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Systems Evaluation of University- Industry Collaboration Efficiency in Iran: Current Situation and Proposed Policy Framework

1- Gerry Edgar, Senior Lecturer, Management Work and Organisation, University of Stirling, UK,
2- Omid Ali Kharazmi, Assistant Professor, Ferdowsi University of Mashhad, Iran

Abstract

The research objective is to develop system models of the university-industry collaboration (UIC) element of a national innovation system and to evaluate its potential as a framework to inform economic policies. A UIC system model for Iran was developed and applied to explore key policy concerns, current performance, and barriers to development. A mixed-method approach was used. Firstly a survey was used to scope system elements from the input of 94 expert stakeholders and to establish related issues. An insight of the difference between university and industry actors' views regarding problems of UIC effectiveness was also formed. Secondly, 25 semi-structured interviews with stakeholders were used for building the conceptual model of the UIC system. Quantitative data were analyzed with Mann-Whitney U test, and for analyzing interviews, theme analysis was applied. Analysis of the causal relationships in the UIC model indicated there are a range of barriers that maintain a predominant negative behaviour pattern that limits UIC performance. This negative equilibrium is manifest as significant lack of trust at all interfaces in the system. The systems model is a complex interaction of reinforcing loops that emphasizes the scale of challenge policy-makers face in creating effective UIC outcomes. A set of policy choices informs an improvement agenda for UIC activities in Iran. This method is a framework to address the current lack of effective approaches to aid understanding of the complexity of behavioural forces that can help politicians to form coherent policies that address often hidden systematic biases.

Keywords: University, Industry, Collaboration, Barriers, Systems Thinking, Iran.

1- Introduction

Learning and innovation are critical drivers to economic development and competitiveness for all nations (Todtling & Trippl, 2005; Bodas Freitas & Verspagen, 2017). In developed and developing nations alike the most widely adopted template for innovation focused national economic development are based on the National Innovation System (NIS) theories (Freeman, 1987; Lundvall, 1992) and Porter's 'Cluster' model for competitive advantage (1990) despite being initially developed to explain the performance difference between developed nations. The establishment of a National Systems of Innovation is now considered essential to create an integrated environment for knowledge creation and flow, regulatory framework, and managed institutional networking (Baghernejad, 2006; Jankowska et al., 2017). Although this role of technological innovation in the economic growth of developed countries has been studied in depth, there has been a more limited albeit growing examination of developing nations with notable exceptions of the transformations of China and India (Metcalfe, 2008; Watkins, 2015). These models are evolving as application yields evidence of effectiveness (Sharif 2006) and more nuanced theories now compete with the wider NIS concept including the Triple-Helix model of university–industry-government interactions developed mainly by Etzkowitz and Leydesdorff (1997, 1998, 2000).

Now a central focus of many NIS systems is to establish or improve the value creating infrastructure based on a knowledge capture, create and sharing system through collaboration of multiple actors (Obrenovic & Jalilov, 2014). This requires significant government coordination and incentivization to bring together the main actors - universities and industry (Liu, 2019). Porter's diamond model is more focused on the cluster concept and highlights the role of industry as the economic growth core while considering other entities as required supporting institutions such as universities to create more robust clusters (Porter, 1990). The Triple Helix Model theories consider the role of universities to be more central for the economic development of countries and highlights the vital and complementary role of government and industry in this regard (Cai & Etzkowitz, 2020). Additionally, as Cai and Etzkowitz (2020) observe, UIC not only fosters innovation but also creates new business ventures and entrepreneurship. A core concept from this literature is the need for interlinking and strong relationship forming between universities as knowledge creators and developers and industry as increasingly sophisticated adopters of new knowledge (UIC). However, research on the behaviour at these interlinkages, and what can create behavioural change is limited. Yet, to realize the benefits these economic synergies can bring it is necessary to identify localized means of enhancing UIC activities and eliminating related barriers to cooperation – these are behavioural issues of the system actors.

Various studies (Sala et al., 2009; Bodas Freitas & Verspagen, 2017; Arenaz & Gonzalez, 2018; Kuwashima, 2018; Meissner et al., 2018) have uncovered major barriers to UIC such as cultural differences, deficiencies in government policies, low degree of firms' absorptive capacity, bureaucracy, financial support challenges, absence or lack of effective intermediary organisations, and deficiencies in technology transfer offices. The literature also highlights culture and trust as important ingredients which have an impact on overall success of different theories of systems of

innovation and UIC activities. For example, Santoro and Bierly (2006), Thune (2007), Bouhamed et al. (2009), and Wirsich et al. (2016) found that lack of trust is a main barrier for the success of UIC. By decreasing barriers to UIC, demotivation for collaboration within both partners will reduce and increase the effectiveness of incentives (Decter et al., 2007). In this respect, NIS theories in general have been found lacking on the detail for specific policy actions, especially in addressing social dimensions that form the interlinkages essentially assumed to operate in a similar way to those in mature developed economies. As Dani Rodrik (Rodrik, 2004) observed on the failures of "rule of thumb" economic growth policies, each country requires a diagnostic approach to understanding their unique circumstances and form policy responses to match. The current investigation proposes the use of a systems modelling method to facilitate this diagnostic-based approach to better informed policy making. This work is based on a first principles approach to creating a system model of UIC activity by incorporating behavioural dynamics to investigate the true extent of the functionality of the assumed interlinkages.

Various studies (Lee & Tunzelmann, 2005; Galanakis, 2006; Brown & Smith 2009) endorse systems thinking approaches as an effective means to illustrate the complexity of innovation processes and enable a meaningful understanding of the dynamics involved. Systems thinking is a tool for understanding how complex, sometimes messy things work since it offers a framework to look beyond events and scrutinise patterns of behaviour (Senge, 1990) – exactly the nature of the problem situation of the research objectives in this investigation.

The context impetus for the current study is the necessity for diversification for Iran for two reasons. Firstly, natural resources do not give a competitive advantage in the long run and are exhaustible, and secondly penetration into world markets requires both knowledge-intensive production and innovation-based competition. Creating comprehensive National Systems of Innovation and enhancing UIC in Iran is a prerequisite of moving towards a more knowledge-based economy (United Nations, 2005; Masoumzadeh, 2006; United Nations, 2006; Gilandeh et al., 2017). Although the process of designing a NIS for Iran began in 2003, there are several technology-supporting institutions and policy instruments which function in isolation and occasionally in conflict; there are also many deficiencies in the system (Ghazinoory, 2003; Mani, 2004; Gilandeh et al., 2017). This situation leads to the emergence of a fractured innovation system in the country (Mani, 2004; Gilandeh et al., 2017). Iran's main concerns regarding the reinforcement of a national innovation system are: how to attract new entrepreneurs, to promote an innovation culture; and finally, what role universities and industry can play to promote innovation and entrepreneurship (United Nations, 2006; Kharazmi & Nedayi, 2013). In Iran university-industry interaction existed for many decades but it took place in an adhoc manner. In the last ten years this has become an important issue for discussion (Gilandeh et al., 2017). A primary objective of Iran is to become a developed nation and the principal economic power in the region by 2025 (Paya & Baradaran Shoraka, 2009).

The main objective of this study is to develop a Systems Model (SM) of university-industry-government interrelations to facilitate diagnostics of policy needs by identifying primary barriers that affect UIC performance in the case of Iran. In this regard, behavioural aspects of university and industry actors regarding these barriers were incorporated into the developed model to capture motivational priorities and drivers. Therefore, the main research questions in this investigation are;

1- What are the major barriers to UIC activity?
2- How do the behaviours of the main system actors relate to these barriers?

3- How barriers to UIC systemically interact to create a UIC performance state?
4- How useful is the derived SM to facilitate diagnostic capability of the UIC to enable targeted policy formation to improve performance?

This represents a methodological challenge. Although there are improvements in theory formulation and evidence from practice, little progress has been accomplished in the development of a universal approach that addresses the behavioural issues and barriers related to UIC activities (Kuwashima, 2018). Also, some researchers have tried to introduce the dynamic behaviour of NIS and related theories in general (e.g. Galanakis, 2006; McAdam & Debackere, 2017); however, no research has focused on the systematic models to identify barriers that interact to affect university-industry collaboration performance, particularly in developing countries.

2- Theoretical Background

The theoretical background consist of two main parts including barriers to UIC and systems thinking concept and related literature.

2-1 University Industry Collaboration and Its Barriers

In mature knowledge-based economies the dialogue and initiatives that form effective collaborations between university, industry and government have proven vital for generating growth through innovation (Dzisah & Etzkowitz, 2008; Etzkowitz, 2008; McAdam & Debackere, 2017; Meissner et al., 2018). Yet, in a bid to evolve their own sustainable knowledge-base, developing countries often opt for an acquisition approach for technological assets as a means of technology transfer from developed countries or attempt to replicate their infrastructure components. Targeted on strategic industries these technology acquisitions and innovation park investments are considered signs of progress for well-planned rapid industrialization. However, delivering on the expected economic growth proves more difficult when the lack of specialized skills, industrial eco-system and research investments limits the pace complex technologies can be absorbed and then adapted. This semi-structured approach to fast commercialization of newly acquired technologies is prone to costly trial and error accompanied by the blame that erodes trust between industry and researchers (Choi, 1986; Saad & Zawdie, 2005). To move on from this requires informed government policy intervention to create the enabling developmental framework as well as provide the early investment and leadership to form sustaining UIC.

University and industry collaboration and the role of government is seen to evolve over four distinct stages which reflect the observed patterns of actor behaviours: isolated, vertical, arm's length, and horizontal triple helices. In the early stages, a variety of barrier causes exist to successful UIC. However, in the final stage of collaboration there are reinforcing experiences of successful collaboration projects, established pathways for knowledge flows and openness to interactions that facilitate a successful UIC network. These interactions include: knowledge flows from universities to firms, knowledge flows through formation of new enterprises, formal R&D co-operations, invest into universities' facilities, and acquiring university research (Inzelt, 2004).

It is arguable that the critical aspects in the design of any economic policy instrument are to understand the barriers to change to be overcome and to facilitate targeted forces to deliver a different and more desirable equilibrium state. To enhance patterns of UIC interactions, the most important step is to identify related barriers to collaboration and try to understand their cause. Some of these barriers have been explored - lack of information on how to access industry,

intellectual property issues, university view (poor reputation) of industry collaboration experiences (e.g. financial gain is industry's only interest) (Mirza et al., 2020), cultural differences between organizations including secrecy of industry vs. open dissemination by university academics, lack of trust, and lack of understanding of university norms by industry staff and vice versa (Arenaz & Gonzalez, 2018; Kuwashima, 2018; Meissner et al., 2018). There are also structural barriers which refers to deficiency of TTO in universities as their members lack the required skills to link firms and academia and also the lack of successful entrepreneurial experiences (Siegel et al., 2004). The required skills for this role are in marketing, practical experiences and familiarity with rules and regulations involved in UIC (Lima, 2021). Other barriers of UIC include bureaucracy in processes within both sectors (Degroof et al., 2004; Singer & Peterka, 2009), low levels of intermediary organizations' involvement (Kodama, 2008), low levels of R&D expenditure, limited firms' absorptive capacity, deficiency in financial structure and lack of venture capitals (Etzkowitz, 2005). For developing countries emigration and the brain drain phenomena are significant knowledge capital problems (Davenport 2004). Governments in developing countries can also impede UIC activities that include instability of regulations and ineffective interventions (Saad & Zawdie, 2005).

According to Plewa and Quester (2007) and Wirsich et al. (2016), lack of trust and cultural differences are the major barriers for UIC. Trust has been uncovered as a key component for success of a regional innovation system (Niosi & Bas, 2001; Chung, 2004; Golichenko, 2016; Moreira et al., 2018). Tillmar (2006) found trust states are influenced by the national culture and regulations and laws of a country and Doney (1998) found that trust is influenced by intermediate institutions, relational factor, and individual circumstances as well as the national culture.

Some factors that drive or motivate collaborative activity have also been found in the literature; strengthening institutional policy on intellectual property rights, increasing stability of government regulations, and by promoting trust, both universities and industry have engaged more positively with collaboration opportunities (Debackere & Veugelers, 2005; Freitas et al., 2009; Meissner et al., 2018). Initiatives to bridging the cultural gap, adopting fair royalty sharing structures and reward system motivates individuals within universities and companies to collaborate (Decter et al., 2007; Bodas Freitas & Verspagen, 2017).

2-2 Systems Thinking

Systems thinking was developed as a tool to better understand complex management issues and problems. This method was developed more than 50 years ago (Checkland, 1999) and aided complex decision making for warfare planning but is now a well-established tool in management discussions (Flett, 2001). With this method, events and their causes are not considered separately or linearly, rather they are considered as a system that consists of parts that interact with each other. The term 'system' signifies a group of interconnected components forming a single, unified pattern that allows planners to get a more comprehensive perspective (Senge, 1990; Edson, 2008). Because managers and policy makers are facing complexity in problem solving and decision making process, they need to consider more holistic and creative methods and systems thinking is considered as a candidate solution in this regard (Jackson, 2006). There are variety of systems methodologies that can be employed to tackle complex problem situations e.g. hard and soft systems thinking (Jackson, 2010). By using systems thinking approach (Patching, 1990) complexity can be analyzed at different levels including various types of organizations to social

systems (Schaveling & Bryan, 2018). Theoretical concepts of systems thinking are mainly based on feedback loops, interconnections, adaptive capacity, emergence, and self-organization. Feedback plays a vital role in the systems thinking approach that can change the static position of analysis to a dynamic one (Williams et al., 2017)

Galanakis (2006), studied innovation processes based on a systems-thinking approach and focused on the systemic interactions of knowledge creation, new product design, development process, and product success in the market. The research highlighted that success in the market required both micro and macro environments be taken into account when modelling systems. Ghalib (2004) also considered the importance of systemic interactions between all related factors that ultimately lead to managing knowledge effectively in an organization. Lee and Tunzelmann (2005) also focused on the importance of the dynamic and systemic approach to national innovation systems. Although there are useful studies of systems thinking applied at different conceptual levels of innovation including firm, local and national levels, there no applications to UIC or collaboration barriers based on systems thinking.

3- Research Methodology

3-1 Research Design

This research involved a multi-stage investigation using both quantitative and qualitative methods. The first stage (the quantitative part) was designed to scope and identify activities and impediments in the UIC collaborations for two major Iranian industry and academic groupings. This also establish the distinct perspectives on UIC activities from a wider range of university and industry stakeholders. In the next stage, the base Systems Model (SM) was constructed using the elements identified in the first stage as well as relationships or barriers to relationships verified or found in the qualitative stage (interviews). The resultant model was then used to characterize the current UIC situation and to explore the cause-and-effect relationship especially linked to identified collaboration barriers. This led to exploring policy ideas based on the knowledge of the systemic barrier sustaining forces and potential change schemes to change the force dynamics. This SM can form a continuous loop in which the real world is subject to a constant comparison with a systems model equivalent. As noted by Checkland and Scholes (1999) the real world situation should be examined to find out if those activities necessary to give the defined system functionality are actually going on in practice.

3-2 Data Collection

In the first stage of data collecting questionnaires were distributed among expert stakeholders from universities and industry. In total, 126 questionnaires were distributed to individuals who had experience of UIC in the selected industrial sectors. 94 valid questionnaires were returned. The survey was based on the literature (section 2-1) and respondents were selected from five major universities and two industrial clusters of automotive and biotechnology in Tehran and Mashhad city. Three respondents were selected for pre-testing the instrument and after amendments, fifty professors and forty four senior representatives from industry provided valid responses. A 7-point

Likert scale was used in an intuitive format where "1" meant not important barrier and "7" meant very important barrier to UIC.

In the qualitative data collection phase, 25 semi-structured interviews were conducted based on snowball sampling technique with experts in the mentioned universities, two industrial clusters and Government bodies. The choice of interview method proved effective in eliciting a focused but thoughtful dialogue from the interviewees (Saunders et al., 2007). In all interviews, consent for recording their voice for the purpose of transcription and data analysis was obtained. Two participants were selected for pilot interviews and pre-testing the instrument. The effect of this testing was subtle on question text but significant for the manner of conducting the interview sessions and final questions. Table 1 represents the interviewees' organization, their positions and interview duration. The interview questions were open-ended as follow:

1- What are the major barriers to UIC?
2- How can these barriers be grouped in order to form sub-systems?
3- How do these barriers interact with others in the same or other sub-systems?
4- Any suggestions for improving UIC performance?

Table 1: Interviewees' Background and Duration of Interviews

Interviewee	Sector	Position	Duration of Interview (Min)
1	Ferdowsi University of Mashhad	Associate Professor	**48**
2	Ferdowsi University of Mashhad	Associate Professor	**74**
3	University of Tehran	Professor	**124**
4	University of Tehran	Professor	**56**
5	Sharif University of Technology	Associate Professor	**68**
6	Amirkabir University of Technology	Professor	**84**
7	Amirkabir University of Technology	Professor	**50**
8	Technology Transfer Office/ Ferdowsi University of Mashhad	Manager	**122**
9	Technology Transfer Office/ University of Tehran	Manager	**45**
10	Tarbiat Modarres University	Professor	**66**
11	Tarbiat Modarres University	Associate Professor	**87**
12	Automotive Company	CEO	**93**
13	Automotive Company	CEO	**72**
14	Automotive Company	R&D Manager	**59**
15	Automotive Company	R&D Manager	**61**
16	Automotive Company	CEO	**76**
17	Biotechnology Company	CEO	**43**
18	Biotechnology Company	CEO	**81**
19	Biotechnology Company	Innovation Manager	**79**
20	Biotechnology Company	Product Development Manager	**98**
21	Iran Small Industries and Industrial Parks Organization	Planning Department Manager	**70**
22	Iran Small Industries and Industrial Parks Organization	R&D Manager	**61**
23	Ministry of Industry, Mine and Trade	Expert in Planning Section	**54**
24	Ministry of Science, Research and Technology	Expert in Planning Department	**41**

25	Ministry of Science, Research and Technology	R&D Expert	**73**
Total			**1775**

3-3 Data Analysis

Quantitative data were analyzed using descriptive statistics and Mann Whitney U test to compare both samples. Cronbach alpha was used to analyze data reliability and was found to be an acceptable 0.76. Qualitative data were analyzed based on thematic analysis techniques. The interviews were recorded and transcribed to increase the accuracy of the interview content. Theme analysis is an effective method in evaluating the content and classification of sources (Myers, 2009). Thematic analysis was also used for factor groupings (sub-systems identification); participants were asked to group UIC barriers into common cause categories which subsequently formed the UIC sub-systems (see Figure 1). Vensim system software was found to be a useful graphing package to illustrate the cause-and-effect relationships between variables in different sub-systems.

3-4 Context of Study and UIC in Iran

University industry collaborations began as a planned economic activity in Iran nearly three decades ago and is still considered as an important driver of the national innovation and economic development system (Kharazmi & Nedayi, 2013; Gilandeh, 2017). However, although Iran has strong industrial bases and university institutions, the pattern for most industries and particularly large ones is to opt for collaboration with partners from developed countries. Oil, steel, automotive, biotechnology, defense, food and petrochemical are among the most important industry in Iran. SMEs in the country account for 96% of industrial enterprises but only 42% of employment (Moradi & Noori, 2020). Most universities in Iran currently have designed technology transfer or entrepreneurial offices to promote collaborations with external enterprises. Many companies, especially SMEs, are very interested in forming collaboration with universities in the hope of improving the quality of their product or processes or managerial consultations (Gilandeh, 2017), but the reality of such collaboration projects is presently of questionable value on both sides (Moradi & Noori, 2020). As in many developing countries, technology parks have been built ostensibly to stimulate collaboration, accompanied by many government initiatives to promote the schemes. However, these policy instruments met many barriers at macro and micro levels that impeded the effectiveness and extent of any collaboration efforts (Kharazmi & Nedayi, 2013). These were identified as wider social environmental issues including administrative, cultural, political and economic barriers, and also mediating conditions such as infrastructural constraints (Moradi & Noori, 2020).

4- Findings:

4-1 Major Barriers to University-Industry Collaboration.

The following section presents the identified major barriers to UIC and also compares the university and industry views regarding these barriers. These are based on the outcomes from the quantitative analysis.

According to the results (Table 2), "bureaucracy and inflexibility of university administrator" was considered by both university and industry respondents to be a very important barrier to collaboration. "Industrial culture which is based on profit maximization" and "lack of understanding of university norms by industrial people" were considered only by university respondents as very important barriers to collaboration. "Lack of understanding of industry norms by university people" and "cultural differences in terms of secrecy vs. dissemination" were considered only by industry respondents as very important barriers to collaboration. "Difficulties in agreeing about a technology transfer deal" was ranked by both university and industry respondents as a medium barrier to collaboration.

The results for the main barriers to UIC confirmed the greater impact of "bureaucracy and inflexibility of university administrator" on the university side (significant at 95% confidence level). Other differences have the emphasis on "industrial culture which is based on profit maximization" and "lack of understanding of university norms by industrial people" in university (Significant at 99% confidence level), and "lack of understanding of industry norms by university people", "cultural differences in terms of secrecy vs. dissemination" and "difficulties in agreeing a technology transfer deal" in industry (significant at 99% confidence level). The differences between university and industry respondents regarding other impeding factors were not significant (Table 2).

Table2: Results of Mann-Whitney U Test regarding UIC Barriers to Collaboration

Barriers to UIC: Test Statistics[a]

	Mean (Industry)	Mean (University)	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Industrial culture which is based on profit maximization	4.92	5.74	696.000	1622.000	-3.243	.001**
Cultural differences in terms of Secrecy Vs dissemination (Intellectual Property Rights' Issues)	5.49	4.56	532.500	1928.000	-3.524	.007**
Time orientation differences	5.59	5.72	844.000	1724.000	-.712	.385
Difficulties in agreeing a technology transfer deal	4.82	4.12	604.500	1755.000	-3.554	.000**
Speed of negotiation of technology transfer	4.75	4.42	852.000	2028.000	-2.326	.244
Financing the technology transfer deal	4.95	4.71	912.000	2224.000	-.856	.312
Poor skills of the people in TTO	5.11	5.37	823.500	1795.500	-.834	.322
Bureaucracy and inflexibility of university administrator	5.39	5.98	695.000	1680.000	-2.793	.035*
Insufficient resources devoted to technology transfer by universities	4.41	4.72	800.000	1794.500	-.854	.467
Lack of understanding of industry norms by university people	5.49	4.59	594.000	1825.000	-3.322	.004**
Lack of understanding of university norms by industrial people	4.46	5.67	512.500	1487.500	-4.212	.002**
Low degree of firm absorptive capacity	5.09	5.32	954.000	1945.500	-.814	.536
Brain Drain	5.46	5.21	1876.000	2277.000	-.927	.425
Instability of government regulations	6.29	6.21	1090.000	1912.000	-.665	.423

a. Grouping Variable: University-Industry

*Indicates statistical Significance of the difference at the 95% confidence level; ** at the 99% Level.

4-2 Current Status of UIC based on Systems Thinking

The analysis of the interviews found the critical university-industry collaboration activities in Iran clustered around five factor groupings. These five groupings are represented as interconnected sub-systems in the overall UIC system model:

- Organisational Structures to Coordinate and Support Partnerships (OS)
- Asset Management (AST)
- Leadership and Culture (LC)
- Organisational Capabilities (OC)
- Creation of an Enabling Environment by Government (GOV)

The developed model (Figure 1) illustrates a high level view how the five factor groupings impact critical system behaviours - the motivation of individuals within universities to collaborate with companies, motivation of companies to collaborate with universities, UIC performance, and motivation of universities to collaborate with industry. These are resolved in more detail in the lower level sub-system models and are graphical representations of the interviews analysis.

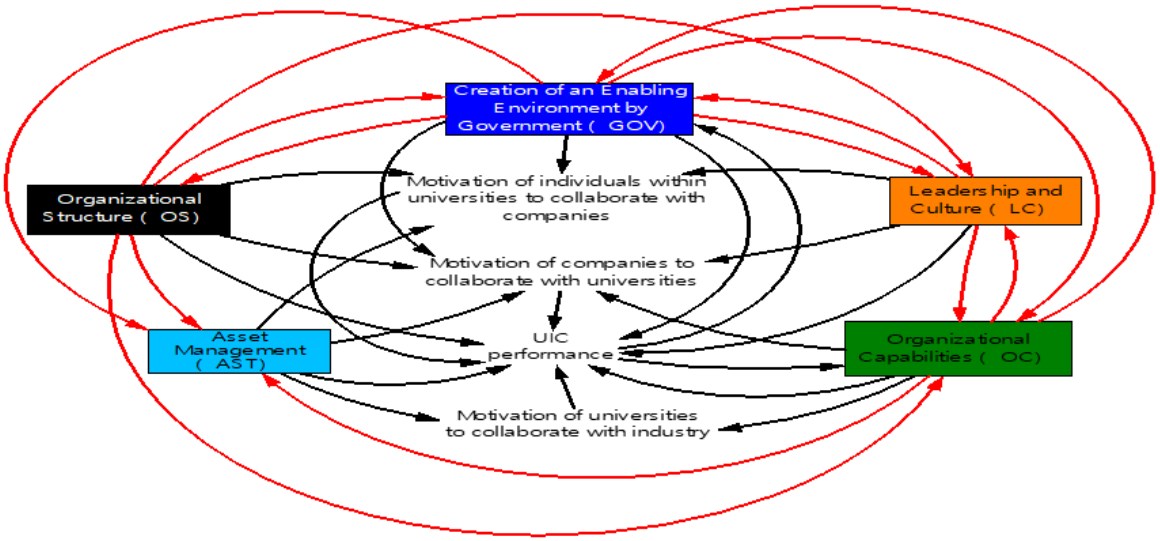

Figure 1: Factor groupings impact on UIC activities- SM

The following sections use the SM to evaluate major barriers to UIC, their interactions and show how they affect UIC performance.

Organisational Structure sub-system (OS)

The outcome of interview analyses is depicted in Figure 2 which shows the interaction of elements in this sub-system.

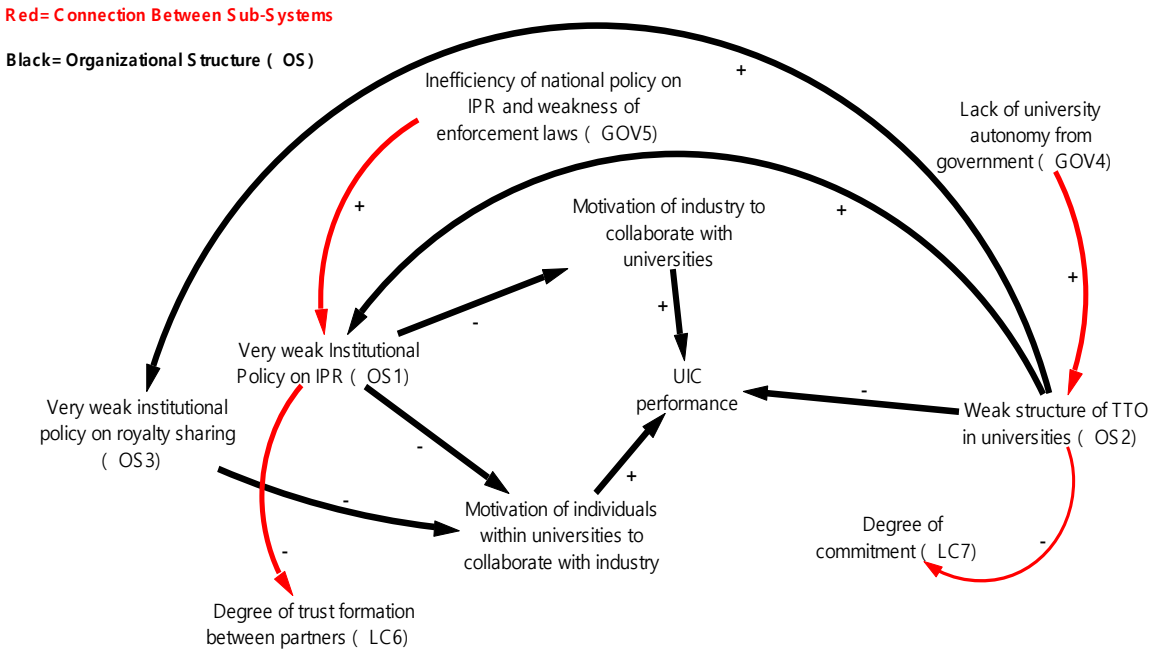

Figure 2: Factors contributing to Organisational Structure Sub-System and their connections

<u>Intellectual property Rights (IPR), Structure of Technology Transfer Offices (TTOs)</u>

The primary features of the current policy framework are clear deficiencies of institutional policy on IPR which in turn decreases motivation to collaborate, and ultimately depresses UIC performance. In collaborative projects this structural barrier caused a deepening lack of trust between partners or potential partners. Ultimately collaboration activities ceased after a time, resulting in little knowledge transfer between universities and industry other than through graduate employment or occasional consultation. According to one of the interviewees, "the main reasons found for the deficiency of IPR ownership in universities are a lack of the necessary skills due to the absence of multidisciplinary teams in TTOs and also at the national level, the weak national policy on IPR protection and deficiency of enforcement laws" (Participant 2). These issues form significant barriers for academics considering collaborating with companies. The absence of strong multidisciplinary-teams in TTOs creates problems in effective formulation of institutional policies on royalty sharing and contractual support, ultimately causing poor commitment among partners.

University autonomy from government, Structure of TTOs

The current low degree of university autonomy from government has a negative impact on structure of TTO in universities. TTOs hierarchical structure and their budget are defined directly by MSRT (Ministry Of Science, Research and Technology) and there is a low autonomy for universities' top management to change this. If this situation remains, capital for the support of, and direct involvement with, entrepreneurial activities will be at a low level; because activities in TTO's and building appropriate teams depends heavily on the budget. Currently, most UIC activities which are arranged through formal university procedures are limited to simpler mechanisms for collaboration (e.g. small scale projects, consultancy, and conferences) due to the perceived barriers and risks for deeper collaboration e.g. inefficiency of IPR. Consequently, informal collaborations i.e. not arranged with institutions, take place through personal networks between academics and companies including friendship, reputation and expertise. The extent of such collaboration is therefore limited to trusted partners and consequently few in number. According to one of the interviewees, "more complex forms of collaboration through formal mechanisms (university system) also happen through personal networks (e.g. personal friendships between TTO staff and individuals in companies) rather than systematic procedures" (Participant 8).

Asset Management sub-system (AST)

The outcome of interview analyses is depicted in Figure 3 which shows the interaction of elements in asset management sub-system.

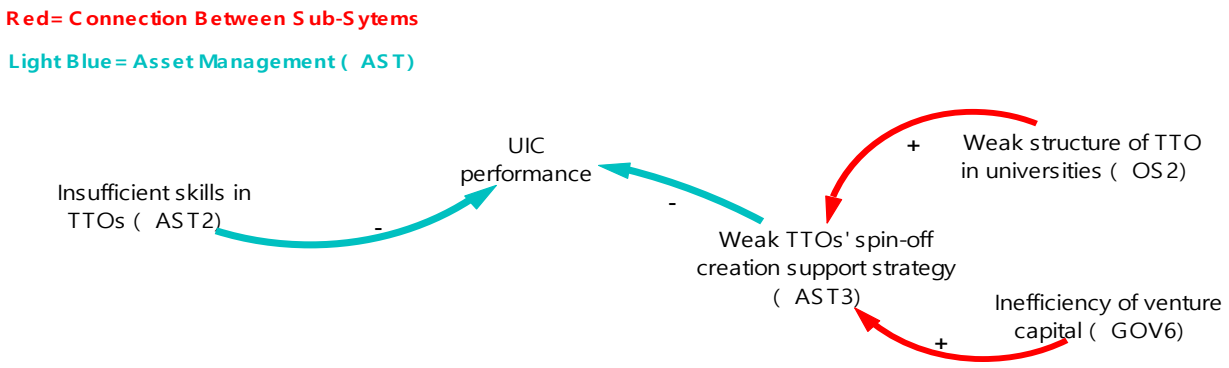

Figure 3: Factors contributing to Asset Management Sub-System and their connections

Venture Capital (VC), Skills in the TTOs, Structure of TTOs

Macho-Stadler et al. (2008) and Meissner et al. (2018) defined spin-off formation as an indication of entrepreneurial orientation of universities. Currently, universities in Iran are considered as low with respect to entrepreneurial orientation since TTOs do not support spin-off company formation creating few instances of spin-off companies from universities. Additionally, the weakness of TTO support for researchers during development phases of their innovations and also the weakness of the network of these offices to connect entrepreneurs to potential venture capitals, their potential to facilitate spin-off company formation is limited. Prolonging this will cause UIC performance to reduce further, since such barriers to academic entrepreneur ambitions facilitate the ongoing national brain-drain, resulting in an increasing concentration of non-entrepreneurial academics in university departments. According to one of the interviewees, "Iran, has ambitions for universities future outlook of the country in 2025 which envisions universities to become completely entrepreneurial. However, by continuation of current policies, Iran is unlikely to achieve this vision, since TTOs play no efficient role in this regard" (Participant 4).

According to the majority of respondents, this shows that although there is a network weakness of TTO's to connect entrepreneurs to VC, a fundamental problem is the low level of VC activities in the country (this is out of control of these offices and related to government support and favourability of entrepreneurial environment for VC activities).

Leadership and Culture sub-system (LC)

The outcome of interview analyses is depicted in Figure 4 which shows the interaction of elements in the leadership and culture sub-system.

Research consortia, Intermediary agents

The weak performance of research consortia and other similar kind of mechanisms for collaboration e.g. R&D contract of joint activities, and also the weak performance of intermediary agents lead to an increase in barriers to collaboration. Consequently, the cultural differences of current and potential partners remains high, and opportunities to increase understanding of partners for each other' norms will decrease or remain low, exacerbating or maintaining the polarization of university and industry.

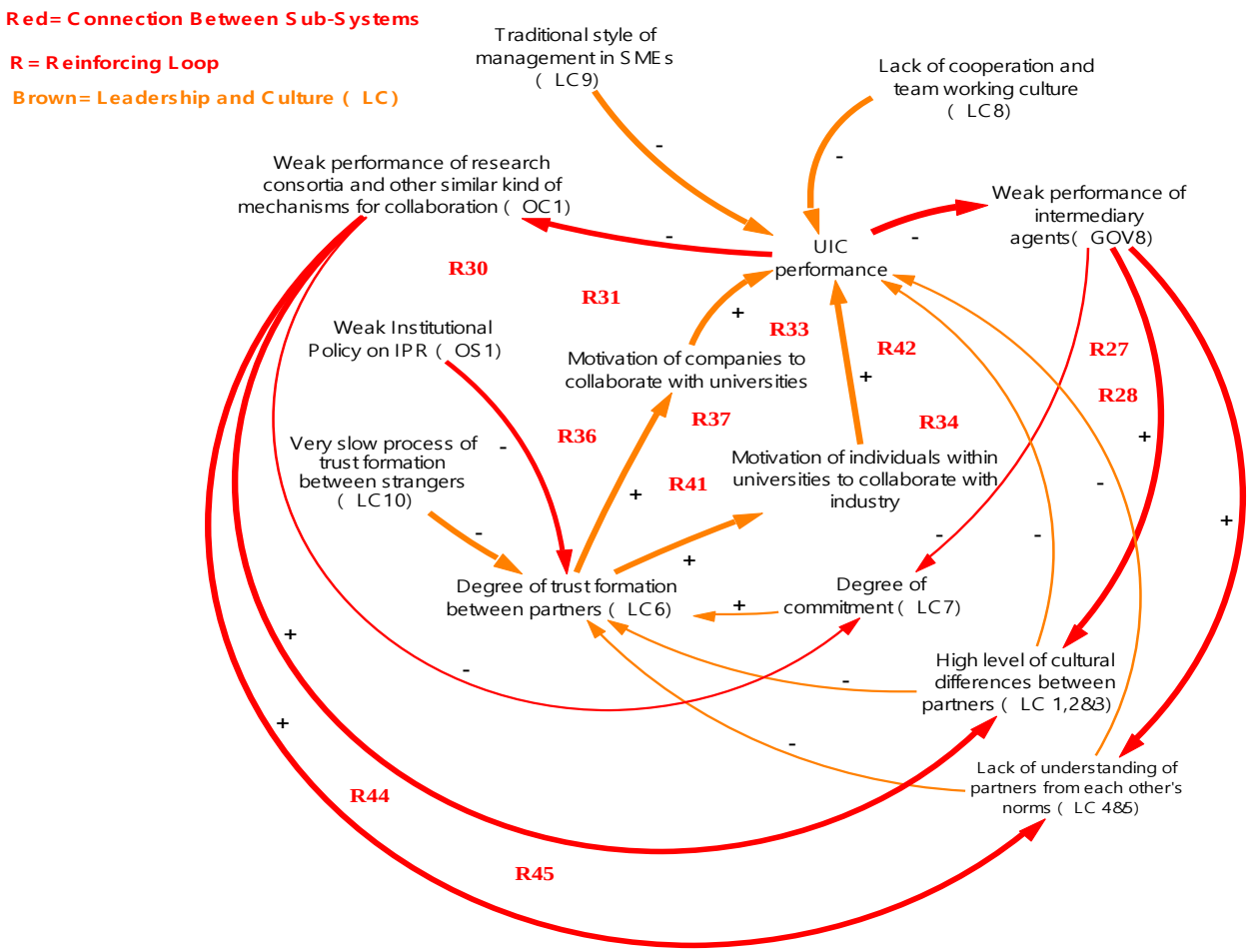

Figure 4: Factors contributing to Leadership and Culture Sub-System and their connections

A majority of respondents highlighted that the Iranian cultural characteristics that require a long term approach to trust formation creates an emphasis on the role and value of efficient and active intermediate organisations and agencies in the National Innovation System. This reliance on indirect trust chains creates an interesting opportunity to develop policy instruments.

Results from the interviews indicate that, cultural difference between partners and also lack of understanding of partners norms were recognized as the major barriers to UIC. This situation leads to a decrease in the opportunities for trust formation between partners. The weak structure of intermediary agents and research consortia causes a reduction in the degree of commitment among partners. This is due to poor procedures of collaboration administration (including contract responsibilities for each partner and penalties if the collaboration terms are abused) to oblige partners to stay committed to each other for the duration of the collaboration project. Such suppression of collaboration commitment ensures trust formation is unlikely. Lack of trust between partners is one of the major barriers which decreases motivation of individuals in universities and companies to collaborate. If there are no changes in the state of these mechanisms (research consortia and intermediary agents) the projected future holds little potential for trust formation or willingness to participate in these collaborations, forming a negative reinforcement loop with poor performance of research consortia and intermediary agents (see Loops R27, R28, R30, R31, R33,

R34, R36, R37, R41, R42, R44, and R45) (Figure 4). According to one of the interviewees, "these negative reinforcing loops are structural in the UIC system, ensuring a situation in which any investments by government, companies and universities to establish mechanisms for collaboration are likely to fail. In this event companies limit their investment from these initiatives and universities will then do likewise. Ultimately, significant economic value to the NIS is lost with the increasingly rare opportunities for more complex forms of collaborations" (Participant 23).

Also from the analysis of the interviews, low levels of team working and non-cooperation culture in the country, coupled to low SMEs management skills based on traditional management practices have a distinct negative impact on UIC performance. Very slow trust formation with strangers is a major cause of low trust formation between partners. These three forces have a strong cultural root in the Iranian context. According to one of the interviewees, "Iran's cultural predisposition to a lack of trust would suggest that formal trust forming mechanisms (contract and IPR) are likely to be more important than in other cultures" (Participant 21). Majority of respondents asserted that, these cultural features also manifest in the lack of trust between partners creating a barrier to motivation of companies to collaborate with universities and also motivation of individuals within universities to collaborate with companies.

Organisational Capabilities sub-system (OC)

The outcome of interview analyses is depicted in Figure 5 which shows the interaction of elements in this sub-system.

IPR (national and institutional)

Weak national policy on IPR protection, deficiency of enforcement laws and also absence of efficient institutional policy on IPR has a negative impact on the performance of research consortia (see Figure 5). This situation creates an environment where companies and universities are reluctant to form joint activities because of the perceived risk of leakage of strategic information. According to one of the interviewees, "in the absence of effective enforcement laws, collaboration investments are risky as a result of the disconnection between collaboration contracts and legal status – the judicial system has no mechanisms to compensate or protect partners regarding the loss of intellectual property" (Participant 10).

Degree of government support from research consortia

Weakness of consortia management and lack of government support from this mechanism were identified as significant barriers which contribute to a decrease in the efficiency of consortia collaborations. As a consequence of the national culture of the country, the low levels for cooperation and team working and the traditional style of management in SMEs have a direct negative impact on the performance of research consortia. According to one of the interviewees, "the tendency of SME's to follow a traditional style of management is a challenge issue in the current situation. Many SMEs are reluctant to seek and adopt new ideas such as collaborate with universities in research consortia" (participant 15).

Research consortia

The overall performance of research consortia is weak with few opportunities to demonstrate a positive impact to enhance the capabilities of universities and industry as a result of collaboration in these consortia. Therefore, reducing the probability of motivation for this mechanism for collaboration (see Figure 5). Universities and companies who invested heavily in this kind of mechanism for collaboration did not get the anticipated return on their investments. As this

situation perpetuates it is likely to de-motivate universities and industries from further participation and limit further investment. These form negative reinforcing loops which will reduce the performance of this kind of mechanism for collaboration in the long term (see Loops R1, R2, R3, R4, R5, R6, R7, R8, and R9) (Figure 5).

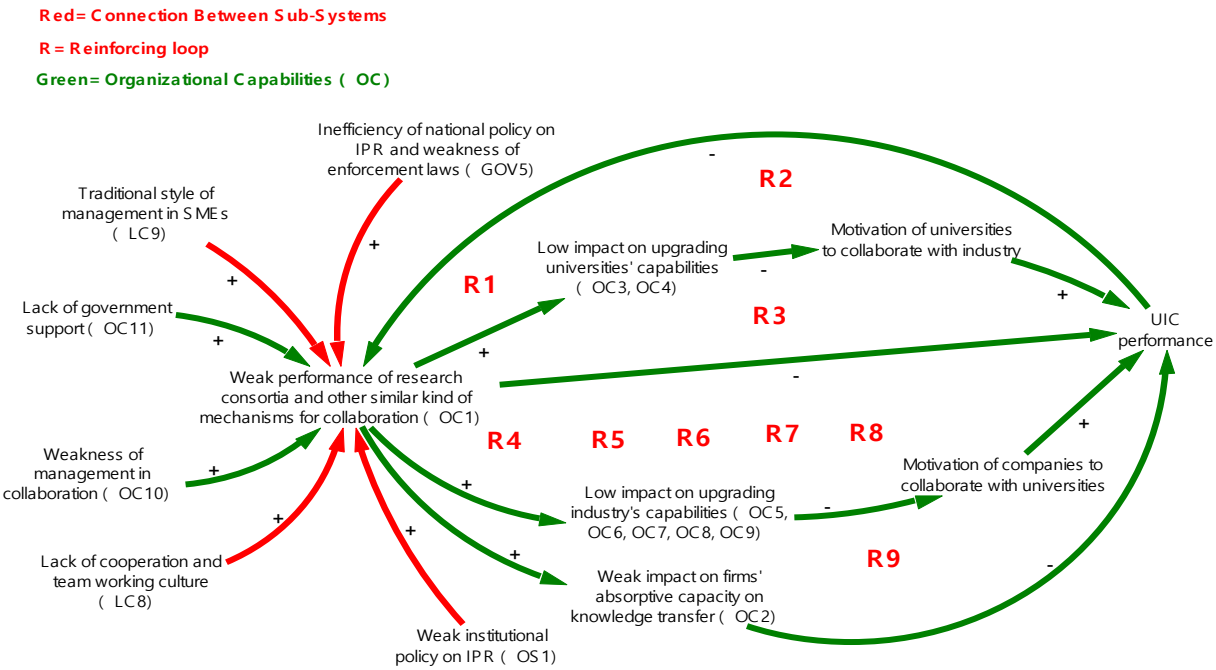

Figure 5: Factors Contributing to Organisational Capabilities Sub-System and their connections

Government sub-system (GOV)

The outcome of interview analyses is depicted in Figure 6 which shows the interaction of elements in government sub-system.

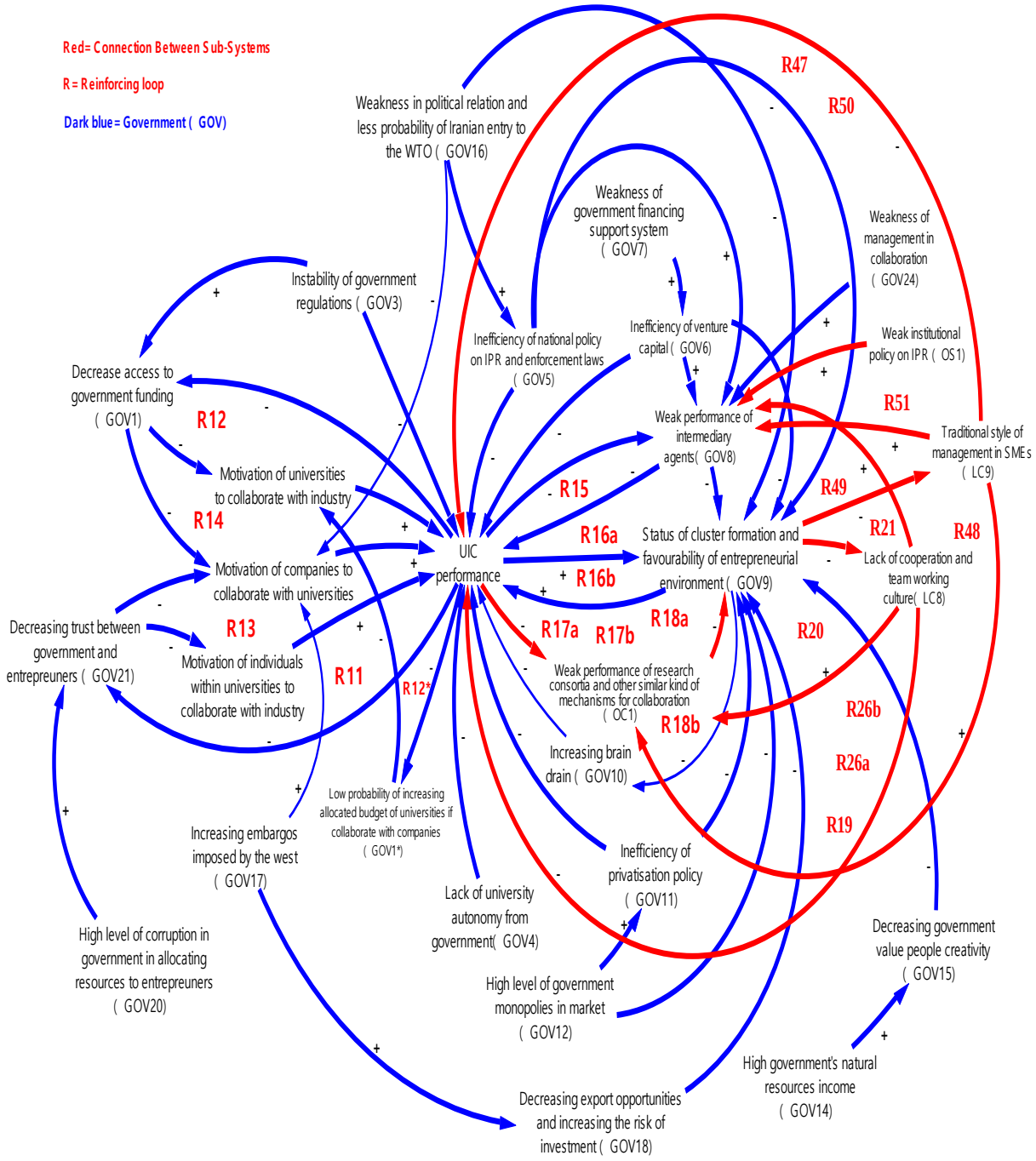

Figure 6: Factors Contributing to government Sub-System and their connections

<u>Stability of government regulations, Government initiatives for collaboration</u>

According to one of the interviewees, "there are various government support mechanisms for collaboration (e.g. tax incentives or partial government funding '60%' for companies which have collaborative activities with universities)" (Participant 22). Majority of respondents indicated that, support activities by government can inject extra money into universities as a result of

collaborative projects. However, these support mechanisms have proved ineffective due to instability of the government regulations (see Figure 6), and inefficient IPR protection and enforcement laws. Most of these collaborations are limited to simpler forms of activities, particularly consultancy. It was found that, instability of government regulations regarding university-industry collaborations is the most important barrier to collaboration. This reflects the difficulties for either party to invest in particular mechanisms of collaboration while there was uncertainty about the terms, conditions and duration of these stop-start support initiatives.

According to one of the interviewees, "the discontinuous (stop-start) pattern of some initiatives created a fragmented and unreliable basis for collaboration resulting in depressing motivation of companies and universities to re-engage in these initiatives" (Participant 18). It is found that, if this situation is repeated, there would be very low level of willingness to participate from either party. This will decrease the amount of government funding which could be delivered effectively from collaborative activities and furthermore decrease the efficiency of these government programmes. These form negative reinforcing loops which continuously decrease the performance of these government initiatives for collaboration (see Loops R12, R14) (Figure 6). Consequently, trust in the government as a facilitator is reduced.

Lack of financial incentives directly demotivates institutions from large scale collaborative activities since universities have no additional resources allocated by government for increasing their collaboration activities with industry. As highlighted earlier, the value and depth of these collaborations is low, limiting the income from industry and therefore motivation for involvement. If this situation continues, universities will view participation in further rounds of UIC activity as economically unfeasible (see Loop R12*) (Figure 6).

University autonomy from government

Iranian universities have a very low degree of autonomy from government. All of their activities are coordinated by Ministry of Science, Research and Technology (MSRT) regulations. This decreases UIC performance and increase degree of bureaucracy in universities even for simple kind of activities (see Figure 6). According to one of the interviewees, "If this situation continues, companies' motivations for UIC activities will decrease to the point where companies may decide to invest and adopt their required technology from alternative sources e.g. other research organisations" (Participant 24).

IPR (national and institutional), Venture capital, Intermediary agents

The Weakness of national IPR policy to protect inventions and new ideas and the absence of effective mechanisms for enforcement of laws, deficiency of institutional policy on IPR, and very weak availability of VC in the country all have a negative impact on both UIC performance and also performance of intermediary agents e.g. science and technology parks and incubators. According to one of the interviewees, "very weak availability of VC creates a situation where intermediary agents are unable to link potential spin-offs or start-ups companies to VCs. Over the long-term, companies (tenants) or universities that establish facilities e.g. incubator facilities in these intermediary agents will find that there are few opportunities to access efficient funding and may decide to withdraw their investment or involvement with these intermediary agents. Consequently, other companies in the region that use the services of these (now impoverished) agents are de-motivated for further collaboration" (Participant 14).

IPR, Government financial support, Venture capital

Weakness of national IPR policy to protect inventions and new ideas and also absence of effective mechanism for enforcement of laws, together with very weak availability of VC have negative impact on the status of cluster formation and favourability of entrepreneurial environment. Weakness of venture capital is related to the weakness of government financing support system to support venture capital activities (see Figure 6).

Intermediary agents, Research consortia

Overall performance of intermediary agents and research consortia were evaluated as weak. According to one of the interviewees, "weakness in the management of research consortia and intermediary agent was identified as another reason for this weakness" (Participant 19). The systems model identifies the poor performance of intermediary agents and research consortia as main cause for UIC underperformance and failure to upgrade the status of cluster formation and the favourability of the entrepreneurial environment.

Cluster activities

The status of economic cluster activity is weak and as a result it in turn has a strong negative impact on UIC activities. According to one of the interviewees, "in the long term, the weakness of cluster will continue to have a detrimental impact on UIC performance, leading to non-achievement of the future outlook of the country in 2025 vision for the country to be the first economic power in the region" (Participant 17). Competition among firms in the clusters is very weak and as a result they are not motivated to increase the quality of their product or innovate new products. Therefore, there will be strong barriers for companies to seek competence enhancing knowledge or new technologies from research organisations and universities. If this situation continues, the probability of enhancing UIC performance will decrease; leading to lower likelihood that universities, researchers and companies will collaborate again in these forms of collaboration (intermediary agents and research consortia) or contribute to cluster forming activities. These activities create negative reinforcing loops that decrease the performance of these mechanisms for collaboration and have negative impact on the cluster formation process in the long term (see Loops R15, R16a, R16b, and R18a) (Figure 6).

According to one of the interviewees, "if this situation continues, there will be two major challenges for Iran in the future, weakness of government activities in providing a favourable environment for entrepreneurs (e.g. deficiency of IPR and enforcement of laws, deficiency of VC, government monopolies in market, corruption, and instability of government regulations) and also the national culture of the country which acts as a barrier for these activities" (Participant 18).

Cluster activities, Political instability, Brain-drain

An unfavorable entrepreneurial environment and weak status of cluster formation, political instability, and low standard of living impact strongly on the decision of entrepreneurs and researchers to leave the country. According to one of the interviewees, "brain drain will be a threat for Iran to attain its objectives which aspires to become a knowledge-based economy" (Participant 6). Brain-drain is also identified as a major barrier to UIC. By decreasing the potential performance of UIC as a result of the national brain-drain, the country will lose more entrepreneurs due to reduced opportunities and developments. Therefore, it has a negative impact on performance of research consortia and intermediary agents, and also the status of cluster formation. These

connected activities create negative reinforcing loops which decrease the performance of the mechanisms for collaboration and also decrease the probabilities of promoting cluster activities (see Loops R17a, R17b, and R18b) (Figure 6).

Degree of monopolies in government, Privatisation process

Effective privatization process positively impacts economy and UIC (Bitzenis, 2003). The monopolies of government in the market are a crucial factor which has a negative effect on any attempt at a privatisation process (see Figure 6). Such deficiencies of the privatisation policy reinforces government monopolies, decreases cooperation of the private sectors in economic activities because of the limited business opportunities, which in turn decrease the level of competitiveness in the country. Overall, this issue has a negative effect on the status of cluster development in Iran. Additionally, such low levels of competitiveness decrease the motivation of companies for collaborative activities with universities. According to one of the interviewees, "prolonging this situation creates a negative perception of entrepreneurs to government initiatives and is likely to de-motivate participation in economic activities" (Participant 16).

Level of government support from entrepreneurial activities

In the current situation, high levels of GDP income from natural resources have a negative impact on government decisions on support for entrepreneurial activities, which in the long-term could entrench government thinking that it is not economically necessary to value individual's creativity. If this situation continues it will decrease levels of trust of government in terms of supporting entrepreneurs, which in turn will have a negative impact on cluster formation and development (see Figure 6).

Political relations and WTO, Embargoes

Barriers like weakness of political relations and the non-readiness of the country, increases ambiguity and delays the process of Iran gaining entry to the WTO. Therefore, it has a negative impact on motivation of companies to collaborate with universities to increase their capacity for innovation to compete in international markets. This issue also has a negative impact on enhancing levels of competition in the cluster (see Figure 6).

According to one of the interviewees, "the current embargo level is somehow sufficient to have much negative effect on companies' relations with foreign partners and joint activities; especially in the automotive or biotechnology sectors. The main problem is the effect on accessibility to raw materials for their operations" (Participant 21). A study carried out by Ghazinoory (2003) and Gilandeh et al. (2017) also identified problems related to embargoes in Iran. It was found that increasing embargoes and greater limitations for joint activities with foreign partners, causes a short-term motivation to collaborate with universities to survive in the market. However, as mentioned earlier in this section, many other problems such as IPR issues, bureaucracy of universities limits the degree of success. Some disadvantages of embargos in the long term were uncovered as well. Increasing the levels of embargoes risks investment and export opportunities. Less export opportunities and higher risks of investment will have a negative impact on both competition in the country and the status of cluster formation (see Figure 6). Torbat (2005) found that as a result of increasing embargoes, the willingness of investors to invest in Iran decreases.

Corruption

High levels of corruption in allocating resources to entrepreneurs was identified as an important factor which decreases trust of government by entrepreneurs, leading to decrease motivation to establish start-up companies. This creates negative reinforcing loops that decrease the degree of trustworthiness of the government (see Loops R11, R13) (Figure 6).

The link between Sub-systems:

The complete picture of connection between elements of different sub-systems and also all other reinforcing loops are presented in Figure 7.

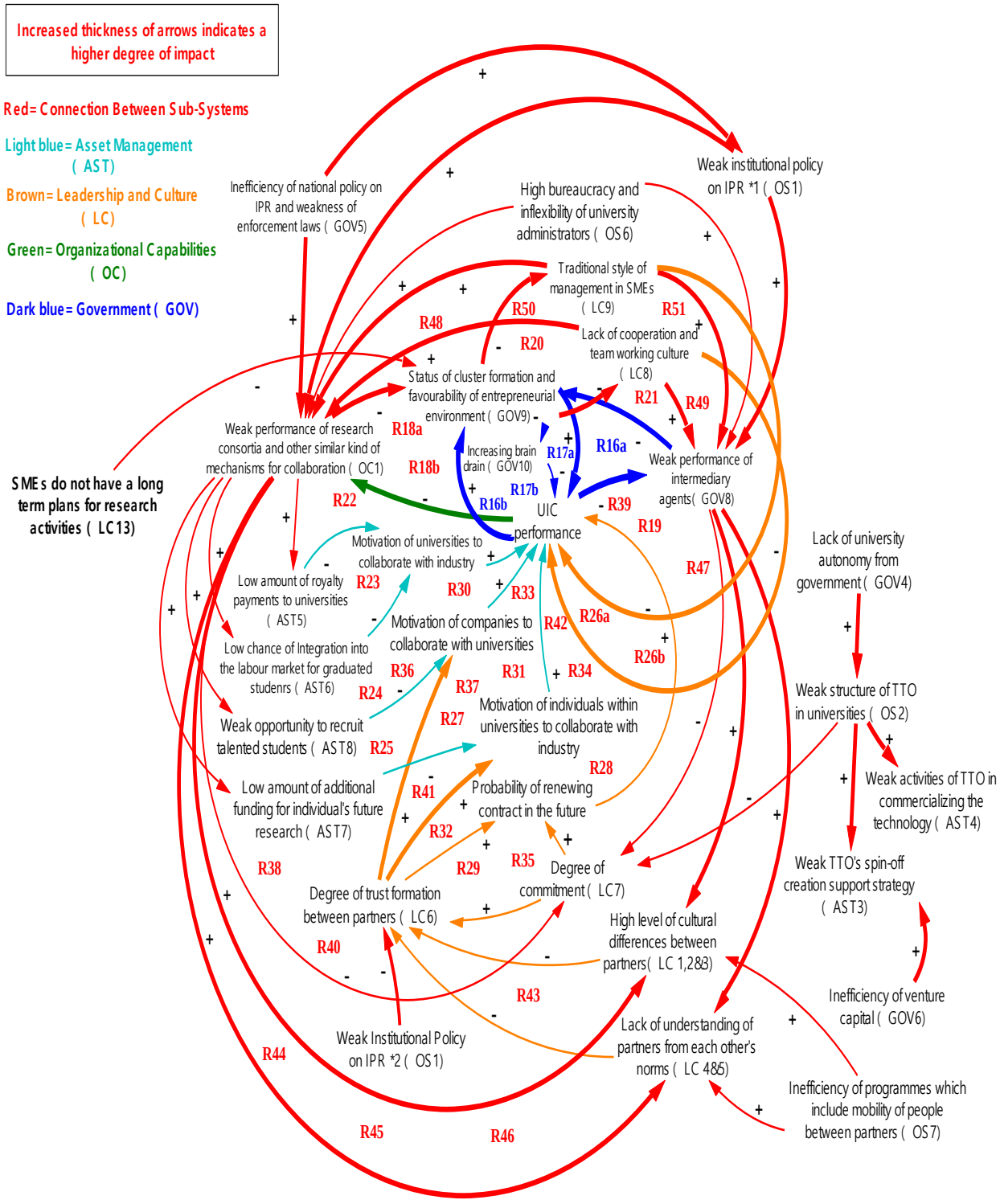

Figure 7: Connection between 5 sub-systems

5- Conclusion and Discussion

5-1 Conclusion

The series of systems models developed provide rich insight to the complexity of university-industry collaboration in general and the role of UIC in the Iranian national systems of innovation in particular. This cause-and-effect systems model can provide researchers, industrial sectors and policy makers, with a deeper understanding of the interdependence between UIC subsystems and the policy challenges for government in applying effective mechanism to manage the development of this national growth engine. This model also provides an insight for stakeholders to consider UIC as a system; to adopt a holistic focus on the whole entity rather than individual parts to eliminate persistent systemic barriers. An extensive investigation of the primary barriers for the case study nation (the current situation in Iran), and their causal relationships to UIC activities found many were biased to create a behaviour pattern (culture) which is overwhelmingly negative. This negative behaviour is manifest as a significant lack of trust at all interfaces between the primary actors in the system. The findings show that trust and cultural development cannot be altered directly, but only indirectly through learned (and long term) experience of new environment conditions.

Results from the Mann Whitney U test indicated that, although there are many similarities between universities and industry views regarding barriers to UIC, there are significant differences in university and industry view regarding cultural barriers to UIC. Therefore, there is a need to identify cultural differences to design appropriate policies to motivate each partner and to promote overall UIC performance.

5-2 Theoretical Implications

This research shows that it is feasible to apply systems thinking to analyzing the interlinkages and behaviours that represent a UIC network. The completeness and interconnective complexities captured in this model represents a diagnostic capability to understand the impact of any policy instruments on the full range of actors and stakeholders. This approach is a departure from the input and output systems metrics methods (OECD 1997), basic systems component identification research (Kayal 2008) and also more recent system component and stakeholder activity models (Carayannis 2018).

Although the details of the causal relationships in the SM were found to be the same for the two industrial sectors, some differences for other industrial sectors should be expected at the micro level; but at the macro level the foundations of these diagrams would be unlikely to change. Therefore it could be generalized to other industrial sectors of the country that have capabilities to collaborate with universities. One of the strengths of this research is that, the SM can be considered as a dynamic systems model consists of five different sub-systems which include all of the major elements related to UIC activities. This model contains numerous feedback loops which integrate the five sub-systems together. Therefore, compared to other innovation systems theories, this model is considered more complete in terms of captured system complexity and relationship density in the model (Structural View), and also dynamics of the model (Functional View).

The SM illustrates the critical role culture and trust has on UIC activities. Informal institutions such as culture (Doney et al., 1998; Tillmar, 2006; Golichenko, 2016; Moreira et al., 2018) and formal institutions such as rules and regulations (Tillmar, 2006) combine to impact trust formation. Although this literature highlights the important factors which have an impact on the process of trust formation, they do not explain the mechanisms involved and list only a few forces considered causal. Furthermore, the literature to explain the impact of important factors on the process of trust formation are chiefly focused on trust and culture from a wider management literature perspective rather than focusing on the UIC concept. One of the strengths of the current research is uncovering mechanisms of the factor influence on the process of trust formation from systematic perspective by considering all identified relevant forces (particularly those related to UIC activities). These findings also highlight the deficiencies in other innovation systems theories (NIS, Triple Helix and Porter's Diamond Model) which pay little attention to the status of trust and the process of trust formation (and destruction) in the system. O'Shaunghnessy (1996) underscored the deficiencies in Porter's Diamond Model, and National Systems of Innovation (Ney, 1999) with respect to dimensions of culture. It is worth mentioning that although the literature (NIS, Porter's Diamond Model, and Triple Helix' concepts) highlight features of university-industry-government collaboration and suggest that culture and trust play a role; they lack sophistication of process models that explain the relationships. This incompleteness of a theoretical framework suggests the current concepts of innovation processes are simpler than they actually are. However, managing real world UIC or wider NIS situations require the less tangible national assets are considered in policy development i.e. trust and culture. This knowledge gap is addressed in the developed systems model from the current research - the SM incorporates the mechanisms by which trust and cultural facets are incorporated into the diagnostic method.

5-3 Implications for Policy Making

The Iranian case does not seem presently inclined to radical change. Therefore, understanding the full range of barriers was critical in generating SM for feasible UIC systems developments. A sustainable and effective Iranian UIC system must involve a series of cultural shifting economic policies and administrative structures designed to evolve actor behaviour in a gradual but consistent way. Unfortunately, short-term, start-stop, incoherent government initiatives have compound the current entrepreneurial cultural malaise. Some of the barriers in the SM were considered as critical infrastructural barriers. Therefore, eliminating these is necessary to manage the effective transition of the Iranian system from its current state. These are therefore important barriers based on scale of impact on many other (three or more) barriers of the system (e.g. IPR policy). The major policy findings for Iran are as follows:

<u>National and institutional policy on IPR and enforcement laws</u>
The current state of IPR policies in Iran form structural barriers to collaboration by demotivating the key system actors. Overcoming these barriers is a long-term and complex process involving many mechanisms for collaboration enhancement including research consortia and other similar mechanisms and intermediary agents, in addition to government initiative for creating an effective national IPR framework and enforcement commitment.

<u>Government financial support and Venture Capital</u>
The current state of government financial support is inefficient but coupled to the lack of VC industry in Iran results in a poor environments for entrepreneurial activities. Availability of

efficient VC (especially international companies) depends heavily on the political relations with other countries.

Stability of government regulations

Increasing stability of government regulations will improve the mechanisms for collaboration. The relatively simple act of government regulation stability at all levels including national and regional policies to encourage collaboration will result in trust between government and entrepreneurs increasing significantly.

Autonomy of universities from government

The low degree of university autonomy is a barrier for collaboration due to significant bureaucracy for UIC activities thus decreasing the likelihood that universities will design their own policies (compatible with their structure and capabilities) in order to attract industry. The Ministry of Science, Research and Technology is therefore recommended to devise policies to increase university autonomy, while still maintains a monitoring role.

Intermediary agents and research consortia

Performance of these mechanisms for collaboration is currently weak. Improving these mechanisms not only requires an efficient and well equipped physical infrastructure, but also requires a comprehensive IPR policy and enforcement laws, high levels of government support and more proactive management in these mechanisms for collaboration. Furthermore, availability of VC is another criterion which defines the likely degree of success of these intermediary agents.

Political environment and Embargoes

Currently, the low probability of Iranian entry to the WTO, and the high degree of embargoes imposed by Western Governments are barriers for UIC activities, and lower the likelihood of developing an entrepreneurial environment. Improvement of the current situation depends on government future political plan which is a highly uncertain topic.

Corruption, Monopolies, and Privatisation process

In the current state, corruption in government when allocating resources to entrepreneurs adversely affects trust formation between government and entrepreneurs, and consequentially the motivation for collaboration. Likewise, the extent of state monopolies depresses the entrepreneurial environment nationally. Joining the WTO and increasing government transparency are the major policy shifts required to change this status.

Cluster activities

The status of cluster formation is currently weak since it depends on the efficiency of many other policies. Cluster performance is likely to be the main beneficiary of a successful application of this system-informed policy framework for UIC development.

5-4 Limitations

In semi-structured interviews, establishing contact with both universities and industry was straightforward. However, with government ministries the process of establishing contact and arranging interviews was long; appointments were cancelled or rescheduled three or four time and

in some cases the procedure to access the interviewee was very bureaucratic and required passing through a series of administrative stages. Nonetheless, interview respondents were carefully selected to align to the needs of the study. As regards the quality of the interview data, the respondents, particularly from the government, seemed to be very careful when expressing their opinions. They appeared to be cautious about revealing information particularly if it was related to government policies. However, when the data for 25 interviewees was analyzed, there was a degree of consensus observed among the interviewee's perceptions and the survey findings.

To validate the model will require experimentation with policy changes and evidence to support predicted outcome. The system modelling method can readily be applied to generating scenarios with probability indicators. These can be developed with range of quantitative techniques from relatively simple weightings for likelihood of a number of negatively reinforcing loops turning positive, or extending the model functionality to include dynamic modelling capability (see 5.5). This is an unlikely prospect for the current case country. However, a more credible, if uncontrolled, approach might involve monitoring policy changes and forecasted the outcomes.

5-5 Proposals for Future Research

Central to the research question in this paper, is how NIS policies can be better informed with a detailed diagnostic method using a systems perspective of the interlinkages, knowledge flows and behaviours of the current regional situation. Two extensions from this work are immediately identifiable. Firstly, it was clear how barriers to UIC performance are diagnosed in the current work on the UIC in Iran and how these can these be further explored in detail by modelled with a series of influence diagrams. However, it is also possible to enhance the model by incorporating a dynamic capability by including rates of change of key variables for UIC collaboration with quantitative modelling. Complexity arises with such an approach on its suitability to the behavioral nature of many of the system elements e.g. dimensions of trust and culture. Secondly, work on developing and comparing more cases of country UIC system models would prove interesting on two fronts; to establish what is generic for all UIC systems and what characterizes the uniqueness of different countries.

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