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Abstract

This paper investigates the nature of the causal linkage between stock markets and foreign exchange markets in Australia, Canada, Japan, Switzerland, and UK from 1992:1 to 2005:12. Recently developed cointegration tests are employed and no evidence of a long-run relationship between the variables is found. Three variations of the Granger causality test are carried out and causality from exchange rates to stock prices is found for Canada, Switzerland, and United Kingdom; weak causality in the other direction is found only for Switzerland. The Hiemstra-Jones test is used to examine possible nonlinear causality and the results indicate causality from stock prices to exchange rates in Japan and weak causality of the reverse direction in Switzerland.

Acknowledgements

I. Introduction

Are foreign exchange markets and stock markets really related? If so, what is the direction of the relation? These questions have received considerable attention along with the emergence of new capital markets, the adoption of more flexible exchange rate policies and the relaxation of foreign capital controls. The current state of research cannot provide us with either theoretical or empirical consensus on the topic.

Two sets of theoretical models, namely flow-oriented models and stock-oriented models have been adopted to explore the above questions in extant literature. Flow-oriented models (Dornbush and Fisher, 1980) assume that a country's current account and trade balance performance are two important factors of exchange rate determination, hence, stock prices and exchange rates are positively related. On the other hand, stock-oriented models emphasize the capital account as the major determinant of exchange rate. There are two subsets in this category, namely portfolio balance models and monetary models. Portfolio balance models (Branson, 1983) posit that increase in stock prices drives up the interest rate of domestic currency, with the consequent effect of a fall in the exchange rate. In other words, the force from stock markets to foreign exchange (FX) markets drives stock prices and exchange rates to move in opposite directions. Monetary models (Gavin, 1989), however, conclude that there is no linkage between exchange rates and stock prices except that both variables are influenced by some common factors. Obviously, these three models give us totally different theoretical results about the interaction and causality between FX markets and stock markets.

Previous empirical studies provide mixed conclusions. Bahmani-Oskooee and Sohrabian (1992) find bidirectional causality between exchange rate and stock price in UK. Fang and Miller (2002) find that the innovation of exchange rate can affect stock price, and vice versa. Abdalla and Murinde (1997) have found causality from FX markets to stock markets in Korea, Pakistan, and India. Ajayi et al (1998) found reverse causations in several advanced markets. Granger et al (2000) fail to find any kind of casual linkage in most countries they studied. Bhattacharya and Mukherjee (2003) also cannot find causal relationship and Stavarek (2005) find no causal linkage between exchange rate and stock price for nine countries for the period 1970-92. However, in some cases the causal relationship is detected to run from stock price to real effective exchange rate (REER) or nominal effective exchange rate.

In summary, there is no consensus on the theoretical and empirical literature and, this paper aims at investigating empirically this hypothesis further. The contributions of this study are : i) we use an extended dataset, ii) both the Johansen (1995) and the Saikkonen and Lutkepohl (2000a,b,c) cointegration tests are employed, iii) three variations of Granger causality tests are estimated and iv) additionally, we carry out the nonparametric causality approach proposed by Hiemstra and Jones (1994) that allows for nonlinear causality.

This paper is structured as follows. Section 2 reviews some previous studies in this subject. Section 3 explains methodological issues and describes the data employed. Section 4 reports and discusses the empirical results and finally section 5 concludes.

II. Literature Review

During the past decade, an increasing amount of empirical research has examined the causality between exchange rates and stock prices. One strand of the literature looks at the long-run relationship based on cointegration techniques. The other strand investigates the short-run dynamics focusing on causality tests and impulse response functions (IRF) among others.

One the first strand Bahmani-Oskooee and Sohrabian (1992) are the pioneers of using cointegration and Granger causality techniques to investigate the interaction between stock prices and FX markets. The data they used consist of monthly Standard and Poor's Composite Index of 500 stock and effective exchange rates of US dollar from 1973:12 to 1983:12. A two-stage systematic autoregressive procedure was employed developed by Hsiao (1981). By using the final prediction error (FPE) as lag selection criterion a unidirectional causation from stock price to exchange rate was found but if both FPE and F-statistic were used then feedback causality between both series was uncovered.

Abdalla and Murinde (1997) studied the prices in FX and stock markets in four less developed countries, namely India, Korea, Pakistan and the Philippines within a VECM (Vector Error Correction Model) framework. For the period 1985:01-1994:07, they find unidirectional causal linkage between exchange rates and stock prices for Pakistan and Korea. The real effective exchange rate Granger cause the stock price index in India, but no causal relationship was found in the case of Philippines.

Nieh and Lee (2001) employ daily observations from October 1993 to February 1996 and through both the Engle and Granger (1987) and the Johansen (1995) procedures they find support for the Bahmani-Oskooee and Sohrabian (1992) findings that there is no long-run relationship between the two variables in the G-7 economies. In the short-run (VECM) the two variables do not have predictive capabilities for more than two consecutive trading days.

For six Pacific Basin countries, Phylaktis and Ravazzolo (2005) examine stock price and exchange rate dynamics and reach a number of conclusions: First, there is no long run equilibrium in these countries, except Hong Kong. When the US stock market is included in the cointegrating relationship more evidence in favor of cointegration is found for some countries for more recent datasets. Secondly, foreign exchange restrictions were not found to be significant in linking the domestic stock and foreign exchange markets. Thirdly, through multivariate causality tests it was found that the US stock market drives the system. More recently Abdelaziz et al (2008) investigated the long-run interaction between stock prices and real exchange rates in four oil exporting Middle East countries and found no evidence of cointegration between the two variables. When oil price was included in the system, evidence of a long-run relationship was found in three countries for the more recent sub-samples.

The second strand of the literature focuses on the short-run dynamics, Ajayi et al (1998) examine the interaction between daily stock returns and changes in the exchange rates for two groups of markets: Advanced economies (including Canada, Germany, France, Italy, Japan, UK and USA) whose data start from 1985:04 to 1991:08 and Asian emerging markets (including Taiwan, Korea, the Philippines, Malaysia, Singapore, Hong Kong, Indonesia, and Thailand) whose data cover 1987:12-1991:09. In the case of Indonesia, the Philippines, Taiwan and all advanced markets, there is one-way causal relationship running

from the stock market to the FX market, while in the case of Korea the relationship is reverse. They also perform causality test on weekly data and find that the results are in line with the daily data for the advanced markets. However, a very different result is obtained for emerging markets: unidirectional causal relationship from the stock returns differential to the change in the exchange rate is found for Thailand and Malaysia.

Granger et al (2000) apply Granger causality test and IRF to examine the interaction between stock prices and FX market. Nine Asian countries and regions are selected for the empirical analysis: Hong Kong, Indonesia, Japan, South Korea, Malaysia, the Philippines, Singapore, Thailand and Taiwan. Their study employs daily data from 3/1/1986 to 14/11/1997 (3097 observations). Three sub-periods are fractionized from the whole analyzed period: the first period started from the first observation to 30/11/1986; the second period extends from 1/12/1987 to the end of 1994 and it is called after crash period; and the third one covers the rest observations. In the first period, by using 10% as significance level, there is no causal linkage for those countries except Hong Kong and South Korea which have one-way causality from exchange rate to stock price and from stock price to exchange rate respectively. In period 2, the authors find unidirectional causal linkage from FX markets to stock markets in Malaysia and the Philippines and reverse linkage in Taiwan. During the last period, it is found that the change in stock prices will lead the change in the exchange rates in Taiwan, and the reverse relationship is found in Japan, Thailand, Singapore and Hong Kong. In the rest markets, bidirectional causal relationships between the two variables were established. Moreover, the study shows that the predictable portion of stock price changes can be improved by including the exchange rate variation within the regression.

Most of the recent empirical literature has focused on Asian emerging markets. For instance, Fang and Miller (2002) investigate the relationship between exchange rate and stock market performance in Korea during the Asian financial crisis and find that currency depreciation significantly affects stock market performance. Bhattacharya and Mukherjee (2003) study the relationship among stock prices, real effective exchange rates of the Indian Rupee, foreign exchange reserves and the value of trade balance and find no causal relationship between stock price and other variables. Muhammad and Rasheed (2003) find two-way long-run causal linkages but no short-run causality between the variables in Bangladesh and Sri Lanka.

A number of methods has been employed in these studies, including standard Granger causality (Granger, 1969), Sims' version of Granger causality test (Sims, 1972), ECM (Error Correction Model, Engle and Granger, 1987), VECM (Johansen, 1995), and the long-run causality test suggested by Toda and Yamamoto (1995). The mixed empirical evidence could be attributed to the different datasets and methods used. Generally speaking, more causal linkages are found in developed markets rather than in developing ones. Moreover, the more recent the dataset, the stronger the linkage. For example, Ajayi et al (1998) find causal relationship in every advanced market they studied and they find less than half of the emerging markets to have this kind of linkage. Stavarek (2005) finds much stronger casual relationship in the later period than in the early period in old EU-member countries and US.

III. Methodology and Data

A. Unit Root and Cointegration Tests

Our first step is to employ unit root and stationarity tests that are well known in the literature (ADF, Phillips and Perron and KPSS). In order to establish the existence of long-run relationship between the two variables we employ the cointegrating methodology of Johansen (1995) who suggest an approach to test cointegration through building a VECM. In Johansen's (1995) notation, we write a p-dimensional VECM as:

$$\Delta y_t = \Pi^* \begin{bmatrix} y_{t-1} \\ 1 \end{bmatrix} + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + u_t \tag{1}$$

where $\Pi^* = \begin{bmatrix} \Pi : v_0^* \end{bmatrix}$ is $(K \times (K+1))$. The intercept can be absorbed into the cointegrating relations; thus $\Pi^* = \alpha \beta^{*\prime}$ has rank r. The trace test-statistic is of the form:

$$LR(r_0) = -T \sum_{j=r_0+1}^{K} \log(1 - \lambda_j) \tag{2}$$

where the λ_j are the eigenvalues obtained by applying reduced rank regression techniques. The trace statistic is preferred to the max-eigenvalue statistic as it is more powerful (see Lutkepohl et al 2001). The lag length of the VECM is determined by the use of information criteria; multivariate version of Akaike's information criterion (AIC) or the Schwarz's Bayesian information criterion (SBIC) of the underlying un-differenced VAR model.

The null hypothesis of the Johansen's approach is that the number of cointegrating vectors is less than or equal to r and the alternative is that there are at most r cointegrating vectors. The test is done sequentially starting from r=0. If the statistic is smaller than the critical value, the null cannot be rejected and it indicates that there is no long-run relationship among the variables.

More recently, Saikkonen and Lutkepohl (2000a, b, c) proposed a two-step procedure in which the mean term (μ_0) is estimated in the first step by the feasible GLS procedure. Substituting the estimate for μ_0 in equation (3) below, one can apply an LR-type test based on a reduced rank

regression. The resulting test statistic has an asymptotic distribution that is different from the one obtained for the intercept version. Saikonnen and Lutkepohl (1999) argue that the power of this test is asymptotically superior to Johansen (1995) trace test and they apply an LR-type test based on a reduced rank regression of the following form:

$$\Delta y_t = \Pi(y_{t-1} - \mu_0) + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + u_t \tag{3}$$

B. Granger Causality Test

In this paper, three variations of Granger causality test are used, namely the standard Granger causality test, Hsiao's version of Granger causality test and causality test through a VECM approach. The first two tests are employed when there is no equilibrium relationship between the variables while last one is suited for the case of cointegration.

Testing for Granger casualty in a VAR framework can be written as:

$$y_t = \alpha_1 + \sum_{j=1}^{m} \beta_{1j} y_{t-j} + \sum_{j=1}^{m} \delta_{1j} x_{t-j} + \varepsilon_{1t} \tag{4}$$

$$x_t = \alpha_2 + \sum_{j=1}^{m} \beta_{2j} x_{t-j} + \sum_{j=1}^{m} \delta_{2j} y_{t-j} + \varepsilon_{2t} \tag{5}$$

α_i are the constant terms, m is the lag order, and ε_{it} are error terms and assumed to be serially uncorrelated with zero mean and finite covariance matrix. In order to test causality from x to y, the null hypothesis (H_{o1}) is expressed as $\delta_{1j}=0$ ($j=1, 2,…,m$), and the alternative is at least one of δ_{1j} ($j=1, 2,…m$) is significantly different from zero. Similarly, H_{o2} of testing the causality from y to x is $\delta_{2j}=0$ ($j=1, 2…m$) against at least one of δ_{2j} is not zero.

In this case, however, the following unequal-length VAR is employed by allowing different values for p, q, r, s:

$$y_t = \alpha_1 + \sum_{j=1}^{p} \beta_{1j} y_{t-j} + \sum_{j=1}^{q} \delta_{1j} x_{t-j} + \varepsilon_{1t} \tag{6}$$

$$x_t = \alpha_2 + \sum_{j=1}^{r} \beta_{2j} x_{t-j} + \sum_{j=1}^{s} \delta_{2j} y_{t-j} + \varepsilon_{2t} \tag{7}$$

The lag order of the above is crucial, since if too many lags are included, the estimators are biased. A two-stage method developed by Hsiao (1979) is used to determine the optimal lag order for the above VAR. In the first stage, assuming causality from x to y, the following equation is estimated:

$$y_t = \alpha_1 + \sum_{j=1}^{p} \beta_{1j} y_{t-j} + \varepsilon_{1t} \tag{8}$$

This equation is similar with equation (6) but does not contain autoregressive terms of X. Then start with $p=1$ and run the above regression. Calculate sequentially up to the maximum lag order Q the Akaike's Final Prediction Error (FPE) criterion which is defined as

$$FPE(p) = \frac{(T + p + 1) \cdot SSR(p)}{(T - p - 1) \cdot T} \tag{9}$$

In the second stage the order of y lags is fixed on p^* and the equation becomes

$$y_t = \alpha_1 + \sum_{j=1}^{p^*} \beta_{1j} y_{t-j} + \sum_{j=1}^{q} \delta_{1j} x_{t-j} + \varepsilon_{1t} \tag{10}$$

Like p in stage one, Q is set as the maximum value of q. Letting q to vary from 1 to Q we determine the optimal lag length for q (r and s are determined in the same way).

Another method employed in this study is Hsiao's version of Granger causality test. In this case, p^* is chosen based on FPE (p) that is obtained from equation (8) and then FPE (p^*, q^*) is selected from a set of FPE (p^*, q). If FPE (p^*,q^*)>FPE (p^*), it indicates the prediction can not be improved by adding lags of x into the system. According to the definition of Granger causality, it is said that x is not the cause of y. Otherwise; there exist causal linkage from x to y^i.

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[1] In standard Granger causality test and Hsiao's version test, all the variables involved in the model should be stationary. Difference operation is necessary for nonstationary variables before employing them in a system. If two variables are cointegrated, there is an error-correction representation between them:

$$\Delta y_t = \alpha_1 + \sum_{j=1}^{p} \beta_{1j} \Delta y_{t-j} + \sum_{j=1}^{q} \delta_{1j} \Delta x_{t-j} + \gamma_1 v_{t-1} + \varepsilon_{1t} \tag{11}$$

$$\Delta x_t = \alpha_2 + \sum_{j=1}^{r} \beta_{2j} \Delta x_{t-j} + \sum_{j=1}^{s} \delta_{2j} \Delta y_{t-j} + \gamma_2 \mu_{t-1} + \varepsilon_{2t} \tag{12}$$

where Δ is the first differenced operator, ε_{1t} and ε_{2t} is *iid* with zero mean and constant variance.

C. Nonparametric Causality Test

Stock prices and exchange rates may empirically lead each other in various forms, including linear and nonlinear interaction. So far we assumed linearity in the specifications above. Baek and Brock (1992) and Hiemstra and Jones (1994) propose a test that can detect nonlinear causality. Under the assumptions of the Hiemstra-Jones test short-term temporal dependence between two variables is allowed; while the Baek-Brock test is suited for independently identically distributed time series.

The Hiemstra-Jones test can be conducted on time series $\{x_t\}$ and $\{y_t\}$ (t=1, 2 …) which are weakly dependent, mixed, and strictly stationary. For notational simplicity, denote X_t^m and X_{t-Lx}^{Lx} as m-length lead and Lx-length lag vector of X_t respectively; while Y_{t-Ly}^{Ly} represents Ly-length lag vector of Y_t. Here m, Lx and Ly are integers greater than or equal to 1. In Baek and Brock (1992) Y does not Granger cause X if:

$$\Pr(\left\|X_t^m - X_s^m\right\| < e \mid \left\|X_t^m - X_s^m\right\| < e, \left\|Y_{t-Ly}^{Ly} - Y_{s-Ly}^{Ly}\right\| < e) = \Pr(\left\|X_t^m - X_s^m\right\| < e \mid \left\|X_{t-Lx}^{Lx} - X_{s-Lx}^{Lx}\right\| < e) \quad (13)$$

where $\Pr(\cdot)$ is probability function, $\left\|\cdot\right\|$ indicates supreme norm, e is a positive number and $t,s = \max(Lx, Ly)+1, …, T-m+1$. There is one conditional probability on each side of equation (12) .The LHS probability can be interpreted as two arbitrary m-length lead vectors of $\{X_t\}$ that are within a distance e of each other, under the condition of the corresponding Lx-length lag vectors of $\{X_t\}$ and Ly-Length lag vectors of $\{Y_t\}$ are within e of each other. The RHS of equation (12) is the probability that two arbitrary m-length lead vectors of $\{X_t\}$ are within a distance e of each other, under the condition that the corresponding Lx-length lag vectors are within e. For notational convenience, let $C1(m+Lx, Ly, e)$, $C2(Lx, Ly, e)$, $C3(m+Lx, e)$, and $C4(Lx, e)$ denote the corresponding probabilities in equation (13). Hiemstra and Jones (1994) rewrite equation (12) as

$$\frac{C1(m+Lx,Ly,e)}{C2(Lx,Ly,e)} = \frac{C3(m+Lx,e)}{C4(Lx,e)}.$$

Based on this equality, they construct the following test statistic

$$\sqrt{n}(\frac{C1(m+Lx,Ly,e)}{C2(Lx,Ly,e)} - \frac{C3(m+Lx,e)}{C4(Lx,e)}) \quad (14)$$

which asymptotically follows normal distribution with zero mean and variance $\sigma^2(m,Lx,Ly,e)$.

The hypothesis of non-Granger causality will be rejected if the statistic is larger than the one-sided critical value.

D.   Data

The official average exchange rates for Australia, Canada, Japan, Switzerland, and UK for the period January 1992 to December 2005 are employed. The exchange rate is the spot rate against the US dollar. With the exception of the US where Dow-Jones Composite Average index is used, we employed the Dow-Jones Country Titans index to represent stock price (see Appendix A for the summary statistics).

IV. Empirical Results

A.   *Unit Root and Cointegration Tests*

ADF and PP unit root and the KPSS stationary tests were employed with and without trend (Tables 1 and 2). The order of ADF test is selected based on Ng and Perron (2001). Firstly, we set up the upper limit of lag length as $p_{max} = \left\lfloor 12 \times \left(\dfrac{T}{100}\right)^{1/4} \right\rfloor$ to 13; therefore ADF regressions are run with lags from 0 to 13. The minimum modified AIC is picked up for each country and the corresponding regression is selected as the correct model of the ADF test. The results for both ADF and PP confirm that all the series are I(1). The latter is confirmed through the KPSS stationary test (see Table 2).

Table 1 Results of ADF and PP Test

Variables	Difference	ADF (No trend)		ADF (With tend)		PP (No trend)		PP (With trend)	
		Lag	Statistic	Lag	Statistic	Bandwidth	Statistic	Bandwidth	Statistic
AUSP	Level	0	-0.542036	0	-2.448192	8	-0.42421	3	-2.41406
CASP	Level	0	-0.926465	0	-1.615196	1	-0.96188	2	-1.75598
CHSP	Level	0	-1.654617	0	-1.489879	5	-1.65505	4	-1.50109
JPSP	Level	0	-1.913751	0	-1.717302	5	-2.18826	5	-2.11897
UKSP	Level	0	-1.679542	0	-1.415936	4	-1.67533	4	-1.3686
AUSP	D1	0	-14.37205***	0	-14.32844***	6	-14.47438***	6	-14.4282***
CASP	D1	0	-11.49843***	0	-11.46310***	2	-11.50436***	2	-11.46914***
CHSP	D1	0	-11.98963***	0	-11.99253***	7	-11.97083***	7	-11.96622***
JPSP	D1	0	-11.67734***	0	-11.67659***	3	-11.66144***	3	-11.66214***
UKSP	D1	0	-12.77386***	0	-12.79172***	5	-12.78714***	5	-12.81248***
AUEX	Level	2	-1.263914	2	-0.893811	4	-1.33739	4	-1.0334
CAEX	Level	1	-1.118405	1	-0.448260	4	-1.36412	1	-0.44853
CHEX	Level	1	-1.983533	1	-1.975081	5	-1.61908	5	-1.60407
JPEX	Level	1	-2.716046	1	-2.787270	2	-2.30857	1	-2.24208
UKEX	Level	2	-1.792154	2	-2.135751	3	-2.18345	2	-2.53495
AUEX	D1	1	-9.272110***	1	-9.371400***	0	-9.80077***	1	-9.91051***
CAEX	D1	0	-9.996096***	0	-10.53138***	2	-9.980462***	3	-10.45895***

CHEX	D1	0	-9.554372***	0	-9.524288***	11	-9.263033***	11	-9.225498***
JPEX	D1	0	-9.190661***	0	-9.191954***	4	-9.178975***	4	-9.172349***
UKEX	D1	1	-10.14695***	1	-10.19447***	1	-9.837102***	2	-9.673625***

*** denotes significance at the 1% level. The bandwidth of PP test is selected by Newey and West (1994)

Table 2 KPSS Stationarity Tests

Variables	Difference	KPSS Statistic	KPSS with trend Statistic
AUSP	Level	1.71	0.101
CASP	Level	1.461119	0.273181
CHSP	Level	1.221584	0.371106
JPSP	Level	0.72578	0.165122
UKSP	Level	1.579947	0.33842
AUSP	D1	0.060644	0.064552
CASP	D1	0.081608	0.074878
CHSP	D1	0.218723	0.102379
JPSP	D1	0.104669	0.081246
UKSP	D1	0.187518	0.088482
AUEX	Level	0.463283	0.228857
CAEX	Level	0.452456	0.342225
CHEX	Level	0.238213	0.231286
JPEX	Level	0.153662	0.114701
UKEX	Level	0.268458	0.179197
AUEX	D1	0.228603	0.12308
CAEX	D1	0.788922	0.064162
CHEX	D1	0.124662	0.102029
JPEX	D1	0.071361	0.056258
UKEX	D1	0.166967	0.050885

Note: Critical Values 0.739 and 0.463 at the 1% and 5% significance level respectively in the case with no trend and 0.216 and 0.146 in the case with trend. We follow Hobijn et al (2004) who suggest applying the Newey and West (1994) automatic bandwidth selection procedure for the Quadratic Spectral kernel.

Since every variable has the same order of integration, we could proceed with employing the Johansen cointegrating framework. The lag length of differenced terms in VECM is selected by information criteria, MAIC and FPE, of the corresponding VAR, whose optimal order is greater than VECM's by one. The optimal lag length suggested by the different information criteria are of the same order and are reported in Table B1.

Next, we estimate equation (1) and calculate the statistic that is defined in equation (2). Table 3 reports the trace statistics together with the associated critical value. In all cases for $r=0$ the former is smaller than the latter. This implies that the null hypothesis of no cointegration between the variables, cannot be rejected for the five pairs. No cointegration is also confirmed by the Saikkonen and Lutkepohl test described earlier (see Table 4). All the *p*-values are above 0.05 confirming the conclusion of the Johansen test. These results are consistent with the findings of Bahmani-Oskooee and Sohrabian (1992) and Nieh and Lee (2001) that there is no long-run relationship between the two variables.

Table 3 Johansen Test

Variables	r	Trace	Critical Value 5%
AUEX/AUSP	0	3.74	15.34
CAEX/CASP	0	5.44	15.34
CHEX/CHSP	0	10.28	15.34
JPEX/JPSP	0	14.01	15.34
UKEX/UKSP	0	14.73	15.34

Table 4 Saikkonen and Lutkepohl test

S&L Test for	AUEX/AUSP		CAEX/CASP		CHEX/CHSP		JPEX/JPSP		UKEX/UKSP	
	LR	p-value	LR	p-value	LR	p-value	LR	p-value	LR	p-value
0	6.99	0.3314	1.64	0.9665	8.74	0.1872	7.19	0.3118	4.55	0.6335
1	1.84	0.2049	0.09	0.8158	0.4	0.5878	3.69	0.0649	0.03	0.9093

B.   *Standard and Hsiao's Version of Granger Causality*

Standard Granger causality test is valid for variables that do not have cointegrating relationship. In this paper there are five pairs of variables that are suited for employing this test, namely AUEX/AUSP, CAEX/CASP, CHEX/CHSP, JPEX/JPSP, and UKEX/UKSP. Before employing Granger causality tests, we determined the optimum lag order. Two methods are used separately to choose lag length: minimum information criterion approach and Hsiao's approach for unequal lag length VAR. We calculate MAIC, MSBIC, and FPE for the model suggested by Granger (1969) and the result is reported in table B2 in appendix B. The order suggested by MAIC and FPE is the same.

Full information estimation of equation (4) and (5) is made on each pair of variables. H_{01}: $\delta_{1j}=0$ ($j=1,2\ldots$m) and H_{02}: $\delta_{2j}=0$ ($j=1,2\ldots$m) are examined by using the Wald test. If the latter rejects the null, it indicates the existence of a causal linkage between the two variables. Table 5 presents the results of the F-statistics of the Granger causality tests.

Table 5 Standard Granger Causality Test

Null Hypothesis	F-Statistic
AUEX-/->AUSP	0.27
AUSP-/->AUEX	1.71
CAEX-/->CASP	6.89***
CASP-/->CAEX	0.51
CHEX-/->CHSP	9.96***
CHSP-/->CHEX	3.23*
JPEX-/->JPSP	0.0053
JPSP-/->JPEX	0.0026
UKEX-/->UKSP	8.74**
UKSP-/->UKEX	1.98

***, **, * denotes significance at the 1%, 5% and 10% level respectively.

There is no Ganger causality from stock market to foreign exchange market in all cases except for Switzerland where the null of CHSP not Granger causing CHEX can be rejected at the 10% level (the p-value of F-statistic is 0.072). The causality from stock price to exchange rate seems to be relatively

strong, since the hypothesis of non-causality can be rejected at the 1% for Canada and Switzerland and at the 5% for UK (*p*-value 0.012).

Overall the results show that there is more evidence that the causation runs from SM to FX markets than the reverse. This is not in line with the empirical literature. For example, Abdalla and Murinde (1997) find there are causal linkages from SM to FX markets in all the four countries they studied, however, only in one case instantaneous causality from the exchange rate to the stock market was found for Korea. Ajayi et al (1998) also find causality run from stock price to exchange rate in several countries, but the reverse relationship exists only for Korea. Therefore, portfolio balance models fit the last two studies better, while in this study the evidence supports more the flow-oriented models.

Causal linkage from stock price to exchange rate exists only for Switzerland. There are at least two explanations for this. Firstly, Switzerland has a well developed financial market making the interaction between FX market and SM possible. Secondly, the industrial and other goods-produce sectors in Swiss economy are relatively weaker, thus stock price have more potential to be influenced by other factors, such as exchange rate.

Granger (1969) model set four lags as equal, however, there is potential for model misspecification. This assumption is relaxed and Hsiao's approach is used to choose the optimal length (see table 6).

Table 6 Optimal Lag Length and Result of Hsiao's version Granger Causality Test

Hypothesis	p*/r*	q*/s*	One Dimension FPE	Relationship	Two Dimension FPE	Conclusion
AUEX-?->AUSP	1	4	1.29878E-03	<	1.30648E-03	AUEX-/->AUSP
AUSP-?->AUEX	3	1	5.03069E-04	<	5.04766E-04	AUSP-/->AUEX
CAEX-?->CASP	1	1	2.25162E-03	>	2.18650E-03	CAEX-->CASP
CASP-?->CAEX	1	1	1.83892E-04	<	1.85537E-04	CASP-/->CAEX
CHEX-?->CHSP	1	1	3.71066E-03	>	3.53937E-03	CHEX-->CHSP
CHSP-?->CHEX	2	2	6.56227E-04	>	6.52581E-04	CHSP-->CHEX
JPEX-?->JPSP	3	1	2.97960E-03	<	3.01157E-03	JPEX-/->JPSP
JPSP-?->JPEX	5	2	6.78166E-04	<	6.83179E-04	JPSP-/->JPEX
UKEX-?->UKSP	1	4	1.78613E-03	>	1.70361E-03	UKEX-->UKSP
UKSP-?->UKEX	2	1	4.22747E-04	<	4.23027E-04	UKSP-/->UKEX

By using the lag length in the table above, a VAR is estimated. The null hypothesizes of $\delta_{1j}=0$ ($j=1,2,...m$) and $\delta_{2j}=0$ ($j=1,2,...m$) are tested through an F-test. These are reported in table (7) and indicate identical results with the Granger causality test.

Table 7 Ganger Causality Test (Unequal Lag Length)

Hypothesis	p*/r*	q*/s*	F-Statistic
AUEX-?->AUSP	1	4	1.3574
AUSP-?->AUEX	3	1	1.4113
CAEX-?->CASP	1	1	6.8893***
CASP-?->CAEX	1	1	0.5136
CHEX-?->CHSP	1	1	9.9602*
CHSP-?->CHEX	2	2	2.4222***
JPEX-?->JPSP	3	1	0.2439
JPSP-?->JPEX	5	2	1.3495
UKEX-?->UKSP	1	4	3.0338**
UKSP-?->UKEX	2	1	1.8563

***, **, * denotes significance at the 1%, 5% and 10% level respectively.

We also examine the causal linkage through Hsiao's version of Granger causality test (see Table 6). For the exchange rate equation, one-dimension FPE was found to be less than the two-dimension FPE in most countries except for Switzerland. The latter implies that the prediction of exchange rate cannot be improved by using lagged information on stock price in most countries except for Switzerland. Thus, the empirical causal linkage from stock markets to FX markets exists only for Switzerland. Moreover, two-dimension FPE is always smaller than one-dimension FPE for Canada, Switzerland and UK, which indicates there is causality from exchange rate to stock price in these countries.

C. Nonparametric Causality Test

To the best of our knowledge, previous studies focus only on linear causality between foreign exchange and stock markets; however, there is no reason theoretically or empirically to assume that the relationship is a linear one. For example, one variable may depend on the power of the other variable's lag. To investigate this possibility we employ the Hiemstra-Jones (1994) test for our dataset. Following the latter, we normalize the data to unity variance and set $m=1$ and vary Lx, Ly

from 1 to 5, and let e=1.

Table 8A   **Nonparametric Causality Test (AUSP-->AUEX)**

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	0.4483	-0.0959	-0.0259	-0.0052	-0.0015
Lx=2	-0.33	-0.1346	-0.0756	-0.029	-0.0375
Lx=3	-0.2759	-0.08	-0.1423	-0.117	-0.0785
Lx=4	-0.4602	-0.1292	-0.3726	-0.2104	-0.2404
Lx=5	0.494	-0.0742	-0.3707	-0.2296	-0.1029

Table 8B   **Nonparametric Causality Test (AUEX-->AUSP)**

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	-0.2236	-0.3764	-0.4721	0.2929	0.4821
Lx=2	-0.3764	-0.3669	-0.321	-0.4364	-0.2759
Lx=3	0.4013	0.4721	-0.4542	0.3501	-0.5
Lx=4	0.4463	-0.2709	-0.2327	-0.3409	-0.3613
Lx=5	-0.4522	-0.3192	-0.49	0.4247	-0.4364

Table 8C   Nonparametric Causality Test (CASP-->CAEX)

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	-0.365	-0.409	-0.3103	-0.12	-0.3764
Lx=2	-0.305	-0.411	-0.266	-0.0959	-0.2611
Lx=3	-0.4641	0.4622	-0.3897	-0.3391	-0.4384
Lx=4	-0.4602	0.4562	0.4661	0.492	0.352
Lx=5	-0.488	0.496	0.3557	0.3688	0.2206

Table 8D   Nonparametric Causality Test (CAEX-->CASP)

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	-0.1282	-0.1469	-0.1012	-0.1854	-0.1991
Lx=2	-0.1788	-0.0838	-0.0423	-0.0432	-0.0636
Lx=3	-0.3264	-0.1292	-0.1457	-0.1599	-0.2404
Lx=4	-0.4052	-0.1599	-0.2643	-0.2389	-0.2643
Lx=5	-0.4542	-0.2709	-0.411	-0.5	0.3557

Table 8E   Nonparametric Causality Test (CHSP-->CHEX)

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	-0.0379	-0.4622	-0.2894	0.3372	0.3878
Lx=2	-0.1379	0.3318	-0.484	0.2192	0.2963
Lx=3	-0.209	0.2342	-0.484	0.2061	0.3282
Lx=4	-0.3897	0.1867	0.4641	0.2005	0.1935
Lx=5	-0.4129	0.2498	-0.4622	0.1841	0.1908

Table 8F   Nonparametric Causality Test (CHEX-->CHSP)

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	0.2946	0.2546	0.2296	0.2843	0.1801
Lx=2	0.4503	0.2578	0.2451	0.3594	0.3264
Lx=3	0.3464	0.1935	0.1335	0.3917	0.3613
Lx=4	0.2998	0.0959	0.0885	0.2595	0.2595
Lx=5	0.2404	0.1457	0.166	0.3354	0.1922

Table 8G   Nonparametric Causality Test (JPSP-->JPEX)

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	0.365	0.025	0.0606	0.1551	0.0247
Lx=2	0.4188	0.0271	0.0994	0.1357	0.0119
Lx=3	0.486	0.0441	0.0542	0.05	0.0554
Lx=4	0.4781	0.0336	0.0192	0.019	0.0351
Lx=5	0.4443	0.1492	0.0396	0.0174	0.0427

Table 8H   Nonparametric Causality Test (JPEX-->JPSP)

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	0.305	-0.3464	-0.1611	-0.2047	-0.0427
Lx=2	0.1469	0.3557	0.488	0.3391	-0.1977
Lx=3	0.305	0.1867	0.2776	0.1648	-0.2726
Lx=4	-0.3632	0.3121	0.2578	0.3745	-0.1723
Lx=5	-0.121	-0.4741	-0.2358	-0.2221	-0.0688

Table 8I   Nonparametric Causality Test (UKSP-->UKEX)

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	-0.1711	-0.1122	-0.2404	-0.1698	-0.2451
Lx=2	-0.4681	-0.1122	-0.4821	-0.3318	-0.3372
Lx=3	0.3228	-0.1562	0.3192	-0.33	-0.411
Lx=4	0.1827	-0.0951	0.4761	-0.2236	-0.2929
Lx=5	0.1469	-0.2743	0.3033	-0.3282	-0.3859

Table 8J   Nonparametric Causality Test (UKEX-->UKSP)

	Ly=1	Ly=2	Ly=3	Ly=4	Ly=5
Lx=1	-0.4404	-0.2133	-0.3483	-0.4325	-0.4542
Lx=2	-0.2843	-0.102	-0.1801	-0.2104	-0.2843
Lx=3	-0.123	-0.0181	-0.1335	-0.1599	-0.2019
Lx=4	-0.0926	-0.0204	-0.0756	-0.1881	-0.2726
Lx=5	-0.2467	-0.0116	-0.0612	-0.2104	-0.3264

Tables 8A-8J report the *p*-values of the Hiemstra-Jones test. The latter is a one-sided test; in other words, we can reject the null hypothesis if and only if the statistic is greater than the critical value. Compared with linear Granger causality test, Hiemstra-Jones test indicates quite lower causal linkages in both directions. In Japan, where the lag length of exchange rate varies from two to five, the null of no causality from stock market to exchange rate market is rejected at the 10% level. In the three variations of linear causality, however, there is no enough evidence to allow us to reject the null. This result implies the causal linkage from JPSP to JPEX is nonlinear. We have found a weak empirical linear linkage from stock market to foreign exchange market for Switzerland; however, the null of non-causality cannot be rejected in this direction. For any other country, we are also failed to establish causality from the stock price to exchange rate, a fact that is consistent with the result of the linear causality test.

In the three variations of linear empirical causality tests, causal linkage from exchange rate to stock price is found for Canada, Switzerland, and United Kingdom. However, the result of Hiemstra-Jones test indicate that there is no nonlinear causal linkage in this direction in each country with the exception of Switzerland. In fact, in Switzerland, 2 out of 25 statistics imply that there is causal linkage.

V. Conclusion

This paper examines the causality between exchange rates and stock prices in Australia, Canada, Japan, Switzerland, and UK in a linear and nonlinear framework. We investigate the nature of the relationship between FX markets and stock markets. If there is one, what is the direction of these linkages? Previous studies have provided mixed results regarding these questions. Firstly we provided evidence that there is no long-run relationship between the two variables using two cointegration approaches and an extended dataset. The latter confirms some of the previous studies. We then focused on the nature of the short-run relationship. We employed three variations of Granger causality tests--standard causality test, test with unequal-lag length model and Hsiao's version of the test. The results from three tests are qualitatively similar: there is causal linkage from exchange rate to stock prices in Canada, Switzerland, and UK. In Hsiao's version test, causal linkage from stock price to exchange rate is only found for Switzerland. In standard and unequal lag length version of Granger causality test, we reject the null of no causality from stock price to exchange rate for Switzerland at 10% level.

We also examined nonlinear causality through Hiemstra-Jones test. The results show that there is causal linkage from stock price to exchange rate for Japan. And in some lag combinations, weak causality from FX to stock market is found for Switzerland.

References

Abdalla I. and Murinde V. (1997), "Exchange rate and stock price interaction in emerging financial markets: evidence on India, Korea, Pakistan and the Philippines", *Applied Financial Economics 7: 25–35.*

Abdelaziz, M, Chortareas G. and Cipollini A. (2008), "Stock prices, exchange rates and Oil: Evidence from Middle East Oil-exporting countries", University of Essex Working paper.

Ajayi, R. A., Friedman J. and S. M. Mehdian (1998), "On the Relationship between Stock Returns and Exchange Rates: Tests of Granger Causality", *Global Finance Journal 9: 241-251.*

Baek E. G. and W. A. Brock (1992), "A Nonparametric Test for Independence of A Multivariate Time Series", *Statistica Sinica 2*: 137-156.

Bahmani-Oskooee, M. and A. Sohrabian (1992), "Stock Prices and the Effective Exchange Rate of the Dollar", *Applied Economics 24:* 459-464.

Bhattacharya, B. and J. Mukherjee (2003), "Causal Relationship between Stock Market and Exchange Rate. Foreign Exchange Reserves and Value of Trade Balance: A Case Study for India", The 5th Annual Conference on Money and Finance in the Indian Economy on January 2003.

Branson, W.H. (1983) Macroeconomic determinants of real exchange rate risk. In: Herring, R.J. (Ed.), Managing Foreign Exchange rate risk, Cambridge University Press, Cambridge, MA.

Dornbusch, R and Fisher, S. (1980) Exchange rates and the current account, *American Economic Review*, 70. 960-971.

Engle, R. F. and C.W.J. Granger (1987), "Co-integration: representation, estimation, and testing", *Econometrica 55*: 251-276.

Engle, R. F and Granger, C. W J, 1987."Co-integration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, vol. 55(2), 251-76.

Engle, R. F. and Kozicki, S. (1993), "Testing for common features", *Journal of Business and Economic Statistics 11*: 369-395.

Engle, R.F. and V. Farshid (1993), "Common Trends and Common Cycles", *Journal of Applied Econometrics 8:* 341-360.

Fang, W. and S. M. Miller (2002), "Currency Depreciation and Korean Stock Market Performance during the Asian Financial Crisis", Working Paper 2002-30, University of Connecticut.

Gavin, M. (1989) The stock market and exchange rate dynamics, *Journal of International Money and Finance*, 8, 181-200.

Granger, C. W. J. (1969), "Investigating causal relations by econometrics models and cross spectral methods", *Econometrica 37:* 424-438.

Granger, C. W.J., B-N Huang and C. W. Yang (2000), "A bivariate causality between stock prices and exchange rates: Evidence from recent Asian flu", *The Quarterly Review of Economics and Finance 40:* 337-354.

Hiemstra, C. and J. D. Jones (1994),"Testing for Linear and Nonlinear Granger Causality in the Stock Price-Volume Relationship", *Journal of Finance 49*, 1639-1664.

Hobijn, B., Franses, P.H., Ooms, M., 2004. Generalizations of the KPSS-test forstationarity. Statistica Neerlandica 58 (4), 483-502.

Hsiao, C. (1979), "Autoregressive modeling of Canadian money and income data", *Journal of the American Statistical Association 74*: 553-560.

Hsiao, C. (1981), "Autoregressive modeling and money-income causality detection", *Journal of*

Monetary Economics 1981 (7): 85-106.

Johansen, S. (1995) *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*, Oxford University Press, Oxford.

Lütkepohl H. & Pentti Saikkonen & Carsten Trenkler, 2001."Maximum eigenvalue versus trace tests for the cointegrating rank of a VAR process," Econometrics Journal, vol. 4(2), pages 8.

Mishra, A. K. (2004), "Stock Market and Foreign Exchange Market in India: Are they Related?", *South Asia Economic Journal 2004 (5):* 209-232.

Muhammad, N. and A. Rasheed (2002), "Stock Prices and Exchange Rates: Are they Related? Evidence from South Asian Countries", unpublished manuscript, Karachi University.

Nelson, C. R. and C. I. Plosser (1982), "Trends and Random Walks in Macroeconomics Time Series: Some Evidence and Implications", *Journal of Monetary Economics 10:* 139-162.

Newey, W. K and K. D, West (1994), "Automatic Lag Selection in Covariance Matrix Estimation", *Review of Economic Studies* 61(4): 631-53.

Ng, S. and P. Perron (1995), "Unit Root Test in ARMA Models with Data Dependent Methods for the Selection of the Truncation Lag", *Journal of the American Statistical Association 90:* 268-281.

Ng, S. and P. Perron (2001), "Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power", *Econometrica* 69(6): 1519-1554.

Nieh, C.C., and C.F. Lee (2001), "Dynamic relationship between stock prices and exchange rates for G7 countries" *Quarterly Review of Economics and Finance*, 41 (4), 477-490.

Phillips, P. C. and P. Perron (1988), "Testing for a unit roots time series regression", *Biometrika 75 (2):* 335-346.

Phylaktis, K. and F. Ravazzolo (2005), "Stock Prices and Exchange Rate Dynamics", *Journal of International Money and Finance*, 24, 1031-1053.

Saikkonen, P. and Lütkepohl, H. (1999) Local power of likelihood ratio tests for the cointegrating rank of a VAR process, *Econometric Theory*, 15, 50-78.

Saikkonen, P. and Lütkepohl, H. (2000a) Testing for the cointegrating rank of a VAR process with an intercept, *Econometric Theory* 16: 373-406.

Saikkonen, P. and Lütkepohl, H. (2000b) Testing for the cointegrating rank of a VAR process with structural shifts, *Journal of Business & Economic Statistics* 18: 451-464.

Saikkonen, P. and Lütkepohl, H. (2000c) Trend adjustment prior to testing for the cointegrating rank of a vector autoregressive process, *Journal of Time Series Analysis* 21: 435-456.

Schwert, G. W. (1989), "Why Does Stock Market Volatility Change Over Time?", *Journal of Finance 44:* 1115-53.

Sims, C. (1972), "Money, income and causality", *American Economic Review 62:* 540-552.

Stavarek, D (2005), "Stock Prices and Exchange Rates in the EU and the USA: Evidence on their mutual interactions", *Czech Journal of Economics and Finance*, 55, 141-161.

Toda, H. Y. and T. Yamamoto (1995), "Statistical inference in vector autoregressions with possibly integrated processes", *Journal of Econometrics 66:* 225-250.

Table A1   Summary statistics for exchange rates

	AUEX[1]	CAEX	CHEX	JPEX	UKEX
Obs.	168	168	168	168	168
Mean	0.3980	0.3265	0.3419	4.7322	-0.4757
Median	0.3627	0.3212	0.3562	4.7260	-0.4685
Maximum	0.6918	0.4702	0.5796	4.9755	-0.3370
Minimum	0.2265	0.1447	0.1283	4.4281	-0.6632
Std. Dev.	0.1329	0.0839	0.1157	0.0977	0.0781
Skewness	0.7121	-0.2269	0.0847	-0.3453	-0.4816
Kurtosis	2.3380	2.2118	2.1663	3.5093	2.5548
Jarque-Bera	17.2651	5.7902	5.0659	5.1535	7.8830
Probability	0.0002	0.0553	0.0794	0.0760	0.0194

Table A2   Summary statistics for stock prices

	AUSP	CASP	CHSP	JPSP	UKSP
Obs.	168	168	168	168	168
Mean	7.7288	6.8118	5.5175	7.9194	5.1630
Median	7.8116	6.8977	5.6652	7.9621	5.2095
Maximum	8.3233	7.5970	6.1681	8.2198	5.6273
Minimum	7.0232	6.1001	4.6001	7.3892	4.5502
Std. Dev.	0.3317	0.3838	0.4603	0.1878	0.2965
Skewness	-0.3207	-0.2530	-0.4621	-0.6637	-0.2721
Kurtosis	1.9668	1.9543	1.9344	2.7202	1.8746
Jarque-Bera	10.3513	9.4468	13.9259	12.8815	10.9390
Probability	0.0057	0.0089	0.0009	0.0016	0.0042

Appendix B

Table B1   Optimal Lag Length That Suggested by Information Criteria in Johansen Test

Variables	MAIC	FPE
AUEX/AUSP	2	2
CAEX/CASP	2	2
CHEX/CHSP	2	2
JPEX/JPSP	2	2
UKEX/UKSP	4	4

Table B2   Optimal Lag Length That Suggested by Information Criteria in Standard Granger Causality Test

Variables	MAIC	FPE
AUEX/AUSP	1	1
CAEX/CASP	1	1
CHEX/CHSP	1	1
JPEX/JPSP	1	1
UKEX/UKSP	2	2