

EXPLORING THE RELATIONSHIP BETWEEN STOCK PRICES AND EXCHANGE
RATES IN NORTH AMERICA AND CHINA

by

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Abstract

This report explores the relationship between stock prices and exchange rates in North America and China during the post-crisis period. It is found that there is a stable long-run relationship between stock prices and exchange rates in Canada and China, but not for the US. Another finding is that Canadian exchange rates and stock prices exhibit bi-directional Granger causality, which supports both “flow-orientated” model and “stock-orientated” model. Conversely, the two financial variables in China interact in a manner consistent with the “flow-orientated” model. On the other hand, no Granger causality is found between these two financial variables for the US in either direction. Finally, this report provides a few implications for monetary policy makers and global investors.

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Chapter 1. Introduction

Since the rapid integration of equity and currency markets in last few decades, there has been an expansion of interest in the field of exchange rate determination among the researchers, policymakers and investors. Particularly, an important area of this literature has been focused on the relationship between exchange rates and stock prices. The linkage between exchange rates and stock prices has important implications, especially from the viewpoint of recent large cross-border investments. It is evident that the dynamic relationships between exchange rates and stock prices play important roles in influencing the development of a country's economy. Such relationships also have frequently been utilized in predicting the future trends for each other by many fundamentalist investors. With the objective of establishing a causal relationship between exchange rates and equity price, a number of studies have emerged over the past 30 years, establishing heterogeneous results that vary with the methodology, time period and data sample.

There are two economic theories about the interactions between exchange rates and stock prices, the "flow-orientated" model and "stock-orientated" model, which have been discussed for a long time in the literature. The first approach, "flow-orientated" model, claims that exchange rates should lead stock prices (Dornbusch & Fisher 1980). For instance, if Marshall-Lerner condition¹ holds, then a depreciation of the domestic currency makes local firms more competitive, leading to an increase in their exports and consequently higher stock prices. This suggests a positive relationship between exchange rates and stock prices. On the contrary, the "stock-orientated" model argues that changes

¹ This refers to the condition that the absolute value of the sum of the long-term export and import demand elasticities exceed unity.

in stock prices can cause movements in exchange rates via portfolio adjustments such as foreign capital inflows and outflows (Branson et. al. 1977). For example, an increase in stock prices induces foreign investors to demand more domestic assets and thereby causes an appreciation in the domestic currency. Under this model, stock prices lead exchange rates with a negative correlation. In fact, exchange rates serve as tools for equating the demand and supply for financial assets.

Although the relationships between stock prices and exchange rates have been empirically analyzed for the past three decades, the results have been mixed in terms of the sign and the direction of influence between the exchange rates and stock prices. For example, some studies found zero or weak association between exchange rates and stock prices (Bartov & Bodnar, 1994; Fernandez, 2006), while others suggested a bi-directional causality between the two variables in the short run but not in the long run (Bahmani-Oskooee & Sohrabian, 1992; Nieh & Lee, 2001). This does not allow generalized conclusions to be drawn on the question which of the above models is the most applicable. In consequence, a few studies have been further conducted to analyze the reasons for these divergent results. For instance, Ramasamy and Yeung (2005) provided one possible explanation that the interaction between currency and equity markets is sensitive to the stage of the business cycle, and a number of economic factors such as changes in the market structures within an economy. In other words, the relationship between exchange rates and equity prices is sensitive to the collections of data samples, and the time period of the data. Therefore, the period of time in which the interaction between currency and equity markets is observed plays a crucial role in the empirical results. Based on this observation, this report aims to investigate whether the

relationships between exchange rates and stock prices have been changed during the post-crisis period, since there is an increase in dependence between international equity markets, and foreign exchange markets due to the uncertainty created by the global financial crisis (Aloui, Aissa, & Nguyen, 2011; Coudert, Couharde, & Mignon 2011; Dalkir, 2004).

In this report, the exchange rates for Canada and China are expressed as number of local currencies per US dollar, whereas the exchange rates for US are the trade-weighted exchange rates. Moreover, an increase in the value of Canadian and Chinese exchange rate means a depreciation of the currency. For the United States, an increase in the exchange rate value indicates the appreciation of the USD.

The remainder of this study is organized as follows. Section II presents a brief review of the two economic theories regarding the association between exchange rates and stock prices, and a summary of existing empirical literature. Section III provides a description of the methods used to analyze the data, including the unit root test, co-integration, and Granger causality. Section IV describes the data and econometrics models employed in the study, and discusses the empirical findings from the analysis. Section V provides conclusions and policy implications.

Chapter 2. Literature Review

2.1 Theoretical Foundations

There are two major macro theories suggesting a causal relationship between exchange rates and stock returns. The first approach is the “Goods Market Hypothesis”, or equivalently the “flow-orientated” model (Dornbusch and Fischer, 1980). According to the theory, any movement of a country’s exchange rate will cause a movement of its asset prices. Under their model, Dornbusch and Fischer (1980) assumed the exchange rate is initially determined by the asset market at a point of time. Any change in a country’s exchange rate significantly affects its trade balance and current account, which in turn impacts many real economic variables such as the aggregate output. In addition, from a macroeconomic perspective, stock prices may be defined as the present value of a company’s expected future cash flows. According to the Efficient Market Hypothesis (Malkiel & Fama, 1970), information that impacts a firm’s performance, and future cash flow should be reflected in that firm’s stock price if the market is efficient. It follows immediately that stock prices should adjust to general economic conditions and outlook, which implicitly suggests a causal relationship between exchange rate and stock returns. For example, in an export dominated economy, a depreciation of home currency will stimulate foreign demand for domestic goods, thus increasing the exports of that country. As a result, the stock prices of firms in that country will increase due to the economic boom. Conversely, when the home currency appreciates, domestic firms suffers from the decrease in foreign demand, which leads to a decrease in their profits, as would prices of their stocks. For an import dominated economy, the relationship between exchange rates and firms’ stock prices are the opposite: a depreciation of home currency makes foreign

inputs more expensive, which increases production costs of firms using these foreign inputs. The increase in production costs eventually leads to a reduction in the domestic firms' outputs and profits, which in turn have a negative influence on their stock prices. On the other hand, an appreciation of home currency leads to an increase in the profits of domestic firms, thus increasing their stock prices. Therefore, exchange rate movements can either positively or negatively affect stock prices depending on whether the economy in general is export or import dominated.

The second approach is the "Portfolio Balance Approach", or the "stock-orientated" model (Branson, 1983; Frankel, 1984). In contrast to the "flow-oriented" model that exchange rate movements cause changes in stock prices, the "stock orientated" model suggests the opposite direction of causality. According to the "Portfolio Balance" theory, fluctuations of stock prices may affect a country's exchange rate through foreign capital inflows and outflows. Under their model, exchange rate is treated the same way as goods and services that are determined by market mechanisms. A boom in domestic stock market will attract foreign investors, which in turn increases the demand for home currency, and eventually lead to capital inflows and an appreciation of home currency. However, a decrease in stock return will discourage foreign investors, thus decreasing the demand for home currency, and leading to capital outflows and a depreciation of home currency. Furthermore, Gavin (1989) also used the demand for money theory to explain the same direction of causality. For example, a decline in the stock prices will lead to a reduction in domestic investors' wealth. The reduction in wealth causes a decrease in the demand for money, and lowers the interest rates, which in turn causes capital outflows and currency depreciation. Therefore, the portfolio balance approach suggests a negative

relationship between stock prices and exchange rates. To what extent that “Portfolio Balance” theory actually explains the stock market fluctuations and exchange rate reactions in practice critically depends on a number of factors such as stock market liquidity. Stock market liquidity refers to the degree which market allows stocks to be sold quickly without dramatic changes in the prices. According to Eiteman et. al. (2004), non-liquid stock markets will make it more difficult and time costly for buyers and sellers to trade stocks, which potentially discourage investments from foreigners.

2.2 Empirical Studies

From a theoretical point of view, it is evident that there are two ways that stock markets and currency markets can interact. This two-way interaction makes empirical analysis particularly interesting, and has attracted a number of researchers to examine the causality by using different techniques. Most empirical studies focus on identifying the direction of impacts, and examining the significance of causality between stock prices and exchange rates. Despite that the “Goods Market” hypothesis and the “Portfolio Balance” theory provide a strong theoretical foundation, the evidence from existing empirical literature provides mixed results.

Aggarwal (1981) provided evidence in support of the “flow-orientated” model with a positive correlation between US exchange rate and US stock prices. His study examined the relationship between the two variables by using monthly data of US trade-weighted exchange rates and changes of US stock market indices between 1974 and 1978. He found that US exchange rate positively affects stock prices during that period, which leads him to conclude that the two variables interacted in a manner consistent with the flow oriented model. On the other hand, Soenen and Hennigar (1988) found the strength

of US dollar has a negative influence on US stock prices by using monthly data between 1980 and 1986, which is quite a contrast to the Aggarwal's study. In addition, they explained the sign is sensitive to the collection of sample data. Nevertheless, both studies support the "flow-orientated" model. Later, Ma and Kao (1990) conducted a study to test the relationship between exchange rates and stock prices in six industrialized countries rather than focus exclusively on the US market. They used monthly data of Canada, France, Germany, Italy, Japan and United Kingdom between January 1973 and December 1983 to test whether stock prices react to exchange rate movements for each country respectively. The results were also consistent with the "flow-orientated" model, which leads to them to conclude that the relationship between exchange rates and stock prices depends on the degree that an economy relies on exports and imports. These early studies established a solid foundation for further studies on the interaction between stock markets and currency markets, however, they had only applied simple regression techniques to test a correlation between the variables.

Subsequent studies focus on newly developed time-series techniques such as the two-step co-integration methodology introduced by Engle and Granger (1987) to examine the relationship between stock prices and exchange rates. Generally, co-integration techniques allow researchers to test whether two variables share a long run relationship instead of a short run interaction. Bahmani-Oskooee and Sohrabian (1992) used the monthly data of the effective exchange rate of the US dollar and the S&P 500 US stock market indices between 1973 and 1988, and they found little evidence that the two variables are co-integrated. Meanwhile, Bahmani-Oskooee and Sohrabian (1992) also applied the autoregressive framework to analyze the correlation between these two

variables, and they found that the US exchange rate and US stock indices exhibited a dual causal relationship. In other words, changes in the effective US exchange rate affect the S&P 500 stock indices, and changes in the S&P 500 stock indices in turn have a feedback effect on the exchange rate. Their results confirmed both the flow orientated and stock orientated models in the short run, and suggested no long run relationships between the two variables. Likewise, Nieh and Lee (2002) came to a similar conclusion. They investigated the relationship of exchange rates and stock returns in G7 countries, and found no long run relationships in the G7 countries. Moreover, Amihud (1994) pointed out that lagged changes in US dollar exchange rate significantly affect firms' current stock returns, while contemporaneous changes of exchange rates have little influence on stock returns.

As for the emerging Asian markets, existing empirical literatures found little evidence supporting causal relationships between exchange rates and stock returns. Ajayi et al. (1998) applied Granger Causality techniques to investigate the relationship between changes in exchange rates and stock indices in both developed and developing countries. Granger Causality in economics typically refers to "predictive causality" instead of "true causality". Ajayi et al. found no causality relation between exchange rates and stock returns for emerging Asian markets such as Singapore, although they found uni-directional causality from exchange rates to stock returns in some developed countries. They explained such difference may be caused by the structural differences of the currency and stock markets between developed and developing countries. For instance, markets in developed countries tend to be more integrated, while markets in developing countries tend to be less accessible to foreign investors. Besides, other factors such as

political stability make foreign investments much riskier, which potentially prevents foreign investors entering the emerging Asian markets. As a result, emerging Asian stock markets have weaker linkages to the currency market. Likewise, Granger et al. (2000) made a similar conclusion. They investigated the interactions between currency markets and stock markets for nine Asian countries during the first period of the 1990 Asian financial crisis, and found no significant relationships between changes of exchange rates and stock prices except for Singapore. Hence, empirical analysis of the causalities between movements of exchange rates and stock returns provide mixed and contradictory results.

The mixed and contrasting results across the body of literature indicate that there is no underlying causal relationship between exchange rates and stock returns across countries. Rather, the interactions between currency markets and stock markets may be affected by a number of factors such as the different economic structures within each country. In other words, the relationship between the two financial variables is sensitive to collection of data samples, and the time period the data is coming from. According to Ramasamy and Yeung (2005), the causality between exchange rates and stock returns is unique within countries, within specific time periods, and is sensitive to the frequency of data analyzed. Similar to Granger et al. (2000), Ramasamy and Yeung examined the causality relation between exchange rates and stock prices in the same nine Asian countries, and analyzed the entire period of the Asian currency crisis rather than the first period of the crisis. As expected, the empirical results of Ramasamy and Yeung (2005) is different from those of Granger et al. (2000). For example, Granger et al. found a uni-

directional causality from exchange rates to stock returns in Singapore, whereas Ramasamy and Yeung (2005) found that stock prices lead exchange rates for that country.

Chapter 3. Methodology

In this chapter, a brief review of the methodology is presented. First, unit root tests are performed to determine whether two time series (exchange rates and stock price indices) follow a unit root process, and their order of integration. Second, unrestricted vector auto-regression (VAR) models are conducted to serve as the foundation for determining the lag-length in the co-integration test, and Granger Causality test. Third, Johansen-Juselius co-integration test is employed to determine whether the two variables are co-integrated. This allows for the detection of a stable long-run relationship between two non-stationary variables. Finally, the Granger causality is applied to detect the direction of influences. A standard Granger causality test based on VAR is used for variables that are not co-integrated, and a vector error correction model (VECM) is used for variables that are co-integrated.

3.1 Unit Root Test

The stationarity of time series data plays an important role in the analysis of economic models. Using non-stationary time series data may lead to spurious regression and meaningless statistical inference. A unit root is a common violation of stationarity in financial time series data. As a result, before establishing a Granger causality or co-integration test, it is crucial to test whether the exchange rates and stock indices follow a unit root process, and whether they are integrated of the same order. If a series is integrated of order h , denoted $I(h)$, then the series must be differenced by h times in order for them to become stationary. This study uses the Augmented Dickey-Fuller (ADF) test to determine the order of integration for exchange rates and stock indices. In general, the ADF values for each variable can be calculated by estimating regression equations

corresponding to a random walk model, a random walk with drift, and a random walk with drift and trend. The following regression equations are used to implement the ADF test:

$$\text{Basic: } \Delta Y_t = \theta Y_{t-1} + \sum_{i=1}^K \gamma_i \Delta Y_{t-i} + \varepsilon_t$$

$$\text{With drift: } \Delta Y_t = \alpha + \theta Y_{t-1} + \sum_{i=1}^K \gamma_i \Delta Y_{t-i} + \varepsilon_t$$

$$\text{With drift and time trend: } \Delta Y_t = \alpha + \delta t + \theta Y_{t-1} + \sum_{i=1}^K \gamma_i \Delta Y_{t-i} + \varepsilon_t$$

Where: Δ is the difference operator, Y is the variable being examined, and K is the number of lags. Especially, the number of lags is selected by the Akaike Information Criterion (AIC) for the above series, because AIC may have better properties than other information criteria in small samples (Lütkepohl, 2005). If the t-statistics for θ is larger than the ADF critical values, then the null hypothesis of a unit root cannot be rejected. On the other hand, if the t-statistics is less than the ADF critical value, then the hypothesis that the examined series have a unit root is rejected. In fact, the level series of exchange rates and stock indices usually contain a unit root, whereas the first differences of these two variables do not.

3.2 VAR models

VAR models are powerful and reliable tools in data description and forecasting (Stock & Watson, 2001). According to Brooks (2002), standard regression analysis assumes that the dependent variable and the independent variables interact at the same point in time. In other words, standard regression framework assumes that the interactions between the variables are contemporaneous. Consequently, the standard regression technique may be limited to examining the causal connection between the

variables. In contrast, VAR models are able to investigate such relationships, because each variable in a VAR model explains its evolution based on its own lags and the lags of the other variables. In this study, the regression undertaken is as follows:

$$\Delta E_t = \alpha_0 + \sum_{i=1}^p \beta_i \Delta E_{t-i} + \sum_{j=1}^p \gamma_j \Delta S_{t-j} + \varepsilon_t$$

$$\Delta S_t = \alpha_1 + \sum_{i=1}^p \theta_i \Delta E_{t-i} + \sum_{j=1}^p \eta_j \Delta S_{t-j} + \mu_t$$

Where: ΔE_t represents the changes in the exchange rate for each country being examined, and ΔS_t represents the changes in their respective stock price index. In order to determine the optimal lag length in the VAR models, this study uses Akaike information criterion (AIC) and Schwarz Bayesian (SC) as the basis. AIC and SC are useful in the determination of lag length, because they are able to find the smallest sum of residuals to establish the optimal model (Charemza & Deadman, 1992). In practice, it is likely AIC and SC suggest different lag length; in that case, AIC is chosen as the criterion, because AIC may choose the correct order more often than SC in small sample size (Lütkepohl, 2005).

3.3 Johansen-Juselius Co-integration

When the level series are non-stationary, and integrated of the same order, it is then possible to examine whether these level series are co-integrated. In other words, this study aims to test whether there is a long run relationship between exchange rates and stock indices. In general, co-integration technique can be used to examine the stable long-run relations between two or more variables. For example, although exchange rates and stock indices each appear to be unit root processes, the combination of the variables may

be stationary. If these two variables are co integrated, then the error correction model may be applied to test short-run dynamics between two series.

This study implements the Johansen-Juselius co-integration methodology to estimate the long-run equilibrium relationship between exchange rates and stock indices. Following Johansen and Juselius (1990), the co-integration test is based on a general VAR model with g variables:

$$Y_t = \alpha + \sum_{i=1}^p \Phi_i Y_{t-i} + \beta X_t + \varepsilon_t \quad t=1, 2, 3, \dots, T$$

Subtracting Y_{t-1} from both sides, and with some manipulation:

$$\Delta Y_t = \alpha + \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \beta X_t + \varepsilon_t$$

$$\text{Where: } \Pi = \sum_{i=1}^p \Phi_i - I$$

$$\Gamma_i = -\sum_{j=i+1}^p \Phi_j \quad i=1, 2, 3, \dots, p-1$$

Where: Y represents the $g \times 1$ vector of endogenous variables, X represents the $g \times 1$ vector of exogenous variables, and ε represents the $g \times 1$ vector of white noise residuals. Φ represents the $g \times g$ matrix of parameters for endogenous variables, β represents the $g \times g$ matrix of parameters for exogenous variables, and I is the $g \times g$ identity matrix, respectively. Moreover, Π captures information about the rank of the matrix, which determines the existence of long run equilibrium relationships among the elements of Y . This matrix can be further expressed as the product of two $g \times r$ matrices α and β ($\Pi = \alpha\beta'$). Matrix α represents the speed of long run adjustment parameters, while the β contains r co-integrating vectors (Johansen, 1990).

There are two methods for testing the number of co-integration vectors, the trace test and the maximum eigenvalue test. The trace test examines the null hypothesis $H_0: r = 0$ (no co-integration) against the alternative hypothesis that $r > 0$ (at least one co-integrating vector). The maximum eigenvalue statistic tests the null hypothesis that the number of co-integrating vectors is r against the alternative hypothesis that the number of co-integrating vectors is $r + 1$. If the trace and eigenvalue test statistics provides different outcomes, the test results of the maximum eigenvalue is preferred. Besides, as the above equation has shown, the lag length used in the co-integration test is actually the optimal lag length of the underlying VAR models less 1 period due to the first difference transformation.

3.4 Vector Error Correction Models

If two series are co-integrated, then their time paths are influenced by the degree of their deviation from long-run equilibrium. In other words, the short-run dynamics are influenced by the last-periods level of disequilibrium that is captured by the error correction term. According to the Granger representation theorem, “for any set of $I(1)$ variables, error correction and co-integration are the equivalent representations”. Therefore, if exchange rates and stock prices are co-integrated, then the error correction model can be applied to resolve the non-stationarity of series. Generally, the error correction model regresses the first difference of each variable in the co-integration equation on the lagged values of the first differences of all of the variables and lagged values of the error term from the co-integration equation. The exact error correction models in this study are expressed as follows:

$$\Delta E_t = \alpha_0 + \sum_{i=1}^p \beta_i \Delta E_{t-i} + \sum_{j=1}^p \gamma_j \Delta S_{t-j} + \lambda_1 V_{t-1} + \varepsilon_t$$

$$\Delta S_t = \alpha_1 + \sum_{i=1}^p \theta_i \Delta E_{t-i} + \sum_{j=1}^p \eta_j \Delta S_{t-j} + \lambda_2 V_{t-1} + \mu_t$$

Where: ΔE_t is the change in the logarithm of the value of domestic currencies against the US dollar from $t - 1$ to t ; ΔS_t is the change in the logarithm of the stock price indices from $t - 1$ to t . Similarly, ΔE_{t-i} and ΔS_{t-j} are the lagged values of exchange rate changes and lagged values of stock price changes respectively; p is the number of lagged differences. V_{t-1} is the error correction term; ε and μ are the error terms. Besides, λ_1 and λ_2 are the error correction coefficients, which capture the long-run dynamics between stock prices and exchange rates; β_i , γ_j and θ_i , η_j are the coefficients for ΔE_{t-i} and ΔS_{t-j} respectively, and they are expected to estimate short-run dynamics between these two variables. Again, the optimal lags of the VEC models are determined by the optimal lag length of the original VAR models less 1 period.

3.5 Granger Causality

Traditionally, empirical studies often employ the concept of Granger causality to examine the causal relationships between two stationary time series. According to Granger, a time series X Granger causes a time series Y if:

$$E(Y_t | I_{t-1}) \neq E(Y_t | J_{t-1})$$

Where: I_{t-1} contains past information on both Y and X, and J_{t-1} contains only information on past Y. When the above condition holds, past value of X is useful, in addition to past Y, for predicting the current value Y_t ; otherwise, X_t does not Granger cause Y_t in mean if the above condition fails. In addition, Granger causality should be interpreted with caution. Granger test finds only predictive causality instead of the true causality. It has

nothing to say about contemporaneous causality between X and Y, so it is impossible to test whether X_t is an exogenous variable in an equation relating Y_t to X_t .

The Granger causality test is traditionally based on the VAR/VECM framework. If the variables X and Y are two stationary time series, then the following Vector Autoregressive models are employed:

$$Y_t = \alpha_0 + \sum_{i=1}^k \beta_i Y_{t-i} + \sum_{j=1}^q \gamma_j X_{t-j} + \varepsilon_t$$

$$X_t = \alpha_1 + \sum_{i=1}^k \theta_i Y_{t-i} + \sum_{j=1}^q \eta_j X_{t-j} + \mu_t$$

Alternatively, if the variables X and Y are non-stationary and co-integrated, then the causal relationship is modeled using the following VECM:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^k \beta_i \Delta Y_{t-i} + \sum_{j=1}^q \gamma_j \Delta X_{t-j} + \lambda_1 ECT_{t-1} + \varepsilon_t$$

$$\Delta X_t = \alpha_1 + \sum_{i=1}^k \theta_i \Delta Y_{t-i} + \sum_{j=1}^q \eta_j \Delta X_{t-j} + \lambda_2 ECT_{t-1} + \mu_t$$

The above equations aim to check whether X_t and Y_t depend on the past information of Y_{t-1}, \dots, Y_{t-i} and X_{t-1}, \dots, X_{t-j} . Testing the first equation amounts to testing the null hypothesis that $\gamma_j=0$, for $j=1, 2, \dots, q$ in the postulated model. Similarly, the null hypothesis for the second equation is $\theta_i=0$, for $i=1, 2, \dots, k$. Under the null hypothesis, any lags of X (Y) should have zero population coefficients, and no significant impacts on the conditional mean of $Y_t (X_t)$. Rejecting these null hypothesis means X (Y) Granger causes Y (X); as a result, the prediction of the Y (X) in the presence of lagged X (Y) is better than the prediction based only on lagged Y (X).

Chapter 4. Analyses and Results

4.1 Data

The data included in this study are monthly exchange rates and stock prices from Canada, China and United State over the period ranging from January 2010 to March 2016. The sample, with a total of 76 observations for each country, is collected from DataStream (Canada and China), and Federal Reserve Bank of St. Louis (the United States). All stock prices are measured using the averaged closing prices of the main local stock indices at the end of each month, namely S&P/TSX Composite Index (Canada), Shanghai SE Composite Index (China), and S&P500 Composite Index (the United States). Similarly, all monthly nominal exchange rates are the average values of daily closing rates. Especially, the exchange rates for Canada and China are expressed as number of local currencies per US dollar, whereas the exchange rates for US are the trade-weighted exchange rates. In addition, an increase in the value of Canadian and Chinese exchange rate means a depreciation of the currency. For the USD case, an increase in the exchange rate value indicates the appreciation of the USD.

The level series of exchange rates and stock indices, denoted by $\ln(S)$ and $\ln(E)$ respectively, are expressed in the natural logarithmic form. The first difference of stock price, denoted by ΔS_t , are calculated as $\Delta S_t = \ln(S_{i,t}) - \ln(S_{i,t-1})$, where $S_{i,t}$ is the monthly stock price at period t for country i . Similarly, the changes of exchange rates, denoted by ΔE_t , are calculated as $\Delta E_t = \ln(E_{i,t}) - \ln(E_{i,t-1})$, where $E_{i,t}$ is the monthly exchange rates at period t for country i . All the descriptive statistics are summarize in the following table:

Table 1. Descriptive statistics for Stock Price Index (logarithm form):

Country	Stock Index	Mean	Min	Max	Std. Dev.	Skewness	Kurtosis
Canada	S&P/TSX	9.48	9.31	9.66	0.09	0.19	2.01
China	SSE	7.86	7.60	8.44	0.20	0.80	3.17
US	S&P500	7.35	6.98	7.66	0.22	-0.05	1.53

Descriptive statistics for exchange rates (logarithm form):

Country	Currency	Mean	Min	Max	Std. Dev.	Skewness	Kurtosis
Canada	CAD	0.08	-0.05	0.35	0.10	1.13	3.03
China	CNY	1.85	1.81	1.92	0.03	0.75	2.44
US	DXY	4.65	4.55	4.83	0.07	1.13	3.07

4.2 Unit Root test

As discussed above, each of the level series is tested for a unit root by using the ADF test. Table 2 below summarizes the result for the three series of stock price indices. As the result has shown, all three level series of stock prices are non-stationary processes at the 5% significance level, regardless whether a drift or trend is included in the testing equation or not. On the other hand, when the first difference of each series is tested for a unit root, the result implies that the first difference of stock prices is a stationary process at the 1% significance level. Therefore, all stock series are integrated if order 1.

Similarly, each level series of exchange rates is tested for a unit root as well. Table 3 shows the test results for the three series of exchange rates. The results suggest that there is a unit root in all three level series of exchange rate at the 5% critical level, no matter whether a drift or trend is included or not. However, after testing the first difference of each series, the ADF test statistic is lower than the 1% critical value, which rejects the null hypothesis of a unit root. Therefore, all exchange rate series are integrated of order 1. The results in this study are consistent with previous studies done on similar

topics; exchange rates and stock prices are non-stationary series, while their first differences are stationary.

Table 2. ADF Unit root test for stock prices:

Country	Basic		Drift		Drift and Trend	
	Level Series	First Difference	Level Series	First Difference	Level Series	First Difference
Canada	0.8997	0.0000	0.2604	0.0000	0.2866	0.0000
China	0.6422	0.0000	0.2937	0.0000	0.4905	0.0000
US	0.9948	0.0000	0.8223	0.0000	0.4918	0.0000

Note: level series refers to natural logarithm of the monthly stock price index for each country. First difference refers to the first difference of the level series. Probabilities are derived using the ADF unit root test, where a unit root is present when ADF probability is greater than 0.05.

Table 3. ADF Unit root test for exchange rate:

Country	Basic		Drift		Drift and Trend	
	Level Series	First Difference	Level Series	Level Series	First Difference	Level Series
Canada	0.8934	0.0000	0.9603	0.0000	0.8349	0.0002
China	0.3392	0.0000	0.2216	0.0000	0.9706	0.0000
US	0.8828	0.0000	0.9051	0.0000	0.4641	0.0001

Note: level series refers to natural logarithm of the monthly exchange rate for each country. First difference refers to the first difference of the level series. Probabilities are derived using the ADF unit root test, where a unit root is present when ADF probability is greater than 0.05.

4.3 Determination of Optimal Lags

A critical issue in using VAR/VECM models is to choose the appropriate lag length. In order to determine the lag length of the VAR models, this report uses the maximum likelihood tests to establish the optimum lag length. Under this approach, the optimum lag length is the one in which the value of most information criteria are minimized. Table 4 displays the results of this maximum likelihood test:

Table 4: Lag Length Selection Criteria

Lag Length	LR	FPE	AIC	HQ	SC
Canada	3	4	4	2	3
China	6	6	6	1	2
US	2	2	2	1	2

Where:

- LR the sequential modified Likelihood Ratio test statistic;
- FPE the final prediction error;
- AIC the Akaike Information Criterion;
- SC the Schwarz Information Criterion;
- HQ the Hanna-Quinn Information Criterion.

The lag length criteria tests are undertaken for lengths between 1 and 12 for the sample period, with most of the criteria optimized at 4 lag length for Canada, 6 lag length for China, and 2 lag length for United State respectively. On the other hand, there may be significant residual autocorrelations at low lags; as a result, this study adds extra lags to remove the residual autocorrelations even though this conflicts with choosing the model

order on the basis of the information criteria. Overall, the lag length is quite subjective, which depends on the purpose of the study and the priority of the criterion. Nevertheless, this study adopts 5 lags for Canada, and 6 lags for China, and 2 lags for the United States respectively, after removing the residual autocorrelations.

4.4 Co-integration test

As the previous results of unit root tests have shown, both exchange rates and stock prices are $I(1)$ variables, and their first difference are $I(0)$ variables. Therefore, the study may proceed to test whether there is a long-run relationship between exchange rates and stock prices. As mentioned before, this study applies J&J test to investigate co-integration among the exchange rates and stock price indices. J&J test is based on VAR models; the lag lengths used in the co-integration test are equal to the optimal lag length of the original VAR less 1. The reduction of the 1 lag is due to the transformation that the VAR model being in the first difference. The trace statistic and the maximum eigenvalue statistic are compared with the critical value at the 5% level of significance. It is likely that the trace and eigenvalue statistics suggest different outcomes; in that case, the test results of the maximum eigenvalue is preferred (Banerjee et al., 1993). The results of the J&J co-integration tests are shown in the Table 5.

The results from the J&J co-integration tests show that the trace statistics and maximum eigenvalue for each country reject the null hypothesis of 0 co-integrating vector at the 5% level of significance, with the exception of United States. Further, the alternative null hypothesis of at most one co-integrating vector is not rejected. Therefore, the J&J test provides evidence of a unique co-integrating vector between the two series.

In other words, there exists a stable long-run relationship between the exchange rates and stock prices in Canadian, and Chinese financial market. However, the above J&J test finds no co-integration relationship between the US trade-weighted exchange rates and the S&P 500 stock price index. The result appears insensitive to lag length. Although AIC suggests 2 lag length for US and it is sufficient to remove autocorrelation, tests with up to 6 lags are also conducted (but not reported) and they provide the same outcome. Therefore, the standard Granger test based on the VAR model is applied for the United States. In addition, the existence of co-integration between exchange rates and stock prices in Canada and China provides some evidence supporting the popular view held by many fundamentalist investors who believe both exchange rates and stock price may serve as tools for predicting each other's future trends.

Table 5. Results of test for co-integration for exchange rates and stock indices (Trace Statistic)

Sample period: January 2010 to March 2016				
Country	Lag interval	Hypothesized no. of CE(s)	Trace Statistic	5 percent critical value
Canada	1 to 4	None*	16.9305	15.4947
		At most 1	0.1729	3.8415
China	1 to 5	None*	23.2602	15.4947
		At most 1	2.5864	3.8415
United State	1 to 1	None	9.1357	15.4947
		At most 1	0.0587	3.8415

Notes: * denotes rejection of the null hypothesis at the 5 percent level

Table 5. Results of test for co-integration for exchange rates and stock indices (Maximum Eigenvalue)

Sample period: January 2010 to March 2016				
Country	Lag interval	Hypothesized no. of CE(s)	Maximum Eigen Statistic	5 percent critical value
Canada	1 to 4	None*	16.7576	14.2646
		At most 1	0.1729	3.8415
China	1 to 5	None*	20.6741	14.2646
		At most 1	2.5864	3.8415
United State	1 to 1	None	9.077	14.2646
		At most 1	0.0587	3.8415

Notes: * denotes rejection of the null hypothesis at the 5 percent level

4.5 Granger Causality test

Most pairs of the exchange rates and stock price indices in the tests above suggest the existence of a stable long run relationship, with the exception of the US financial market. As a result, two different models are employed to test for Granger causality depending on whether the variables are co-integrated or not. Especially, the VECM is applied to the countries with co-integration relationships, while the conventional VAR model is used for the United States. The regression results of the VAR/VECM models are presented in the Table 6, and the results of the Granger causality test are provided in Table 7.

In the VECM, the existence of a stable long-run relationship between the currency market and the equity market is captured by the statistical significance of one or both of the coefficients of the error correction term (λ_1 and λ_2). In fact, the coefficients of the error correction term, are expected to capture the speed of adjustments of ΔS_t and ΔE_t towards their long-run equilibrium. On the other hand, the short-run dynamics between the two markets are captured by the coefficients of ΔE_{t-i} and ΔS_{t-i} .

As the Table 6 has shown, the coefficients of the error correction term for the Canadian markets are statistically significant at least at the 5% level, which confirms the existence of a stable long-run relationship, and implies a long-run causality between the two variables. In particular, the long-term adjustment coefficient for exchange rate is 0.0865, which means the exchange rate gap closes by approximately 8.65% each month by changes in the TSX indices. Similarly, the coefficient of the error correction term for TSX indices is -0.1106, which implies the fraction of the long-term stock price gap closes by about 11.06% each month by changes in the Canadian exchange rate. The results also indicate that the exchange rates take a longer time to achieve equilibrium after a shock when compared to its stock price indices. Moreover, the Table 7 shows that the Granger causality test based on the VECM for the Canadian exchange rate and TSX composite index finds a bi-directional Granger causality at the 1% level of significance. It is apparent that the causality is two-way, running both from stock prices to exchange rates, and from exchange rates to stock prices. Such results implies that both exchange rates and stock price may help to predict each other's future trends. Especially, the impact of stock prices on the Canadian exchange rates can be seen from the sign and t-test values of ΔSP_{t-3} . The negative coefficients on ΔSP_{t-3} is almost statistically significant at the 5%

level, and it indicates that an immediate past increase in stock price has a negative effect on the exchange rate. In other words, a boom in domestic stock market may lead to an appreciation of Canadian currency, which is consistent with the “stock-orientated” model. Likewise, the negative coefficient on ΔEX_{t-1} and positive coefficient on ΔEX_{t-2} suggests that an immediate past increase in the exchange rate has a negative influence on the stock price indices, but it will stimulate the Canadian stock market on the following month.

Table 6 also suggests that there is a stable long-run relationship between the Chinese exchange rates and stock prices, because both the speed of adjustment coefficients are statistically significant at least at the 5% level. The VEC equations for China shows that the remaining long-term exchange rate gap closes by about 1.306% in each period, while the gaps in the stock price close by about 11.625%. As a result, the exchange rates in Chinese market take a much longer time to achieve equilibrium after a shock when compared to its stock price indices. Such a difference possibly reflects the fact that China’s exchange rate regime is a hybrid of fixed and floating system. In contrast with Canada, the null hypothesis that SSE stock index does not Granger cause Chinese exchange rate is not rejected at the 5% level of significance. Conversely, the null hypothesis that the Chinese exchange rate does not Granger cause SSE stock index is rejected at the 1% level of significance. Therefore, there is evidence supporting a uni-directional Granger causality in the Chinese markets, with causality running from exchange rates to stock price index. Such result is consistent with the “flow-orientated” model that exchange rates movements influence stock prices through firms’ profitability. The different test results between Canada and China might be due to deeper causes, not merely from the observed financial factors. Especially, the differences in the degree of

capital control between these two countries may play an important role. For example, Chinese Yuan is still pegged to the US dollar even though it is allowed to fluctuate within a narrow margin. Consequently, the movement of Chinese Yuan is affected by not only the fluctuations of its stock market, but also its monetary policies. In addition, the impact of the exchange rates on the Chinese stock prices can be seen from the sign of ΔEX_{t-2} . The positive sign on ΔEX_{t-2} suggests that a depreciation of Chinese Yuan has a positive influence on the stock price indices, which is in line the fact that China is the world's largest exporter.

On the other hand, since the trade-weighted US exchange rate is not co-integrated with the S&P 500 stock index, therefore, the Granger causality test for the United States is conducted using the conventional VAR Granger causality methodology with the first differenced data. The results from the VAR model finds no significant Granger cause in either direction for the two first-differenced variables considering any of the appropriate lag lengths (tested up to 6 lags). Such results indicate that there is no short-run interactions between these two financial variables. Therefore, the trade-weighted exchange rate and S&P500 stock index have little power in predicting each other's future trends, either in the short run or in the long run.

Finally, this study carries out some diagnostic tests such AR Roots test for the VAR/VECM models to examine their stability condition. The model is considered stable if all roots have a modulus less than one, and lie inside the unit circle. As the graph (Appendix, Figure 1) has shown, the VAR and VECM models satisfy the stability condition, because all roots have a value of less than one and lie within the unit circle, except for the imposed unit root in the VECM models. Besides, LM autocorrelation test

is also applied to test the serial independence of residuals. Generally, the serial correlation in the VAR/VECM models implies the dynamic regressions function have not been completely specified, in consequence, extra lags may be needed (Wooldridge, 2015). The results of the LM autocorrelation test (Appendix, Table 8) suggest that all models used in this study cannot reject the null hypothesis of no serial correlation at least at the 5% level of significance. In other words, the residuals of those models are considered to be white noise.

Table 6. Estimation of VAR/VECM for stock market indices and foreign exchange rates

Variable:	Canada		China		US	
	ΔEX	ΔSP	ΔEX	ΔSP	ΔEX	ΔSP
EC-term	0.0865*** (3.30)	-0.1106** (-2.44)	0.0131*** (4.13)	-0.1163** (-2.52)	-	-
ΔEX_{t-1}	0.3960*** (3.38)	-0.5409*** (-2.67)	0.1446 (1.09)	1.6831 (0.87)	0.4894*** (3.95)	-0.6983** (-2.07)
ΔEX_{t-2}	-0.2313* (-1.77)	0.6256*** (2.76)	-0.2811** (-2.19)	4.7245** (2.52)	-0.0662 (-0.52)	0.5015 (1.45)
ΔEX_{t-3}	-0.2848* (-1.95)	0.2055 (0.81)	-0.0007 (-0.01)	1.0073 (0.51)	-	-
ΔEX_{t-4}	0.0121 (0.09)	-0.0612 (-0.27)	0.1120 (0.82)	2.7133 (1.36)	-	-
ΔEX_{t-5}	-	-	0.2930** (2.10)	-7.5734*** (-3.72)	-	-
ΔSP_{t-1}	-0.0798 (-1.15)	0.0766 (0.64)	-0.0202** (-2.24)	0.3103** (2.36)	0.0275 (0.61)	0.0460 (0.37)
ΔSP_{t-2}	-0.1071 (-1.53)	0.2867** (2.37)	-0.0214** (-2.30)	0.1024 (0.76)	0.0816* (1.80)	-0.0807 (-0.65)
ΔSP_{t-3}	-0.1374** (-1.97)	0.2723** (2.26)	-0.0095 (-1.02)	0.2228 (1.63)	-	-
ΔSP_{t-4}	-0.1243* (-1.81)	-0.1214 (-1.02)	-0.0081 (-0.83)	0.2619* (1.85)	-	-
ΔSP_{t-5}	-	-	-0.0053 (-0.54)	0.0102 (0.07)	-	-
Constant	0.0018** (2.1513)	0.0003 (0.2240)	-0.0002 (-0.76)	0.0007 (0.19)	0.0002 (0.29)	0.0037** (2.20)

Notes:

1. The numbers inside parentheses below the estimated coefficients are the t-statistics.
2. The symbol ***, **, and *, represent the significant at 1%, 5%, and 10% levels, respectively.

Table 7. Results of Granger Causality test for exchange rates and stock indices

Country	Hypothesis	Probability
Canada	ΔSP does not Granger cause ΔEX	0.0276
	ΔEX does not Granger cause ΔSP	0.0014
China	ΔSP does not Granger cause ΔEX	0.0651
	ΔEX does not Granger cause ΔSP	0.0013
United States	ΔSP does not Granger cause ΔEX	0.1749
	ΔEX does not Granger cause ΔSP	0.1029

Note: Numbers in the table are p-values for the test of the null hypothesis that there is no Granger causality.

Chapter 5. Discussion and Conclusion

This report attempts to investigate the dynamic relationship between the stock price indices and the exchange rates in North America and China. The ADF test is initially employed to check the stationarity of two variables for each country. After that, this study uses Johansen co-integration tests to determine whether there is a potential long-run equilibrium relationship between the exchange rates and the equity indices for each country. Then the Granger causality tests are used to determine the existence and direction of short-run causal relationships. Especially, the Granger causality tests based on the VECM is applied to the countries with co-integration relationships, whereas the standard Granger causality based on the VAR model is used for countries without such relationship.

From the analysis in this study, the level series exchange rates and stock prices are non-stationary, while their first differences are stationary. In addition, Canadian exchange rates and Chinese exchange rates are found to be co-integrated with their respective main local stock indices. Moreover, Canadian exchange rates and stock prices also exhibit significant bi-directional Granger causality, running both from stock prices to exchange rates, and from exchange rates to stock prices. Conversely, the two variables in China only show a uni-directional Granger causality, with causality running from exchange rates to stock price index. On the other hand, there is no long-run relationship between these two financial variables for the United States, and no Granger cause is found in either direction. This implies that the S&P500 stock index and the strength of the US dollar cannot be depended on when predicting the future in the US, either in the short-run or in the long-run.

These results may have important implications for monetary policy makers. Policy makers should be cautious about the direction of change in the domestic currency against the US dollar. For example, policy makers should take into account the possible impacts on the average stock price in the Chinese market when considering the devaluation or revaluation of Chinese Yuan. Furthermore, investors, both institutional and individual, should be concerned about the direction of influence between the exchange rates and stock prices before investing in any foreign stock market. Understanding the direction of influence would be important for the portfolio managers in diversifying their portfolios.

The limitation of this report is that the movements of interest rates is neglected in the VAR/VECM. In fact, interest rates may play an important role on stock prices and exchange rates; it may become a potential link between the two variables. The zero association between stock prices and the exchange rate in the US might be the result of the omission of interest rates from the equation. Therefore, future research may be extended to the linkage among the three variables of stock prices, exchange rates, and interest rates, as well as the co-integration and Grange causality with them.

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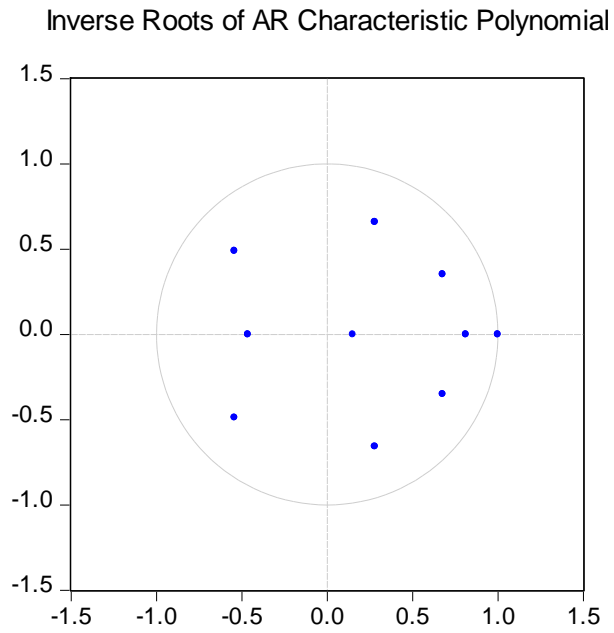
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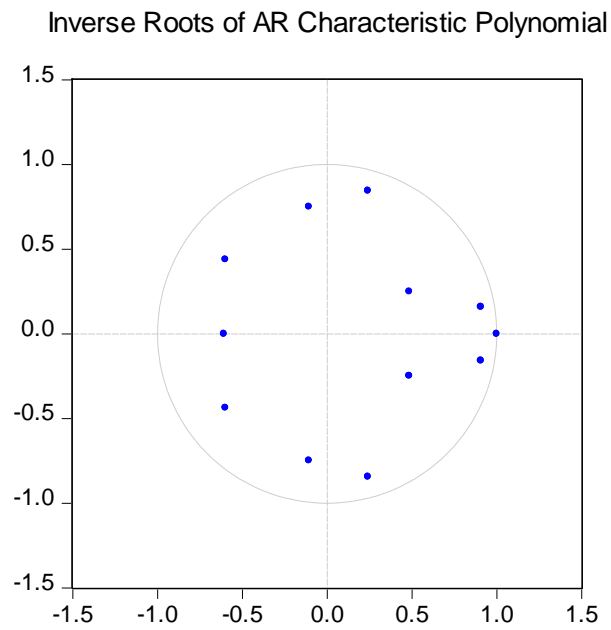
Appendix

Figure 1. Graphs of AR roots test for VAR/VECM

Canada



China



United States

Inverse Roots of AR Characteristic Polynomial

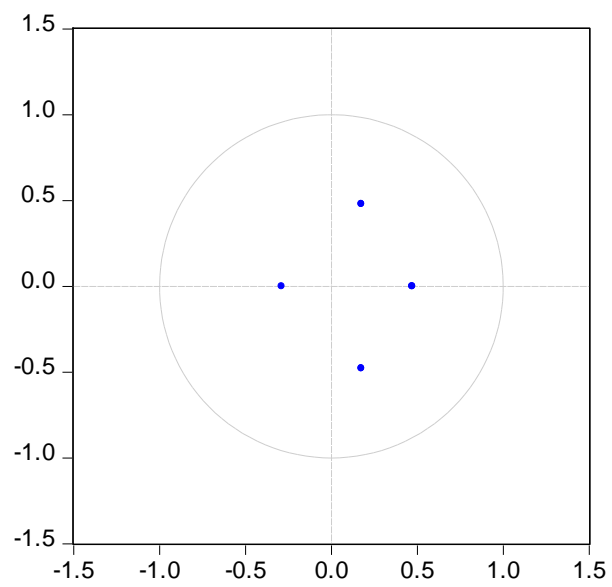


Table 8. Results of Autocorrelation test for the VAR/VECM models

Canada		China		United States	
H₀: no serial correlation at lag order h					
Lags	Prob.	Lags	Prob.	Lags	Prob.
1	0.4865	1	0.4528	1	0.7107
2	0.6846	2	0.3269	2	0.9799
3	0.4057	3	0.7756		
4	0.5120	4	0.8082		
		5	0.4215		

Note: Numbers in the table are p-values for the test of the null hypothesis that there is no serial correlation at the selected lag order.

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