineering since fundamental research projects normally face difficulties in finding good markets for commercialization’. He argued that researchers should meet industry needs and help to solve industry’s problems. He thought that the roles of engineering and science in technically change were with related to each other. He and his staff use science and analysis by formulating the right methods and the uses of suitable raw materials. Engineering was more about the design of machines and equipment.

Interviewee 39

This respondent was a scientist working with an agriculture-related and government research institute. He has an MSc in food engineering from an Australian university. His research is on the mechanization of food machinery. Users of the findings were individual entrepreneurs with small-scale commercial activities and family businesses with traditional food-making processes. He also got funding for up-scaling his machines, and for the institutes apart from the IRPA fund to do the prototype. He argued that the use of machines helped the business to maintain itself as 'there is no competition in term of machine development'. The machines were improved regularly, and could not be easily superseded by others.

He spoke of how commercialization of his research findings helped individual entrepreneurs to succeed by providing machines, advice, and training. He suggested that the government should also provide financial support to small businesses as the cost of machines was very high for them. Installation procedures could be developed and the business people used to help the transfer of technology become easier.

Finally, on technical change in the food industry, normally the main problem faced by the industry was about the formulation of ingredients. Food technologists did research to help to turn them into commercial products. Engineers developed machines to make the food products. All this was investing in the amount and quality of food production.

Interviewee 40

This lady scientist was 53, with a degree and in MSc in agriculture science. Her PhD was in genetics. Her research concerned distilled root crops. The findings had helped to develop several varieties of high-yield and good quality cassavas and sweet potatoes. The research had also been on downstream products such as flours. The findings were being commercialized using a special unit of the Institute that supplied planting materials, training, and ways of mechanizing food production. She emphasized her view that the Institute's research was focused on market pull rather than technology push. It was also helping SMEs to process sweet potatoes into other kinds of food product.

She spoke mostly about problems associated with of commercialization of her Institute's research findings. These included limited land area for economic cultivation of sweet potatoes, the readiness of the fresh market for sweet potatoes, the fact that most companies seemed to be 'afraid to be pioneers' in marketing new food products and of how big food companies generally had their own research units, and resisted research findings from government laboratories.

Finally, she claimed that commercialization depended on the whole packages of knowledge and technology being transferred to companies. The general public mistakenly thought that GRIs offered findings for nothing, and this was hard to change. Many small companies were always hoping to get free findings and help from the government.

Technology Transfer Office Senior Officers (eight interviewees)

Interviewee 41

The interviewee was in his early 50s and held a first degree and a PhD in fuel and energy engineering from an English university. He was the deputy director of the research management centre at his university. He has been in the centre for less than a year. At first he thought that the centre was only responsible for protecting intellectual property. He then found that although the centre was targeted to commercialize one or two products every year, it did not do so. This was because the idea and experience of commercialization were new to them. He would have preferred to see the centre changed into a business entity. The problem of commercialization for universities was that the research findings mostly were 'not tested yet, and would require a development stage, which probably [would] need to incubate'.

He went on to argue that working with business people needed a different approach, when compared to universities as government entities. Most companies wanted to expedite their investments as quickly as possible, to get things done. However 'with bureaucratic procedures being imposed' it was not possible for his centre to react quickly to the requirements of companies'. He argued when most universities in the West getting their research funds from companies, in Malaysia, most universities were getting theirs from their government. To find the right Malaysian business people to invest in research was difficult.

He also argued that his university's top authority had no direction and seemed confused in determining the ways to engage in commercialization and technology transfer. Therefore, the university's approach 'had remained *status quo*'. It had not changed much since interest in it began some years ago.

Interviewee 42

The interviewee was 58 and since 2000 he had been the group managing director of the technology transfer private company of his university. He held a first a degree in medical science and a PhD in pharmacology from an Australian university. He was appointed to his present post because of his wide experience in his field. He was a former professor and a dean of his university's school of pharmaceutical science. He was responsible for the strategy of the company, and for formulating and executing its policies. He emphasized his view that in university commercialization and technology transfer 'there should be a mechanism to help scientists to commercialize their product and to do the technology transfer'. Regarding the involvement of scientists in helping companies, he argued that scientists are the ones who know what are the problems that face many industries are. For scientists to take their research further in terms of prototyping, problem-solving, trouble-shooting and up-scaling to the requirements of industries was a good complement to their research work, showing that it had practical value.

On problems of commercializing research findings, he argued that scientists must have open minds and be willing to listen to criticism, and that they 'must be very open to advice given by their top administrators'. This was because, in general, scientists were 'very proud people and suspicious of any suggestions'. Furthermore, scientists sometimes put a very high value on their R and D, and sometimes refuse to reveal details of their research to companies. Scientists did not like to feel that companies had abused their confidence and trusts.

Interviewee 43

This interviewee was a professor in the department of chemical and environmental engineering of his university. He held a first degree in chemical engineering, an MSc in environmental engineering and a PhD in chemical engineering, all from an English university. He held a post as director of technology commercialization in his university's business unit. He said that commercialization and technology transfer were 'two different things'. Commercialization was focused on money. Technology transfer was about ideas and techniques, national or foreign. The main problem that he perceived with commercialization was that, a product could be good and innovative but it … [could] not [be] ready, or be good and innovative, but too costly'. Furthermore, his unit did not have the capacity to be run like a business, and to market research findings as the university researchers' products. So the findings were usually unknown outside the academic world.

The interviewee then noted how diverse scientists were, and how they were not directly 'in contact with industries' and 'did not work in the commercial world'. However, in other subjects like engineering, medicine, business, accounting and economics, 'there is a constant link because they have projects'. He said that, scientists discover something new just to satisfy themselves and to increase their knowledge and that this was a kind of capacity building for them. Some scientists were not interested in pursuing commercialization as it 'takes time, is very difficult, and they didn't see any money in that'.

Interviewee 44

This interviewee was 51, and was an animal scientist interested in animal nutrition and animal feed processing technology. He had worked in his laboratory and pilot plant for animal feeding for more than 20 years. He had tried to commercialize his own findings for national and international markets. He was attached to a company under his institute for four and a half years. He was in-charge of technology development, marketing and commercialization in his unit. He said that research findings that do not make business sense will not attract potential commercializers. He named several factors that scientists should look for in seeking successful commercialization. They included the novelty of the process, formula, or product, the status of the intellectual property, how repeatable the technology is, whether it can be demonstrated, whether it is technically viable, and whether it is economically viable. If it was too expensive, it would not interest companies. Scientists also needed to be excited by the prospect of commercialization.

In addition, on the side of companies, he had several reasons for explaining why some companies failed to commercialize research findings of government research institutes. They included the fact that some companies did not focus on the technology that they were taking, that they broke promises to researchers and others, and that 'they are low strategic-fit companies in terms of distribution, marketing, sales and funding'.

Interviewee 45

This interviewee was a general manger in his late 40s a subsidiary company of one of the GRI. He had a first and an MSc agricultural engineering. His company focused on commercialization and technology transfer. He claimed that the company was run in a different way to technology transfer offices of other companies. But they were struggling between taking advantages of an embryonic stage of R and D and pursuing technology generation and commercialization.

On the important characteristics of successful commercialization of work by GRIs, he argued that his company had the 'desire to grow' and that it was taking on the name of the government's company to get recognition for their findings in the market. Therefore, there had to be a significant business interface between scientists and business people to create a success story. However, by following existing government policies, his company had failed to attract outside companies. Then he said that his company had been operating on the basis of a 'balance between risk and future gain'. His type of company shared risks on behalf of the government. He also argued that since companies were profit-oriented, their capacity 'to handle new technology is less'. They often did not know and understand know their markets and what they wanted well enough.

Interviewee 46

This interviewee was with two people. One was the senior officer in the Technology Transfer office. He had been in post for the past two months. He held a first and an MSc in electrical engineering. The second interviewee, a subordinate of the first, had a first degree in science, an MSc in information technology and an MBA in marketing. He was assisting his senior in the interview as he had more experience in their office. Their job included strategic planning for marketing and financial aspects of technology transfer. Their office now had the same level of line authority as other units or departments in the Institute. This showed that with the new structure, the Institute has given more emphasizes to the commercialization of research findings.

Both of them described problems of being in a government institute beginning to be concerned with commercialization and technology transfer. There were no formally approved ways of commercializing government activities. Their institutes had been involved in the commercialization for nearly six years, but it had been consisted mostly of service and consultancy jobs. They had managed to generate income for their work and had put it into their trust fund. However, in the processes of commercialization, profit and loss tended to cancel each other out. They said that 'you can count the revenues, but it does not cover all the other things, like operating costs' and they found, in general, that it was difficult commercialize research. They argued that there was 'a gap between business people and scientists as the former was looking for profits, and the latter for technology advancement'. Scientists and research administrators did not know market needs and the business people did not know what to ask for. Their own working environment was not pressurized to make a profit. Yet it was their responsibility now to help industries to sustain themselves by keeping up date. They also said that universities should focus on basic research, while GRIs should focus on applied research.

Interviewee 47

This interview was also given by two interviewees. The first was its director of Information Technology and Corporate Services. He was in his 50s, and had a first and an MSc both in marketing. The second was a Principal Research Officer in his early 40s. Both interviewees said that their Institute had successfully transferred 250 technologies to business people and that about 30 percent had been commercialized. Technology transfer had taken place through research papers and their publication, consultancy services, exhibitions and seminars. They also held Customer Days which to which business and other people and could come and discuss their needs and requirements for new and supporting technologies. However, commercialization was not easy, as most scientists 'were pure scientists' who had 'no knowledge about… businesses'. Therefore their scientists had been sent on short business management courses. The institute had produced several memoranda of understanding or agreements with companies. Moreover, it had also formed a special advice committee to discuss and develop a focus on the research needs taken from the business people.

On weaknesses in commercialization, they argued that some research was not related to industry, that scientists showed a lack of 'economic calculation of cost and benefit', and most of them were doing basic research which was of little help to companies. However, they both agreed that efforts in the area of commercialization were time-consuming for most scientists, and that therefore, some research findings that had commercial potential would not get through to companies. Finally, it was a waste of government money if some companies failed to commercialize relevant discoveries because they were given rights of exclusive use of the research findings. Therefore, companies had to be committed to pursuing and exploring the whole process if they wanted the benefits of research findings.

Interviewee 48
This interviewee was in her 40s and a Professor of Coastal and Offshore Engineering Institutes of her university. She held a senior post in commercialization office. She was specialized in maritime hydraulics and some of her research findings had been commercialized. She said that her office had to be a 'one-stop centre for transfer of knowledge or technology for industry'. She argued that scientists should more inclined to be informed about business so that they 'will tailor their invention or knowledge for a product, otherwise it just be on the shelves'. She herself had 10 years of experience in commercializing research findings and she was enthusiastic about commercialization.

On the most important characteristics of successful commercialization, she argued that the government should have strong guidelines and policies. Technology Transfer Offices should match scientists with potential partners among business people. However, most research findings needed to be up-scaled, and yet business people were reluctant to invest more for development purposes. Other problems included business people is perceptions of the quality of research findings, and a lack of funding for business people's who wanted to use research findings. Most business had to disburse their money in the process, and this prolonged it. Finally, she admitted that her university had yet to offer a really successful set of research findings that would definitely give confidence to companies that wanted to be interested in and to use research.

Top research administrators (six interviewees)

Interviewee 49
The interviewee was 53 and a professor of chemical science in his university. He obtained his PhD from an English university. He held a senior administrative post and was in charge of his university's research and innovation program. He has been awarded several fellowships from, among others, the Petroleum Research Institute of Malaysia, the Japanese Society for the Promotion of Science, and Universite' Henri Poincare in France. He was also a Fellow of the Malaysian Scientific Association and the Malaysia Institute of Chemical Engineering.

He had prepared some answers in advance for the interview. His university had set up a private company for handling knowledge, technology transfer and commercialization of products and processes. It had multi-disciplinary subject areas and it had developed clusters for research. The university had special program that it called acculturation of research. It meant that every scientist was meant to share values about research. He argued that successful commercialization depended on the willingness of industries to take up bench-scale research findings into piloting and manufacturing. The government should be more flexible in giving grants to industries and universities. Under the rules and regulations of the University Act, scientists were not rewarded enough.

Other weaknesses affecting commercialization included the lack in Malaysia of significant companies or products that boosted the universities, when compared to such Western companies as Nokia which was synonymous with Sweden. Therefore, although Malaysia produced many research findings there were none that raised expectations. Venture capitalists were quite reluctant to invest as they 'normally want to see money tomorrow'. Some of the facilities that were supposed to support the work of scientists slowed research activities down.

On the roles of engineering and science in technical change, for this interviewee, everything started from science. However, it was the engineers who picked things up from the start. They were the ones who defined expectations and then they asked the scientists for the materials to work with.

Interviewee 50
This interviewee was 53 and a graduate in education specializing in scientific and mathematical subjects. He was a senior officer of his university. He claimed that his university was among the universities that received the highest research grants from his government. He said that the main contribution of commercialization is giving services to societies, meaning that 'they improve something, we provide alternative procedures and methods'. The university had allocated £40,000 to help scientists to commercialize its research findings. However this amount was not enough because a 'cost to commercialize R and D is more expensive than doing it, or the ratio one tenth of a hundred'.

The interviewee described the critical factors in the commercialization of university research findings. There included their quality, market viability, functions, strengths, and commercial value. Although the university had undertaken several initiatives to do with commercialization, it did not have a big success story to boast about, and he argued that commercialization was still new to it. Commercialization's main weaknesses at his university included the inability of university to attract venture capitalists and that of industry to commercialize findings. Another problem between the university and industries was poor mutual understanding. Some business people had said that, 'Your product doesn't help us, because your researches are too ideal'. Yet there were research contracts that had helped many companies.

On the roles of engineering and science in technical change, the interviewee emphasized that the two complemented each other. Engineers needed the knowledge from science, because 'engineers applied whatever scientists had suggested'. This is a very conventional STH view from someone apparently with little direct experience of industry. Thus the scientists provided the knowledge, and the engineers used it.

Interviewee 51

This interviewee was in his late 40s and he held a degree and a PhD in resources management and policy. He was not an engineer or scientist, but an economist. He was responsible for managing, facilitating, coordinating and monitoring scientific research in research management office of his university. The centre that he works for has rules and procedures for making sure that every grant application meets all government-specified requirements with various levels of committee evaluation. He claimed that out of its 1500 scientists, 50 to 60 percent were active researchers.

On technology transfer and the commercialization of university research findings, he felt that they were bonuses. Research projects that reached the end stage of product commercialization could be considered fully successful, because ‘they have been able to complete the full cycle from idea conceptualization’. Yet commercialization was not the main aim of research in the university. Its scientists ‘did their research and disseminated it in terms of ideas and formulas, and then it will become in the public domain’. Lecturers had to fulfil their social obligations. The university scientists did meet with business people and often worked with them as commercial partners. But the original aims of university research were scientific, and many scientists did not know much about markets. There was no contact with venture capitalists because their objectives were so different.

On the roles of engineering and science in technical change, he said that they could be separated. Their functions depended on the types of problems experienced in technical change.

Interviewee 52

This interviewee, in his early 50s was the director of a GRI. He had just been promoted to this, his highest position, after working for nearly 27 years in the Institute. He held a first degree in geology, an MSc hydrology and a PhD in risk management. The institute had many scientists with different backgrounds, such as physics, chemistry, biology, mathematics, and chemical, mechanical, electrical and electronic engineering. It was its policy to collaborate with companies. Therefore its research was designed with the needs of end-users or prospective customers in mind.

Establishments, whether from the private or public sector, were influenced by both work technology push and technology pull. They included companies and institutes like his. Institutes like his should always be considering ‘If they want an apple, give them an apple, and if you have orange, is no use to them’. All in all, the market-driven ratio of his institute’s work was about 80 percent. At present, the institute was in contact with around 4000 business people or companies. It gained, from fees and payments, 30 to 40 percent of its yearly operating expenditure. The funds gained were returned to them for R and D purposes. IRPA was one of its sources of funding for research.

Regarding commercialization and technology transfer from the Institute, he claimed that the only weakness was, being a government entity, it has to abide by rules and regulations, especially for spending government money, which most of the time delayed it in its wish to operate at the request and to meet the time scales of business people. Its financial policy needed to be reformed, to make its commercialization work more effective.

Interviewee 53
This interviewee, who looked to be in his late 40s, was a head of department in the above institute. He held a degree in mechanical engineering and has two MScs in law and in business administration. He was asked to answer certain questions on behalf of his director. He described how the institute's research was funded by, and designed to benefit, specific industry sectors.

He argued that there were no 'one size fits all' answers to questions about the levels of research findings being taken on by the business people. The levels varied from laboratory to pilot plant scale. It is depended from 'one product to another product and from one technology to another technology'. Therefore, in commercialization and technology transfer the best way was to try 'to try as early as possible, for example, to find a business partner. This is, there is no point in investing so much money and finally finding that there are no takers'. However the Institute had learnt that sometimes business people were unconvincing at the laboratory scale. It tried to do more work on the pilot scale, so that business people would say that 'when you finish at the pilot plant scale you are ready for commercialization'. Finally, he made clear that in commercialization and technology transfer, success usually depended on 'the strategic importance of the technology and the significance of the research findings'.

Interviewee 54
The interviewee was in his early 50s, and also held a senior post in the above GRI. His first degree was in agriculture, zoology, forestry, and wildlife. He had considerable knowledge of fish feeding, pond feeding and fish cultures. He had been working in the same institute for about 30 years. He was responsible for technology promotion and development. As with interviewee 45, he was answering on behalf of his director. He argued that in his department, commercialization meant 'any technology has been well transferred, diffused and used by the client'. It was more specific than various businesses making use of knowledge and techniques. The institute had a social obligation to conduct research for the use of the public or smallholders in agriculture and food. It also had to explore any research findings that matched the private sector requirements. These two functions were made explicit about 10 years previously, when hitherto the institutes did not do anything with research findings except to publish them.

The interviewee explained that the institute had restructured itself to suit the requirements of technical and scientific development and to link research and its end-users. It relied on the National Innovation System which was just being introduced. On the weaknesses in CTT, he argued that the IRPA fund was for having to do with research only. He stressed that 'no one forces us to do the up-scaling of the technology, and to test the technology whether it is commercially viable or not'. Apart from financial reasons, he argued that companies and researchers had no experience or confidence in working together. He also claimed that SMIs still needed 'direct support, subsidies, and soft loans from the government scheme'.

VENTURE CAPITALISTS (three interviewees)

Interviewee 55
This interviewee was the chief executive officer of a fund management company and in his late 40s. The company's biggest shareholder was the Ministry of Finance. The company funded ventures focusing on ICT and biotechnology. It had a time limit for operating until 2010, when

it would have to be closed down. Initially it had £400,000 and until the date of the interview it had been about £80,000. Mostly, about 30 percent of the funding goes to company set-ups and or 'goes to the seed'. The seed fund is for the initial study of a product or process and its business plan. The other 70 percent goes to the extensions for operating companies. He argued that university scientists needed to get business people involved in their funding proposals. However, most proposals failed as scientists did not 'develop what the market wants'. Therefore there was a mismatch. He also argued that some scientists were people who 'are not easy to handle'. This was because they had high incomes and it was merely a bonus if their findings were commercialized.

The company did not have to make any contacts with MITI or MOSTI, but with their parent company, as they had been their targets for managing their fund. He said that generally university scientists became consultants to companies and were actually working for their own outputs to be used by businesses. Therefore, it was not the job of fund managements to give new companies their funds. He argued that most scientists were not good doing business and they had also time constraints by having to do their main jobs.

Finally, he described problems that arose in assessing funding for companies. These included the facts that some companies were not ready, some were not willing to tolerate intervention of third parties, some companies often did not agree with the process of the evaluations by fund managers, companies' business plans and proposals were often not justified and some did not agree with the system of punishment by them. All in all, fund mangers were becoming more frustrated about giving funds to business people.

Interviewee 56

This interviewee, in his early 40s, was an accountant by qualification, but had never practiced. He had worked in banking before joining his company. He had been in the venture company for six years as its Head of Investment. He spoke about his company's background and its working with companies in ICT, life sciences and biotechnology, and advanced manufacturing, whether it included ICT, life sciences or not. He said his company did not gave their funds to universities but he believed that 'ideas…technology must be mixed with commercial ones. Therefore if there is no mixing of ideas … it will not be successful'. Companies had to be commercial as they were bound to their shareholders.

On the ability of university researchers and their administrators to understand what companies need, he mentioned that there was a gap and no link across it, as commercial people knew mainly where to find funds, whereas researchers knew how to develop products. There were different objectives that seldom came together. Some university technology transfer offices were administered by lecturers. They should be managed by people from outside science or private sector people, as they might bring different views and objectives. He pointed out that 80% of research findings in Malaysian were 'still on the shelf'. Malaysia did not seem strong in terms of innovation. He added that 'most of our things are replicas, rather than from our own innovators'.

Interviewee 57

This interviewee was in his 40s. He held a degree in banking. He had experience of auditing and of a shipping company before joining his present employer, a venture funding company, as

Senior Vice-President. He spoke about his company's role in assessing applicant' for venture funding. Other than machines, technology, and ways of marketing things, the 'people or promoter or shareholder of a company form the vital element'. They could be 'con people' and might deceive venture capitalists. Technical people from universities might not be good at management. The chief executive officer 'must know everything in the company'. However, his company had successfully ventured into one ICT company from a university and profited from its listing on the stock exchange.

He suggested that universities should establish their own private companies, functioning as mediators between researchers, business people and venture capitalists. The company was then 'easier for us to communicate with…and whatever they have stays in the university, rather than I go to the university and buy outright'. He added that a university could have hundreds of products and hundreds of companies. It seemed as if universities did not capitalize on their research findings.

Finally, university research findings made by scientists lacked an 'entrepreneurial environment'. This was partly because some of the outputs were only slightly better or 'above the standard', and might only seem to offer changes in the speed or power the processes, products, and so on. This did not do much for commercialization. However, there was a difference between the abilities of scientists in universities and those in GRI Scientists in the latter had some practical elements in them. The universities were more academic. There was a free market for scientific knowledge in Malaysia, of course, as 'we cannot control that'. Business people could stay in or leave markets whenever they wanted to.

JOURNALISTS (two interviewees)

Interviewee 58

The first interviewee in this group was a newspaper businessperson. He held a BA degree. He had experience of working in a publishing company for 30 years. He spoke about the failure of GRIs in helping business people to enhance their products for agriculture or manufacturing. Although scientists had done much research, their outputs did not satisfy the expectations of most business people, especially in agriculture. Some research findings were not passed on to them. Some business people were willing to support research that could eventually benefit them. He emphasized a need for 'a clearance, a mid-way house' to make sure that research benefited potential end users whenever possible.

On the question that many companies seem unable to put scientific knowledge to use, he admitted that business people were different from university ones, being more practical and less theoretical. Universities should prepare more of their students 'for the real world'. Government and business people seemed not to have same objectives as he said that 'industry is going one way; the government is going another'.

In educating qualified people, he argued that the country should produce 'holistic students who understand and not only excel in academic things, but who are also patriotic, creative and more generally knowledgeable'. Therefore there must be flexibility in education, where, for example people may have than one academic degree, so as to be mobile from one sector or skill to another. He then argued that he was against some of the Malaysian ways of managing, and that he supported the Western management, especially the American kind. He pointed out that

Americans were good at ‘selling and that branding’ and they had ‘the biggest and largest economy in the world’.

Interviewee 59
This interviewee was a journalist for a national newspaper. He wrote its science and technology column. He argued that although the efforts at CTT were very important, it seemed that there was ‘not much success in these areas’. He had encountered one scientist who had ‘had a tough time selling his research findings to foreign and national companies’. However there were some Malaysian start-up companies in the IT sector that had commercialized research findings successfully. He claimed that most Malaysian business people tended to opt ‘for the easier route of doing business, while others tend to do hard technology’.

He also said that many Malaysians were too much influenced by American management ideas. He said that they placed ‘too much importance on the short-term’. He condemned the use of word ‘technopreneur’ that had been developed by Americans. The idea was that scientists and technologists were expected to become entrepreneurs and it had come was from an idea from a 1998 issue of Business Week, that had discussed Stanford University and its collaboration with entrepreneurs. He argued that it was time for Malaysian government to separate ‘the techno and preneur’, to distinguish their roles.

THE POLITICIAN

Interviewee 60
The only interviewee of this type was the Parliamentary Secretary of Ministry of Science, Technology and Innovation. He was 51, with a first degree in electrical engineering. His MSc was in systems engineering, and his PhD was in systems engineering and control, both from an English university. He was a university lecturer and a scientist himself before he went into politics. He spoke about all the parties involved in research and its commercialization. He argued that under the Seventh Malaysian Plan (from 1996 to 2000), the government’s intention was to foster capacity building in terms of numbers of university and Government Research Institute scientists. In the Eighth Malaysia Plan (for 2001 to 2006), commercialization of research findings became the main focus. He argued that university scientists were only knowledgeable about their research and that they had no understanding of commercialization and entrepreneurship. University administrators were focused on patent filing and lacked knowledge about marketing their universities’ research findings. However, those weaknesses had been understood and the situations had improved. Research should generally be begun with researchers having their industry partners.

Most Malaysian companies did not have the capacity for carrying out research. University research findings were not ready to be marketed. His Ministry was now determined that every research effort ‘must have demand input or market input’. In the government’s new Ministry restructuring of 2004, the process of research and commercialization had been put together. Private venture capitalists in Malaysia were too anxious about taking ‘risks to help commercialization of research findings from university and GRI’.

On question of globalization and its problems, he argued that ‘developed countries always protect their rights’ when compared to developing countries. Thus the developing countries were not competitive as they did not maintain any patent rights. About knowledge workers and k-economy, he argued that in any economy, there are cycles. For any manufactured products, the life span was very short. Business people had to produce more quality products and at more competitive prices. He claimed that 'in commercialization, companies had to think about how to attract people to buy their products, either in terms of packaging and or of design.

He admitted that Malaysian education was more or less the same as British education. However Germany, it was very different. Germany emphasized competencies and skills more. Their lecturers were mostly experienced at working with business people. It meant that 'their lecturers have experienced in industry first, and then only become academicians. Hence they were producing more research finding'. This suggests that he did not understand the German system fully, and that he was a rather naive believer in the STH model of technical change. German technical universities hardly ever do scientific research (Hutton and Lawrence, 1981; Sorge and Warner, 1986).

Finally, he agreed that American ways of managing often stifled creative people. Developed countries used trade barriers against products from other countries, control international markets and quality assurance, such as the International Standard Organization (ISO). He also argued that science was more academic than engineering and engineering was more practical than science.

DOCUMENTARY DATA

Originally it was hoped that policy and other documents, some hopefully unpublished, from universities, government research institutes, companies and so on would be important sources data for this study. However most of the organizations visited only made publicity material of a bland public relations-centred kind available, or more often, made nothing available. Only three companies were willing to give me policy documents. Government departments and research institutes and universities generally referred me to their widely available plans, publicity material and reports, many of which I was familiar with well before starting the fieldwork. Therefore I was unable to obtain much that was more than marginally relevant for improving understanding of research commercialization, technology transfer and the low take-up issue.

From the government, MOSTI (2003a) provided me with a policy document that included its mission statement that is about the National System of Innovation and the rules of relevant stakeholders in optimizing the uses of research and development. This is a very rational and managerial document that 'makes all the right noises' about flexible knowledge management and 'empowering' researchers (see also Universiti Sains Malaysia, USM, 2004).

A more critical stance is to be found in a report by the University of Technology of Malaysia (UTM) to MOSTI (MOSTI, 2003b). This noted such problems and commercialization as ones concerning the volume and quality of research, difficulties with intellectual property rights, inexperience in the design of commercialization strategies and lack of interest from entrepreneurs. However while criticisms appear to be plentiful in Malaysian government circles and from politicians (see also USM 2002; UTM 2004; MOSTI 2003b) the assumptions on which they are based, that technical change is optimized when it is 'science-based', and that innovation must be comprehensively and rationally 'managed', are left unquestioned. Hints at the 'despair' of researchers (Aton, 2005) about companies' apparent ignorance of their work, and the apparently unreasonable financial and technical expectations of universities (Johari 2006) suggest that at least some fundamental questioning might be productive.

Some evidence for slightly more optimism in this context comes from the USM (2003) and USM (2004). These reports have more of a 'bottom-up' emphasis on experience, sharing, collaboration, and 'clusters'. Yet the context remains one in which Malaysian industry is much less innovative that that of industries in such established industrial countries as the USA (see Stiglitz and Wallsten, 1999, on patents awarded; also see EPU 2006).

Malaysian politicians have argued that manufacturing companies are too 'reserved to ask for what they need from universities' research' (Abdullah, 2004). Politicians have claim that the government was not satisfied with R and D returns under the Eighth Malaysian Plan and that the policy makers had to 'improve R and D fund management' (Jaafar, 2004). According to Jeffrey and Teng (2003) many researchers had produced many innovations, but did not 'know to market their products and whom to deal with'. However, Stiglitz (2002) suggested that commercialization is a politically-motivated notion, and that it did not work on many occasions when its advocates, funders and organizers wanted it to. It was a word used to replace and reframe innovation by politicians, and by others and in around government who wanted to channel, control, structure and monitor relevant processes, and perhaps subconsciously to stifle them. Their mentality was sometimes very convergent, inward-looking and small-minded (Hughes 1985). Child (1982) explained long ago that there is always tension between innovation and control in organizational life, and it is possible that those who seek to narrow the notion and practice of innovation down by renaming it commercialization are perhaps revealing their prejudices and other inadequacies, including lack of direct experience of, or at least sympathy for, engineering, industry in general and manufacturing in particular.

Company brochures and policy documents

During the study the researcher managed to get three company brochures and two policy documents, one each from a company and a venture capitalist. The three company brochures were about relatively contained company products' information. The policy document were relatively contained merely company profiles. One company policy document did state its commitment towards changes and meeting customers' needs and market demands. It also summarised its history of company, company range of products, human resource management programme and health and safety measures.

THE MAIN FINDINGS: A SUMMARY

Companies: Entrepreneurs and Engineers (n=23)

Interviewees said that research findings were often not relevant, or not attractive, or there was nothing new to them. Most companies used reverse and imitative engineering design and research. Universities did not have good dissemination processes. Companies often did not have the resources to take up research findings. Most companies were doing 'part-time' and 'production engineering department' research. Companies wanted to be self-reliant on their own technologies. They did not want partnerships with universities and government research institutes. This was partly because the time taken for research findings to be commercialised was often much longer than expected, as most findings were generated in laboratory-scale work.

Company interviewees claimed that scientists generally thought differently from business people. Further, most companies approached to be risk-averse about funding and about spending time on processes of commercializing research findings. To sum up, most companies relied on imported technologies, either from parent companies or foreign partners. Companies were reluctant to engage in, or with, research in the hope of innovating.

Universities and Government Research Institutes: Scientists, Research Administrators and Technology Transfer Officers (n=31)
Most of the interviewees were concerned that companies resisted change in the area of technology development. As there were no test beds in firms, manufacturing new things or in new ways was a problem. This means that government funding of research did allow for the development of the research, but some companies were still not interested. One respondent said that companies refused to co-operate with scientists who worked on the improvement of technology. In addition, interviewees were generally agreed that universities and government research institutes were more bureaucratic than companies in their processes for commercializing research findings. Furthermore, one responded, 'most scientists were burdened with multi-tasked jobs that included elements of management, which distracted them from thinking about how to help companies'.

Generally scientists and research administrators argued that the IRPA system did not support the development part of research findings. They argued that research funding did not facilitate technology up-scaling, yet as it was vital. This was because business people seldom willing to risk the sharing of costs of developing and commercializing research findings. They also argued that, bureaucracy slowed down the pace of commercialization. As one of the respondents said: '… under [the] government, you know that we have to go through certain financial procedures and everything, and then whatever problem exists on the ground about using the technology, we cannot solve it right away'.

Many interviewees argued that elements of trust and commitment from both parties were important for successful commercialization, but also said that the parties lived in rather different worlds. For universities, successful commercialization of their findings was a bonus, not their bread and butter. And as for companies, many would rather be followers of technical changes to products or processes, rather than in the perhaps vulnerable vanguard of innovation.

Other Views: Venture Capitalists, Journalists, and a Politician (n= 3, 2 and 1 respectively)
Two of the venture capitalists felt that while scientists should understand markets, in doing so they should be able to mix commercial and technical information in terms of viability, feasibility and the usefulness of research findings. Most venture capitalists did not work with scientists, as the latter could not commit themselves to business development work. Furthermore, some companies depended completely on 20 year-old plant and other physical resources when more modern hardware was needed for successful commercialization. All six of these interviewees claimed that there was a gap between scientists and business people in understanding research and its commercialization, as they had different perspectives, attitudes and knowledge. A journalist argued that Malaysian universities and GRIs should have private research management offices to develop links between the actors involved in commercialization of research findings. However the other journalist argued that Malaysia is lacking in indigenous technology. Generally Malaysian companies are more successful in IT sector than

manufacturing. The politician argued that generally scientists perceived that they are only researchers and they are not usually in positions to market their research findings.

SOME COMPARISONS

Two common themes have emerged from the data. They are the most relevant for answering the research questions, about company uptake researcher's persuasiveness. Problems of company uptake are very evident in the content analysis and are nicely illustrated by the following quotations from interviewees among companies. One respondent said that 'the way the government system or the institutions system works, is that if they need to buy spare parts, they need to go through a quotation process, and this may take some time, and this is why research in this country is difficult, and I can see that while technology transfer is often commercially viable, we still face problems that are mainly to do with financial resources'. Another said that 'we just buy the machines and the moulds. We are the market leaders, and we have our own R and D. The university research is on a different track, which cannot be commercialized, and our people can't cope with the ideas being given us'. Several companies claimed that the several markets for new technology were not promising and did not try to use new research findings. Larger companies were more likely than smaller ones to recruit researchers and graduate engineers for their own R and D departments.

From the data on researcher persuasiveness, it would seem that companies regard researchers as being much more interested in their science than in its commercial potential. Researchers preferred presenting papers to seminars and conferences to working with industry, as this carried more promise for career advancement. Company respondents claimed that scientists refused to change their perceptions of their own areas of expertise when a more adaptable assumption would help with commercialization. Technology transfer officers also claimed that most scientists were not interested in doing business. Both venture capitalist interviewees said the same thing.

The scientists, from both universities and government research institutes, held different views, as one would expect. On the problem of company uptake, one scientist respondent said that although 'the solution was simple, they refused it, and they tried to pull me out. Many of them are afraid to be pioneers'. However, when, less often, company uptake was successful, researchers could be enthusiastic and proud. One said: 'It is a transfer technology meeting. I will give new things to them, new findings based on new experience. Many companies are interested in my presentation, and one of them has already taken up the idea and will commercialize it. What really matters is mutual understanding'.

On the other hand, senior officers of technology transfer offices argued that problems of company uptake occurred '…because proposals are not convincing at the laboratory scale. People in business want to do things fast. Also many research findings are not be able to be commercialised because they don't have any value for industry'. The venture capitalists felt that research administrators were too bureaucratic and slow and that many research findings take too long to increase company profits. The journalists claimed that there must be more synergy between researchers and companies to encourage uptake. The politician who was a respondent claimed that most scientists did not have the experience to commercialise their research findings. Certainly, scientists only knew how to do research and were not business-minded, ‘even though their researches have strength’.

All the findings suggest that most companies do not have much interest in taking up university and government research institute findings. Notably, many small companies lack the capital needed to realise the commercial potential of research findings. This is part of more general problem, perhaps, of undercapitalization of SMIs. Venture capitalists find that if the research findings belong to highly specialized technical areas, many companies seem unable to produce firm enough technical or market-related reasons for the venture capitalists to lend to them. Obviously, relevant discoveries, inventions, ideas and knowledge can be inherently high risk and high cost, with long-term paybacks. From company perspectives, quite often the findings suggest that the significant problem seems to be gaining an understanding of university attitude.

Scientists also often regard themselves as obliged to understand company attitudes if they want their work to be commercialized. Scientists often argue that universities are not in the business of commercializing discoveries, inventions, ideas and knowledge, and this can clearly limit universities from reacting quickly enough to meet the demands of companies. This attitude has important strengths, because universities have educational and moral functions, and their research is often either not relevant or not yet relevant to industry, and scientists often produce their best work when they are free to do what they (and not companies) or university managers want. However much university research does have strong practical relevance and it should be put to good use quickly. Universities do often have rather slow decision-making procedures, which times are contrary to the operational methods of companies.

It is difficult from the data discussed above, to see the successful commercialization of discoveries, inventions, ideas and knowledge in such simple terms as those of Laparche (2002, p. 149) as ‘the result of the application of an “organic paradigm” consisting of the four closely interacting factors of legislation, the economic environment and entrepreneurship, technical progress and university strategy’. All parties involved should obviously be willing to work together, but economic, political and social activities are nowadays so diverse, interdependent and difficult to predict, that simplistic comparisons between the private and the public, between business and science, and between flexible and the rigid ways of managing, can confuse thought and action more that they usefully inform them.

CONCLUSION

This appendix presents the results of the research, mainly from interviews along with a little documentary evidence. Interviews were carried out over three months from early October 2004 to early January 2005. The respondents came mainly from engineering companies, universities and government research institutes, and six were with other interested parties, meaning three venture capitalists, two journalists and a politician.

The most significant findings were about resistance to change from the companies. Companies tended to be too under-capitalised or focused on survival to use discoveries and inventions from scientific researchers working in universities and government research institutes. The company respondents seemed to be biased towards foreign technology and risk-adverse in general. The necessary underlying element of trusts often also offer seemed to be lacking between various parties. Therefore, the process of technology transfer tends to be slow as the parties involved did not seem to appreciate what they might gain from each other, or to be realistically aware there was not, in some cases, much anything to gain.

APPENDIX 2:

TWENTY-FIVE CONCEPTS

These concepts are grouped under five main headings: subject classifications; socioeconomic development; academic; industrial; and ones linking universities and industries. The reasons for choosing them are explained under each of the headings.

1. Subject Classifications:

1. a. *Kunst, Technik and Wissenschaft*

These definitions are included because they separate engineering and science, unlike such English language terms as applied science and technology. They make a clear distinction between those who make things, *techniker* or engineers, and those who study them, scientists or *Wissenschaftler*.

1. a. i *Kunst*

Kunst means the fine and performing arts, which are meant to be beautiful and inspiring. They are thought in German and in other Continental parts of British arts colleges.

1. a. ii *Technik*

This word means engineering and technical excellence, and many other practical subjects. It is concern with usefulness and cost, design and use. It relies unpredictable ingenuity far more than on use of scientific principal. On the Continent university-level *technik* subjects have long been taught in institutions with very high social status.

1. a. iii *Wissenschaft*

Wissenschaft means science and scholarship. Its literal translation into English is 'knowledge-ship'. Its includes all subjects which are concerned with discovering and recording the truth. Examples include history, the study of language and literature (but not creative writing), geography, economics, psychology and sociology and political science, as well as mathematics and physical sciences. These subjects are taught in traditional universities like Alexander Humboldt University in Berlin and the Sorbonne in Paris. Their outputs are judged in terms of truth or rightness against some scale. They consist of public knowledge (Ziman, 1970) or verifiable knowledge of phenomena (Fores and Rey, 1979).

1. b. The 'pure' and 'applied' science and the arts and humanities

These are included because they appear less than logical compared with the previous classification, and because in the cases of the 'pure' and 'applied' sciences their illogical character informs much conventional and/or English language research, thought and rhetoric about technical change and commercialization.

1. b. i Science

Science used to be called natural philosophy. The word science did not come into use until the nineteenth century, with the first use of the word scientist, in 1844, often being attributed to the Cambridge University mathematician Whewell. Science has two-dimensional paper outputs and the best short definition of scientific activity is the production of verifiable knowledge of phenomena. The scientist aims to get as close as to truth as possible, and is not primarily interested in usefulness or profit. Science is a non-commercial type of activity, at least in principle and the first instance. However, the term 'pure science' is very dubious. It means science that no one will use. But there are many examples of knowledge once thought to have no practical uses or implications that has been used eventually. It is politically motive because its use attempts to distance certain activities and people from the everyday, practical concerns of people.

Ziman (1970) defined science as public knowledge. Fores and Rey (1978) defined it as verifiable knowledge of phenomena. These definitions are virtually identical. Scientists study things. Scientific knowledge is a public good like the air, free for anyone to question and use at any time. Since it is impossible to predict whether new scientific knowledge will be used or not in the future, the idea of 'pure' science is very questionable. For example, astronomical knowledge was once seen as having no conceivable practical use. However, it is now in widespread use in satellite communications. Bell and Hill (1978) suggested, further, and agreeing simultaneously with Ziman and Fores and Rey in the process, that science is definable by its method of trying to disprove conjectures as much as by the nature of the knowledge that it produces.

1.b.ii Engineering

Engineering is not applied science and it is not a part of science either because it does not produce knowledge as its primary output. Its output consists of hardware and supporting software. Most working engineers will agree that engineering is sensibly called the 'industrial arts' because it is much more art than science (Fores, 1978).

The root of the word engineering is ingenuity. Engineering is a, in fact *the*, useful art, and it is intuitive and unpredictable and private to its creators in many respects. Engineers make things, and their work includes the design and technical development of processes and products, and the production of three-dimensional artefacts of all kinds. Engineers use technical, scientific and other knowledge in their work, but their work is not part of science. The output of the latter is verifiable and published knowledge of phenomena in the form of scientific papers, books, and so on. The output of engineering consists of useful and commercially viable products. Engineering is often ahead of the frontiers of scientific knowledge, with there being no science to apply, as when drugs are marketed without full knowledge of why they are successful, or when bridges are built without complete certainty about their long-term future and safety. Engineering in one form or other has existed since prehistoric humans began to make and use tools. The most comprehensive definition of our species is *homo faber*, the maker and doer (Glover and Kelly 1987). Engineering also uses all kinds of accounting, financial marketing, and people management expertise. It has many branches, for example aeronautical, civil, mechanical, electronic and electrical, chemical and mining.

1.b.iii Technology

This popular word, which in many lay minds, at least, appears to be identified mainly with information and communication technology (ICT) is often used to differentiate ICT from apparently older and cruder technologies, like those of electrical, mechanical, mining or civil engineering. However it is more complex word than this suggests, although as shall be seen, the gently implied criticism of it being a status-concerned substitute for engineering has more than a grain of truth in it.

Dictionary definitions of technology tend to note and stress the relevance of the literal translation from the Latin: knowledge or study or the science of technique and/or techniques. In both everyday and academic usage, however, and as just suggested, the word generally has more practical connotations, ones 'traditionally' and more accurately identifiable with engineering. Most practising 'technologists' are engineers by qualification, function and title, so this is unsurprising. Fores (1978), an engineer and economist interested in the status of engineering across the industrial world in the 1970s, asked how engineering, which principally aims to produce three-dimensional objects for sale, could sensibly be described an '-ology'. He also wondered whether technology means 'ideas, hardware, or something that arts graduates love to hate'.

Such criticisms do, whether they are perhaps too strongly stated or not, provide support for the suggestion that technology is a rather vague notion. If is possible that it is so because it means quite literally means so much, so that it is easy to interpret and describe in several different ways, usually without straying disastrously far from the truth.

In management and organization studies the term technology has different levels of meaning (Loveridge, 2001). This is also often the case in social science more generally. At the highest level of abstraction, technology means, according to Loveridge, 'all modes of organizing people for the purposes of controlling or co-ordinating their activities, (p. 6375). At a slightly lower level (p. 6376) it means 'bodies of disciplined knowledge [that] have emerged in which causal and systematic relations between material and/or social elements in specified situations are postulated and related to empirical observations'. This means, more simply, the bodies of knowledge and skill, of virtually all kinds, that enable particular ways of producing and driving things to be repeated more or less predictably and reliably. Examples could include assembly line technology, biotechnology, chemical process technology, information technology, missile technology and waste disposal technology. For Loveridge, with whom I agree on this point, the ways in which those relations and processes are categorised and explained conceptually 'can be seen as constituting more or less scientific knowledge in terms of its reproducibility and generalizability' (p. 6376). However the knowledge used within each type of technology is, of course, mainly technical knowledge. This definition is closest to the literal translations of technology from Latin and to most dictionary definitions of technology as knowledge or study of techniques.

A third, 'lower level', and more practical kind of definition focuses on the 'techniques or procedures adopted in processing information [about] data on social or material operations' (p. 6376). Such techniques are useful partly because they drew on past scientific and/or practical observations that have come to be seen as reliable. Such observations and the techniques that relied on them were very often 'codified in… texts and manuals or embodied in tacit routines' (p. 6376). The techniques and the tacit and other forms of knowledge involved was often sector- defining.

Loveridge goes on to call techniques that are incorporated in the mechanical, material or electronic design and programming of hardware and software, in other words in machines and capital equipment as 'the most articulated forms of technology' (p. 6376). This is his fourth way of defining and discussing technology. From all of his definitions, all of which are used widely, we can see how the word rivals and indeed potentially surpasses culture (qv) in terms of complexity. Clearly it is partly synonymous with technical knowledge or know-how, but it is self-consciously upmarket and ‘modern’ in the way in which, in use, as well as etymologically and in theory, it makes rather biased claims about the science upon which practical procedures are, or should be, ‘based’.

Loveridge also discusses ‘technological innovation’ or change and the distinctions between product and process or production technology (p. 6376). On the former, see the discussions of technical change and especially that of technological change below for the ways in which Loveridge’s discussions of technology is relevant there. On the latter, Loveridge argues that it is important, at the sector or firm level of analysis, to distinguish between the ‘importing’ of technological resources and the ‘exporting' to other firms, sectors or final consumers, of value added products. He notes how different researchers had tended to focus on either one or the other, with installation and use of ‘imported’ processes ‘or with the invention and design of new products’. However, since the 1970s relationships between the two types of innovation had been studied more often, ‘particularly’ in designer-user inter-firm transactions within the value chain’ (p. 6376).

The definition of technology used by Bell and Hill (1978) was knowledge about a machine, a product, or a method of production. It could include the underlying knowledge, which has been drawn on to produce the machine, product or method. Methods meant the same as techniques. Some features of technology are products of self-conscious searches for information, knowledge and skill. Many are results of more tacit experience and learning that takes place as firms operate, which often consist of very important parts of business activities, taking place in production and other technical departments (Itami, 1987). Sources of technology not only came from R and D but also from production, quality control, testing, marketing, feedback from users; plant design and construction, feedback from contractors and suppliers, scanning relevant academic and professional literature, patents and other technical information sources, the recruitment of engineers and scientists, contacts with university engineering and science faculties, contacts with government research organizations, the acquisition of other firms, or mergers, joint ventures, and cooperative engineering, design and other arrangements; licensing and cross-licensing of new products and processes, know-how transfer agreements, and from contract research (Freeman, 1992). Perhaps the best (short) working definition of technology that emerges from this discussion is that it is a generic, cross-sector and/or sector-specific bundle of information, knowledge and skill.

1.b.iv The arts and humanities

Arts subjects in the UK and other former British Empire countries are normally of three kinds; the humanities, languages, and the fine and performing arts. The humanities are often thought of as including languages but they are principally those subjects which study humankind and its experience, such as geography, history and study of literature and various other manifestations of human artifice. Partly because the social sciences, like anthropology, economics, political science, psychology and sociology, study human artifacts like tools, products, services, thoughts, motives, attitudes, and social institutions, processes and actions, they have often been classified as arts rather than as sciences, rather, that is, as part of what would be *Wissenschaft* in German. Language subjects often include the study of the histories, economies and institutions of the societies of which the where languages are being learnt, and they can therefore be regarded both/either as humanities and/or social scientific subjects. The fine and performing arts subjects are more or less the same as the *Kunst* ones in German and on elsewhere the European Continent. They are more directly vocational than the other arts and humanities subjects. Those who qualify in them are proportionately less likely to teach them than those with other arts and humanities qualifications, or not to use what they have learnt at all (or very little) in subsequent employment, or more likely to make careers out of them. What is of specific interest here is the tendency of many arts and humanities teachers, researchers and practitioners to distance themselves from the useful industrial arts of design, engineering, manufacturing and construction. In the UK, for example, design is taught for industrial and related purposes to engineers and architects. It is also taught, separately, in art college or university arts faculties, with a generally and significantly less practical and more aesthetic (and at times anarchic or frivolous) emphasis (Hudson 1978).

2. Socioeconomic development: culture; development; and sustainable development

These are included to help clarify some of the major background assumptions used in this thesis. The specific relevance of each is made apparent in each case.

Culture

According to Williams (1976), culture was the most complex word in the English language. Traditionally it has often been associated with intellectually and socially prestigious elite leisure pursuits, including the often expensive fine performing arts, and their conspicuous consumption for predatory purposes, in the pursuit of status and women (Veblen, 1921).

Since the 1960s, one interpretation of the word has increasingly been employed as a category in the study of management. This seems to have been because the countries in which the academic study of management largely began, the USA and the UK, started to be overtaken economically by Sweden, West Germany, France, Japan and a few other countries from the 1960s and 1970s onwards, until they began to reassert themselves economically in the 1980s and 1990s. From around 1970 British and North American researchers began to study comparative management to see what the UK and the USA might learn from Continental Europe and the Far East (Dore, 1975; Fores and Sorge, 1978; Macmillan, 1978; Lawrence, 1980; Jamieson, 1981, Maurice, Sorge and Warner, 1980; Sorge and Warner, 1986; Lee and Smith, 1992). Thus management has increasingly been thought of and discussed in cross-cultural terms. Unfortunately many early comparisons of managers and management in different countries tended to be rather shallow and concerned with superficial attitudes and behaviour, and researchers often made things worse by inferring values from them (cf. Hofstede, 1980).

Further, academics sometimes yielded to pressures from managers and companies to suggest ways in which 'organizational cultures' could be changed so that employee performance might be improved. Organizational culture was often very inadequately and indeed illiterately described as 'the way we do things round here' and managers were not criticised for naively saying such things as 'I want a new culture by Toosday!' 'Culture' was thus (re-) defined as a mechanism of control. In some respects it is, of course, as for example when organizations deliberately recruit people with specific backgrounds, such as when the UK's fire services used to recruit heavily from former members of the Royal Navy, or when managements try to develop companies and other organizations with 'family' atmospheres and so on. However Sorge (1982-83, 1985) explored the history of the term to help arrive at a comprehensive definition. He discussed the roots of the word in the Latin verb *colere*, which means to grow, in the context of living organisms. He argued that the culture of a human group or social institution is made up of everything that it consisted of, everything that characterised it, everything that the people involved were and are. Culture was so all-embracing and its roots were so deep that appearance was often taken for substance, with attitudes and ways of behaving only parts of culture, being thought of as all of it.

For Sorge (1982-83, 1985), the culture of any human society had three equally important components: ideational, material and social. Using France as an example, the ideational ones would include French values, attitudes, beliefs, ways of acting, a desire for change to be gradual, Parisian rudeness, artistic and design flair, flair at soccer and rugby, French style and fashion and French philosophy. Material components would include French clothes, aircraft, buildings, people, cars, crockery, farmland, televisions, harbours, furniture, climate and sheep. Social institutions would include French schools, the French family, the Catholic religion, French health care, French machine tool companies and French banks. Together, all such things and many others constitute France and its culture. What Sorge implied was, as many others have stated since, was that countries do not ‘have’ cultures. They *are* them. The same point is often made about organizations. This all means that, as Sorge (1982-83) argued, the more one writes or talks about the culture of something, the more one glosses over its essence. It also means that it is unacceptable to ‘explain’ those aspects of events that cannot be explained using familiar influences and logical reasoning by attributing them to ‘culture’. For example the performance of a company is often hard to explain completely by considering its financing, its material resources, its human assets and liabilities, and so on, and by then ‘explaining’, but not really explaining it at all, what remains to be explained by referring to its ‘organizational culture’. But all of these factors, for example material human resources, attitudes and ways of doing things, are parts of its ‘culture’, ‘organizational’ or otherwise. So culture should never be used as a residual, for ‘explaining’ that which is less easy to explain rationally and conventionally.

One of the main reasons why culture is so hard to understand is its very deep, old and all-pervasive nature. Further, human characteristics develop over many generations and are subject to many influences and most of this is of course unknown to the individuals concerned, and we only ever really understand our own culture to a limited extent, and the understanding of it that we do have is normally very subjective, virtually by definition.

What is the relevance of these points to the present study? The main point is that Malaysia is unique, like all nations, and therefore just as hard for non-Malaysians to understand as it is for Malaysians. Further, to try to convert the Malaysian economy to something like a European Union, or a North American, or some other more ‘advanced’ one is like trying to turn a Nissan Micra into large Mercedes car by putting a Mercedes engine in it, or *vice-versa*. Such an attempt would be thoughtless, crude, destructive and in every other way impracticable. To make a Nissan Micra faster and more comfortable, it would be far more sensible to develop selected parts of it in highly specific and creative ways, to engage in what Sorge (1985) called ‘judicious tinkering’. Thus to expect Malaysian companies to respond exactly like counterparts in older industrialised countries might respond to offers of and actual help from university researchers would be naïve.

Development

In economic terms, development has traditionally meant increasing the capacity, potential and output of a national economy. It concerns the capacity of a nation to generate and sustain annual increases in its gross national product (GNP). Another is the ability of a nation to expand its output at a faster rate than the growth rate of its population. Levels and rates of growth of ‘real’ per capita GNP, example, monetary growth of GNP per capita minus the rate of inflation, are normally used to measure the overall economic well-being of a population.

In the 1950s and 1960s, much thinking about economic development was focussed on less developed countries (LDC) and stressed rapid industrialization at the expense of agriculture and rural development (Todaro, 1988). But standards of living of most LDCs remained unchanged in the 1970s, and economic development came to the thought of more in terms of reduction and elimination of poverty, inequality, and unemployment in the context of a generally growing economy. Therefore the new definition of development is one of a multidimensional process involving changes in social structure, attitudes and national institutions, as well as acceleration of economic growth, the reduction of inequality, and eradication of absolute poverty.

Apart from its uses covering general economic and societal development, and that of LDCs, the term development is also used as part of the terms sustainable development (qv) and research and development (qv). The first of these is discussed immediately below. The second is discussed immediately after that in the academic subsection (part 3) of this section and more. The word also has a fifth meaning, which includes the second part of R and D, and other usually within-firm technical development activities. The fifth and final meaning is discussed briefly below in the industrial subsection of this section.

Parker (1978) saw the development of innovative processes as lengthy sequences of focused technical activities through which original concepts are modified until they are ready for production and sale. Such concepts, and improved or new processes and products, can come from inventions or scientific discoveries (Cory, 1996). The development of processes and products can be described as a chain of acceptance by management in its path from idea conceptualisation to marketplace. Haeffner (1979) argued that technical development included three components: research results, engineering innovation and product development. Technical development was necessary to the industrial progress and economic growth of industrialized nations. However Haeffner might have more logically put engineering innovation first in his short list and called it engineering and process innovation, and also to put research results last, partly because to do so would have been to list the three items in ideologically and socially neutral alphabetical order, and partly because an impression that scientific research needs to precede process and product development would have been avoided.

Sustainable development

Sustainable development, as described by the Brundtland Report of 1987, is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Sustainable development demands that we seek ways of living, working and being that enable all people to lead healthy, fulfilling, and economically secure lives without harming the environment and without endangering future welfare. Levine (1998: 688) noted that links between R and D and economic performance were generally acknowledged, but that environmental problems concerning biodiversity, climate change and pollution are now increasingly relevant. Thus, sustainable development goals should be at the forefront of coherent national frameworks for development, education, research and industry. The USA’s government’s policy on scientific R and D, for example supported the ability to promote sustainable development in various areas, including reproductive health, medical and population science, food security through agricultural research and food preservation, storage and distribution technology, resource stewardship, involving sustainable management of forest and marine resources, and natural disaster reduction through the development and implementation of technologies for preparation, monitoring and mitigation (Levine, 1998: 679).

For Rauch (1998) sustainable development should have two simultaneous goals: the achievement of human development to secure high standards of living; and protection and improvement of the environment now and for future generations. According to Kuhlman and Edler (2003), national systems of innovation, and by implication, environmental protection, tended reflect national political histories, structures and traditions. For example that of France is more centralized that those of Germany and the USA. Developing countries have tended to be careless with their natural environments. Their politicians can have more power and more ambition than those in older, wealthier societies. Such points may have some relevance for Malaysia.

3. Academic: research and development; and discovery

Research and development

This is a rather vague notion which is often used to include many types of technical work, often of a quite routine nature, like maintenance. Most industrial R and D appear to consist of development work. However university and directly government organized and funded R and D has become more and more important in the last 50 years, and this is a major focus of the thesis. More details regarding these points are to be found under the same heading in the next section.

Discovery

Discoveries meaning new knowledge about the natural world, are often confused with inventions (qv) and vice-versa. Major scientific discoveries occur infrequently and unpredictable intervals, although the validity of this claim is of course partly dependent on what the word major means. Once made, discoveries open up extensive scope for refinements to scientific theories and sometimes they are involved in paradigm shifts (Kuhn, 1962). These refinements arose from work undertaken in an ever-widening range of laboratories (Hawthorne, 1978). According to Parker (1979) each industry tended to help create its own knowledge base. Doubts about whether science and engineering operate in parallel or together might can be answered as follows: industry may create a range of problems for which basic science may not have answers. Industries tend to be concerned only with design, production and development problems, ones of practice and not ones of fact or principle. Technical knowledge built up from experience, is usually sufficient. This is not scientific knowledge. Discoveries that may help industry may not occur unless those concerned are conditioned to think about particular industrial problems and subjects and are under pressure to solve them. The knowledge required is usually interdisciplinary (p. 31), and industry is normally more involved with inventions than discoveries. But not all discoveries are irrelevant, and some are very important indeed.

4. Industrial: production, design, entrepreneurship, innovation, invention, technical change, management of change, performance; success

Production

Production includes all the activities involved in the physical transformation of artefacts. Production includes assembly and testing, and processes such as machining, extruding and forging, and its quality and efficiency are usually improved by automation. Production is important in virtually all manufacturing and also in construction, extraction and energy supply industries, and encompasses a broad range of activities, for example; heavy industry; light industry; high-technology industry; precision technology and specialist production. Heavy industry production includes foundry work, where molten metals are cast; large scale assembly such as in car plants where pressing machines stamp out car bodies, and robots moves, weld and paint; and continuous process oil refineries and petrochemical works. Light industry includes manufacturing furniture, clothing, and food, 'white goods' such as refrigerators, ovens and air-conditioners, consumer electronics and computer assembly. High technology industries include semiconductors and complex pharmaceutical products. Precision engineering involves machining high-value metals to tolerances measured in microns, as for example, in aerospace. Specialist production includes one-off special projects, such as air traffic control systems and such products and equipment as prefabricated houses or sound systems for musicians.

For many years, at least since the 1950s, production tended to be undervalued in the UK, and seen as the cockpit of industrial conflict, as a cost rather than as a source of profit, and as offering work unfit for a gentleman or intellectual (Glover and Kelly, 1987). However, relevant priorities, attitudes and behaviour appear to have changed somewhat in the UK since the early 1980s (Owen, 1999; Glover, Tracey and Currie, 1998). Important contrasts with Germany, based mainly on 1970s' evidence, led Lawrence (1980) emphasized how production is what defines manufacturing is general, and specifically, so that the type of product and production involved in each manufacturing sector defines it. He emphasized how production is the most vital and central function of any manufacturing organization, preceded by design, development, marketing and finance and followed by accounting and sales. He also noted how in Germany production generally meant 'the whole company minus sales and finance, so that it included design, technical development, purchasing and maintenance, unlike the situation in the UK a generation ago.

Design

Design is central to technical change, yet neglected in the literature on it. It is a private act because it is intuitive and specific to the individuals who undertake it, unlike the public nature of scientific work. Von Stamm (2003) argued that design is the conscious decision-making process by which information is transformed into an outcome, be it tangible, a product or intangible, a service. However many would argue that unpredictable ingenuity and intuition are vital features of the arts of designing, that much of the 'thought' involved in unconscious and that much of the knowledge used is tacit (Fores, 1978).

Design is the main activity of many engineers, and more central to engineering than even production is, but academics concerned with commercialization, technical change, and R and D, have tended to neglect it compared with them. It is indeed the core activity of engineering (Fores 1978). The act of deciding into what forms material should be manipulated in order to have added value is the essence of designing (Archer 1967). Design is at the very root industrial activity (Schwarz 1990). In Britain, design is seen as separate from industry in many ways, because industrial managers, including some engineers, tend to regard it is unscientific and intuitive, as of course it is in many respects. Further, designers who have been educated in art colleges have tended to evaluate themselves and their work using aesthetic more than practical criteria.

In a study by Salford University (1982) of the instrument industry, measurements were made of the time to assemble six different types of meter in Japan, West Germany, the USA and the UK. It was concluded that 'design has an important influence on manufacturing costs, and far-reaching changes in design and manufacturing technology were recommended to the UK firms' (Bessant and Grunt, 1985). In designing new products, the general strategy is first, to identify the relevant customer groups; then to discern their needs; and finally, to develop product and the technology to meet the customers' needs. This general approach is appropriate in most cases because most innovations are incremental (Anderson and Tushman, 1990).

Entrepreneurship

Entrepreneurial action is needed for new knowledge and techniques to be made productive and commercially viable,. According to Kuratko (2001), an 'entrepreneur undertakes to organise, manage and assume the risks of business', and more comprehensively and in contemporary contexts, is an 'innovator or developer who organizes and seizes opportunities, converts those opportunities into workable/marketable ideas, adds value through time, effort, money or skill, assumes the risks of the competitive marketplace to implement those ideas, and realizes the rewards from these efforts', (p. 1763). The characteristics of entrepreneurs included 'personal initiative, the ability to consolidate resources, risk taking, competitiveness, goal-oriented behaviour, opportunistic behaviour, reality-based actions and the ability to learn from mistakes' and also 'a "dark side" which could result in destructive (sic) behaviour (p. 1763). Entrepreneurial activity inside established businesses is often called intrapreneurship. There is of course nothing new in either entrepreneurship or intrapreneurship. They are useful in not-for-profit organizations: they are also helpful in education, government, health care, research, the armed forces and the emergency services, and so on.

For present purposes, entrepreneurship is relevant in the research, design, engineering, management, finance and marketing that result in the commercialization of discoveries and inventions. As suggested in the last paragraph there is no need to restrict thinking about it, or the phenomenon itself, to commercial, for-profit, private sector business activities and organizations. Enterprise can be social as well as economic, and in modern political terminology, left-wing as well as right-wing (Keats and Abercombie, 1994). However there would appear to be overwhelming evidence to the effect governments cannot build geographical or other clusters of innovative firms, and that such clusters generally products of 'systems of innovation' in which companies, universities, banks, and other sources of venture capital and other finance, and government agencies, facilitate, support and stimulate each other to generate innovation, rather than to locate, channel or control it (Saxenian 1994; Feldman and Audretsch 1996; Feldman 2003; Clark and Tracey 2004). Factors which favour sophisticated entrepreneurial industry activity included the presence of highly and relevantly qualified people in particular and fecund labour markets in general, and large enough scale industrial and other organizations and markets for innovations to take out root and for spin-off companies to find profitable market niches. While all or most of these factors may be present in LDCs their roots tend to be shallower than in established industrial countries

Innovation

Innovation consists of inventions first being used to commercial effect, profitably and for the first time. The process of innovation is viewed as occurring in three phases: generation of an idea, problem-solving or development, and implementation and diffusion. Generation of an idea involves synthesis of diverse, usually existing, as opposed to original, information, including information about market or other needs and possible technical means to meet the end. Problem-solving includes setting specific technical goals and designing alternative solutions to meet them. Implementation consists of engineering, tooling, and plant and market starts-up required ‘bringing an original solution or invention to its first use or marketing introduction’ (Utterback, 1982, p. 30). Marquis (1982) argued that about a quarter of successful technical innovations required virtually no adaptation of information readily obtainable from some source, and that another third were was modifications of existing products or processes. As noted in the previous sub-section, on entrepreneurship, innovations tend to be more successful when they occur in the contexts of systems of innovation.

Invention

This is a simple but important notion discussed at more length in the next section. However a few points should be made here. First, inventions are created by new syntheses of existing techniques and knowledge. They consist of new products or processes or component parts of them. Invention is not part of science. It is art, although science often helps, indirectly in most cases. Inventions come about through both scarcities and surpluses of resources, or without resource considerations being of any real significance. Inventors tend to be rather different kinds of people from innovators.

The management of change

Commercialization is a kind of organizational change, and to be successful it obviously needs to be managed suitably. Those involved and responsible, such as managers and professionals in companies, research administrators and researchers in universities and research institutes, and relevant members of government departments and governments, need to know about how change in organizations is best managed, including what to focus more strongly on and what to handle with a lighter touch. In general, entrepreneurial attitudes and habits tend to help management to handle change well, but stable bureaucratic foundations are also very important. Accurate, detailed and precise technical knowledge is the *sine qua non;* but commercial and financial expertise and awareness are vital too. The management of change needs, above all, to be holistic, meaning that all necessary actions should be taken, neither more nor fewer. More details of the management literature on organizational change and of how it relates to commercialization are to be found in the next section, under the same sub-heading.

Performance

Performance criteria are of several kinds and they operate at several levels: international, societal, sectoral, organizational, group and individual. At the international and sectoral levels, influence is often what is evaluated. For example does an organization, like Honda or Ford, or very high-powered and effective managers, like Soichiro Honda or Henry Ford, influence industry and technical and managerial and practices and standards for good or ill, and in his how widespread a way, and for how long? Following Child (1984), well-known performance criteria include product and service quality, process quality, service quality, quality and/or volume of employment, return on investment, profit, ecological friendliness, market share, and corporate social responsibility. Sector-specific performance criteria are very numerous: examples might include infant and other patient mortality in health care, crimes solved in policing, examination passes in education, output and sales volume in manufacturing, enemy aircraft downed in air warfare, or houses built in construction. There are also multiple performance criteria-defining stakeholders such as customers, citizens, voters, suppliers, government departments, communities, shareholders, the physical environment, parents, employers and special interest groups. All have different interests in the survival as well as the performance of organizations. Conflict as well as co-operation between stakeholders is routine and normal.

The issue of the short versus long term in considering performance is also important, as are historical and societal contexts. Reducing expenditure on market research, technical development or training can be useful in the short term but have bad long-term consequences, including ones not always easy to foresee. In the 1970s and 1980s Germany and Japan were held up in the UK and the USA as sources of role models of successful manufacturing enterprises and technical innovation, as countries in which educational, financial and other institutions and techniques of management and organization had been designed and run with the long term in mind. However from an early twenty-first century perspective it is reasonable to suggest that the economic and related policies of Germany and Japan after their catastrophic military defeats in 1945 were actually much more ‘medium-termist’, being concerned with national economic and political regeneration and self-respect, although long-termist in others too. It is reasonable to suggest that Anglo-American short-termism is, in at least one fundamental respect, as ‘long-termist’ as it is possible to be. Thus by eschewing the collectivism of Continental European and Far Eastern societies, and in trusting individuals and individual firms to perform, they assume that the pursuit of individual self-interest and the creative destruction of market forces will, *in the long run*, optimise societal outcomes.

Success

Just as innovation is more than invention, success is more than performance. It may also be impossible to measure. According to Addison (18??), the ancient Roman Cato wrote that ‘’tis not in mortals to command success, but we’ll do more Petronius, we’ll deserve it’. The point being made here is rather like saying that however able, well resourced and well managed and organized people may be, it will all be of no use unless there are markets for their outputs, or if their efforts are undermined, subverted or overcome by rivals, competitors or opponents, but that at the deepest level it does not matter in an always uncertain and often unjust world. In other words, it may be enough simply to deserve success, because even when all possible contigencies are understood and catered and accounted for, achievement may still be impossible. Because what is generally regarded as good and successful human behaviour is that which enhances the survival and welfare prospects of our species, the higher the proportion of competent and suitably motivated individuals in a population, the greater the prospects of the population as a whole.

According to Landes (1998), economic success, when achievable, is normally a product of two phenomena: hard and focussed effort, and a refusal to believe in one's own mythology or propaganda. Also, although there were many diverse routes to success, like German and Japanese perfectionism, British imagination and persistence, and determined, systemic and thorough American management, they all tended to look the same from the standpoint of the relevant product or service. Considerable and clear-eyed effort had been applied, with appropriate attention to detail and necessary imagination.

As regards technical change, successful inventions are generally those which achieve profit and market share, ones which are commercialized successfully. According to Rothwell (1974: 258) successful industrial innovation demanded excellent understanding of user needs, efficient but not necessarily quick development work, and competent use of outside technology and relevant scientific advice, although not always of obviously and directly useful kinds (see also Teubal 1990). Moncada-Paternò-Castello et al (2003) argued, further, that involvement of suppliers in technology transfer reduces uncertainty and enhances the probability of success.

5. Linking universities and industries: commercialization; technical change; technological change, technology transfer

Commercialization

Commercialization is a process which seeks to make new scientific and technical profitable after it has been produced in universities or other research organizations. As noted earlier, commercialization may, in fact and in practice, be a term that described government over-control of universities and industry, with innovation potentially stifled rather than stimulated (Hughes, 1985). Government aims for commercialization in Malaysia are generally the same as those pursued by governments elsewhere, and it involves the same parties, namely government departments, universities and research institutes, companies and so on.

Technical change

Technical change affects products and processes (Bell and Hill, 1978, p. 226). Often two types of technical change are distinguished, innovation and diffusion. Most technical change is piecemeal and small-scale and may hardly merits the use of the word innovation. Most changes use technical knowledge far more than scientific knowledge. Some does originate in scientific research, and some of this is of considerable use to industry and this is the kind that most discussions of commercialization are concerned with. Technological changes use new scientific knowledge or techniques used in scientific research and technical change tends not to. As with the more general phenomenon, technical change, technological changes are sometimes widely diffused across industries and sometimes not. From this it follows that it is not always easy to distinguish between technical and technological change, with each being able to be described, quite legitimately, as a special case of the other. However given the greater prevalence of technical change it will normally be more helpful to regard technological change as a special case of it, rather than the other way round.

Technological change

There is awareness that the successes of organizations often depend directly on the effective use of technology (Joynt, 2001). Unfortunately however, technological change is rarely distinguished clearly of openly from technical change. It would be useful to distinguish it in a relatively open and formal way by regarding it as a special case of technical change, in which, unlike the case with the latter, new scientific knowledge may combine with new and old techniques to help generate, not only improved or new processes and products, but new and often generic technologies with systemic implications. There are many examples of technical change which achieve this through developments using technical knowledge entirely or largely on its own, and lack or relative unimportance of inputs of new scientific knowledge suggest that use of the '-ology' suffix is very often unjustifiable. As regards manufacturing, Fores (1978, p. 146) was but one of those to have observed that even the most discontinuous types of technical change, known as (commercially viable) inventions, do not typically stem from a new use of knowledge from science. Instead scientific knowledge generally flowed into manufacturing and other engineering sectors through its ambient nature, meaning that it is used in a background and surrounding way, as for example when knowledge of the melting points of different metals are known and taken into account in designing ovens or aircraft.

Technology transfer

Typical definitions of technology transfer include 'the process by which a technology is applied to a purpose other than the one for which it was originally intended' or 'technology transfer is putting technology into a different context' (Bradbury, Jervis, Johnston and Pearson, 1978). According to Brooks (1966), however, technology transfer was the very general process by which science and technology were diffused throughout human activity. Whenever useful knowledge developed by one person, group or institution was embodied in a way of doing things by another person group or other institutions we had technology transfer. This could either be transfer from scientific knowledge into technology, or adaptation of an existing technology to a new use. Technology transfer also often refers to the transfer of a commercial right to use new technology. Technology transfer differs from ordinary scientific information transfer in that to be really transferred; it must be embodied in processes and products. In practice, technology transfer means the transfer of technical knowledge, practical know-how, and not just scientific knowledge, but the former tends to be played down in discussions of technology transfer, and the importance of the latter to be exaggerated.

APPENDIX 3:

THE SEVEN MOST SALIENT CONCEPTS

Of the 25 concepts discussed in Chapter 3 and Appendix 2, the following seven are regarded as the most salient and relevant to be concerned of the thesis, and further points are now made about them.

Commercialization and its rhetoric

Previuosly, commercialization was defined, and a doubt expressed about it sometimes being an iatrogenic phenomenon (Illich, 1976). This was, for Illich, a situation in which the intended cure for an illness made the problem worse, or was worse, in itself, than it. Attempts generated by governments to make institutions more innovative and profitable may consist of ambitious politicians taking ownership of problems and employing people at public expense in pursuit and conspicuous consumption of prestige, power and status, with personal vested interests being served through the persistence of problems, rather than their cure. Normally, the best, most economic, solution to any lack of innovation in industries is to ensure that the professionals, managers, technicians, skilled operatives and so on, are very innovative people who are able to use universities and researchers when necessary. Anything else maybe a sub-optimal.

Technical changes brought about by commercialization may include both process and product ones. Most practicable and commercially viable technical changes are instituted by engineers, including designers, rather than by scientists, and build on previous ones, more than on new scientific knowledge (Jewkes, Sawers and Stillerman. 1959; Langrish, Gibbons, Evans and Jevons, 1969; Marquis, 1982). Technical change is an often unpredictable process involving various kinds of actor, in which the use (if any) of academic knowledge is often much more untidy and less rational than those who produce it often appeared to assume (Benneworth, 2001). The kinds of commercialization being pursued in Malaysia are of the same kinds as what are generally understood by the term elsewhere. They may draw on scientific research, but do so in contexts in which it is only one of many inputs to invention and innovation.

Brown, Berry and Goel (1991) identified six kinds of commercialization activity. They involved universities and government research institutes contracting R and D to industrial partners, working with industrial consortia, licensing knowledge and processes to industry, influencing decision makers in industry, working with broker organizations, and generating end-user demand.

The study of commercialization can tell us something about the competence of universities. Universities have always been providers of academic and professional knowledge of many kinds. However, recent increases in demand for university contributions to economic development have been questioned (Matkin, 1994). Researchers have asked, for example, whether policy makers invest too much public money in it (Benneworth, 2001, Jolly, 1997). Jolly (1997, p. 3) argued that ‘many technologies actually do not make it to market…let alone become commercial successes’. Some ended up in journal articles, while others were ‘simply forgotten’. Rates of commercialization of some new technologies are sometimes too slow. Funding research is not often cheap, so policy makers are sensible to be concerned about its potential effects (Jolly, 1997).

In Hertzfeld's analysis of the USA's National Aeronautical and Space Agency's (NASA) patents from 1959 to 1979, only 1.5 percent of them were used outside the patent agency (Hertzfeld, 1989). We can also ask whether there are markets for the results of scientific research and how far firms may invest to develop products which may not be profitable (Benneworth, 2001; Larpache, 2002). Many governments have taken measures to encourage 'scientific and technological' advances, without evidence of customer interest. Further, demand from firms is far from uniform, varying considerably, depending on characteristics of sectors, processes and markets. There is, however, reason to believe that demand for relevant scientific and technical outputs will usually be stronger in regions that are richer in human and financial capital than in poorer ones (Laparche, 2002).

Entrepreneurship

Entrepreneurship, as noted previously, is about taking risks in innovative ways, about showing initiative and adding value. It can either mean starting a new organization or developing an existing one creatively. Many entrepreneurs seek venture capital or funding to start new businesses. Sweeney (1999) argued that entrepreneurial potential is sensibly considered as the propensity to establish a new firm, which often exists in communities with already high proportions of small independent businesses. He also argued that it was useful to build innovative local social environments as well as to take action to enhance purely economic activity.

Cunningham and Lischeron (1991) summarised a few approaches used to describe entrepreneurship. They included an entrepreneurial model which considered the variety of central foci or purposes, assumptions, behaviour, skills and situations of entrepreneurs. The 'entrepreneurial model' drew on a 'great person' school, a 'psychological characteristics' school, a 'classical' school, a 'management' school, a 'leadership' school, and an 'intrapreneurship' school. The most relevant model here is the classical one, in which the central characteristic of entrepreneurial behaviour is innovation. This sort of technically creative entrepreneurship is usually most evident in business start-up and early growth phases. In the USA a pattern of commercialization for biotechnology has been supported by the establishment of new biotechnology firms, under entrepreneurs of this type, as spin-offs from university research (Senker, 1996). Many good engineers and scientists are entrepreneurial, and effective commercialization is also likely to be so, and in this classical way.

So far, strong emphasis has been placed in this chapter on the importance for entrepreneurship of such factors as the presence of good numbers of people with relevant attitudes and expertise, of venture and other forms of finance, of suitable labour markets, of supportive organizations and of relevant product markets. Such conditions favoured entrepreneurial and innovative behaviour and the development of systems and clusters of innovation.

Clearly, then, entrepreneurship is relevant for this study as entrepreneurs in business are the main people responsible for delivering technological innovation from universities to marketplaces. Entrepreneurship has been defined as an input added to land, labour and capital in ways designed to extend theories of production. Casson (1982) suggested that entrepreneurship means dealing with uncertainty and innovation and increasing profits in relevant markets. He argued that entrepreneurs with greater knowledge will have the ability to judge their situations with less uncertainty than others. Colombo and Delmastro (2002) found (in the USA) that entrepreneurs with strong educational backgrounds, especially in technical and scientific subjects and in particular, entrepreneurs with Ph.D.s in engineering, had significantly high levels of involvement in technology incubators. Shane and Venkataraman (2003) felt that, despite the traditional literature on entrepreneurship, which was person-centric, the role of technology, technical systems and institutions were especially relevant for setting up technological firms. Entrepreneurs had the main role in generating 'technology diffusion'. However the defining characteristics of entrepreneurship included, for example, the entrepreneur's opportunities for growth, and the resources gained by them over and above those that they might have been expected to have, because of their personal characteristics (Miller and Garnsey, 2000).

For connecting the study of entrepreneurs and their behaviour to macroeconomic views of entrepreneurship, the financial/capital school thinking about entrepreneurship is focused on the capital-seeking process. The search for seed capital and growth capital is the main focus of this entrepreneurial emphasis. Clearly the venture capital process is often crucial to the development of an entrepreneur. Business planning guides for entrepreneurs often emphasize this phase, and there are development seminars in many countries focusing on funding application processes. As we would expect from the microeconomic view of entrepreneurship, the venture opportunity school focuses on the opportunity aspects of venture development. Concerns in this area include sources of business ideas, the product development and marketing concepts, and creativity and market awareness. According to such views, developing the right idea at the right time for the right market is the key to entrepreneurial success (Kuratko, 2001, p. 1766).

Innovation

Innovation consists of invention plus commercialization. Whether innovation is mainly supply-push, based on technical change, or demand-led, based on social needs and market requirements, or both has long been debated. One view here is that recognition of demand is a more frequent factor in successful innovation than recognition of technical potential (Marquis, 1969). Innovation studies literature stresses the role of user-supplier links in innovation. Technology push involves commitment to change and opportunities for technological activity in an industry.

Suppliers may undertake a whole series of innovations and thus changes may occur anywhere along the chain of production (Parker, 1978). Customer or demand-pull is the pressure exerted by purchasers of products. Innovation is achieved for many reasons and in many ways in business. On the job modifications of practice are the main one, through exchanges and combinations of professional expertise. An invention is a new technique, device, process or product that has not been made marketable. Innovation is the use of expertise, skill, technical or market knowledge and so on, to improve processes or to create new ones, and/or to offer desirable new products and services. A product is new in that its attributes are new or improved. Afuah (2003) stated that a new product is always an innovation, through the creation of new market or technical knowledge, or because it is new to certain customers.

In this study, innovations are thought of as any changes, continuous or discontinuous, radical or incremental, that lead to new, better or more profitable products. Radical innovations refer to new products that result from advances in knowledge/technology. Incremental innovations include improvements to process or product design, with or without upgrading machinery or the acquisition of new machinery. Innovation researchers have asked many questions about types of innovation activities such as radical or incremental ones (Freeman, 1974); changes over life cycles (Abernathy and Utterback, 1978); efforts that result in the emergence of dominant designs (Abernathy and Utterback, 1978); changes that have ‘transilience’ in that they affect existing ways doing things (Abernathy and Clark, 1985); changes that are continuous or discontinuous, (Tushman and Anderson, 1986); modular, that is occurring in components and subsystems without addressing the systems of which they are a part; or architectural, that they attempt systemic improvements without great attention to the component parts (Henderson and Clark, 1990); and sustaining or disruptive (Christensen, 1997).

Innovation requires efforts to create purposeful, focused change in an enterprise’s economic and/or social potential (Srica, 2001). Innovation is also the successful use of ideas and processes to solve problems and to create thinking, ingenuity and focus. The contributions of universities to innovation and economic development are much more diverse and recurrent than through commercialization of new knowledge, through such activities as providing expert and skilled labour forces, technical consultancy services and even forming firms, often in technically advanced fields. The university’s role is recast as the provider of particular services to economic development, but is problematic in that it overlooks the role that the activity of producing knowledge ‘for its own sake’, or for moral purposes, may play in generating economic benefits (Benneworth, 2001, p. 226), as well as in producing active citizens who are capable of finding morally and socially beneficial uses for knowledge of all kinds. The OECD’s concept of a national system of innovation is relevant here (OECD, 1999).

Malaysia’s government has emphasised the economic importance of knowledge being transferred through scientific discoveries and technical changes. However any rapid increase in investment in R and D in universities as one of the sources of innovation in the national innovation system will only benefit the Malaysian economy if the conditions and processes of innovation are manageable. Unfortunately, attempts to manage innovation, especially by people without experience of engineering and marketing, people who work in less obviously creative functions like research administration or accountancy, or as civil servants or university non-academic administrators, may be too strenuous, and stifle it (Child 1981, 1984; Hughes 1985).

Innovation performance can be assessed in several ways, such as evaluating interaction between science and business, networking and collaboration among firms, roles of small and medium-sized enterprises (SMEs) in the development and diffusion of new technology, and the nature and scale of international trade (OECD, 1999). Generally, numbers of patents per year are indicative of rates of innovation. Mansfield (1986) showed that patent protection has less effect on the commercialization of inventions in most industries than in pharmaceuticals and chemicals. In the latter, almost 80% of patentable inventions are patented.

Teubal (1990, p. 270), after conducting a study of user needs, argued that innovation is characterised on the market side by at least two types of uncertainty: that of innovator firms about user needs and their concrete translation; and that of user firms about product quality. Lundvall (1985) argued that relationships between universities which produced scientific knowledge and firms as potential users of it may be analysed usefully as one specific arena of user-producer interaction.

Invention

Invention means creating new products or other artefacts and/or processes or parts of them. It is art rather than science. Invention usually involves at least some design, but is usually thought of as more inspired than design. There are two main schools of thought about conditions leading to invention. One argues that a lack of resources leads people to invent. The other argues that only an excess of resources will result in inventions. So in one case necessity is the mother of invention, and in the other affluence and leisure are. This idea of a contrast between two schools seems specious. Both sources should be fruitful, or not, in different places and at different times. Parker (1978: p. 29) argued that in terms of originality, basic scientific research might appear, at least to some, to be the activity most likely to yield inventions. However, basic research tended not to generate tangible inventions and its main outputs usually consisted of published scientific knowledge. In some non-English-speaking societies few would feel a need to labour what they would regard as this very obvious point. On the whole, scientists discover, and it is engineers who invent, although experienced researchers with noses for relevant if unconventional evidence also often suggest that sales and marketing specialists, production operatives, skilled workers, technicians have very often been highly inventive in industrial contexts too.

For Parker, invention was the first stage in the process of technical innovation. There were three general theories of invention: the transcendentalist, the mechanistic and the cumulative synthesis one. The transcendentalist one gave pride of place to individual activity. The lone inventor with a single creative thought had dramatic effects on the world. The mechanistic approach argued that invention proceeds under the force of necessity, where need dictates and technology complies. Economic forces predominated and individual genius is played down or rejected. The cumulative synthesis approach sees invention arising from what already exists. An act of insight is required and here individuals often play crucial problem-solving roles (Parker, 1978: p. 46). All three approaches are compatible. Mathias (1991, p. 26) felt that inventions were more individual and personally rewarding events than innovation and diffusion, and less commercially motivated.

According to Hawthorne (1978), invention meant ‘the idea’, ‘the conception of the design of the idea’ or ‘prospective utility’. He and others have also noted that periods of inquiry and synthesis were largely dominated by the degrees of interest of individual engineers, scientist or private inventors in creating or exploring something new, and how periods between invention and innovation were increasingly influenced by non-technical factors like market size and segmentation. Srica (2001) concluded that the inventor was a person who produces ideas, whereas an innovator made new things happen, and was a doer who could visualise practical possibilities of an idea and who wanted to see it realized.

It may be concluded that many inventions involve minor improvements to products, processes and techniques, with major inventions often very important indeed, but relatively rare (Parker, 1978). Individuals are still significant despite the growth of corporate design and development. Scientific research has important but usually indirect links with engineering (Mathias, 1991).

The management of change

This concept comes from organizational behaviour and development. Some writers have advocated constant proactive change in what are assumed to be increasingly rapid and unpredictable environments. Others have argued that constant change is exhausting and self-defeating, and often only the product of individual managerial ambition, and that more judicious and careful change will be more effective. It is generally agreed that it is good to anticipate the relevant trends and events, external and internal to organizations. Changes vary from shallow to deep, and from tactical to strategic. Management writers have argued, for nearly 50 years, that organizations should become less mechanistic and bureaucratic and more organic and flexible. They accept that some people find change difficult, and that most do not react productively in the medium or long term to continuous pressure and change. Resistance to change is due to the differences in interests and values, the understanding and perceptions of outcomes, and sometimes to low tolerance of change. To understand and address resistance it is first necessary to analyse the interests and views of stakeholders, and usually to involve those active in and/or affected by implementation.

Participative approaches are often time-consuming, but can stimulate commitment and creativity. However, and while ‘soft’ management skills are generally helpful for change management, major and urgent corporate transformation can necessitate coercive and even dictatorial approaches. It is important to understand the interdependence and importance of all relevant factors, such as the context, substance, politics and processes of change and how they affect events from the individual up to the organizational and societal levels of analysis. Nevertheless, understanding and analysis alone are likely to be ineffectual, without thoroughly planned and executed actions affecting virtually all parts of organizations (Child, 2005).

Technical and technological change and/or innovation and/or commercialization and technology transfer are all overlapping and specific kinds of change. Grindley (1993) argued that they raise considerations of uncertainty, appropriateness, timing and effect. Uncertainty could be inherent in new technology or due to managerial ignorance or lack of ability. Technical, manufacturing and marketing abilities were needed along with those of change and innovation management. Innovation management was a special, more focused, form of change management. Appropriateness and timing were interdependent. Patents and secrets would only protect new knowledge and expertise for so long. The idea of effect was relevant because product innovations could open up new markets, process ones could alter cost and quality parameters significantly.

Slow adoption or non-adoption of technical changes could lead to organizational death. Firms could choose different types of technical change: innovation or adoption; product or process innovation; radical or incremental innovation; technology push or market-pull. These types of change may not have the same technical/marketing skill requirements, unpredictability, or time pressures. Firm could choose between strategies: leader or follower; collaborative or exclusive; open or proprietary; and license-out or manufacture (ibid. p. 61). The literature on managing change was not traditionally linked with that on innovation. Yet there was currently a *rappróchement* among these strands, as companies sought survival by trying to become learning, self-designing and renewing institutions. There was growing recognition that innovation requires companies to absorb external information, as well as ability to tolerate changes in structure, human resources, and so on. The most innovative organizations were often those that had an internal proclivity for change (Penning 2001: 3031).

Henderson and Clark (1990) noted how many firms, large and small, were poor at absorbing change, even when little adaptation was needed. Often, in their experience, few if any organizational changes were needed to support improvements to processes and products. Minor changes to organization structures or practices more often all that were needed, although benefits could be considerable. Sorge (1988) in his praise of ‘judicious tinkering’ is also helpful on this important point.

In manufacturing, companies cannot negate market forces and technical developments, which often drive change and alter the basis of competition (Roth, 1996). Grindley (1993, p. 61) made some further points about change: there must be opportunities and incentives, and organizations need to contain mechanisms for responding to market and technical developments; and technical change, beyond other forms of change, involves a unique class of strategies stemming from its particular characteristics. As there was no one best way to achieve successful organizational change, by making efforts to understand the wide variety of change situations and to be familiar with their different characteristics, organizations and their members should find it easier to introduce appropriate paths to change. The growing interdependence of organizations meant that successful change management would increasingly require negotiation and consultation beyond organizations within which change is happening.

Research and development

This term normally refers to future-oriented, longer-term activities in science and engineering which may be undertaken without much regard for profit. Statistics on industrial R and D may imply things about the state of an industry, the nature of its competition, or the lure and prestige of scientific effort. Some common measures include company budgets, numbers of employee-generated patents, or even those of peer-reviewed and other scientific and professional publications. The notion of R and D is fundamental to the STH model of technical change. It emphasizes the scientific inputs to it more than the more numerous, widespread and in most sectors more influential technical, design and other inputs. However universities and various government and other research institutes are often engaged in major elements of R and D. Such work constitutes university and government R and D for the purposes of this thesis.

The history of much industrial R and D began in the USA in the 1950s. Ideas about good practice began to evolve from here. R and D department-produced designs, which matched user requirements rather than satisfying ‘their own egos’ (Rothwell et al, 1974, p. 290). They made sure that their designs were practicable, capable of being manufactured, and suitable for users’ environments, (p. 290).

An OECD (1993) definition of R and D was: ‘research and experimental development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications’. R and D is generally defined as being the sum of three activities; basic research; applied research; and experimental research. Basic research is theoretical and develops hypotheses while acquiring new knowledge without giving direct consideration to its use (OECD 1993). Applied research seeks to ascertain the possibility of practical use of knowledge discovered through basic research. Experimental development in this context is the use of such knowledge to develop new materials, equipment, systems or processes. According to Schwarz (1990), such definitions, quite reasonably, emphasize only the more scientific inputs to and features of engineering. Unfortunately, however, much lay and public use of the term then tends to regard science as the source of all or almost all technical change, as when politicians speak about ‘getting ideas out of laboratories and into production’.

Research evidence on technical change, invention, innovation and so on has generally led researchers to emphasise the importance of market pull and invention or technology push compared with discovery or science push. In the UK only about one in eight engineering and science graduates working in industry, usually as engineers of a kind in the latter case, of course, have appeared to be engaged in R and D and most of these were involved directly in development (Engineering Council, 2005). In Sweden, Japan, West Germany and many other countries, companies have technical development, design, and development departments, not R and D ones. British government statistics have long suggested that only 10 percent of innovative effort in British industry occurs R and D departments. Such statistics excluded plant design, plant development, product design and development from innovative work (Department of Trade and Industry, 2005).

It is nonetheless still argued by many that technical progress is primarily achieved through investment in R and D. For example, Goto (2000) discussed how Japan was more interested in the 1990s than in previous decades in university R and D. In contrast with their own past actions, Japanese policy makers now felt that it was a mistake to continue to neglect university R and D, because industrial innovation was greatly influenced by R and D activities of universities and governments in some other advanced countries. However DeMarchi (1976) argued that the important development component of R and D had been the subject of too little attention on the part of policy makers and management researchers. In this study the focus is on university and government research, which tended to contribute to basic and generic technologies. The knowledge and technologies created in universities were transferred into parts of industry, which can then use the knowledge and techniques to develop products and services, with the former spreading more wisely. In general, however, R and D remains a concept used in varied and vague ways.

Technology transfer

Chen (2001, p. 3392) argued that this term was controversial. He also discussed how some disagreed about the factors that influence transfer. Some had argued that technology is not transferred unless it is used by the transferee. Others argued that how a transferee deals with a transferred technology is irrelevant. However, unless technology transfer led to sales of improved products, it could be a more complicated concept than one only concerned with trading goods. By transferring knowledge about how to make a product, a transferor had not automatically given up the knowledge but has, rather, shared it with the transferee. So it was not unreasonable to argue that a transfer is not achieved until the transferee understands and can work with the technology.

Technology transfer means using new knowledge and technologies in processes, organizations and sectors in which they have not been used hitherto. Many firms, universities, and governments have Offices of Technology Transfer (or similar) dedicated to identifying research results and technical changes of potential commercial interest, and to finding ways to exploit them. For instance, a research result may be of commercial interest, but patents are normally only issued for inventions, and so there will be a need to identify companies that use processes that could benefit from the results. Another consideration is commercial value. For example, while there might be several ways to accomplish nuclear fusion, the only ones of long-term commercial interest will only be those that produce more energy than they use. Therefore, technology transfer organizations are often multidisciplinary, employing accountants and economists, for example, as well as engineers and scientists.

A further definition of technology transfer was ‘the transfer of the results from universities to the commercial sector’ (Bremer, 1999, p. 2). This implies that technology dissemination or transfer can occur in many different forms. The publication of results in scientific journals and books is the most common form of dissemination. In some cases the transfer may occur only if the intellectual property is protected and then commercialised in a planned and structured way. In the present study, the main focus is on technology transfer between university research laboratories and industries. The Malaysian government concerned about the apparently limited amount of technology transfer of this type. Several studies have suggested that there are many contradictions between university priorities and market needs (Bozeman, 1994; Lee, 1994; 1998; Matkin, 1994; Rahm, 1994; Saad and Zawdie, 2005). Link and Siegel (2005) have argued that universities that have more attractive incentive structures, especially financial ones for practitioners tend to be more efficient in technology transfer activities.

Technology transfer is normally a complex and poorly defined process, even if experience can make it simpler (Bell 1993; Brown, Berry and Goel 1991). Geisler, Furino and Kiresuk (1990) referred to companies' problems with internal management, of their technology strategies, with relations with other firms and industries, and with universities, and to various individual attributes of their founders, owners and managers. Alam and Langrish (1984) criticized failings of R and D utilization in government agencies due to technical problems such as imperfect technology, marketing problems, difficulties in procuring raw materials, and problems with government departments and with competitors allowed to import technology.

Technology transfer from universities can consist of policy and/or regulatory support and the public dissemination and advancement of knowledge. In practice much of this is specialised and not discussed widely. Means of technology transfer can include collaborative R and D with companies, R and D consortia, and strategic R and D alliances. Companies' means of commercialization of technology transfer include external investment, prototype development, incubator and spin-off. An incubator is a facility that aids the early-stage growth of technology-based companies by providing shared facilities such as space and office services and business consulting assistance. Spin-off refers to start-up companies originating from university or research institute where employees with ideas to start their own businesses leave the university or research institute and does using their knowledge from the university or research institute. Universities involved in technology transfer help to develop consortia, research or technology parks, and targeted forms of industrial marketing (Engelking 1992).

In the literature on technical change of the 1970s, there was reasonably solid body of evidence on company decisions about the adoption of new technology (see for example Rothwell, 1979). Rothwell listed companies' reasons for buying foreign-built machines, in studies conducted from 1970 to 1979, of hundreds of textile companies in the UK. They included cost, specific user requirements, design, performance, reliability, output, operational efficiency and back-up service from manufacturers. Technical factors like how advanced design was, user requirements, and operational efficiency, were the most important ones for decisions of textile companies about buying such machines.

Sutz (2000) explored the reasons why weak relationships between universities and industries existed in Latin American countries. Privatisations of public enterprises had undermined some relationships. Also Latin American economies could be characterised as exchanges of goods and services with low technology content. Enterprises distrusted and were unwilling to have closer relationships with public universities, with their stronger research capacities and sophistication. Socio-economic inequality in Latin America was high, with low incomes, low attention paid to training and education, and low concern with employee commitment. Finally, weaknesses in Latin Americans' national innovation systems were associated with their historic neglect of technical change.

We have seen how technology transfer is a rather elastic, general and vague concept in use. However the literature on it also shows how varied and interesting a phenomenon it is, and suggests how difficult it may be for some LDCs to achieve.

APPENDIX 4:

COMMERCIALIZATION IN MALAYSIA

Support for Commercialization in Malaysia

Since the mid-to-late 1980s, Malaysia's government has developed a number of institutional supports for the commercialization of R and D. The relevant agencies and mechanisms include its Intensification of Research in Priority Areas (IRPA) fund, the Industry Research and Development Grant Scheme (IGS), the Multimedia Super Corridor (MSC), the Research and Development Grant Scheme (MGS), the Demonstrator Application Grant Scheme (DAGS), the Malaysia Technology Park (TPM), the Malaysia Technology Development Corporation (MTDC), the Human Resource Development Scheme (HRDS), the Industrial Technical Assistance Fund (ITAF) and the Malaysia Industry Government Group for High Technology (MIGHT). The existence of these agencies and mechanisms might be seen as suggesting that the government has identified the funding, human resources, the technology and the advanced information infrastructure needed to develop an environment favourable to growth of technically advanced businesses and industries.

The stated purpose of the IRPA is to support R and D activities in the public sector in priorities area which the government regards as those most worthy of help. Other purposes include funding projects which address the needs of Malaysian industries and encourage collaboration efforts among research institutions. The Industry R and D Grant Scheme is meant to help increase private sector R and D and to promote closer collaboration between private and public sector research institutes as well as between universities and industry. The R and D Grant Scheme is there to help innovative local companies, including joint venture companies, to develop multimedia technologies. The purpose of the DAGS is to encourage Malaysians to adapt and customise existing IT and multimedia technologies. The Malaysia Technology Park exists to help in the development of indigenous technologies and the commercialization of R and D findings. It provides links between companies, the government, government research institutes and universities.

Under the Human Resource Development Scheme, there are three funds: the Science and Technology Human Resource Development Fund (STHRD Fund), the National Science Fellowship (NSF) and the Postgraduate and Postdoctoral Programme. These exist to enhance the pool of skilled and trained people in engineering and science. ITAF helps small and medium-scale industries by giving matching grants for consultancy studies, product development, design, quality and productivity improvements, and market development. This matching grant meaning that 50% of the project cost will be borne by the government and the balance by the applicants. The MIGHT is responsible for exploiting research and technology for new business. The expenditure on these programmes were £0.50 billion from 2001 to 2005 and £0.78 billion were allocated for 2006 until 2010. These agencies and mechanisms are designed to link universities and industries so as to facilitate exchanges of technology. The government invested a total of about £0.4 billion under its IRPA program from 1986, when it was launched, to 2005 (EPU, 2006).

Commercialization of Outputs of Malaysian University and Government Research Institutes

Research and Development

Commercialization efforts by Malaysia's government, companies, universities and research institutes are meant to help underpin the medium to long term development of the national economy. Malaysian discoveries and inventions are used to try to boost Malaysian industrial development. The IRPA fund is one of the sources of funding for R and D in universities. The Malaysian Technology Development Corporation (MTDC) was introduced in 1992 due to a lack of interest from Malaysian companies. Spin-off and start-up companies were established to create critical masses of local companies needed for taking up indigenous R and D. The MTDC also supports the process of commercialization of Malaysian university R and D results. This includes technology transfer consultancy, technology marketing and promotion, market and feasibility studies, commercialization project management and intellectual property protection. The MTDC provided funds to 121 companies of about £6.5 million between 2001 until 2005 under the Eighth Malaysia Plan (EPU, 2006).

IRPA funds support researchers either from universities and government research institutes. However, priority was given to universities as government research institutes have other government funding. After researchers publish their findings, then the technology transfer offices handle their commercialization of it by either through formation of spin-off companies and licensing. MTDC roles will then direct R and D collaboration with funding. The financing part includes buying capital equipment and funding marketing.

Apart from helping companies to acquire further scientific and technical knowledge and expertise, through technology transfer, either through spin-off companies from universities or direct R and D collaboration, the MTDC also facilitates funding for companies. The Financial Group under the MTDC aims to increase capital available to companies in need of capital equipment and funding for marketing, Funding for commercialization of R and D comes from the Commercialization of R and D (CRDF) and the Technology Acquisition Funds (ATF). Funding of £14 million was allocated for five years from 2001 until 2005. From 2006 until 2010, the budget allocation is £38 million for both funds (EPU, 2006). The CRDF provides partial grants to successful applicants ranging from 50 percent to 70 percent. The funding includes market surveys and research, product and process design and development, and standard and regulatory compliance and intellectual protection. Out of 162 applications for this fund from early 1996 to the end of 2000, only 36 were approved.

Besides capital, the Malaysian government, through the MTDC, has set up three incubation centres in collaboration with local universities. They include the UPM-MTDC Technology Incubation Centre, under University Putra Malaysia, the UM-MTDC Technology Innovation Centre and the UKM-MTDC Intelligence Technology Centre. These incubation centres are for the initiation and nurturing of a new technology companies. They offer help with technology transfer, spin-off and new venture development. They play a useful role in bringing research and capital together while nurturing and accelerating development of new companies.

R and D in Malaysian universities

The number of scientific researchers in Malaysia was estimated at 17,790 in 2002. Of these, 10,527 were university employees, 3,914 were in government research institutes and 3,349 were in companies. Malaysia had only 0.15% of its labour force in R and D in 2002 (MASTIC 2004). Funding for research in Malaysia is estimated at £173 million a year, of which about £8.5 million a year is for the IRPA. Nearly 50% of the government budget for R and D goes to universities. The universities recorded significant growth in their R and D expenditure from 1992 to 1998. The emphasis is on applied and developmental research. Research was concentrated on manufacturing, and on information and communications technology (ICT), followed by energy resources (EPU 1999). Under the IRPA programme, the pattern of technology development has changed to advancement of such strategic technologies as biotechnology, and also photonics, concerned with generating and transmitting light (photons).

A mid-1990s' government assessment of the benefits and effectiveness of research funded under the IRPA indicated that the extent of commercialization of R and D results remained low across all sectors (EPU, 1996). There were a few takers of potential technologies and products, as private sector companies wanted to minimise risk on untried and untested technologies and products. University links with companies through collaborative R and D efforts were still negligible. More seemed to need to be done by university and government research institute staff to work with more closely with the private sector to generate more market-oriented R and D. The National Productivity Corporation (NPC 2003) advocated measures for overcoming such problems. They included a databank for research results, more emphasis on research related to market needs, more rewards for and recognition of researchers, provision of more venture capital and more networking between researchers, companies and government officials. The authors of the NPC report felt that some university researchers were too interested in academic work. Some of the NPC's thinking and recommendations seem quite directive and slightly heavy-handed, and might encourage doubts in the minds of some about whether innovation actually should be managed or, indeed, whether it can be (see Webb, 1992, for example).

APPENDIX 5:

INTERVIEW SCHEDULES

Provisional Title of the Study:
An Investigation of the Commercialization of Discoveries and Inventions in Malaysia

Interview Schedules

For companies, entrepreneurs and managers

1. How would you describe the processes of technology transfer, and those of commercialization?
2. How relevant to your company's work are discoveries made in universities?
3. And in government research institutes?
4. Do university researchers, in your experience, invent new processes or products of interest to your companies?
5. And researchers in government research institutes?
6. Do you have, or have you had, contacts with the Ministry of Science, Technology and Innovation, and if so have they been helpful to you (why/why not?).
7. And the Ministry of International Trade and Industry?
8. And venture capitalists?
9. And universities?
10. And government research institutes?
11. And banks?
12. How do you value the efforts of the government to increase the flow of new scientific knowledge to industry?
13. Finally, how do you think about the roles of engineering, and of science, in technical change? Please compare them.

For university and government research institute researchers

1. How relevant to industry do you think that your research findings are?
2. What sorts of time scale are you thinking about?
3. How widely do you expect your findings to be used in the future?
4. Are you involved in transferring the knowledge that you produce to companies?
5. And in transferring technology to them?
6. What do you think of the ways in which your kinds of research findings are commercialized (or not, as the case may be)?
7. How effective are your relationships with the university administrators who help to organize commercialization?
8. And with equivalent staff of the companies who may use your findings?
9. Who else, if anyone, is involved with you in commercialization and technology transfer and how effective are your relationships with them?
10. Do you have any further comments to make on the processes of commercializing university research findings in Malaysia?
11. Finally, how do you think about the roles of engineering, and of science, in technical change? Please compare them.

For administrators in university technology transfer office and in government research institutes

1. How would you describe technology transfer and commercialization?
2. Scientists broadly work to discover and introduce knowledge. How far should they if at all, be involved in helping companies to invent ways of such knowledge, and in doing so in ways that improve the commercial value of what companies do?
3. What do you think the most important characteristic of the successful commercialization of university/government institutes research are?
4. And the main problems involved?
5. What in your experience are the most and least effective aspects of your relationships with companies?
6. What in your experience are the most and least satisfactory aspects of your relationship with companies?
7. How have the processes of technology transfer and commercialization changed over time at your university/institute?

For top research administrators (for example Deputy Vice-Chancellors (Research) of universities or Directors of government research institutes)

1. How important is the commercial use (actual and potential) of the research findings of your university/institute to it, compared with its other outputs?
2. And for industrial and other sectors like health care, the armed forces, government departments, and insurance, where the knowledge that you produce could be used?
3. What is your university's/institute's strategy for commercialization and technology transfer?
4. What do you regard as being the critical factors in the commercialization of your university's/institute's research?
5. What do you see as your university's/institute's main strengths and weakness as regards the commercialization of its research findings?
6. Do you have or have you had contacts with the Ministry of Science, Technology and Innovation, and if so have they been helpful to you (why/why not?).
7. And the Ministry of International Trade and Industry?
8. And venture capitalists?
9. And universities?
10 And government research institutes?
11. And banks?
12. How have the processes of technology transfer and of commercialization changed over time at your university/institute?
13. How do you value the efforts of the government to increase the flow of new scientific knowledge to industry?
14. Finally, how do you think about the roles of engineering, and of science, in technical change? Please compare them.

For venture capitalists/banks

1. How helpful do you think that the commercialization of new scientific knowledge is to the industry?
2. In your experience of your work in helping companies to fund such commercialization, what ideas have you developed about the following:

a) the ability of university researchers and research administrators to understand what companies need?
b) the ability of researchers and administrators of government research institutes to understand what companies need?
c) about the abilities of entrepreneurs, managers and companies to use new scientific knowledge profitably?
d) about relevant government policies?
e) about the two ministries (the Ministry of Science, Technology and Innovation and Ministry of International Trade and Industry) involved?
f) about the roles of intellectual property rights companies?
g) about the relationships between all or any of you (venture capitalists) and the others referred to in the previous questions 2a) to 2f)?

3. Finally, how do you think about the roles of engineering, and of science, in technical change? Please compare them.

4. Is there a free market for useful scientific knowledge in Malaysia? Please explain your answer.

For journalists

1. The government has actively encouraged companies to use the results of scientific research, and university and government research institute researchers to work with companies and other organizations to help make this happen. How important do you think these efforts at 'commercialization' of scientific research and technology transfer are for Malaysia's economic future?
2. So far these attempts have not been very successful. Many companies seem unable or unwilling to put new scientific knowledge to use. Why do you think this is?
3. Part of the government's strategy is to increase the numbers of people qualified in business, engineering and scientific subjects for many kinds and levels of employment. Some thinkers in universities think that this approach can stifle originality and creativity and result in there being too many qualified people chasing too few jobs. They think, also, that the main purpose of education is to produce civilized adults, and that a strong emphasis on business and industry in education can lead to neglect of its true purpose. What do you think of these two criticisms of the policy?
4. Do you think that Malaysia may, as some have suggested, be being too much influenced by Western (mainly American) management ideas, which often seem to be ignored by more successful, focused and hard-working business people in the West and everywhere else?
5. Finally, how do you think about the roles of engineering, and of science, in technical change? Please compare them.

For politicians

1. How important is commercialization to the future of Malaysia's economy? Why?
2. In the processes of commercialization what do you regard as being the main strengths and weaknesses of the following participants?
   a) university researchers?
   b) university research administrators?
   c) government research institute researchers?
   d) government research institute research administrators?
   e) companies?

f) Your Ministry
g) The Ministry of International Trade and Industry/the Ministry of Science, Technology and Innovation?
h) venture capitalists?
i) banks?
j) intellectual property rights companies?

3. I have found, in the United Kingdom, that a number of experienced Western researchers question some of the assumptions made by those who regard commercialization as crucial to economic progress. For example they are concerned about:
    a) the idea that globalization of business is a permanent trend (that international trade will grow and grow for ever, and so on). They accept that globalization of communications is happening, but say that international trade in goods and services has always grown, and then contracted, and then grown again, and so on, throughout history.
    Comments?
    b) They argue that currently fashionable ideas about knowledge workers and the so-called k-economy have been advocated and demolished about once every generation since around 1780 A. D.
    Comments?
    c) They criticise the idea that producing more and more 'relevant' graduates and other qualified people for industry will result in economic success. They argue that many jobs, even many very complex ones, are often best learnt mainly on the job, and not by attending schools, colleges and universities, and that many formal qualifications produce what in the UK are called 'glorified clerks', meaning people with academic knowledge but little creativity or skill. They point to many examples of a basic education plus hard heads and crafty hands, producing industrial success, for example Henry Ford and many of those who created Britain's industrial revolution.
    Comments?
4. Some writers have argued that Western (mainly American) ways of managing are too controlling and that they can stifle creative people, and that developing countries accept them too uncritically.
    Comments?
5. How important are the roles of engineering, and of science, in technical change? Please compare them.
6. How do you see the future of commercialization and technology transfer in Malaysia?

Prepared by:
Noraini Abu Talib
Department of Management and Organization
Faculty of Management
University of Stirling
Date: 15 October 2004