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The impact of exchange rates on stock index returns: New evidence from seven free-floating currencies*

This paper provides evidence of a significant exchange rate effect on stock index returns using data from seven selected countries practicing free-floating exchange rate regimes. This research uses parity and asset pricing theories, thus placing it within the monetary-cum-economics framework for international asset pricing. In this study, we apply a system of seemingly unrelated regression to control for unobserved heterogeneity and cross-sectional dependence. The findings constitute evidence of a statistically significant exchange rate impact on stock index returns across selected countries. These findings can be considered as falling under the arbitrage pricing approach of international capital asset pricing model of Solnik who also used the parity-theoretical framework on exchange rate determination.

Keywords: exchange rates; international asset pricing; arbitrage pricing; parity factors; macroeconomic factor

JEL Classification: F23; F31; G12

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1. Introduction

This study presents new findings showing statistically significant exchange rate influence on stock index returns from seven major countries practicing free-floating exchange rate regimes. The motivation for this study emerged following an examination of publications on the impact of exchange rates on individual stock returns. Little support for Solnik's (1974) prediction of an exchange rate impact is found in the literature. Solnik's contribution is in itself an extension of Sharpe's (1964) capital asset pricing model (CAPM). Furthermore, exchange rate studies are notorious for computing the average exchange rate impact using *individual* stocks as observation units, and then applying time-series or cross-sectional methodologies. Both methods are well known to have serious econometrics challenges requiring further special care to avoid spurious results. Therefore, it is observed that the impact of exchange rate on stock index returns is seldom studied using country-level variables within a multi-factor or arbitrage pricing model, since there has been a preference for exchange rate testing at an individual stock-return level. More to the point, researchers need to frame research questions using the monetary theoretical frameworks or the arbitrage pricing theory factors (Ross 1976) in order to understand the exchange rate impact on stock index returns at macro level. These said frameworks or factors are applied in the present study to formulate our research questions.

This study adopted the variable selections in previous research by Solnik (1974), Ross (1976), Roll (1992), Ferson and Harvey (1993: 1994), and Bahmani-Oskooee and Saha (2016). In order to test the arbitrage theory using insights of the arbitrage pricing model as in Chen, Roll, and Ross (1986), we developed an economy-wide model using aggregate variables to restrict the factors to a few macro variables in the model. We used a system of seemingly unrelated regression (SUR) developed by Zellner (1962, 1963) to allow for a generalization of the linear asset pricing regression into country-specific regression equations. The current methodology proposed is (i) to avoid the data pooling restriction in a single equation setup, while introducing a proliferating dynamic such that a triangular arbitrage condition binds across the whole system of exchange rates (Smith & Hunter, 1985) and (ii) to impose control for unobserved heterogeneity, and cross-sectional dependence across different markets. The findings from this broader approach drawing factors from parity theorems provide a framework that is consistent with Ross' arbitrage pricing theory.

The rest of the study is organized as follows. Section 2 contains an overview of the theoretical and empirical literature. Section 3 explains the methodology and econometric issues relevant to macro-modelling, while sections 4 and 5 present the results and discussions of the exchange rate impact on the stock index returns. The final section concludes the paper.

2. International asset pricing model and exchange rate

In this section, the relevant literature is reviewed to identify exchange rate factor-models at the aggregate level. There has been a decline in research interest on the international capital asset pricing model (ICAPM of Solnik) to verify an exchange rate effect on stock returns. The lack of interest is attributable to the fact that most studies at the individual stock-return level failed to find a significant exchange rate influence.[1] The approach taken in this study is to assess the country-wide factors, as theory-relevant factors for the selected countries, which have free-floating currencies and their capital markets are well developed and open to international investors. The relevant publications discussed are those that examine the exchange rate effects at the aggregate level, thus we expect to obtain statistical support for an exchange rate impact on stock *index* returns at such aggregate level. In this context, we also review a number of factors that are consistent with the arbitrage pricing approach and exchange rate parity theorems.

2.1 Asset pricing theories for individual assets

Asset pricing theories generally concern the pricing of assets, as shown by Chen, Roll, and Ross (1986) in a study based on Ross' (1976) arbitrage pricing theory. The exchange rate ought to exert some influence on the stock returns at the aggregate level in a world of exchange rate volatility, where the level of uncertainty is determined by expectations of respective investors or economic agents regarding the market's valuation of risk and returns of assets.

To better understand the development of theories, the origins of the core theoretical ideas will be traced and the resulting models will then be summarized. The CAPM is an early asset pricing approach, independently developed during 1964–1966 by Sharpe (1964), Lintner (1965), and Mossin (1966). This single factor model specifies j-th stock returns as SR_j:

$$sr_j = r_f + \beta_j(r_m - r_f) \tag{1}$$

R_f is the risk-free rate with $(R_m - R_f)$ as the risk-permium in a market, while β_j is the systematic risk of the asset. Fama and French (1992) extended this model as a three-factor model with j=i.

$$sr_i - r_f = a + \beta_1\left(r_m - r_f\right)_i + \beta_2 E(SMB)_i + \beta_3 E(HML)_i \tag{2}$$

where SMB is the small stock portfolio return minus large stock portfolio return. HML represents the portfolio return of a high book-to-market stocks minus portfolio return of a low book-to-market stocks.

Solnik's ICAPM applies a risk pricing relation for stocks called the "international systematic risk" with exchange rate risk, which is equal to the risk premium of a particular security over its national risk-free rate (Ariff & Marisetty, 2012):

$$sr_i = r_f + \beta_1 \left(r_m - r_f\right)_i + \beta_2 (FCRP)_i \tag{3}$$

where $FCRP_i$ denotes foreign currency risk premium.

Adler and Dumas (1984) suggested a new model suitable for a country-level test on exchange rate exposure. The exchange rate factor, SR_{it}, is suggested as the only explanatory variable that determines the return of individual stocks i:

$$SR_{it} = \alpha_i + \gamma_i XR_{it} + \varepsilon_{it} \tag{4}$$

where γ_i measures the total exposure of firms to the exchange rate.

Jorion (1991) developed a model in which the exchange rate factor is added to the market index factor as an additional variable at macro level, producing a two-factor model:

$$SR_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i XR_{i,t} + \varepsilon_{i,t} \tag{5}$$

where $R_{m,t}$ is a proxy for market index and XR is the same as in Equation (4).

A different stream of literature was later developed following Ross' (1976) arbitrage pricing theory, leading to the use of macroeconomic factors as in Chen et al. (1986) who found that market index alone lacks sufficient power to explain all the cross-sectional differences in the average returns. This is a fact already established by the low coefficient of variation reported in preceding studies. In principle, they identified a number of variables such as risk premium (UPR), industrial production (MP), term structure of interest rate (UTS), unanticipated inflation (UI), as well as changes in expected inflation (DEI), thus making significant contributions to stock returns. Notably, these are all macro-level variables. Stock market index was deemed a meaningful explanatory variable for measuring stock return variability based on a multi-factor setting proposed by Ross (1976); subject subscript is omitted from the equation:

$$SR_t = a_i + b_{iMP}MP_t + b_{iDEI}DEI_t + b_{iUI}UI_t + b_{iUPR}UPR_t + b_{iUTS}UTS_t + e_t \tag{6}$$

Although this model as in Equation (6) uses *macro factors*, where two of the factors come from monetary theory (inflation and interest rate) and the others from macroeconomic theory, no specific reference to exchange rate theories is made. Going back to the connection between the exchange rate and asset (stock) return valuation, our aim is to apply a relatively modified version of an asset pricing model that; (1) incorporates Solnik's approach, and (2) employs some ideas from Chen et al. (1986), which operationalized arbitrage pricing theory with five factors as discussed above. Further, we rely on parity theories (Cassel 1918; Fisher 1930), which were tested recently by Ariff and Zarei (2016). A large body of literature has since developed models on the exchange rate impact. However, these studies largely ignore the exchange rate impact on the stock index returns.

2.2 Empirical evidence on exchange rate and asset prices

Following the 1973 collapse of the Bretton Woods system (rules on exchange rate management) and the subsequent introduction of a newer free-floating exchange rate regime, the focus of empirical studies in finance shifted to the role of exchange rates in individual asset pricing. Considering the models described in section 2.1, the CAPM-based model was initially tested to measure the exchange rate risk of individual firms directly exposed to exchange rate volatility. Jorion (1990) found that the exchange rate risk is priced for individual stocks with correlation coefficients ranging between 0.05 and 0.10, depending on the level of a firm's operation in international markets.

The strand of literature further provides evidence from major studies generally addressing the international pricing of broad-based stock indices at macro level using the so-called "integrated market models". A seminal study of this type was developed by Roll (1992), linking the stock *index* returns to monetary phenomena such as behavior of inflation and exchange rates, as well as each of the 23 sampled country's industry structure. Ferson and Harvey (1993) applied a conditional form of international asset pricing of stock index returns using exchange rates, inflation, interest rates, international default risk, and the world industrial production. Another study by Ferson and Harvey (1994) reported supporting evidence. Dumas and Solnik (1995) applied the single-factor model of Adler and Dumas (1984) and reported that the model holds statistically for the exchange rate effect on stock index returns in four countries. Likewise, De Santis and Gerard (1998) applied the single-factor model for exchange rates and stock index returns in selected countries, confirming support for the model. Patro, Wald, and Wu (2002) reported supporting evidence for a time-varying foreign exchange effect on stock index returns as well. A recent study (Chen, Hong, & Ren, 2016) finds evidence of cointegration between durable consumption and asset returns,

A common feature of these studies is clearly concerned with the use of world market portfolio (world index) as an independent variable explaining the returns of broad-based equity indices. The use of industrial production is also found to be a usual practice in asset pricing model specification since it captures an economic variable used in tests of arbitrage pricing theory. Such studies used industrial production index as a proxy for macroeconomic factor. Thus, in the spirit of Ross (1976), who initially coined the arbitrage approach to asset pricing, we too used the macro-level index series in our test procedure. All firm-specific variables, as well as variables that have been shown in other studies to be less relevant, are not selected. We added specific parity variables as they are part of the monetary variables at the aggregate level and their omission would result in under-specification of the test model. Importantly, the choice of variables is in line with the application of the arbitrage pricing model.

Nonetheless, a rather distinct yet scant stream of empirical literature is refocused on the long-run association and/or short-run dynamics using cointegration and causality between stock price and exchange rate series. Aggarwal (1981) and Soenen and Hennigar (1988) examined the relationship between the United States (US) stock index prices and currency values over the post-Bretton Wood period, reporting a relationship between the two variables. Applying the mainstream approaches of cointegration, namely the two-step procedure of Engle and Granger (1987) and the maximum likelihood method of Johansen (1995) led to weak findings and provided no evidence of cointegration, while also confirming short-run bi-directional causality between stock index prices and exchange rates in Bahmani-Oskooee and Sohrabian (1992). The most recent empirical studies on the dynamics of stock prices and exchange rates (Wu, 2000; Hatemi–J & Irandoust, 2002; Caporale, Hunter, & Ali, 2014) produced similar results, suggesting the absence of cointegration. The study of Tsagkanos and Siriopoulos (2013) assessed the long-run relationship between stock prices and exchange rates in the European and US markets, using the advanced model of structural non-parametric cointegration test of Wang and Phillips (2009). Their findings suggested a significant causal relationship between stock prices and exchange rates that is valid in the long run in the European market but significant only in the short run in the US market. A recent study (Chen et al., 2016) finds supporting evidence of a significant effect of durable and nondurable consumption growth in determining the returns in the long-run.

Bahmani-Oskooee and Saha (2016) took this research a step further and examined the asymmetric effect of exchange rate changes on stock index prices using a nonlinear auto-regressive distributed lags approach, whose findings provided evidence of an asymmetric effect of nominal effective exchange rates on stock index prices in the short run only. The study did not take into account an evaluation of the long-term effects of exchange rates on stock prices, since these models generally lead to unstable findings. Our model specification is therefore distinguished from the ones reviewed in this section.

3. Data sources, hypotheses and methodology

3.1 Data sources and variables

Data are collected from DataStream and the IMF CD-ROM. The monthly data series is in line with the standard use of monthly data in asset pricing studies. We also reset the data in quarterly intervals to reduce the noise in monthly data, and as a robustness testing with different intervalling of data series. Widespread controversies have surrounded the choice of time horizon in stock price estimation as in Chow, Lee, and Solt (1997), and Martin and Mauer (2003). Often, the difference in estimation when using high- and low-frequency data is associated with the level of noise. By using the low-frequency data series, the impact of noise is likely to be mitigated, resulting in smoothened trend behavior for exchange rates and stock returns as well as other variables. Evidence for significant exchange rate effects on stock returns using monthly data is also found in Bodnar and Wong (2003).

The test window in this study ran from February 1999 to March 2016, yielding a total of 68 quarterly and 206 monthly observations for each country. Seven countries with floating exchange rate regimes are analyzed: Australia, Canada, Germany, Japan, Sweden, the United Kingdom (UK) and the US. Countries were selected using the following criteria:

(1) Whether a country adopts a free-floating currency regime in its monetary management during the period of study,

(2) Whether these countries, in total, account for a substantial (43%) global gross domestic product (GDP) as of 2016, and

(3) Whether the markets in these countries have low volatility in stock index returns.

Some countries are excluded from this study if they did not meet the strict selection criteria as outlined above. We included more observations on the test period as major changes occurred in the exchange rates of these countries during the last 25 years, i.e. the course of time when the free-floating period coincided with our 18-year test period.

Table 1 summarizes the description of variables. The variables computed from the data series are; (1) log change of composite stock price index (*S*R) in each country, (2) log change of world stock price index (ΔWSI), (3) log change of real exchange rates (ΔRER), (4) inflation and interest rate, which are included as a single factor following the usual practice of using the term structure of interest rate specified as the difference between the long T-bond yield and the short T-bill yield (TSIR), and (5) economy-wide income growth measured as the log change of industrial production index of the respective countries (ΔIPI). The dependent variable is stock index return, whereas the right-hand side variables are the other mentioned factors. The currency unit of the stock price is in local numeraire of each country.

(**Insert Table 1 about here**)

The expected sign on each variable is determined based on a direct exchange rate quote. We took a logarithmic change for each variable (except TSIR) to normalize the data: see Table 2. The mean values of the stock index return (0.2475 for monthly and 0.9193 for quarterly) are relatively low, because the stock-return data covers the period over 1999-2016, a period encompassing the IT bubble, 9/11 event, and the 2008–2009 global financial crisis, all of which affected the stock index returns badly. The exchange rate variable is consistent for monthly and quarterly observations. The large standard deviation is also symptomatic of a relatively higher volatility in stock market performance during the same test period. TSIR, likewise, collapsed after a short period of spikes in interest rates during 2006–2009. Thus, the mean of TSIR is around 1 percent[2] with low volatility in this period. The IPI (industrial production index) also shows very small growth due to the impact of various turmoil on macroeconomic performance.

(**Insert Table 2 about here**)

3.2 Test hypotheses

The following three null hypotheses were tested:

Hypothesis 1: There is no significant association between changes in exchange rates and stock index returns.

Hypothesis 2: There is no significant association between parity factors (e.g. inflation and interest rates) and stock index returns.

Hypothesis 3: There is no significant association between income growth (e.g. GDP growth as represented by industrial production index) and stock index returns.

This study aims to obtain test statistics that can reject these null hypotheses, which have been suggested in theories. In the modified asset pricing approach used in this study, we aim to reject the above test hypotheses and thereby demonstrate that these factors do have the theory-suggested impact on stock returns for countries with free-floating currencies.

3.3 Cross-sectional dependence

The basic premise of panel-data methodology is based on the evidence of cross-sectionally independent errors and homogenous slopes to control for heterogeneity across panel units (Baltagi, 2014). Given the ever-increasing trends of economic and financial integration across several economies during the most recent few decades, the level of interdependencies among many cross-sectional units has improved substantially. Recent literature on panel data therefore offers evidence of substantial cross-sectional dependence in the errors, arising from the presence of common shocks and unobserved components, spatial dependence and idiosyncratic pairwise dependence in the disturbances. Serious consequences can result as a result, leading to *biased* estimates if these econometric issues are not tested and corrected.

Conventional panel data estimators such as the fixed and random effects or even generalized methods of moments (GMM) (see Badarudin, Ariff, and Khalid (2011)) could lead to misleading inferences and inefficient estimators. According to Phillips and Sul (2003), if cross-sectional dependence is not tested and dealt with in the panel data, the panel estimators will provide little gain over the ordinary least squares. In this study, we use the standard technique of Lagrange Multiplier (LM) test of Breusch and Pagan (1980) for cross-sectional dependence. This test is based on the average of the squared pair-wise correlation coefficients of the residuals and is suitable for our data structure with fixed or small cross-sectional dimension N as $T \rightarrow \infty$ (Pesaran, 2015):

$$\mathrm{LM} = \mathrm{T}\sum_{\mathrm{i}=1}^{\mathrm{N}-1}\sum_{\mathrm{j}=\mathrm{i}+1}^{\mathrm{N}}\hat{\rho}_{\mathrm{ij}}^{2} \tag{7}$$

Where $\hat{\rho}_{ij}$ is the sample estimate of the pairwise correlation of the residuals,

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} \frac{\sum_{t=1}^{T} \hat{u}_{it}\hat{u}_{jt}}{(\sum_{t=1}^{T} \hat{u}_{it}^{2})^{1/2}\left(\sum_{t=1}^{T} \hat{u}_{jt}^{2}\right)^{1/2}} \tag{8}$$

and $\hat{u}_{it}$ is the estimate of disturbance term. The obtained test statistics is distributed as χ^2 with $N(N-1)/2$ degrees of freedom under the null hypothesis of u_{it} being independent and identically distributed over periods and across cross-sectional units. This LM test procedure is a residual-based diagnostic following our estimation of the SUR system of equations.

3.4 Test models

We test our model using the SUR, which is developed by Zellner (1962,1963). The SUR method allows for a generalization of the linear asset pricing regression into several country-specific regression equations with endogenous dependent variables and a set of exogenous variables as regressors. Another intuition behind the use of the SUR is also in the spirit of Smith and Hunter (1985), who provide important guideline on the appropriate specification of general exchange rate equations in view of triangular arbitrage conditions. This manner of implementation offers efficiency gains over the ordinary least squares (OLS) by accounting for the likely correlation across equations within the system. Moreover, the SUR method is a standard estimation approach to control for cross-sectional dependence across units of panel as argued in Chudik and Pesaran (2013). The general specification of the SUR system of equation in our study can be represented as follows:

$$\begin{aligned}
SR_1 &= \alpha_{11} + \beta_{11}\Delta WSI_{11} + \beta_{12}\Delta RER_{12} + \beta_{13}(i_L - i_S)_{13} + \beta_{14}\Delta IPI_{14} + \varepsilon_1 \\
SR_2 &= \alpha_{21} + \beta_{21}\Delta WSI_{21} + \beta_{22}\Delta RER_{22} + \beta_{23}(i_L - i_S)_{23} + \beta_{24}\Delta IPI_{24} + \varepsilon_2 \\
&\vdots \\
SR_6 &= \alpha_{61} + \beta_{61}\Delta WSI_{61} + \beta_{62}\Delta RER_{62} + \beta_{63}(i_L - i_S)_{63} + \beta_{64}\Delta IPI_{64} + \varepsilon_6
\end{aligned} \tag{9}$$

Where SR denotes the stock index returns, ΔWSI stands for the world stock index returns, ΔRER represents changes in the real exchange rate, i_L is the long-term domestic interest rate measured by the government bond rate, i_S is the domestic short-term interest rate of the Treasury bill rate to determine the TSIR, ΔIPI is a proxy for income growth as the changes in industrial production index and ε is the disturbance term. The standard assumption is that the disturbance terms should have zero means and satisfy homoscedasticity. In addition, they must be allowed to be correlated across equations, such that:

$$E\left[\varepsilon_i \varepsilon_j^{'} | X_1, X_2, \dots, X_6\right] = \sigma_{ij} I_T \qquad (10)$$

Where I_T is an identity matrix, and the covariance of disturbances of the i^{th} and j^{th} equations, σ_{ij}, is assumed to be constant over all observations. Using the OLS to estimate each equation separately, given these conditions, the estimates of β are unbiased and is consistent possibly not efficient (Kmenta, 1971) because the OLS estimators do not take into account the covariance of the disturbances across equations. Under the OLS approach, the assumptions of homoscedasticity and uncorrelated disturbances across observations within the single equations are not met. The SUR system alternatively follows a two-stage procedure, which is asymptotically equivalent to the generalized least squares (GLS) assumptions and therefore is asymptotically efficient under the assumptions of homoscedastic and serially uncorrelated error terms. The application of the SUR systems can be further extended to an iterative procedure to yield maximum likelihood (ML) estimates under the assumption that the disturbances are drawn from a multivariate normal population (Kmenta & Gilbert, 1968; Oberhofer & Kmenta, 1974). Both the GLS and ML estimators of SUR are derived in this study and these are expected to yield robust standard errors compared to the OLS estimators when dealing with large samples.

As a prerequisite to our estimation using the SUR, a test procedure is further applied following Hunter and Wu (2014) to correct for the likely endogeneity and model misspecification. More specifically, a two-stage least square (2SLS), or instrumental variable (IV) regression approach is applied to eliminate the correlation between endogenous regressors and disturbances. We generated a range of predicted values as instruments derived from optimized autoregressive distributed lagged (ARDL) regressions of the endogenous regressors on other variables. The generated regressors are further evaluated and verified using the Durbin-Wu-Hausman (DWH) tests of endogeneity (Durbin, 1954; Wu, 1973; Hausman, 1978). Several studies have argued that the presence of generated regressors in the test equations would result in biased standard errors (Liang & Zeger, 1986; Souleles, 2004). However, there is still mixed evidence as to whether such corrections are required in testing. We followed a generalization in our estimation to allow for the use of actual data alongside the stacked instrumental variables in order to obtain consistent standard errors leading to calculation of correct cross-sectional residuals by relying on the actual values in the mean equation. Finally, we tested the hypotheses involving cross-equation restriction against the null hypothesis of identical explanatory variables (i.e. $X_i = X_j$). Rejection of the null hypotheses would indicate greater efficiency gains in the use of GLS and ML over the OLS estimators, as is the case in our study.

4. Exchange rate impact on stock markets

In this section, we discuss the empirical results arising from the application of the system of regression Equation (9). The statistics are summarized for monthly and quarterly observations in tables 3 and 4, respectively, providing the summary in three columns: OLS, GLS and ML. We present the obtained statistics: the coefficients, significance level, and the standard errors, followed by the obtained LM test-statistics of residual correlation and Wald test-statistics of cross-equation coefficient equality. It is worth noting that the standard errors for the GLS and ML methods for both frequencies (i.e. monthly and quarterly) are uniformly smaller than those for the OLS. This would indicate that our results are consistent in providing more efficient estimates compared to the OLS. The ML estimators are found to yield even smaller standard errors than those yielded by the two-stage GLS method.

(**Insert Table 3 about here**)

Examining the factor effects, the variable ΔWSI is statistically significant in the determination of all cross-sections of stock index returns using monthly data. It is further clear that the *real exchange rate changes* ΔRER are statistically significant for all countries with the exception of Germany and the USA (with coefficients ranging from 0.192 to 0.529 having t-statistics larger than two units, therefore significant at the usual acceptance level of 0.05). This suggests that changes in exchange rates do significantly influence the stock index returns in the selected countries. In other words, with per unit change (or appreciation) in the value of real exchange rates of the selected countries against the US dollar, the stock index returns tend to increase within the range of 0.192 to 0.529 unit, in the quarterly series. Note that the coefficients have the "−" signs, which would indicate that the ex-ante appreciation of the home-country's currency will lead to higher stock index returns for foreign investors.

As for the TSIR, the evidence of a significant correlation with stock index returns is notable in the case of Sweden, UK the USA. The interest rate differences are found to increase stock index returns by about 0.624 to 2.131 unit (in the case of quarterly data) for every unit of marginal increase in the term-structure of interest rates, which could be the representative for maturity risk.

This relationship also holds in terms of monthly data for Sweden and the USA, by a smaller magnitude, around units of 1.00 once using the GLS and ML estimators. There is further evidence of significant income growth in the determination of country-specific stock index returns. The income growth over quarterly periods are found to affect stock returns of Germany, and Japan. In the case of monthly data, the income growth can only determine the index return behavior of Japan by about 0.123 unit.

(**Insert Table 4 about here**)

The LM and Wald test-statistics are reported in the penultimate panels of the tables 3 and 4. The results indicate presence of significant cross-equation correlation of error terms, and unequal coefficients across the equations. This finding is more reliable in terms of monthly data.

The overall estimation procedure has been evaluated such that the structural parameters are specified based on a range of prior information and the dynamic properties of the structural equations. Accordingly, the components of the cross-country equations in terms of lag distribution of data and serial correlation properties of error terms are partially specified to imply and maintain the structural equation assumptions as in Zellner and Palm (2004). Nevertheless, our two-stage process of estimation followed by the implementation of the system of structural equations leads to some corrections in the model specification, which are mainly restricted to finding and optimizing appropriate lagged level of variables. This would have implications on the magnitude of the LM test statistics suggesting the likely insufficient power of the test to exploit full spatial information[3].

5. Concluding Remarks

This study aims to reveal results from a macro model using monetary and economic theories to verify the existence of significant currency exchange rate impact on stock index returns. The theories guiding this research are; (1) parity theorems, (2) an income effect on stock market prices, and (3) an exchange rate theory, which is mostly tested at the individual stock level with firm-specific factors. Available studies on asset pricing rely heavily on econometric applications that suggest that panel regression is growing in popularity since the 1990s. Simplifying the statistical-test approach through pooled panels has not avoided biased parameter estimation problems due to cross-sectional dependence and the lack of controls for heterogeneity and endogeneity issues.

Hence, our decision to apply a reliable method as explained in the methodology section (Hunter and Wu, 2014) in this study as well as our procedures to correct deficiencies in the adopted approaches, is appropriate for our data set. Importantly, this research is guided by the theoretical intuition found in the ICAPM Solnik (1974) and Ross (1976), which are applied in this study in a slightly different manner at the macro level with macro variables. We deliberately maintained consistency with the international asset pricing framework and the arbitrage pricing theory approach as in most cited applied studies. We did not follow the direction of Chen, Roll, and Ross (1986) as we were more interested in the impact of exchange rate on stock index returns, a result which was not found in the aforementioned study.

The seven countries included in this study adhered to a free-floating exchange rate management regime. The limited number of currencies of these countries enabled us to truly observe market-determined exchange rate effects. All the stock markets of the sampled countries are also known to be Fama-efficient.

The results are interesting: Income growth is shown to exert strong effect on stock index returns. Likewise, theory-suggested parity factors are also found to significantly influence stock index returns, while changes in exchange rates significantly affect stock index returns in the sampled countries. Thus, the intuition provided by the international asset pricing models and the monetary economics parity theorems helped to produce theory-consistent findings of a statistically significant exchange rate effects on stock index returns. Continued research with other countries not included in this study is needed to allow these findings to be generalized to other major economies with different currency regimes.

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Table 1: Variable Specification, Definitions and Expected Results

Table is a summary description of the variables along with their definitions and expected signs from theories. The variables are calculated in logarithm change except for term structure of interest rate.

No.	Variables	Definition	Expected Sign
1.	SR	Log change of Stock Index Prices over time	Dependent Variable
2.	ΔWSI	Log change of MSCI World Stock Index Prices over time	+
3.	ΔRER	Log change of Bilateral Real Exchange Rate of each country over time	−
4.	TSIR	Long-term minus Short-term interest rate	+
5.	ΔIPI	Log change of Industrial Production over time	+

Table 2: Descriptive Statistics of Pooled Data, 1999-2016

This table reports the descriptive statistics for the variables. The mean, median, standard deviation, skewness and kurtosis are reported for each variable to reveal normality of distribution for respective variables.

Variables	Mean	Median	Std. Dev.	Skewness	Kurtosis	Observation
Monthly Observations						
SR	0.2475	1.0744	6.4181	-1.1700	6.7069	1236
ΔWSI	0.1425	1.0348	5.1903	-1.4803	10.9115	1236
ΔRER	0.0449	0.0265	2.7999	0.1310	4.5024	1236
TSIR	1.1685	1.1801	1.0144	0.0055	2.8178	1236
ΔIPI	0.1037	0.1164	7.8843	-0.5199	5.7219	1236
Quarterly Observations						
SR	0.9193	2.8316	10.8925	-0.8542	5.0479	476
ΔWSI	0.4107	1.7330	8.2491	-1.5637	7.3391	476
ΔRER	-0.0551	-0.2139	5.2790	0.1798	4.3081	476
TSIR	1.0467	1.0647	1.0219	0.0669	2.7157	476
ΔIPI	0.1742	0.4157	2.1780	-3.4164	30.8054	476

Table 3: Results from Seeming Unrelated Regression (Quarterly Observations)

This table reports estimates of systems of seemingly unrelated regressions using quarterly data, along with the significance level and standard errors. The results are reported for seven countries. The stock index returns are found to be statistically affected by exchange rates for Australia, Canada, Japan, Sweden and the UK.

	Estimation Procedure					
	OLS		**GLS**		**MLE**	
	Coefficient	**S.E.**	**Coefficient**	**S.E.**	**Coefficient**	**S.E.**
$\beta_{\Delta WSI1}$	0.909***	(0.084)	0.678***	(0.084)	0.712***	(0.089)
$\beta_{\Delta WSI2}$	-0.290***	(0.118)	0.670***	(0.108)	0.696***	(0.106)
$\beta_{\Delta WSI3}$	-0.007	(0.604)	0.989***	(0.141)	0.980***	(0.142)
$\beta_{\Delta WSI4}$	0.343***	(0.421)	0.773***	(0.120)	0.766***	(0.120)
$\beta_{\Delta WSI5}$	0.770	(0.164)	0.861***	(0.149)	0.858***	(0.150)
$\beta_{\Delta WSI6}$	-1.132	(0.359)	0.641***	(0.103)	0.655***	(0.101)
$\beta_{\Delta WSI7}$	0.269**	(0.394)	0.894***	(0.185)	0.889***	(0.184)
$\beta_{\Delta RER1}$	-0.871**	(0.497)	-0.0761	(0.081)	-0.192***	(0.069)
$\beta_{\Delta RER2}$	0.360***	(0.584)	-0.451***	(0.174)	-0.349**	(0.160)
$\beta_{\Delta RER3}$	0.001	(0.408)	-0.136	(0.145)	-0.1740	(0.140)
$\beta_{\Delta RER4}$	-3.195***	(1.222)	-0.514***	(0.142)	-0.529***	(0.138)
$\beta_{\Delta RER5}$	1.247	(0.611)	-0.356***	(0.121)	-0.391***	(0.113)
$\beta_{\Delta RER6}$	0.995	(0.132)	-0.196*	(0.117)	-0.302***	(0.099)
$\beta_{\Delta RER7}$	1.446	(0.221)	-0.0688	(0.205)	-0.0658	(0.194)
β_{TSIR1}	-0.145	(0.368)	0.568	(0.598)	0.825	(0.527)
β_{TSIR2}	0.298	(0.284)	0.530	(0.568)	0.552	(0.524)
β_{TSIR3}	0.282***	(0.537)	0.374	(0.978)	0.377	(0.952)
β_{TSIR4}	0.000	(0.335)	-1.388	(1.915)	-1.070	(1.856)
β_{TSIR5}	1.415	(0.963)	2.082***	(0.772)	2.131***	(0.728)
β_{TSIR6}	0.261	(0.676)	0.421	(0.343)	0.642**	(0.304)
β_{TSIR7}	-0.392	(0.444)	1.263**	(0.604)	1.223**	(0.578)
$\beta_{\Delta IPI1}$	0.000	(0.294)	0.312	(0.399)	0.283	(0.334)
$\beta_{\Delta IPI2}$	0.717*	(0.654)	0.364	(0.316)	0.392	(0.291)
$\beta_{\Delta IPI3}$	1.261**	(1.081)	0.488	(0.313)	0.602**	(0.304)
$\beta_{\Delta IPI4}$	1.543	(0.646)	0.244	(0.220)	0.260	(0.215)
$\beta_{\Delta IPI5}$	0.015	(0.430)	-0.168	(0.263)	-0.0834	(0.249)
$\beta_{\Delta IPI6}$	2.268	(2.846)	-0.0380	(0.439)	0.194	(0.371)
$\beta_{\Delta IPI7}$	-1.222	(2.579)	-0.150	(0.649)	-0.0500	(0.621)
LM Test-Statistics of Error Correlation (χ^2)	318.40***		558.792***		562.246***	
Wald Test of Coefficient Equality (χ^2):						
$H_0 = \beta_{\Delta WSI1}=\beta_{\Delta WSI2}=\beta_{\Delta WSI3}=\beta_{\Delta WSI4}=\beta_{\Delta WSI5}=\beta_{\Delta WSI6}$						13.98***
$H_0 = \beta_{\Delta RER1}=\beta_{\Delta RER2}=\beta_{\Delta RER3}=\beta_{\Delta RER4}=\beta_{\Delta RER5}=\beta_{\Delta RER6}$						25.91***
$H_0 = \beta_{TSIR1}=\beta_{TSIR2}=\beta_{TSIR3}=\beta_{TSIR4}=\beta_{TSIR5}=\beta_{TSIR6}$						6.80
$H_0 = \beta_{\Delta IPI1}=\beta_{\Delta IPI2}=\beta_{\Delta IPI3}=\beta_{\Delta IPI4}=\beta_{\Delta IPI5}=\beta_{\Delta IPI6}$						14.36***

Note: Country codes are 1: Australia, 2: Canada, 3: Germany, 4: Japan, 5: Sweden, 6: UK, and 7: USA

Table 4: Results from Seeming Unrelated Regression (Monthly Observations)

This table reports estimates of systems of seemingly unrelated regressions using monthly data, along with the significance level and standard errors. The results are reported for six countries. The stock index returns of Canada, Japan and UK are found to be statistically affected by the exchange rates.

	Estimation Procedure					
	OLS		**GLS**		**MLE**	
	Coefficient	**S.E.**	**Coefficient**	**S.E.**	**Coefficient**	**S.E.**
$\beta_{\Delta WSI1}$	0.544***	(0.059)	0.434***	(0.056)	0.436***	(0.056)
$\beta_{\Delta WSI2}$	1.048***	(0.099)	0.674***	(0.084)	0.674***	(0.084)
$\beta_{\Delta WSI3}$	1.217***	(0.063)	0.655***	(0.071)	0.656***	(0.071)
$\beta_{\Delta WSI4}$	0.854***	(0.102)	0.533***	(0.081)	0.534***	(0.082)
$\beta_{\Delta WSI5}$	0.789***	(0.084)	0.405***	(0.068)	0.406***	(0.068)
$\beta_{\Delta WSI6}$	1.536***	(0.117)	0.624***	(0.091)	0.624***	(0.091)
$\beta_{\Delta RER1}$	-1.841***	(0.136)	-0.452***	(0.107)	-0.444***	(0.105)
$\beta_{\Delta RER2}$	-0.413	(0.296)	-0.047	(0.088)	-0.0496	(0.086)
$\beta_{\Delta RER3}$	-2.284***	(0.193)	-0.411***	(0.106)	-0.401***	(0.106)
$\beta_{\Delta RER4}$	-1.119***	(0.272)	-0.062	(0.078)	-0.0685	(0.076)
$\beta_{\Delta RER5}$	0.385***	(0.145)	0.261**	(0.120)	0.262**	(0.118)
$\beta_{\Delta RER6}$	-0.735***	(0.180)	-0.261	(0.165)	-0.259	(0.163)
β_{TSIR1}	-0.013	(0.109)	0.278	(0.196)	0.280	(0.191)
β_{TSIR2}	0.102	(0.308)	0.292	(0.303)	0.289	(0.297)
β_{TSIR3}	0.440**	(0.184)	-0.837	(0.761)	-0.858	(0.757)
β_{TSIR4}	0.238	(0.240)	1.018***	(0.300)	1.011***	(0.289)
β_{TSIR5}	-0.018	(0.213)	0.106	(0.153)	0.109	(0.150)
β_{TSIR6}	0.217	(0.187)	0.591***	(0.208)	0.596***	(0.205)
$\beta_{\Delta IPI1}$	0.001	(0.038)	-0.0296	(0.041)	-0.0323	(0.041)
$\beta_{\Delta IPI2}$	-0.042	(0.046)	-0.0288	(0.025)	-0.0274	(0.025)
$\beta_{\Delta IPI3}$	0.167***	(0.037)	0.120***	(0.037)	0.123***	(0.037)
$\beta_{\Delta IPI4}$	0.015	(0.030)	-0.0002	(0.017)	-0.0006	(0.016)
$\beta_{\Delta IPI5}$	0.009	(0.052)	-0.0206	(0.032)	-0.0181	(0.032)
$\beta_{\Delta IPI6}$	-0.044	(0.201)	-0.0588	(0.135)	-0.0551	(0.133)
LM Test-Statistics of Error Correlation (χ^2)	952.88***		1457.31***		1458.78***	

Wald Test of Coefficient Equality (χ^2):	
$H_0 = \beta_{\Delta WSI1}=\beta_{\Delta WSI2}=\beta_{\Delta WSI3}=\beta_{\Delta WSI4}=\beta_{\Delta WSI5}=\beta_{\Delta WSI6}$	43.73***
$H_0 = \beta_{\Delta RER1}=\beta_{\Delta RER2}=\beta_{\Delta RER3}=\beta_{\Delta RER4}=\beta_{\Delta RER5}=\beta_{\Delta RER6}$	39.76***
$H_0 = \beta_{TSIR1}=\beta_{TSIR2}=\beta_{TSIR3}=\beta_{TSIR4}=\beta_{TSIR5}=\beta_{TSIR6}$	14.14**
$H_0 = \beta_{\Delta IPI1}=\beta_{\Delta IPI2}=\beta_{\Delta IPI3}=\beta_{\Delta IPI4}=\beta_{\Delta IPI5}=\beta_{\Delta IPI6}$	14.67**

Note: Country codes are 1: Canada, 2: Germany, 3: Japan, 4: Sweden, 5: UK, 6: USA.

Notes

1. A number of theories and models have been developed since the 1960s, for *individual* asset valuation purposes: Williams (1938) for bond valuation and Harvey, Liu, and Zhu (2016), provided a review on this perspective. Apart from an economy-wide impact, a segmented market impact also exists in the individual stock impact. Ariff and Khan (1998) considered each capital market as consisting of separately priced asset clusters Accordingly, it is possible to model pricing behaviour away from the embedded practice of analysing individual stocks and towards macro-level markets (the latter was attempted by King (1966), who showed that 52 per cent of share price changes are due to macroeconomic factors). Studies on aggregate level are few: De Santis and Gerard (1998) and Dumas and Solnik (1995).

[2] In this revised version, the coefficients reported for all variables are from rechecking as pointed out during the review process. This variable was one of them that had a changed size.

[3] We followed a generalization of the model to estimate the system of equations so that the standard errors of each equation are made to rely on the actual data by entering the mean equation while any generated regressor appear only as instruments from the first step estimation. This application led to significant improvements in our estimation by deriving standard errors which are robust to some kinds of misspecifications.