**Morley, B., 2009. Exchange Rates and Stock Prices in the Long Run and Short Run. Working Paper. Bath, UK: Department of Economics, University of Bath, (5/09).**

Exchange Rates and Stock Prices in the Long Run and Short Run

Bruce Morley

No. 5/09

# BATH ECONOMICS RESEARCH PAPERS

Department of Economics and International Development

UNIVERSITY OF BATH

# Exchange Rates and Stock Prices in the Long and Short Run

## by

**B. Morley**

**Abstract:**

Using the ARDL bounds testing approach to cointegration this paper provides evidence of a stable long run relationship between the exchange rate and stock prices for the UK, Japan and Swiss currencies with respect to the US dollar. The resultant error correction models suggest a positive relationship between stock prices and the exchange rate, which in an out-of-sample forecast outperforms the random walk. We compare these results with a similar model incorporating interest rates, suggested by Solnik (1987), however this does not in general improve the results.

**Keywords**: Exchange Rates, Stock Prices, Forecast, Cointegration.

**JEL Classification**: F30, F40

**Contact Details:** Department of Economics and International Development, University of Bath, Claverton Down, Bath, BA2 7AY. Email: B.Morley@bath.ac.uk

## I Introduction

Over recent years there have been a number of occasions when movements in national stock markets have corresponded with changes in the respective exchange rates. This was particularly evident during the East Asian financial crisis, where a collapse in the exchange rates was preceded by falls in the respective stock markets (Granger *et* al. (2000). Increasingly foreign exchange movements are determined by international investors rather than the more traditional reasons based on consumer demand for foreign goods. This phenomenon has been facilitated by the increasing flows of capital between international financial markets following the removal of capital controls and the deregulation of financial markets during the 1970s and 1980s. The aim of this paper is to add to the recent literature by determining the nature of any direct relationship between the exchange rate and stock prices in the long-run, by using the Autoregressive Distributed Lag (ARDL) approach to cointegration and the short-run using the corresponding error correction model (ECM) for out-of-sample forecasting.

There have been a variety of studies examining the relationship between stock prices and exchange rates over recent years, some of which have concentrated on a direct relationship between stock prices and exchange rates, whilst others have analysed the relationship within the context of a specific model. One of the first attempts to model and test the relationship between exchange rates and stock prices was Solnik (1987), where he suggested that stock prices reflect expectations about future economic activity and therefore affect exchange rates. He found that the nature of the relationship varied across countries as well as depending on whether capital controls existed. More recent contributions include Ehrmann *et al*. (2005) and Hau and Rey (2006), who have developed a model relating stock prices to exchange rates in an "uncovered equity parity" based model.

Studies using the Granger causality test have also been used extensively to test the direction of causality between these variables. Bahmani-Oskooee and Sohrabian (1992) show that there is bi-causality whilst other tests suggest that causality is predominantly from stock prices to the exchange rate (Granger *et al.* 2000), possibly due to the higher number of market participants. A further category of research explores the relationship between stock prices and exchange rates in the context of a conventional exchange rate model. Smith (1992) develops a model based on the portfolio balance approach and Morley (2007) incorporates stock prices into the monetary model. In common with other studies, both approaches show that stock prices have a significant effect on the exchange rate. A final related area of research emphasises international equity flows and their effects on the respective capital markets. These studies comprise mainly empirical studies such as Bekaert and Harvey (2000) and Richards (2005) and more theoretical studies, such as Griffin *et al*. (2004).

Over the recent floating exchange rate era, following the demise of the Bretton-Woods system, the evidence on the predictability of the exchange rate using conventional models has been mixed. The forecasting performance of these models depends on the techniques, the economic models and countries tested, as well as the time period over which the model is estimated and forecast. One of the most devastating results was the Meese and Rogoff (1983) finding that standard exchange rate models failed to outperform the random walk. However recent studies by [1]Clarida *et al*. (2002) as well as Rapach and Wohar (2002) have been more successful, both producing models which outperformed the random walk in out-of-sample forecasts.

Following the introduction and review of the literature, there is a brief description of the model and the Autoregressive Distributed Lag (ARDL) methodology. The data and results are then discussed and the final section concludes and assesses any policy implications of the results.

## II Model and Methodology

Exchange rates and stock prices can be directly modeled in a conventional asset parity condition, in which the return on equities is used rather than the usual return on bonds. The basis for such a relationship stems from the efficient market version of PPP (Roll, 1979)[2]. The main difference is that instead of using a commodity price index, a stock market index is used. Assuming the model consists of country A and country B, the model implies that the expected real return (*r*) from speculating in commodity index (*i*) in country A and index (*j*) for country B is:

---

[1] The paper by Clarida *et al*. (2003) incorporates non-linear adjustment into the model, however other studies including Meese and Rose (1991) have suggested that non-linearities are relatively unimportant for exchange rate models. As a result we have chosen to concentrate on a linear model. For a general discussion on the problems associated with using macroeconomic fundamentals to explain short-term exchange rate movements, see Taylor (1995).

[2] See Roll (1979) for a complete explanation of this relationship. The empirical model is also based on Roll's Efficient Markets version of PPP model, with the appropriate rearrangement following the assumption of markets being efficient. Roll demonstrates this assumption holds in his study.

$$E(r(i,j,t) \mid Q_{t-1}) = 0 \quad (1)$$

Where $Q$ is the information set at time (t-1). If the speculator resides in country B and the price index is $j$, then Roll (1979) shows that the real return from foreign intertemporal speculation in an index of goods $i$ can be expressed as:

$$\begin{aligned} &E\{\log(e(B,A,t)) \setminus Q_{t-1}\} \\ &\quad - \log(e(B,A,t-1)) = E\{I(j,B,t \setminus Q_{t-1}) - I(i,A,t \setminus Q_{t-1})\} \end{aligned} \quad (2)$$

This suggests that the expected change in the exchange rate *e* (Country *B* per Country *A*'s currency) is equal to the expected change in an index of prices *I* (inflation rate over the time period *t*-1 to *t*) of country *B*'s goods *j*, minus the expected change in an index of prices of country *A*'s goods *i*. Given that the expected change in the price index can be viewed as a capital gain or return and assuming markets are efficient, this can be simplified to:

$$E(\Delta e_t) = \alpha_0 + \alpha_1 (r_{S,t} - r^*_{S,t}) + \varepsilon_t \quad (3)$$

where $r_{S,t}$ is the return on a stock price index, * denotes a foreign variable (US variable) and $\varepsilon_t$ is a white noise error term. In equilibrium as with Roll (1979), $e_t = \beta(p_{S,t} - p^*_{S,t}) + u_t$, where $p_{S,t}$ is the stock price index (main market index) and $u_t$ is the error term(all variables in logarithms). Equation (3) can be viewed as an asset parity relationship, where the return (capital gain) on domestic equities exceeds the return on foreign equities to compensate for the expected depreciation of the currency.

The second related model is based on Solnik's (1987) model, where we use the nominal bilateral exchange rate, to ensure comparability with the first model. The basic model suggested by Solnik (1987) is:

$$\Delta e_t = \beta_0 + \beta_1 \Delta(s - s^*)_{t-i} + \beta_2 \Delta(i - i^*)_{t-i} + u_t \qquad (4)$$

Where it is assumed $\beta_1, \beta_2 > 0$ and where the variables are as defined previously, with the addition of $i$ the nominal interest rate and $s$ the real stock price market index (In differenced form it represents the return on the market in terms of the capital gain). Solnik (1987) argues that both coefficients should be positive, however the theory underlying this argument differs slightly to the approach adopted by Roll (1979). Solnik argues that stock prices reflect economic activity and as a result there is a positive relationship between economic activity and the exchange rate. He suggests that in many ways stock prices are better than the traditional macroeconomic variables as they incorporate expectations about future economic events. The model is based in a rational expectations framework, where stock prices immediately reflect the effects of a shock to the future economy. The same argument can be applied to both exchange rates and interest rates, which can be equally regarded as assets and future information is immediately discounted in their current value. The interest rate is incorporated into the model to reflect changes in the monetary sector, whilst stock prices reflect changes in the future level of economic activity.

The empirical model used to test the short-run relationship between stock prices and exchange rates and to conduct out-of-sample forecasting is an error correction model, which is based on the above two models, with the addition of error correction terms:

$$\Delta e_t = \alpha_0 + \alpha_1 \Delta(s - s^*)_{t-i} + \alpha_2 \Delta e_{t-i} + \tau ect_{t-1} + u_t \qquad (5)$$

Where the variables are as defined previously, with τ being the coefficient on the error correction term (*ect*) produced by the long-run cointegrating relationship between the level exchange rate and stock price differential. The lag structure of the ECM is determined by the Schwarz-Bayesian criteria. As with Roll's (1979) finding, we would not expect an extensive lag structure as we expect asset markets to adjust quickly. For the tests on the Solnik (1987) model, the interest rate is added to the above model, including the error correction term.

A feature of the tests on the relationship between stock prices and exchange rates is the ambiguity over whether the relationship is positive or negative[3]. Although according to both the approach of Roll (1979) and Solnik (1987) it should be positive. Other studies such as Hau and Rey (2006) using a slightly different approach to that adopted here and Bahmani-Oskooee and Sohrabian (1992) argue that it could be negative. Bahmani-Oskooee and Sohrabian (1992) suggest the negative relationship could occur if an exogenous rise in domestic stock prices causes a positive wealth effect which increases the demand for money. This in turn leads to a rise in the

[3] This reflects the literature on the relationship between stock prices and macroeconomic variables in general. For instance Friedman (1988) suggests theoretical reasons for the relationship between the money supply and stock prices being either positive or negative.

domestic interest rate, producing a capital inflow and an appreciation of the exchange rate.

The ARDL approach to cointegration (See Pesaran *et al.*, 2001) requires estimating the conditional error correction version of the ARDL model for the exchange rate and stock price differential:

$$\Delta e_t = \lambda_0 + \sum_{i=1}^{p} \lambda_1 \Delta e_{t-i} + \sum_{i=0}^{p} \lambda_2 \Delta ds_{t-i} + \delta_1 e_{t-1} + \delta_2 ds_{t-1} + u_t \qquad (6)$$

Where *ds is* the difference between the domestic and foreign real stock price. We then 'bounds test' for the presence of a long-run relationship between exchange rates and stock prices using two separate statistics. The first involves an F-test on the joint null hypothesis that the coefficients on the level variables are jointly equal to zero (See Pesaran *et al.*, 2001). The second is a t-test on the lagged level dependent variable. The statistics have a non-standard distribution and depend on whether the variables are individually I(0) or I(1).

Instead of the conventional critical values, this test uses two asymptotic critical value bounds, depending on whether the variables are I(0) or I(1) or a mixture of both. If the test statistic exceeds their respective upper critical values, then there is evidence of a long-run relationship, if below we cannot reject the null hypothesis of no cointegration and if it lies between the bounds, inference is inconclusive. If the test statistic exceeds its upper bound, then we can reject the null of no cointegration regardless of the order of integration of the variables. The error correction model is estimated by the ARDL approach to cointegration, where the conditional ECM in (6) is estimated using OLS and then the Schwarz-Bayesian criteria is used to select the optimal lag structure for the ARDL specification of the short-run dynamics.

**III Data and Results**

The models are estimated using monthly data from January 1985 to April 2005, with a further 12 months for out of sample forecasting. January 1985 [4]is chosen as the start date, as the process of removing capital controls in the countries tested was not fully completed until 1984. The existence of capital controls has an important effect on the relationship between exchange rates and stock prices as noted by Solnik (1987) and when a longer span of data was used, there was little evidence of a long-run relationship. The data is from the *International Financial Statistics* produced by the *IMF*.

The exchange rates available for testing are limited by the recent introduction of the European Single currency[5] in 1999, we have therefore used the Canadian, Japanese,

---

[4] In all cases the Schwarz-Bayesian criteria indicated a parsimonious model was sufficient, with only a limited lag structure required, never exceeding 3 lags in any model, which is not surprising given the speed of adjustment in asset markets. The models were all estimated from 1985 month 5 to allow the differenced variables and lags to be computed and ensure all models are estimated over the same period of time. The Solnik (1979) study uses 1979 as the beginning of the era for capital mobility, however although the USA and other countries had completed lifting their capital controls by then, Japan had still to remove many of its controls, which were gradually lifted during the early 1980s.

[5] In the study by Ehrmann *et al*. (2005) they used the US dollar/DM rate before 1999 and US dollar/Euro rate after 1999, using the Euro/DM conversion rate to produce a complete series. However as we are forecasting with this method, this would not be practicable in this study. Alternatively we

Swiss and UK currencies against the US dollar. In addition these countries also have reasonably well established International stock markets. The exchange rate is the individual currency per US dollar, the price index the consumer price index and the stock price measures are the main market index as supplied by the *IFS*, except Switzerland, which was supplied by the OECD, as the *IFS* index was not available. The interest rate is the 3 month treasury bill rate. Other indexes were also tried such as an index incorporating dividend payouts and the capital gain, but the results were not as good.

The appropriate lag length in the ARDL test for cointegration was determined using the Schwarz-Bayesian Information criteria, whilst ensuring that there was no evidence of serial correlation present. As noted by Pesaran *et. al.* (2001), the ARDL approach is very sensitive to the presence of serial correlation. The results in Table 1 indicate a stable[6] long-run relationship between exchange rates and stock prices for the UK, Japan and Switzerland, as both the F and T statistics exceed their respective upper

---

could have used high frequency data and test the relationship post-Euro, however such a short data span is not appropriate for cointegration and would be restrictive in terms of the price and interest rate data.

[6] Testing the data to determine the individual variables order of integration is not necessary with the ARDL approach, when the test statistic exceeds the upper critical value bounds, as in this case. However when tested using the Augmented Dickey-Fuller test, the variables were either I(1) or borderline I(1)/I(0), which facilitated the use of the ARDL approach rather than one of the many other tests. The specific ARDL results from which the ECMs are generated, are also not reported as they closely follow the ECM results, but are available from the author on request

bounds. However the result for the Canadian exchange rate indicates that there is no long-run relationship between exchange rates and stock prices. This may simply reflect the relatively lesser importance of the Canadian stock market internationally, particularly compared to the other markets included in the tests, or that the Canadian exchange rate has simply been more difficult to model relative to the others over recent years. For instance using a monetary model of the exchange rate Rapach and Wohar, (2002) among others fail to produce results which accord with the monetary model theory unlike their tests on other countries, whilst Chen and Rogoff (2003) suggest the importance of the commodity markets in Canada affect their exchange rate. The tests for a long-run relationship between the exchange rate, stock prices and interest rates indicate that there is evidence of cointegration for all four countries, although the result for Canada is only significant at the 10% level.

Table 2 contains the error correction models for the three currencies using the exchange rate and stock price model, where there was evidence of cointegration. The error correction models are based on the appropriate ARDL model, again this suggested a parsimonious model with only a limited lag structure required. To ensure that the Swiss model did not suffer from serial correlation, further lagged exchange rate variables was added until the problem was solved.

The UK ECM produces a positively signed stock price differential as expected, suggesting the alternative asset parity version is appropriate in this case. It is also the same result as Solnik in his post-1979 results, when most capital controls had been removed, a similar era to the one tested here. This suggests a 1% increase in the stock price differential produces a 0.2% depreciation of the exchange rate. The error correction term (ECT) is highly significant, although the coefficient indicates about 7% of any adjustment back to equilibrium, following a disturbance would occur within one month. The highly significant t-statistic on the ECT further supports the evidence of a long-run relationship between exchange rates and stock prices.

Both the Japanese and Swiss ECMs are very similar, with both producing a positively signed stock price differential, although the Japanese differential is not significant. The error correction terms are both highly significant, again supporting the evidence of cointegration, with identical coefficients, suggesting about 5% of any disturbance is corrected within a month. The ECMs are well specified and appear to show little evidence of any omitted variable or functional form problems, despite the parsimonious nature of the models.

The ECMs for the stock price and interest rate models are contained in Table 3 this time including the Canadian results. The results for the UK, Japan and Switzerland are again very similar, however the Canadian result differs in a number of respects. For the first three countries the stock price is again positively signed and the interest rate is negatively signed, all being significant except Japan again. The Canadian relationship contrasts with these results, as the stock price differential is negative whereas the interest rate differential is positive, both being significant. All four tests produce highly significant error correction terms, with similar speeds of adjustment.

A standard measure of any exchange rate is whether it outperforms a random walk in out of sample forecasting. The root mean square of the error (RMSE) statistic, presented in Table 4, was then compared between the models, over a 3 month time horizon and longer time horizons up to 12 months. In addition we use the Diebold

Mariano test statistic[7] to determine if the forecast is significant. In the short-term, the models easily beat the random walk, with ratios of 0.732 for the UK, 0.814 for Japan and 0.796 for Switzerland between the RMSEs of the two models. However the difference declines over the longer horizons, as might be expected with asset markets. The Diebold-Mariano statistic indicates that the forecast are significant for all three countries.

The forecasts for the second model are in general not as good as the exchange rate and stock price model, with the RMSEs lying between the random walk and the first model. The RMSE for the Canadian model is above that of the random walk suggesting that the model does not forecast well, another difference to the other three countries. Again this suggests different currencies need different models depending on the strength of their financial markets among other factors. Other forecasts were also examined from other models, including the stock price model with a richer lag structure with respect to the stock price variables, however these did not perform as well suggesting much of the ability to forecast was produced by the error correction term.

## IV Conclusion

Using the ARDL approach to cointegration, there is evidence of a long-run relationship between exchange rates and stock prices, with the exception of the

[7] This test required the use of the Newey-West adjusted variance-covaraince matrix, with Parzen weights, in order to overcome the problems of autocorrelation. All models were estimated using Microfit version 4.1

Canadian/ US exchange rate. In the short-run, they produce a well specified error correction model, in which the exchange rate and stock price differential are positively related. The alternative approach suggested by Solnik (1987), in which interest rates are incorporated into the model, also provides evidence of a long-run relationship, including the Canadian currency. The first model outperforms the random walk in out-of-sample forecasts as does the alternative model incorporating the interest rate. However this latter model fails to beat a random walk using the Canadian currency.

The results also indicate that this relationship may not be appropriate for all currencies, with evidence that the relationship is fundamentally different for Canada relative to the other three currencies. This may be due to the nature of the financial markets in these countries, with Canadian markets not attracting the same amount of international capital as the other three. Unfortunately due to the recent introduction of the Euro, we were unable to conduct these tests on European currencies. Given the different nature of their financial systems relative to the UK and USA, we would expect a different result to that obtained for the UK, Japan and Switzerland.

As with similar models, there is evidence that to prevent mis-specification and improve forecasting performance, stock prices could be incorporated into models of the exchange rate. They might possibly be incorporated as an alternative to the standard asset parity relationship or into monetary based models through a Friedman money demand function. However this will only apply to those countries with internationally important equity markets, it may be that particularly in the Euro zone countries, where equity markets are less important relative to the banking sector, other models are more appropriate. This suggests further research could involve models which incorporate measures of banking or corporate bond market activity.

## References

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

Bekaert, G. and C. Harvey, 2000, “Foreign Speculators and Emerging Equity Markets,” *Journal of Finance*, 55, 565-613.

Chen, Y. and K. Rogoff, 2003, “Commodity Currencies,” *Journal of International Economics*, 60, 133-160

Clarida, R., L. Sarno, M. Taylor and G. Valente, 2003, “The Out-of-Sample Success of Term Structure Models as Exchange Rate Predictors: A Step Beyond,” *Journal of International Economics*, 60, 61-83.

Ehrmann, M., M. Fratzscher and R. Rigobon, 2005, “Stocks, Bonds, Money Markets and Exchange Rates: Measuring International Financial Transmission,” *NBER Working Paper 11166.*

Friedman, M., 1988, “Money and Stock Prices,” *Journal of Political Economy*, 96, 221-45.

Granger, C.W.J., Huang Bwo-Nung and Chin-Wei Yang, 2000, "A Bivariate Causality Between Stock Prices and Exchange Rates: Evidence from Recent Asian Flu," *The Quarterly Review of Economics and Finance*, 40, 337-354.

Griffin, J.M. , F. Nardari and R.M. Stulz, 2004, "Are Daily Cross-Border Equity Flows: Pushed or Pulled?" *Review of Economics and Statistic*, 86, 641-657.

Hau, H. and H. Rey, 2006, "Exchange Rates, Equity Prices and Capital Flows," *The Review of Financial Studies*,19, 273-317.

Meese, R. and K. Rogoff, 1983, "Empirical Exchange Rate Models of the Seventies: do they Fit out of Sample?" *Journal of International Economics*, 14, 3-24.

Meese, R. and A. Rose, 1991, "An empirical assessment of non-linearities in models of exchange rate determination" *Review of Economic Studies*, 58, 603-619.

Morley, B., 2007, "The Monetary Model of the Exchange Rate and Equities: An ARDL Bounds Testing Approach," *Applied Financial Economics,* 17, 391-397.

Pesaran, M.H., Y. Shin and R.J. Smith, 2001, "Bounds Testing Approaches to the Analysis of Level Relationships," *Journal of Applied Econometrics*, 16, 289-326.

Rapach, D. and M. Wohar, 2002, "Testing the Monetary Model of Exchange Rate Determination: New Evidence from a Century of Data," *Journal of International Economics*, 58, 359-85.

Richards, A., 2005, "Big Fish in Small Ponds: The Trading Behavior and Price Impact of Foreign Investors in Asian Emerging Equity Markets" *Journal of Financial and Quantitative Analysis,* 40, 1-27.

Roll, R., 1979, "Violations of Purchasing Power Parity and their Implications for Efficient International Commodity Markets," in M. Sarnat and G. Szego (eds), *International Finance and Trade*, 1, Cambridge, Mass, Ballinger.

Smith, C., 1992, "Stock Markets and the Exchange Rate: A Multi-Country Approach," *Journal of Macroeconomics*, 14, 607-629

Solnik, B., 1987, "Using Financial Prices to Test Exchange Rate Models: A Note," *Journal of Finance*, 42, 141-49.

Taylor, M.P., 1995, "The Economics of Exchange Rates," *Journal of Economic Literature*, 33, 13-40

**Table 1 Test for Cointegration**

| | Stock Prices | | Stock Prices and Interest Rates | |
|---|---|---|---|---|
| | F-test | t-test | F-test | t-test |
| Δuk*e* | 5.887* | -3.389* | 5.039* | -3.831* |
| Δjpe | 7.818* | -3.841* | 6.774* | -3.609* |
| Δswe | 8.079* | -2.911** | 6.846* | -2.131 |
| Δcne | 2.130 | -1.750 | 4.562** | -3.211** |

Notes: In the first row Δ*e* is the dependent variable for the UK (uk), Japan (jp), Switzerland (sw) and Canada (cn). The upper limit of the critical value for the F-test statistic for the stock price model (All I(1) variables) is 5.73 (4.78)for the t-test statistic is –3.22 (-2.91) at the 5% (10%) significance levels. For the stock price and interest rate model the F-test critical value is 4.85 (4.14) and the t-test value is -3.53 (-3.21) at the 5% (10%) significance levels. T-statistics are in parentheses, * (**) indicates significance at the 5% (10%) level.

**Table 2. Error Correction Models for the Stock price model**

| Country | *Δuke* | *Δjpe* | *Δswe* |
|---|---|---|---|
| Constant | -0.033** (3.089) | 0.232** (3.881) | 0.016** (2.434) |
| Ect(-1) | -0.069** (3.226) | -0.049** (3.904) | -0.049** (2.998) |
| *Δ*ds | 0.179** (2.948) | 0.003 (0.787) | 0.223** (3.874) |
| *Δe*(-1) | | | 0.081 (1.307) |
| R- Bar-squared | 0.063 | 0.057 | 0.118 |
| DW | 1.799 | 1.875 | 1.967 |
| LM(12) | 1.424 | 1.726 | 1.792 |
| Reset(1) | 0.000 | 0.053 | 0.203 |

Notes: Ect is the error correction term, DW is the Durbin-Watson statistic, LM(12) is the Lagrange Multiplier test for $12^{th}$ order autocorrelation, Reset is the test for functional form, critical values F(1, 253) is 3.92 and F(12,242) is 1.83 (5%). A* indicates significance at the 5% level, ** at the 1% level of significance

**Table 3. Error Correction Models for the Stock Price and Interest Rate Model**

| Country | *Δuke* | *Δjpe* | *Δswe* | *Δcne* |
|---|---|---|---|---|
| Constant | -0.039**<br>(3.561) | 0.201**<br>(3.209) | 0.007<br>(1.055) | 0.017**<br>(3.511) |
| Ect(-1) | -0.090**<br>(3.849) | -0.044**<br>(3.381) | -0.038**<br>(2.263) | -0.045**<br>(3.389) |
| *Δ*ds | 0.178**<br>(2.957) | 0.005<br>(1.295) | 0.202**<br>(3.522) | -0.094**<br>(3.660) |
| *Δ*di | -0.003*<br>(2.149) | -0.002<br>(1.607) | -0.003*<br>(2.639) | 0.008**<br>(3.801) |
| *Δe*(-1) | | | 0.054<br>(0.861) | |
| *Δe*(-2) | | | -0.048<br>(0.773) | |
| R- Bar-squared | 0.077 | 0.063 | 0.136 | 0.141 |
| DW | 1.797 | 1.901 | 1.988 | 1.927 |
| LM(12) | 1.339 | 1.676 | 1.732 | 1.443 |
| Reset(1) | 0.566 | 0.298 | 1.108 | 0.005 |

*Notes*: See Table 2. di is the interest rate differential.

**Table 4. Out-of-sample Forecasting. (RMSE)**

| Country | Model | 3 | 6 | 9 | 12 |
|---|---|---|---|---|---|
| Δuke | SP model | 0.0267* | 0.0254* | 0.0277* | 0.0302* |
| | SP/I model | 0.0257* | 0.0259** | 0.0284** | 0.0311** |
| | RW | 0.0365 | 0.0287 | 0.0287 | 0.0301 |
| Δjpe | SP model | 0.0166* | 0.0155* | 0.0175* | 0.0186* |
| | SP/I model | 0.0178* | 0.0163* | 0.0177* | 0.0186* |
| | RW | 0.0204 | 0.0184 | 0.0193 | 0.0190 |
| Δswe | SP model | 0.0257** | 0.0236** | 0.0238** | 0.0250** |
| | SP/I model | 0.0275* | 0.0237** | 0.0243** | 0.0250** |
| | RW | 0.0323 | 0.0248 | 0.0241 | 0.0265 |
| Δcne | SP/I model | 0.0141* | 0.0221* | 0.0199* | 0.0233* |
| | RW | 0.0107 | 0.0199 | 0.0179 | 0.0212 |

Notes:* (**) indicates significance at the 5% (10%) level of significance based on the Diebold-Mariano statistic for the two models using the random walk as the benchmark. The RMSE are for the stock price model (SP), stock price and interest rate model (SP/I) and the random walk (RW).