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Abstract

This paper investigates fundamentals-based exchange rate predictability from a different perspective. We focus on predicting currency swings (major trends in depreciation or appreciation) rather than on quantitative changes of exchange rates. Having used a non-parametric approach to identify swings in exchange rates, we examine the links between fundamentals and swings in exchange rates using both in-sample and out-of-sample forecasting tests. We use data from 12 developed countries, and our empirical evidence suggests that the uncovered interest parity fundamentals and Taylor rule model with interest rate smoothing are strong predictors of exchange rate swings.

Keywords: exchange rate swings, fundamentals

JEL Classification: C22, F31

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1 Introduction

Short-run exchange rate forecasting has been an extremely difficult, although not impossible, task for economists. In particular, a seminal study by Meese and Rogoff (1983) shows that it is difficult for exchange rate models with basic macroeconomic fundamentals such as interest rates, purchasing power and monetary supply to outperform a random walk model in terms of out-of-sample forecasts. Indeed, a frequent finding is an empirical disconnect between exchange rates and economic fundamentals, which is known as the Meese–Rogoff puzzle.

An alternative approach to the puzzle is to consider long-horizon predictability. Using long-horizon regression tests, Mark (1995) and Mark and Sul (2001) find evidence that current-period deviations from monetary fundamental values help to predict future changes in nominal exchange rates at horizons of two to four years. However, Cheung et al. (2005) show that no single exchange rate model consistently performs better than the random walk model in out-of-sample predictions considering a wider set of exchange rate models, different empirical model specifications, a variety of forecasting evaluation criteria and a comprehensive set of forecasting horizons from short to long term. A pessimistic conclusion may be drawn from Cheung et al. (2005) that forecasting exchange rates seems to be a hopeless effort because there is no predictability on any horizon.

Lately, based on alternative specifications of Taylor rule fundamentals motivated by Engel and West (2005), and a more powerful out-of sample test statistic developed by Clark and West (2007), a recent study by Molodtsova and Papell (2009) provides strong evidence of short-horizon exchange rate predictability, and hence offers renewed hope for empirical success in this literature. They show that Taylor rule fundamentals with interest rate smoothing (i.e., the predictors include inflation rates, output gaps and lagged interest rates) yield superior forecasts to the commonly used interest rate, monetary and purchasing power parity (PPP) fundamentals.

Moreover, Engel et al. (2007) also confirm the usefulness of economic models (monetary, PPP and Taylor rule fundamentals) in forecasting exchange rates over a horizon of 16 quarters using panel data. However, Rogoff and Stavrakeva (2008) document that the excess optimism in the recent literature about the somewhat more positive short-term forecasting results may be built on "misinterpretation of some newer out-of-sample test statistics for nested models, over-reliance on asymptotic out-of-sample test statistics and failure to check for robustness to the time period sampled" (see Rogoff and Stavrakeva (2008)).

In this paper, we take a fresh look at exchange rate predictability by examining the usefulness of various fundamentals in predicting swings in the foreign exchange market; i.e., appreciation trend or depreciation trend markets. There are two reasons why this exercise is useful and appealing. First, it is well documented in Engel and Hamilton (1990), Engel (1994) and Klaassen (2005) that there are long swings in exchange rate data. That is, the foreign exchange market is characterized by the feature that once it changes direction, it tends to continue in the same direction. Noting such long-swing behavior of exchange rates, we suspect that predicting exchange rate swings may be an easier task than predicting exchange rate returns in the short run. Second, market participants may benefit from such predictions because predictability would help them to form market-timing strategies, which is known as currency swing trading.

We first use a nonparametric Bry–Boschan method to identify movement trends in the exchange rates. We then examine the in-sample and out-of-sample predictability of exchange rate swings with several macro fundamentals. Using monthly data from 1973:M1 to 2010:M12 for 12 developed countries (Australia, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Portugal, Sweden, Switzerland and the UK, with the US as the numeraire), we find evidence that the uncovered interest rate parity (UIP) model and the Taylor rule model with interest rate smoothing are the two most powerful predictors of swings in exchange rates.

Moreover, it is found that predicting exchange rate swings is easier than predicting exchange rate returns.

The rest of the paper is organized as follows. Section 2 presents the empirical methodology. In Section 3, we report the data, and Section 4 provides the empirical evidence along with robustness checks. Section 5 provides evidence from high frequency data, and Section 6 concludes.

2 Empirical Model

To characterize the trend movements in the foreign exchange markets, we employ a nonparametric dating method to locate the turning points (peaks and troughs) of the exchange rate series by seeking a local maximum (or minimum) in a q-period window using the Bry–Boschan algorithm. The algorithm developed by Bry and Boschan (1971) is intended to date turning points in real output fluctuations, and is widely used in the business cycle literature. For recent applications, see Monch and Uhlig (2005), Stock and Watson (2010a,b) and Darne and Ferrara (2011). The Bry–Boschan algorithm is also implemented to characterize the cyclical features of asset prices such as the stock price. The fluctuations in the stock market are identified as bull (expansion) and bear (recession) markets. For example, see Pagan and Sossounov (2003), Kaminsky and Schmukler (2008) and Candelon et al. (2008).[1]

[1] Although the long swings in exchange rate have been identified by Markov-switching models in previous literature (see Engel and Hamilton (1990) and Engel (1994)), there are two reasons that we do not use such a parametric model here. First, our aim is to simply characterize the exchange rate swings: depreciations or appreciations. However, the Markov-switching model used by Engel and Hamilton (1990) and Engel (1994) has identified two regimes: one with an appreciation trend and low volatility and another with a depreciation trend and high volatility. That is, the identified regimes feature both the mean and variance of the exchange rate return, which is inconsistent with our original goal to model the mean of the exchange rate return only. On the other hand, if we simply apply a Markov-switching model with constant variance, the evidence for switching in the mean is indeed weak, and this makes the regimes difficult to distinguish. We attempted to estimate a Markov-switching model with constant variance but failed to obtain reasonable estimates.

Let s_t denote the natural log of the nominal exchange rate, measured as the domestic currency per unit of the US dollar (which serves as base currency) so that an increase in s_t represents a depreciation of domestic currency against US dollar. Therefore, the turning point (TP_t) at time t in a q-period window is identified by the Bry–Boschan algorithm as:

$$\text{TP}_t = \begin{cases} \text{local peak} & \text{if} \quad \{s_t > s_{t+j}\} \text{ and } \{s_t > s_{t-j}\}, \\ \text{local trough} & \text{if} \quad \{s_t < s_{t+j}\} \text{ and } \{s_t < s_{t-j}\}, \end{cases} \tag{1}$$

for all $j = 1, 2, \ldots, q$.

Once turning points are obtained, the peak-to-trough and trough-to-peak periods are identified as the appreciation ($D_t = 1$) and depreciation trend ($D_t = 0$) markets, respectively. D_t is a binary dummy variable to indicate the swings of the exchange rate.

To investigate whether macroeconomic fundamentals can forecast exchange rate swings, we consider the following predictive probit model:

$$\mathbf{P}(D_{t+k} = 1) = \Phi(\alpha + \beta z_t), \tag{2}$$

where Φ represents the cumulative standard normal distribution function, $z_t \equiv f_t - s_t$ denotes the deviation of the exchange rate from its fundamental value as a logarithm suggested by f_t and k represents the forecast horizon.

We follow Estrella and Mishkin (1998) in computing the pseudo R^2 developed by Estrella (1998). Let L_u denote the value of the maximized probit likelihood, and let L_c denote the value of the maximized likelihood under the constraint that all coefficients are zero except for the constant. Then the measure of fit is defined by:

$$\text{Pseudo-}R^2 = 1 - \left(\frac{\log L_u}{\log L_c}\right)^{-(2/T)\log L_c}. \tag{3}$$

A low value of the pseudo-R^2 suggests "no fit", while a high pseudo-$R^2 = 1$ represents "perfect fit".

2.1 Fundamentals

Following Molodtsova and Papell (2009) and Engel et al. (2007), the choice of fundamentals is informed by standard exchange rate models.[2] All variables are in logs except for interest rates. Asterisks denote foreign country variables.

1. Monetary Fundamentals: $f_t = (m_t - m_t^*) - \eta(y_t - y_t^*)$, where m_t and y_t are (log) money supply and real output, respectively. This is motivated by the conventional monetary model of exchange rates, where an increase in monetary supply differential between the domestic and foreign countries leads to an increase in the price differential and thus a depreciation in the domestic currency through PPP. On the other hand, an increase in relative income causes an appreciation in the domestic currency. Note that the income elasticity of money demand, η, is assumed to be one. That is, we consider $f_t = (m_t - m_t^*) - (y_t - y_t^*)$.

2. PPP Fundamentals: According to the purchasing power parity (PPP) in logarithm:

   $$s_t = p_t - p_t^*,$$

   where s_t and p_t denote the (log) nominal exchange rate and price level, respectively. Thus, we have $f_t = p_t - p_t^*$ as the PPP fundamental.

3. UIP Fundamentals: According to the uncovered interest rate parity (UIP):

   $$E_t s_{t+1} - s_t = i_t - i_t^*.$$

   Thus, we have $f_t = (i_t - i_t^* + s_t)$ as the UIP fundamental, where $i_t - i_t^*$ is the interest rate differential.

4. Taylor Rule Fundamentals: In each country, the monetary authority sets the nominal interest rate to react to the inflation rate and the output gap. We consider three different

[2]See Engel et al. (2007) for detailed derivations.

versions of Taylor rule fundamentals. The first assumes that the home country also considers real exchange rates further in the interest rate reaction function. This leads to the following fundamental:

$$\text{(Taylor I)} \qquad f_t = 1.5(\pi_t - \pi_t^*) + 0.1(\tilde{y}_t - \tilde{y}_t^*) + 0.1(s_t + p_t^* - p_t) + s_t,$$

where π_t and $\tilde{y}_t$ represent the inflation rate and the output gap, respectively. This is called the *asymmetric* Taylor rule by Molodtsova and Papell (2009).

The second Taylor rule specification assumes that the monetary authority only reacts to inflation and the output gap in both countries:

$$\text{(Taylor II)} \qquad f_t = 1.5(\pi_t - \pi_t^*) + 0.1(\tilde{y}_t - \tilde{y}_t^*) + s_t.$$

Molodtsova and Papell (2009) denote it as the *symmetric* Taylor rule.

Finally, we consider the Taylor rule with interest rate smoothing:

$$\text{(Taylor III)} \qquad f_t = 0.1[1.5(\pi_t - \pi_t^*) + 0.1(\tilde{y}_t - \tilde{y}_t^*)] + 0.9(i_{t-1} - i_{t-1}^*) + s_t,$$

which suggests that the central bank implements monetary policy with a partial adjustment mechanism.

The output gap is the difference between actual and potential output. The values of the parameters in the Taylor rule are simply taken from Engel et al. (2007) and are arguably standard. Moreover, we follow Engel et al. (2007) in measuring output gap as the deviation of actual output from a Hodrick–Prescott (HP) trend. Letting y_t^{hp} denote the HP trend obtained by the HP filter, the output gap is defined as: $\tilde{y}_t = y_t - y_t^{hp}$.

3 Data Description

We analyze the bilateral exchange rate data from 12 countries: Australia, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Portugal, Sweden, Switzerland and the UK. The US was chosen as the numeraire; i.e., the foreign country. Monthly data, typically from 1973:M1 to 2010:M12, obtained from the International Financial Statistics (IFS) published by the International Monetary Fund are used. We use M2 to measure the money supply for most countries unless the M2 series was not available. The exceptions include Australia (M1) and the UK (M0). The industrial production index is used as a proxy of real output, while the price level is measured by the consumer price index (CPI).[3] The inflation rate is constructed as the annual change (12-month difference) in the log of the consumer price. It is worth noting that the industrial production series for Australia and Switzerland, and the CPI series for Australia, are available quarterly. We thus transform these into monthly frequency by interpolation.[4] Following Engel and West (2005) and Rogoff and Stavrakeva (2008), the euro exchange rate after 1999:M1 has been converted to DEM/USD, FRF/USD, ITL/USD, NLG/USD and PTE/USD for Deutsche mark, French franc, Italian lira, Dutch guilder and Portuguese escudo, respectively.[5] The short-run interest rate is measured by the money market rate (or "call money rate") for most countries (IFS line 60B). We use the three-month treasury bill rate for France and Sweden, and the 90-day rate on prime corporate paper for Canada because the money market rate for these countries has a large amount of missing data.

[3] CPI data is available from 1973:M1 to 1991:M12 for West Germany and from 1991:M1 to 2010:M12 for United Germany. We therefore use West German CPI data from 1973:M1 to 1991:M12 and extend it to 2010:M12 using the growth rate computed from the CPI data of United Germany.

[4] We use the `@DISAGGREGATE` procedure provided by RATS.

[5] The conversion rates are: 1 euro = 1.95583 DEM, 6.55957 FRF, 1936.27 ITL, 2.20371 NLG and 200.482 PTE. For example, the FRF/USD rate for French francs post 1999 is simply Euro/USD times 6.55957.

4 Empirical Results

4.1 Identifying the Swings in Exchange Rates

The exchange rate swings identified by the Bry–Boschan method are plotted in Figure 1 with short-run moving average, $q = 6$. That is, a local peak occurs at time t whenever $\{s_{t-6}, \ldots, s_{t-1} < s_t > s_{t+1}, \ldots, s_{t+6}\}$, and there will be a trough at time t if $\{s_{t-6}, \ldots, s_{t-1} > s_t < s_{t+1}, \ldots, s_{t+6}\}$. The shaded areas indicate the appreciation trend period against the US dollar. It is clear that the nonparametric method suggests persistent appreciation and depreciation periods; that is, the movements in the exchange rate are characterized by long swings. For most European countries (Denmark, France, Germany, Italy, the Netherlands, Sweden, Switzerland and the UK), the currencies were in a state of depreciation against the dollar from 1980 to 1984, and were in a state of appreciation against the dollar from the end of 1984 to 1987. The results are consistent with the previous findings in Engel and Hamilton (1990), which applies a parametric method—the Markov-switching model—to suggest long swings in exchange rates using quarterly data from 1973:Q4 to 1988:Q1. Finally, the identification of the turning points (peaks or troughs) in the foreign exchange market is robust to the choice of the window period. Changing the window of six months into four or eight months does not substantially alter the inferences of the state of depreciation or appreciation.

4.2 In-Sample Results

After obtaining estimates of the turning points from the Bry–Boschan method, we construct a binary variable $D_t = 1$ if the exchange rate is in the appreciation regime, and $D_t = 0$ if it is in the depreciation regime. We then use the probit model to run the predictive regression shown in equation (2). The empirical results, including coefficient estimates, t-statistics, p-values and pseudo-R^2, are reported in Tables 1 and 2 for short-run forecasting horizons of one month ($k = 1$) and one year ($k = 12$). The Newey–West heteroskedasticity and autocorrelation consistent (HAC) standard errors are used with the Bartlett kernel. The truncation parameter m is determined by $m = 0.75T^{1/3}$, rounded to the nearest integer.

At the one month horizon, investigating each fundamental in turn shows that UIP and Taylor rule fundamentals with interest rate smoothing produce consistently strong results across most countries (Italy and Sweden are exceptions). For other fundamentals, we also find some predictive power for approximately half of the sample countries. According to Table 2, the one-year-ahead forecasts provide us with more gratifying results. For all $6 \times 12 = 72$ cases (six fundamentals and 12 countries), 58 of 72 cases suggest a short-run connection between exchange rate swings and fundamentals. The PPP fundamental is a particularly strong predictor at the 12-month horizon, which is in accord with the long-run PPP hypothesis.

4.3 Out-of-Sample Results

In this section, we shift our focus to an out-of-sample forecast exercise. In the research on exchange rate forecastability, Meese and Rogoff (1983) have established a paradigm that out-of-sample prediction should be used to judge the relative merits of the economic models to protect against the data mining that may occur when relying solely on in-sample inference. [6]

To conduct out-of-sample forecast tests, the total sample of T observations is divided into in-sample and out-of-sample portions. There are R in-sample observations, $t = 1, ..., R$, and P out-of-sample observations, $t = R + 1, ..., R + P$. Obviously, $R + P = T$. We use data over the period 1973:M1–1983:M11 for estimation and reserve the remaining data for out-of-sample forecasting so that the ratio $P/R \approx 2.5$. If data for the whole sample span (1973:M1–

[6] See Inoue and Kilian (2005) for more discussions on this issue.

2010:M12) is not available, we adjust the forecast starting date to maintain $P/R \approx 2.5$.[7] A recursive estimation scheme is used so that the in-sample observations are $R, R+1, \ldots, R+P-1$.

To evaluate out-of-sample probit model forecasts, we adopt the quadratic probability score (QPS) proposed by Diebold and Rudebusch (1989):

$$\text{QPS} = P^{-1} \sum_t 2[\hat{\mathbf{P}}(D_{t+k} = 1) - D_{t+k}]^2, \tag{4}$$

where $\hat{P}(D_{t+k} = 1) = \Phi(\hat{\alpha} + \hat{\beta} z_t)$. The QPS ranges from 0 to 2, with a score of 0 corresponding to perfect accuracy.

Tables 3 and 4 present the QPS statistics along with the associated bootstrap p-values for $k = 1$ and $k = 12$, respectively.[8] In Table 3, we can see that UIP fundamentals provide the greatest out-of-sample predictive power among all fundamentals that we consider at the one-month horizon. The bootstrap p-value is less than 1% for eight out of 12 cases. The Taylor rule model with interest rate smoothing also performs well forecasting one month ahead: the QPS statistics are statistically significant for seven out of 12 currencies. However, when we turn to the results from a longer forecast with $k = 12$ in Table 4, the results are much less satisfactory. The forecasting performance of each fundamental is poor. We may thus conclude that UIP fundamentals and the Taylor rule model with interest rate smoothing are reasonably good predictors of exchange rate trend movements at a very short-run horizon.

4.4 A Comparison with Return Predictability

As a comparison, it may be of interest how these fundamentals perform when the object of forecast is exchange rate returns rather than swings. We consider the following predictive re-

[7] The P/R ratio is approximately 2.4 in Engel et al. (2007), and $P/R \approx 2.7$ in Molodtsova and Papell (2009). Below, we check for robustness by considering other P/R ratios.

[8] For details on the bootstrap used, see Appendix.

gression:

$$\Delta s_{t+k} = \alpha + \beta z_t + \varepsilon_t, \tag{5}$$

where $\Delta s_{t+k} = (\log S_{t+k} - \log S_t) \times 100$ is the exchange rate return. It is worth noting that the capacity of macroeconomic fundamentals to predict exchange rate returns in-sample has already been investigated in the previous studies. However, an exercise using the same data, and sample periods, makes the comparison more informative.

The results for in-sample returns predictions are reported in Tables 5 and 6, respectively. Comparing the results in previous sections, it is obvious that the prediction power is similar for $k = 12$. However, the macroeconomic fundamentals we consider perform much better predicting exchange rate swings than exchange rate returns in the very short run ($k = 1$).

We then turn to the out-of-sample return forecastability. Again, although it is not appropriate to compare directly the above forecasting performance of the *swing prediction* with the *return prediction* in the previous studies, it may be of interest to observe the forecasting performance of the return prediction using the same data set and sample period. Following the recent studies on exchange rate return predictability, we consider both the older Theil's U test statistic and the newer out-of-sample test statistic proposed by Clark and West (2007) for the return predictive regression model in equation (5).

Theil's U test statistic is defined as the ratio:

$$\text{TU} = \sqrt{\frac{\text{MSPE}_2}{\text{MSPE}_1}},$$

where MSPE_1 and MSPE_2 represent the mean-square prediction errors (MSPE) obtained from the restricted (driftless random walk) and unrestricted (economic) models. Therefore, $\text{TU} < 1$ implies that the economic model outperforms the driftless random walk model. The statistical significance is tested via a bootstrap. Moreover, let $\hat{u}^1_{t+k}$ and $\hat{u}^2_{t+k}$ be the forecasting errors for the restricted and unrestricted models, respectively. The forecasts of Δs_{t+k} from the two models are denoted $\Delta\hat{s}^1_{t+k}$ and $\Delta\hat{s}^2_{t+k}$. The Clark and West (2007) MSPE-adj statistic is computed as:

$$\text{CW} = \frac{\sqrt{P}\,\bar{f}}{\sqrt{\hat{V}}}, \tag{6}$$

where $\bar{f} = P^{-1}\sum_t \hat{f}_{t+k}$, $\hat{f}_{t+k} = (\hat{u}^1_{t+k})^2 - [(\hat{u}^2_{t+k})^2 - (\Delta\hat{s}^1_{t+k} - \Delta\hat{s}^2_{t+k}]$, and $\hat{V}$ is the sample variance of $(\hat{f}_{t+k} - \bar{f})$. The Clark–West test is an approximately normal test for equal predictive accuracy in nested models. The null hypothesis is rejected if the test statistic is sufficiently positive, and the asymptotic distribution of the statistic is simply the standard normal distribution. However, Rogoff and Stavrakeva (2008) criticized the asymptotic Clark–West test as possibly oversized; we thus apply the bootstrap method to compute the p-value. Tables 7 and 8 report Theil's U and Clark–West test statistics and the associated p-values for $k = 1$ and $k = 12$. It is clear that the forecasting performance is very poor at both one- and 12-month horizons.[9]

In summary, both in-sample and out-of sample evidence appears to suggest that predicting major appreciation/depreciation trends is easier than predicting exchange rate returns, i.e., the exchange rate swings in the foreign exchange market using macro fundamentals. This result may demonstrate the greater usefulness and superiority of forecasting market trends over predicting exact exchange rate changes.

[9]It is worth noting that such poor forecasting performance seems inconsistent with the previous findings reported in Molodtsova and Papell (2009), who find good one-month ahead out-of-sample exchange rate return predictability with Taylor fundamentals. We have attempted to use our computer code with the data provided by David H. Papell (`http://www.uh.edu/~dpapell/papers2.htm`), and we are able to qualitatively replicate their results using the same data span and model specifications. In Molodtsova and Papell (2009), they estimate a reduced-form forecasting equation such as: $\Delta s_{t+1} = \omega + \omega_1\pi_t + \omega_2\pi^*_t + \omega_3\tilde{y}_t + \omega_4\tilde{y}^*_t + \omega_5(s_t + p^*_t - p_t) + \omega_6 i_{t-1} + \omega_7 i^*_{t-1} + \varepsilon_t$. Clearly, they do not consider an error-correction specification as in Engel et al. (2007) and the current paper. Indeed, using data by Molodtsova and Papell (2009) with the same sample span and a rolling window, an error-correction specification produces worse forecasting performance, similar to the results in Table 7.

4.5 Robustness

To check the robustness of the empirical results, we consider the following modifications of the out-of-sample forecasting exercise. We focus on the two fundamentals: UIP and the Taylor rule with interest rate smoothing because they provide the most powerful prediction performance.

First, Rogoff and Stavrakeva (2008) made the criticism that results from previous studies do not appear to be robust against different forecast windows. We thus consider a variety of first dates for which a forecast is calculated by varying the P/R ratio. The alternative P/R ratios that we consider are 0.5, 1.0, 1.5 and 2.0, so that the starting dates of the postsample forecasts are 1998:M5, 1992:M1, 1988:M4 and 1985:M9, respectively. Empirical results reported in Table 9 indicate that the evidence regarding the forecasting content of the UIP fundamentals and Taylor rule model with interest smoothing do not change substantially over different forecast windows, which suggests that our main empirical results are robust.

Second, we consider different window widths q for the Bry–Boschan algorithm. The first two columns of Table 10 present the results for $q = 3$ and $q = 9$, and the results indicate that our main findings stand.

Finally, as discussed in Pagan and Sossounov (2003), they suggest modifying the Bry–Boschan algorithm for recognizing fluctuations in asset prices. We thus follow their suggestion to apply the Bry–Boschan algorithm without removing extreme observations, which is done by not smoothing the data series initially. The empirical results from the modified Bry–Boschan algorithm proposed by Pagan and Sossounov (2003) are reported in the third column of Table 10. It is obvious that UIP fundamentals and the Taylor rule model with interest rate smoothing are still good predictors of exchange rate swings.

5 High Frequency Forecasts

We have shown in our main empirical results that UIP fundamentals can predict trends in exchange rates one month ahead. As the interest rate data is available at high frequency, we thus take advantage of this to investigate the predictability of the exchange rate swings using UIP fundamentals with weekly data from 1994:1:5 to 2011:6:15. Such an exercise with high frequency data is particularly useful and appealing to the market participants.

The weekly WM/Reuters nominal exchange rate data was obtained from Datastream. The weekly rates of interest are as follows: Australia 30-day Dealer Bill Rate (Middle Rate), Canada 1-month Treasury Bill (Middle Rate), Italy 7-day Interbank Offered Rate, Japan Gensaki T-Bill Overnight Rate (Middle Rate), Sweden 1-week Interbank Rate (Middle Rate), Swiss 7-day Interbank Rate (Bid Rate), UK interbank Overnight Middle Rate, US Federal Funds Rate as well as 1-month Interbank Rate (Offered Rate) for Denmark, France, Germany, Netherland and Portugal. All the interest rate data were also collected from Datastream.

We first identify the trend movements using weekly exchange rate data in Figure 2, which shows very similar appreciation/depreciation movements as Figure 1.

Table 11 reports the results for different specifications and settings. The evidence is encouraging: the UIP fundamentals have strong predictive power one week ahead for almost all cases considered. Such a strong result is indeed robust.

6 Concluding Remarks

This paper investigated whether economic models were useful in predicting trend movements in the foreign exchange market; i.e., swings in exchange rates. Fundamentals such as monetary fundamentals, UIP fundamentals, PPP fundamentals and a variety of Taylor rule fundamentals were evaluated. We first identified the exchange rate swings using the Bry–Boschan algorithm, and then conducted both in-sample and out-of-sample tests of predictive ability for the above fundamentals.

Using monthly data from 1973:M1 to 2010:M12 for 12 developed countries, our empirical results from in-sample and out-of-sample forecast tests confirm the effectiveness of exchange rate models in predicting exchange rate swings. In particular, UIP fundamentals and the Taylor rule model with interest rate smoothing outperformed other conventional models in terms of providing the strongest supporting evidence for a short-run connection between exchange rates and fundamentals. It was also found that macro fundamentals are better predictors of exchange rate swings than predicting exchange rate returns in the foreign exchange market. We then showed that the empirical results are robust for different forecast windows and other specifications. Finally, evidence was shown that the UIP fundamentals have strong predictive power for exchange rate swings one week ahead. Hence, we have provided more support for the link between exchange rates and macro fundamentals. That is, *exchange rate models are not as bad as you think.*

Appendix

This appendix presents a bootstrap procedure to calculate the p-value of QPS statistics given data $\{D_t, z_t, s_t\}$, where D_t is a dummy variable so that $D_t = 1$ in an appreciation trend and $D_t = 0$ in a depreciation trend. Moreover, z_t denotes the deviation of the exchange rate from the fundamentals. Under the null hypothesis that z_t has no predictive power for exchange rate swings, the bootstrap DGP can be represented as follows. For $t = 1, 2, \ldots, T$:

$$D_t^* = \begin{cases} 1 & \text{with probability} \quad \Phi(\tilde{\alpha}), \\ 0 & \text{with probability} \quad 1 - \Phi(\tilde{\alpha}), \end{cases} \tag{7}$$

where $\tilde{\alpha}$ is the estimator of the probit model in equation (2) with $\beta = 0$:

$$\mathbf{P}(D_t = 1) = \Phi(\alpha). \tag{8}$$

Following Davidson (2007), the bootstrap samples are generated by drawing a random number y_t from the uniform U(0, 1) distribution first. Then we generate D_t^* as $\mathbf{I}\{y_t \leq \Phi(\tilde{\alpha})\}$, where $\mathbf{I}$ denotes the indicator function.

We also conduct a residual bootstrap using:

$$\Delta z_t = \mu + \gamma z_{t-1} + \sum_{j=1}^{p} \delta_j \Delta s_{t-j} + \sum_{j=1}^{p} \theta_j \Delta z_{t-j} + \varepsilon_t^z$$

to resample $\{\varepsilon_t^z\}$ and then generate bootstrap sample $\{z_t^*\}$. The appropriate number of lags p is selected by the Akaike information criterion.

With the bootstrap sample $\{D_t^*, z_t^*\}$, the out-of-sample forecasting exercise is implemented and the QPS statistic is calculated. With 1000 replications, a bootstrap distribution of the QPS statistic is obtained. We then calculate the bootstrap p-value as the portion of the bootstrap QPS distribution below the estimated QPS value using the observed data.

Table 1: One-Step-Ahead In-sample Test Results for Predicting Currency Swings: Probit Regression Models ($k = 1$)

	Monetary Fundamental				Taylor I Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2
Australia	0.33	2.19	**0.03**	0.01	0.06	3.78	**0.00**	0.03
Canada	0.09	0.30	0.77	0.00	0.06	2.36	**0.02**	0.01
Denmark	-0.65	-1.81	**0.07**	0.01	0.00	0.12	0.91	0.00
France	0.09	0.21	0.83	0.00	-0.04	-1.89	**0.06**	0.01
Germany	-0.42	-2.29	**0.02**	0.02	0.01	0.36	0.72	0.00
Italy	1.62	3.41	**0.00**	0.04	-0.04	-3.74	**0.00**	0.03
Japan	0.00	-0.02	0.99	0.00	0.02	1.47	0.14	0.00
Netherlands	-0.13	-0.84	0.40	0.00	0.02	0.80	0.42	0.00
Portugal	-0.22	-0.96	0.34	0.00	-0.02	-3.80	**0.00**	0.03
Sweden	-0.16	-0.26	0.79	0.00	-0.03	-2.19	**0.03**	0.01
Switzerland	-2.22	-6.07	**0.00**	0.13	0.02	1.04	0.30	0.00
U.K.	-0.10	-0.35	0.73	0.00	-0.01	-0.65	0.51	0.00

	UIP Fundamental				Taylor II Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2
Australia	0.07	3.69	**0.00**	0.03	0.05	3.77	**0.00**	0.03
Canada	0.15	4.24	**0.00**	0.04	0.06	2.36	**0.02**	0.01
Denmark	0.04	2.08	**0.04**	0.01	0.00	0.13	0.90	0.00
France	0.09	3.46	**0.00**	0.03	-0.04	-1.88	**0.06**	0.01
Germany	0.07	3.28	**0.00**	0.02	0.01	0.38	0.70	0.00
Italy	-0.01	-0.52	0.61	0.00	-0.04	-3.73	**0.00**	0.03
Japan	0.16	8.23	**0.00**	0.15	0.02	1.48	0.14	0.00
Netherlands	0.15	5.74	**0.00**	0.12	0.02	0.82	0.41	0.00
Portugal	0.06	3.29	**0.00**	0.05	-0.02	-3.80	**0.00**	0.03
Sweden	0.02	1.39	0.16	0.00	-0.03	-2.18	**0.03**	0.01
Switzerland	0.13	6.96	**0.00**	0.13	0.02	1.05	0.30	0.00
U.K.	0.08	4.30	**0.00**	0.04	-0.01	-0.65	0.51	0.00

	PPP Fundamental				Taylor III Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2
Australia	-1.11	-3.01	**0.00**	0.02	0.09	4.60	**0.00**	0.05
Canada	0.52	1.08	0.28	0.00	0.15	4.15	**0.00**	0.04
Denmark	0.48	1.31	0.19	0.00	0.03	1.77	**0.08**	0.01
France	0.84	2.19	**0.03**	0.01	0.07	2.84	**0.00**	0.02
Germany	1.04	2.79	**0.01**	0.02	0.07	3.12	**0.00**	0.02
Italy	1.64	4.11	**0.00**	0.04	-0.02	-1.55	0.12	0.01
Japan	0.35	1.20	0.23	0.00	0.15	7.79	**0.00**	0.14
Netherlands	1.35	3.52	**0.00**	0.03	0.16	5.68	**0.00**	0.12
Portugal	0.70	2.29	**0.02**	0.01	0.05	3.10	**0.00**	0.05
Sweden	0.33	1.07	0.28	0.00	0.01	0.56	0.58	0.00
Switzerland	0.50	1.36	0.17	0.00	0.13	6.78	**0.00**	0.12
U.K.	0.66	1.55	0.12	0.01	0.06	2.77	**0.01**	0.02

Note: The predictive regression model is $\mathbf{P}(D_{t+k} = 1) = F(\alpha + \beta z_t)$, where D_{t+k} is a dummy variable so that $D_{t+k} = 1$ if in an appreciation trend and $D_{t+k} = 0$ if in a depreciation trend. The market trend is identified by a Bry–Boschan method. Bold entries indicate significance at the 10% level; 0.00 indicates the value is smaller than 0.005.

Table 2: Twelve-Step-Ahead In-sample Test Results for Predicting Currency Swings: Probit Regression Models ($k = 12$)

	Monetary Fundamental				Taylor I Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2
Australia	0.17	1.09	0.28	0.00	0.07	4.75	**0.00**	0.05
Canada	-0.58	-1.81	**0.07**	0.01	-0.03	-0.97	0.33	0.00
Denmark	-2.12	-5.07	**0.00**	0.12	-0.03	-1.73	**0.08**	0.01
France	-2.52	-5.43	**0.00**	0.12	-0.04	-1.83	**0.07**	0.01
Germany	-1.12	-5.71	**0.00**	0.11	0.03	1.42	0.16	0.00
Italy	-2.14	-4.36	**0.00**	0.07	-0.03	-2.59	**0.01**	0.02
Japan	-0.28	-2.08	**0.04**	0.01	0.04	2.89	**0.00**	0.02
Netherlands	-0.20	-1.28	0.20	0.01	0.08	3.77	**0.00**	0.03
Portugal	-1.00	-4.14	**0.00**	0.08	-0.02	-3.10	**0.00**	0.02
Sweden	-2.15	-2.94	**0.00**	0.06	0.05	2.96	**0.00**	0.02
Switzerland	-3.82	-8.67	**0.00**	0.30	0.06	2.98	**0.00**	0.02
U.K.	-1.11	-3.75	**0.00**	0.04	-0.01	-0.43	0.67	0.00

	UIP Fundamental				Taylor II Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2
Australia	0.07	3.79	**0.00**	0.03	0.07	4.73	**0.00**	0.05
Canada	0.06	1.82	**0.07**	0.01	-0.03	-1.00	0.32	0.00
Denmark	0.01	0.61	0.54	0.00	-0.04	-1.75	**0.08**	0.01
France	0.10	3.91	**0.00**	0.04	-0.04	-1.86	**0.06**	0.01
Germany	0.08	3.90	**0.00**	0.03	0.03	1.40	0.16	0.00
Italy	0.01	0.94	0.35	0.00	-0.03	-2.61	**0.01**	0.02
Japan	0.14	6.38	**0.00**	0.10	0.04	2.87	**0.00**	0.02
Netherlands	0.11	4.30	**0.00**	0.06	0.08	3.75	**0.00**	0.03
Portugal	0.10	5.08	**0.00**	0.13	-0.02	-3.11	**0.00**	0.02
Sweden	0.05	2.69	**0.01**	0.02	0.05	2.93	**0.00**	0.02
Switzerland	0.13	7.17	**0.00**	0.14	0.06	2.97	**0.00**	0.02
U.K.	0.02	1.27	0.20	0.00	-0.01	-0.45	0.65	0.00

	PPP Fundamental				Taylor III Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2	$\hat{\beta}_k$	t-stat	p-value	Pseudo-R^2
Australia	-2.69	-6.66	**0.00**	0.11	0.07	3.54	**0.00**	0.03
Canada	-2.28	-4.49	**0.00**	0.05	0.05	1.41	0.16	0.00
Denmark	-1.87	-4.83	**0.00**	0.05	0.01	0.57	0.57	0.00
France	-2.02	-4.90	**0.00**	0.06	0.10	3.71	**0.00**	0.03
Germany	-1.74	-4.39	**0.00**	0.05	0.08	3.34	**0.00**	0.03
Italy	-1.58	-3.89	**0.00**	0.03	0.00	0.16	0.87	0.00
Japan	-1.34	-4.41	**0.00**	0.04	0.13	6.10	**0.00**	0.09
Netherlands	-1.64	-4.11	**0.00**	0.04	0.12	4.53	**0.00**	0.07
Portugal	-0.92	-2.98	**0.00**	0.02	0.10	5.42	**0.00**	0.15
Sweden	-1.46	-4.54	**0.00**	0.05	0.08	4.27	**0.00**	0.04
Switzerland	-1.85	-4.62	**0.00**	0.05	0.14	7.02	**0.00**	0.14
U.K.	-2.69	-5.80	**0.00**	0.08	0.06	2.51	**0.01**	0.01

Note: The predictive regression model is $\mathbf{P}(D_{t+k} = 1) = F(\alpha + \beta z_t)$, where D_{t+k} is a dummy variable so that $D_{t+k} = 1$ if in an appreciation trend and $D_{t+k} = 0$ if in a depreciation trend. The market trend is identified by a Bry–Boschan method. Bold entries indicate significance at the 10% level; 0.00 indicates the value is smaller than 0.005.

Table 3: One-Step-Ahead Out-of-sample Test Results for Predicting Exchange Rate Swings: Diebold and Rudebusch (1989)'s QPS Statistics ($k = 1$)

	Monetary Fundamental		PPP Fundamental		Taylor II Fundamental	
	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.504	0.194	0.509	0.847	0.502	0.323
Canada	0.639	1.000	0.582	1.000	0.612	1.000
Denmark	0.513	0.649	0.518	0.999	0.540	1.000
France	0.562	1.000	0.514	0.989	0.522	1.000
Germany	0.568	1.000	0.525	1.000	0.503	0.595
Italy	0.487	**0.008**	0.524	1.000	0.526	1.000
Japan	0.497	0.389	0.489	0.198	0.489	0.270
Netherlands	0.581	1.000	0.515	0.995	0.502	0.656
Portugal	0.695	1.000	0.588	1.000	0.597	1.000
Sweden	0.708	1.000	0.524	0.999	0.547	1.000
Switzerland	0.472	**0.010**	0.498	0.426	0.505	0.922
U.K.	0.492	**0.089**	0.499	0.392	0.493	0.160

	UIP Fundamental		Taylor I Fundamental		Taylor III Fundamental	
	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.494	**0.021**	0.502	0.304	0.496	**0.045**
Canada	0.556	1.000	0.612	1.000	0.601	1.000
Denmark	0.515	0.998	0.540	1.000	0.528	1.000
France	0.486	**0.006**	0.522	1.000	0.492	**0.024**
Germany	0.488	**0.011**	0.503	0.614	0.488	**0.014**
Italy	0.540	1.000	0.526	1.000	0.536	1.000
Japan	0.390	**0.000**	0.489	0.270	0.403	**0.000**
Netherlands	0.461	**0.001**	0.502	0.666	0.427	**0.000**
Portugal	0.481	**0.084**	0.597	1.000	0.506	0.594
Sweden	0.525	1.000	0.547	1.000	0.548	1.000
Switzerland	0.473	**0.004**	0.505	0.925	0.472	**0.004**
U.K.	0.469	**0.000**	0.493	0.159	0.489	**0.068**

Note: The predictive regression model is $\mathbf{P}(D_{t+k} = 1) = F(\alpha + \beta z_t)$, where D_{t+k} is a dummy variable so that $D_{t+k} = 1$ if in an appreciation trend and $D_{t+k} = 0$ if in a depreciation trend. The market trend is identified by a Bry–Boschan method. Bold entries indicate significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

Table 4: Twelve-Step-Ahead Out-of-sample Test Results for Predicting Exchange Rate Swings: Diebold and Rudebusch (1989)'s QPS Statistics (k = 12)

	Monetary Fundamental		PPP Fundamental		Taylor II Fundamental	
	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.590	1.000	0.484	**0.000**	0.553	1.000
Canada	0.747	1.000	0.694	1.000	0.691	1.000
Denmark	0.523	0.822	0.548	1.000	0.590	1.000
France	0.622	1.000	0.528	0.999	0.551	1.000
Germany	0.668	1.000	0.561	1.000	0.541	1.000
Italy	0.657	1.000	0.575	1.000	0.578	1.000
Japan	0.606	1.000	0.547	1.000	0.507	0.980
Netherlands	0.675	1.000	0.550	1.000	0.581	1.000
Portugal	0.831	1.000	0.694	1.000	0.727	1.000
Sweden	0.846	1.000	0.587	1.000	0.561	1.000
Switzerland	0.415	**0.000**	0.504	0.779	0.522	0.999
U.K.	0.580	1.000	0.496	0.233	0.536	1.000

	UIP Fundamental		Taylor I Fundamental		Taylor III Fundamental	
	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.579	1.000	0.553	1.000	0.575	1.000
Canada	0.675	1.000	0.691	1.000	0.698	1.000
Denmark	0.563	1.000	0.590	1.000	0.587	1.000
France	0.526	1.000	0.551	1.000	0.550	1.000
Germany	0.568	1.000	0.540	1.000	0.572	1.000
Italy	0.597	1.000	0.578	1.000	0.596	1.000
Japan	0.469	**0.013**	0.507	0.978	0.466	**0.006**
Netherlands	0.539	1.000	0.580	1.000	0.520	0.985
Portugal	0.535	0.978	0.728	1.000	0.530	0.967
Sweden	0.549	1.000	0.560	1.000	0.545	1.000
Switzerland	0.543	1.000	0.521	0.998	0.546	1.000
U.K.	0.531	1.000	0.536	1.000	0.519	0.998

Note: The predictive regression model is $\mathbf{P}(D_{t+k} = 1) = F(\alpha + \beta z_t)$, where D_{t+k} is a dummy variable so that $D_{t+k} = 1$ if in an appreciation trend and $D_{t+k} = 0$ if in a depreciation trend. The market trend is identified by a Bry–Boschan method. Bold entries indicate significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

Table 5: One-Step-Ahead In-sample Test Results for Predicting Exchange Rate Returns ($k = 1$)

	Monetary Fundamental				Taylor I Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	R^2	$\hat{\beta}_k$	t-stat	p-value	R^2
Australia	-0.17	-0.44	0.66	0.00	-0.01	-0.30	0.77	0.00
Canada	0.40	0.88	0.38	0.00	-0.04	-1.17	0.24	0.00
Denmark	1.18	1.33	0.18	0.01	-0.06	-1.20	0.23	0.00
France	1.59	1.43	0.15	0.01	0.03	0.60	0.55	0.00
Germany	0.90	1.83	**0.07**	0.01	-0.06	-1.20	0.23	0.00
Italy	1.60	1.40	0.16	0.01	0.04	1.43	0.15	0.00
Japan	0.46	1.35	0.18	0.00	-0.05	-1.36	0.17	0.00
Netherlands	0.48	1.13	0.26	0.00	-0.05	-0.96	0.34	0.00
Portugal	-0.32	-0.54	0.59	0.00	0.04	2.61	**0.01**	0.02
Sweden	2.74	1.66	**0.10**	0.02	-0.01	-0.18	0.85	0.00
Switzerland	2.79	3.16	**0.00**	0.03	-0.04	-0.80	0.42	0.00
U.K.	0.95	1.40	0.16	0.00	0.03	1.09	0.27	0.00

	UIP Fundamental				Taylor II Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	R^2	$\hat{\beta}_k$	t-stat	p-value	R^2
Australia	-0.01	-0.20	0.84	0.00	-0.01	-0.29	0.77	0.00
Canada	-0.04	-0.85	0.40	0.00	-0.04	-1.16	0.25	0.00
Denmark	-0.03	-0.61	0.54	0.00	-0.06	-1.19	0.23	0.00
France	-0.06	-0.96	0.34	0.00	0.03	0.61	0.54	0.00
Germany	-0.05	-0.95	0.34	0.00	-0.06	-1.19	0.23	0.00
Italy	0.05	1.29	0.20	0.00	0.04	1.44	0.15	0.00
Japan	-0.12	-2.40	**0.02**	0.01	-0.05	-1.36	0.17	0.00
Netherlands	-0.05	-0.80	0.42	0.00	-0.05	-0.95	0.34	0.00
Portugal	0.02	0.53	0.59	0.00	0.04	2.61	**0.01**	0.02
Sweden	0.03	0.70	0.48	0.00	-0.01	-0.17	0.86	0.00
Switzerland	-0.06	-1.35	0.18	0.00	-0.04	-0.79	0.43	0.00
U.K.	-0.06	-1.32	0.19	0.00	0.03	1.10	0.27	0.00

	PPP Fundamental				Taylor III Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	R^2	$\hat{\beta}_k$	t-stat	p-value	R^2
Australia	1.44	1.56	0.12	0.01	-0.02	-0.33	0.74	0.00
Canada	1.19	1.69	**0.09**	0.01	-0.01	-0.21	0.83	0.00
Denmark	1.64	1.75	**0.08**	0.01	-0.04	-0.94	0.35	0.00
France	1.93	1.96	**0.05**	0.01	-0.03	-0.44	0.66	0.00
Germany	1.86	1.91	**0.06**	0.01	-0.04	-0.61	0.54	0.00
Italy	1.24	1.28	0.20	0.00	0.07	1.69	**0.09**	0.01
Japan	1.24	1.65	**0.10**	0.01	-0.12	-2.42	**0.02**	0.01
Netherlands	1.86	1.88	**0.06**	0.01	-0.10	-1.56	0.12	0.01
Portugal	-0.47	-0.60	0.55	0.00	0.02	0.36	0.72	0.00
Sweden	1.52	1.93	**0.05**	0.01	0.06	1.30	0.19	0.00
Switzerland	2.59	2.47	**0.01**	0.01	-0.04	-0.97	0.33	0.00
U.K.	1.95	1.96	**0.05**	0.01	-0.04	-0.66	0.51	0.00

Note: The predictive regression model is $\Delta s_{t+k} = \alpha + \beta z_t + \varepsilon_t$, where $\Delta s_{t+k} = (\log S_{t+k} - \log S_t) \times 100$ is the exchange rate return, and $z_t = f_t - s_t$ is the deviation of the exchange rate from its fundamental value suggested by f_t. the Bold entries indicate significance at the 10% level; 0.00 indicates the value is smaller than 0.005.

Table 6: Twelve-Step-Ahead In-sample Test Results for Predicting Exchange Rate Returns ($k = 12$)

	Monetary Fundamental				Taylor I Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	R^2	$\hat{\beta}_k$	t-stat	p-value	R^2
Australia	-1.49	-1.04	0.30	0.00	-0.29	-2.17	**0.03**	0.01
Canada	6.31	3.84	**0.00**	0.03	-0.25	-1.84	**0.07**	0.01
Denmark	18.86	6.42	**0.00**	0.15	-0.33	-1.72	**0.09**	0.01
France	26.95	6.40	**0.00**	0.14	0.35	1.83	**0.07**	0.01
Germany	10.62	6.19	**0.00**	0.11	-0.82	-4.17	**0.00**	0.04
Italy	29.43	6.38	**0.00**	0.12	0.54	5.08	**0.00**	0.06
Japan	5.54	4.35	**0.00**	0.04	-0.58	-4.39	**0.00**	0.04
Netherlands	3.71	2.38	**0.02**	0.02	-0.76	-4.21	**0.00**	0.04
Portugal	0.10	0.04	0.97	0.00	0.49	7.70	**0.00**	0.12
Sweden	40.13	6.82	**0.00**	0.25	-0.41	-2.57	**0.01**	0.02
Switzerland	32.67	12.82	**0.00**	0.35	-0.45	-2.38	**0.02**	0.01
U.K.	13.11	5.34	**0.00**	0.07	0.47	4.02	**0.00**	0.04

	UIP Fundamental				Taylor II Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	R^2	$\hat{\beta}_k$	t-stat	p-value	R^2
Australia	-0.49	-3.08	**0.00**	0.02	-0.28	-2.15	**0.03**	0.01
Canada	0.12	0.64	0.52	0.00	-0.24	-1.80	**0.07**	0.01
Denmark	-0.12	-0.71	0.48	0.00	-0.33	-1.69	**0.09**	0.01
France	-0.53	-2.18	**0.03**	0.01	0.36	1.87	**0.06**	0.01
Germany	-0.45	-2.23	**0.03**	0.01	-0.82	-4.13	**0.00**	0.04
Italy	0.40	2.50	**0.01**	0.01	0.55	5.10	**0.00**	0.06
Japan	-1.22	-6.84	**0.00**	0.10	-0.58	-4.36	**0.00**	0.04
Netherlands	-0.53	-2.33	**0.02**	0.02	-0.76	-4.18	**0.00**	0.04
Portugal	-0.04	-0.22	0.83	0.00	0.49	7.70	**0.00**	0.12
Sweden	-0.05	-0.30	0.76	0.00	-0.41	-2.53	**0.01**	0.01
Switzerland	-0.54	-3.46	**0.00**	0.03	-0.44	-2.34	**0.02**	0.01
U.K.	-0.32	-1.86	**0.06**	0.01	0.47	4.04	**0.00**	0.04

	PPP Fundamental				Taylor III Fundamental			
	$\hat{\beta}_k$	t-stat	p-value	R^2	$\hat{\beta}_k$	t-stat	p-value	R^2
Australia	23.84	7.40	**0.00**	0.11	-0.65	-3.79	**0.00**	0.03
Canada	16.48	6.71	**0.00**	0.09	0.12	0.63	0.53	0.00
Denmark	22.04	6.52	**0.00**	0.09	-0.14	-0.78	0.44	0.00
France	27.58	7.68	**0.00**	0.12	-0.46	-1.79	**0.07**	0.01
Germany	24.94	7.37	**0.00**	0.11	-0.57	-2.61	**0.01**	0.02
Italy	22.55	5.86	**0.00**	0.07	0.54	3.33	**0.00**	0.03
Japan	15.97	5.78	**0.00**	0.07	-1.25	-6.97	**0.00**	0.10
Netherlands	24.80	7.12	**0.00**	0.10	-0.68	-2.74	**0.01**	0.02
Portugal	-3.60	-1.09	0.28	0.00	-0.01	-0.08	0.94	0.00
Sweden	22.75	7.77	**0.00**	0.12	-0.19	-1.01	0.31	0.00
Switzerland	30.42	8.68	**0.00**	0.15	-0.59	-3.61	**0.00**	0.03
U.K.	26.79	7.35	**0.00**	0.11	-0.17	-0.79	0.43	0.00

Note: The predictive regression model is $\Delta s_{t+k} = \alpha + \beta z_t + \varepsilon_t$, where $\Delta s_{t+k} = (\log S_{t+k} - \log S_t) \times 100$ is the exchange rate return, and $z_t = f_t - s_t$ is the deviation of the exchange rate from its fundamental value suggested by f_t. the Bold entries indicate significance at the 10% level; 0.00 indicates the value is smaller than 0.005.

Table 7: One-Step-Ahead Out-of-sample Test Results for Predicting Exchange Rate Returns ($k = 1$)

	Monetary Fundamental				Taylor I Fundamental			
	TU-stat	p-value	CW-stat	p-value	TU-stat	p-value	CW-stat	p-value
Australia	1.041	0.759	-0.740	0.691	1.053	0.845	-0.403	0.613
Canada	1.096	0.990	-0.421	0.566	1.104	0.997	-0.328	0.516
Denmark	0.961	0.180	0.181	0.337	0.999	0.441	-1.424	0.869
France	1.016	0.588	-0.401	0.550	0.995	0.348	-0.730	0.647
Germany	1.001	0.424	0.049	0.503	0.978	0.176	0.758	0.258
Italy	1.026	0.689	0.946	0.430	1.040	0.909	-2.014	0.968
Japan	0.988	0.300	-0.569	0.836	0.987	0.341	1.424	0.365
Netherlands	1.042	0.754	-0.860	0.743	0.987	0.273	0.349	0.356
Portugal	0.993	0.484	-0.840	0.971	0.968	0.245	-0.665	0.961
Sweden	1.148	0.980	0.184	0.347	1.031	0.770	-1.650	0.913
Switzerland	0.901	**0.010**	1.115	0.307	0.963	0.099	0.967	0.405
U.K.	1.017	0.634	-0.280	0.522	1.017	0.664	-2.012	0.955

	UIP Fundamental				Taylor II Fundamental			
	TU-stat	p-value	CW-stat	p-value	TU-stat	p-value	CW-stat	p-value
Australia	1.052	0.875	-0.224	0.521	1.053	0.872	-0.408	0.648
Canada	1.115	0.996	-0.122	0.439	1.104	0.997	-0.340	0.520
Denmark	0.997	0.386	-1.136	0.810	0.999	0.449	-1.430	0.883
France	0.993	0.345	-0.713	0.671	0.995	0.363	-0.717	0.639
Germany	0.986	0.281	0.516	0.371	0.978	0.191	0.749	0.264
Italy	1.037	0.900	-0.639	0.788	1.040	0.903	-2.015	0.974
Japan	0.974	0.191	2.495	0.105	0.987	0.336	1.420	0.388
Netherlands	1.008	0.521	-0.560	0.702	0.987	0.303	0.341	0.379
Portugal	0.936	0.204	0.133	0.737	0.968	0.241	-0.665	0.960
Sweden	1.026	0.715	-1.377	0.873	1.031	0.751	-1.656	0.921
Switzerland	0.950	**0.050**	0.898	0.355	0.963	0.103	0.962	0.405
U.K.	1.016	0.642	-0.238	0.561	1.017	0.675	-2.009	0.964

	PPP Fundamental				Taylor III Fundamental			
	TU-stat	p-value	CW-stat	p-value	TU-stat	p-value	CW-stat	p-value
Australia	1.056	0.877	-1.514	0.892	1.053	0.852	-0.058	0.499
Canada	1.093	0.988	-0.453	0.546	1.113	0.997	-0.803	0.681
Denmark	0.995	0.338	0.018	0.412	1.001	0.447	-1.401	0.870
France	0.988	0.245	0.169	0.338	0.991	0.333	-1.779	0.938
Germany	0.980	0.211	1.277	0.183	0.982	0.224	0.213	0.425
Italy	1.041	0.918	-0.494	0.782	1.038	0.888	-0.648	0.774
Japan	0.982	0.259	1.060	0.423	0.982	0.296	2.504	**0.080**
Netherlands	0.988	0.256	1.111	0.176	0.998	0.448	0.591	0.301
Portugal	0.974	0.237	0.417	0.838	0.934	0.180	0.141	0.708
Sweden	1.019	0.641	0.188	0.355	1.033	0.787	-1.158	0.829
Switzerland	0.956	**0.074**	1.369	0.309	0.948	**0.041**	0.740	0.384
U.K.	1.016	0.660	0.302	0.340	1.019	0.683	-1.108	0.821

Note: The predictive regression model is $\Delta s_{t+k} = \alpha + \beta z_t + \varepsilon_t$, where $\Delta s_{t+k} = (\log S_{t+k} - \log S_t) \times 100$ is the exchange rate return, and $z_t = f_t - s_t$ is the deviation of the exchange rate from its fundamental value suggested by f_t. TU-stat and CW-stat are Theil's U and Clark–West test statistics, respectively. The Bold entries indicate significance at the 10% level.

Table 8: Twelve-Step-Ahead Out-of-sample Test Results for Predicting Exchange Rate Returns ($k = 12$)

	Monetary Fundamental				Taylor I Fundamental			
	TU-stat	p-value	CW-stat	p-value	TU-stat	p-value	CW-stat	p-value
Australia	1.113	0.995	1.103	0.945	1.103	0.997	1.055	0.889
Canada	1.098	0.968	1.337	0.503	1.126	0.993	0.152	0.746
Denmark	0.828	0.104	2.759	0.220	1.065	0.849	-1.310	0.968
France	1.038	0.715	1.683	0.543	0.996	0.444	-0.778	0.947
Germany	1.091	0.958	1.981	0.812	1.016	0.902	2.093	0.849
Italy	0.982	0.997	2.784	0.999	0.989	0.972	-0.573	1.000
Japan	0.956	0.996	1.693	0.999	0.946	0.991	3.098	0.999
Netherlands	1.169	0.990	0.293	0.961	1.031	0.911	1.165	0.872
Portugal	1.177	1.000	0.518	1.000	0.931	1.000	0.613	1.000
Sweden	0.993	0.573	1.906	0.497	1.029	0.874	0.522	0.933
Switzerland	0.756	0.505	3.035	0.976	0.961	0.989	2.007	1.000
U.K.	0.902	0.254	1.921	0.670	0.956	0.579	-0.464	0.982

	UIP Fundamental				Taylor II Fundamental			
	TU-stat	p-value	CW-stat	p-value	TU-stat	p-value	CW-stat	p-value
Australia	1.084	0.984	1.036	0.876	1.104	0.996	1.049	0.913
Canada	1.138	1.000	-0.550	0.916	1.126	0.995	0.141	0.753
Denmark	1.042	0.766	-0.796	0.936	1.066	0.867	-1.316	0.970
France	1.011	0.569	-0.835	0.956	0.996	0.475	-0.764	0.941
Germany	1.015	0.908	1.703	0.900	1.016	0.886	2.081	0.822
Italy	1.016	0.983	0.038	0.999	0.989	0.982	-0.568	1.000
Japan	0.903	0.961	5.201	0.891	0.946	0.993	3.088	0.995
Netherlands	1.145	0.990	0.626	0.915	1.031	0.912	1.143	0.900
Portugal	0.756	0.928	1.263	1.000	0.931	1.000	0.613	1.000
Sweden	1.029	0.894	-0.405	0.988	1.029	0.872	0.512	0.941
Switzerland	0.971	0.975	2.255	0.988	0.962	0.993	2.002	0.999
U.K.	0.968	0.657	-0.164	0.979	0.956	0.544	-0.453	0.987

	PPP Fundamental				Taylor III Fundamental			
	TU-stat	p-value	CW-stat	p-value	TU-stat	p-value	CW-stat	p-value
Australia	1.034	0.885	2.283	0.684	1.089	0.990	1.266	0.897
Canada	1.061	0.826	1.980	0.299	1.140	0.999	-0.724	0.939
Denmark	0.982	0.357	2.408	0.181	1.056	0.849	-1.148	0.955
France	0.922	0.111	2.677	0.168	1.006	0.534	-1.130	0.958
Germany	0.947	0.654	3.475	0.585	1.026	0.935	1.826	0.877
Italy	0.991	0.983	1.557	0.994	1.011	0.990	-0.248	1.000
Japan	0.922	0.980	2.900	0.993	0.910	0.965	4.716	0.948
Netherlands	0.959	0.597	3.387	0.491	1.140	0.986	1.268	0.802
Portugal	1.007	1.000	1.638	1.000	0.739	0.896	1.298	1.000
Sweden	0.953	0.542	2.449	0.676	1.039	0.916	-0.580	0.994
Switzerland	0.878	0.882	3.052	0.988	0.976	0.972	2.289	0.985
U.K.	0.907	0.302	2.331	0.694	0.985	0.729	-0.759	0.991

Note: The predictive regression model is $\Delta s_{t+k} = \alpha + \beta z_t + \varepsilon_t$, where $\Delta s_{t+k} = (\log S_{t+k} - \log S_t) \times 100$ is the exchange rate return, and $z_t = f_t - s_t$ is the deviation of the exchange rate from its fundamental value suggested by f_t. TU-stat and CW-stat are Theil's U and Clark–West test statistics, respectively.

Table 9: Robustness Check: One-Step-Ahead Out-of-sample Test Results for Predicting Exchange Rate Swings with Alternative P/R Ratios ($k = 1$)

	UIP Fundamental							
	$P/R = 0.5$		$P/R = 1.0$		$P/R = 1.5$		$P/R = 2.0$	
	QPS	p-value	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.502	0.517	0.498	0.146	0.521	0.999	0.497	0.076
Canada	0.647	1.000	0.536	1.000	0.540	1.000	0.590	1.000
Denmark	0.517	0.992	0.504	0.669	0.504	0.644	0.523	1.000
France	0.496	0.171	0.483	0.005	0.481	**0.002**	0.487	**0.008**
Germany	0.482	**0.022**	0.514	0.986	0.500	0.254	0.492	0 **0.052**
Italy	0.513	0.973	0.513	0.984	0.519	0.999	0.549	1.000
Japan	0.389	**0.000**	0.370	**0.000**	0.376	**0.000**	0.384	**0.000**
Netherlands	0.500	0.362	0.441	**0.000**	0.424	**0.000**	0.436	**0.000**
Portugal	0.456	**0.038**	0.460	**0.022**	0.466	**0.026**	0.471	**0.031**
Sweden	0.486	**0.096**	0.491	0.131	0.496	0.253	0.524	1.000
Switzerland	0.410	**0.000**	0.448	**0.000**	0.455	**0.000**	0.494	0.241
U.K.	0.497	0.441	0.484	**0.044**	0.480	**0.016**	0.469	**0.000**

	Taylor Rule III Fundamental							
	$P/R = 0.5$		$P/R = 1.0$		$P/R = 1.5$		$P/R = 2.0$	
	QPS	p-value	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.527	1.000	0.520	0.998	0.545	1.000	0.510	0.962
Canada	0.746	1.000	0.580	1.000	0.556	1.000	0.629	1.000
Denmark	0.511	0.958	0.504	0.707	0.510	0.963	0.517	0.997
France	0.489	**0.046**	0.491	**0.032**	0.486	**0.008**	0.489	**0.012**
Germany	0.481	**0.020**	0.533	1.000	0.503	0.461	0.494	**0.058**
Italy	0.507	0.836	0.504	0.488	0.513	0.980	0.524	1.000
Japan	0.402	**0.000**	0.389	**0.000**	0.387	**0.000**	0.398	**0.000**
Netherlands	0.509	0.750	0.450	**0.000**	0.434	**0.000**	0.427	**0.000**
Portugal	0.482	0.163	0.470	**0.056**	0.470	**0.041**	0.475	**0.061**
Sweden	0.489	0.132	0.494	0.217	0.507	0.898	0.518	0.998
Switzerland	0.418	**0.000**	0.457	**0.000**	0.458	**0.000**	0.492	0.196
U.K.	0.510	0.954	0.496	0.339	0.483	**0.026**	0.480	**0.013**

Note: The predictive regression model is $\mathbf{P}(D_{t+k} = 1) = F(\alpha + \beta z_t)$, where D_{t+k} is a dummy variable so that $D_{t+k} = 1$ if in an appreciation trend and $D_{t+k} = 0$ if in a depreciation trend. The market trend is identified by a Bry–Boschan method. P/R indicates the ratio of the in-sample and post-sample observations. Bold entries indicate significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

Table 10: Robustness Check: One-Step-Ahead Out-of-sample Test Results for Predicting Exchange Rate Swings with Alternative Moving Average Window Width (q) and Pagan-Sossounov Modifications for the Bry-Boschan Algorithm

	UIP Fundamental					
	$q = 3$		$q = 9$		Pagan-Sossounov	
	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.494	**0.021**	0.494	**0.021**	0.510	0.970
Canada	0.522	1.000	0.569	1.000	0.533	1.000
Denmark	0.515	0.998	0.506	0.874	0.496	**0.035**
France	0.494	**0.022**	0.483	**0.007**	0.485	**0.002**
Germany	0.488	**0.011**	0.488	**0.011**	0.497	**0.088**
Italy	0.540	1.000	0.540	1.000	0.547	1.000
Japan	0.398	**0.000**	0.380	**0.000**	0.384	**0.000**
Netherlands	0.488	**0.026**	0.461	**0.001**	0.461	**0.000**
Portugal	0.483	0.155	0.481	**0.040**	0.481	0.250
Sweden	0.525	1.000	0.493	**0.028**	0.493	**0.028**
Switzerland	0.473	**0.004**	0.462	**0.003**	0.460	**0.033**
U.K.	0.479	**0.007**	0.442	**0.000**	0.489	**0.003**

	Taylor Rule III Fundamental					
	$q = 3$		$q = 9$		Pagan-Sossounov	
	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.496	**0.045**	0.496	**0.045**	0.527	1.000
Canada	0.563	1.000	0.620	1.000	0.563	1.000
Denmark	0.528	1.000	0.530	1.000	0.516	0.998
France	0.499	**0.100**	0.492	**0.084**	0.493	**0.027**
Germany	0.488	**0.014**	0.488	**0.014**	0.497	**0.072**
Italy	0.536	1.000	0.536	1.000	0.547	1.000
Japan	0.403	**0.000**	0.396	**0.000**	0.401	**0.000**
Netherlands	0.455	**0.000**	0.427	**0.000**	0.427	**0.000**
Portugal	0.506	0.694	0.506	0.509	0.506	0.795
Sweden	0.548	1.000	0.509	0.936	0.509	0.936
Switzerland	0.472	**0.004**	0.463	**0.005**	0.461	**0.037**
U.K.	0.495	0.212	0.456	**0.000**	0.496	**0.047**

Note: The predictive regression model is $\mathbf{P}(D_{t+k} = 1) = F(\alpha + \beta z_t)$, where D_{t+k} is a dummy variable so that $D_{t+k} = 1$ if in an appreciation trend and $D_{t+k} = 0$ if in a depreciation trend. The market trend is identified by a Bry–Boschan method. q is the window width used in the Bry–Boschan algorithm. Pagan-Sossounov indicates the modified Bry–Boschan algorithm proposed by Pagan and Sossounov (2003). Bold entries indicate significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

Table 11: One-Step-Ahead Out-of-sample Test Results for Predicting Exchange Rate Swings with Weekly Data

	UIP Fundamental					
	$P/R = 1.5$, $q = 24$		$P/R = 2.0$, $q = 24$		$P/R = 2.5$, $q = 24$	
	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.330	**0.000**	0.311	**0.000**	0.322	**0.000**
Canada	0.418	**0.000**	0.416	**0.000**	0.421	**0.000**
Denmark	0.447	**0.016**	0.428	**0.000**	0.414	**0.000**
France	0.389	**0.000**	0.375	**0.000**	0.366	**0.000**
Germany	0.389	**0.000**	0.372	**0.000**	0.363	**0.000**
Italy	0.512	1.000	0.486	1.000	0.455	0.363
Japan	0.252	**0.000**	0.249	**0.000**	0.303	**0.000**
Netherlands	0.386	**0.000**	0.370	**0.000**	0.364	**0.000**
Portugal	0.553	1.000	0.498	0.969	0.465	**0.052**
Sweden	0.582	1.000	0.523	1.000	0.489	**0.040**
Switzerland	0.418	**0.000**	0.384	**0.000**	0.362	**0.000**
U.K.	0.503	0.997	0.480	0.287	0.492	0.847
	$P/R = 2.5$, $q = 6$		$P/R = 2.5$, $q = 8$		$P/R = 2.5$, $q = 12$	
	QPS	p-value	QPS	p-value	QPS	p-value
Australia	0.308	**0.000**	0.307	**0.000**	0.307	**0.000**
Canada	0.431	**0.000**	0.431	**0.000**	0.421	**0.000**
Denmark	0.411	**0.000**	0.411	**0.000**	0.414	**0.000**
France	0.398	**0.000**	0.398	**0.000**	0.398	**0.000**
Germany	0.397	**0.000**	0.397	**0.000**	0.397	**0.000**
Italy	0.462	0.671	0.474	0.814	0.473	0.712
Japan	0.303	**0.000**	0.303	**0.000**	0.303	**0.000**
Netherlands	0.399	**0.000**	0.399	**0.000**	0.399	**0.000**
Portugal	0.509	1.000	0.509	1.000	0.509	1.000
Sweden	0.489	**0.040**	0.489	**0.040**	0.489	**0.040**
Switzerland	0.385	**0.000**	0.385	**0.000**	0.385	**0.000**
U.K.	0.486	0.841	0.486	0.841	0.487	0.978

Note: The predictive regression model is $\mathbf{P}(D_{t+k} = 1) = F(\alpha + \beta z_t)$, where D_{t+k} is a dummy variable so that $D_{t+k} = 1$ if in an appreciation trend and $D_{t+k} = 0$ if in a depreciation trend. The market trend is identified by a Bry–Boschan method. P/R indicates the ratio of the in-sample and post-sample observations. q is the window width used in the Bry–Boschan algorithm. Bold entries indicate significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

Figure 1: Monthly Exchange Rate Swings (shading areas indicate appreciation-trend periods): 1973:M1–2010:M12

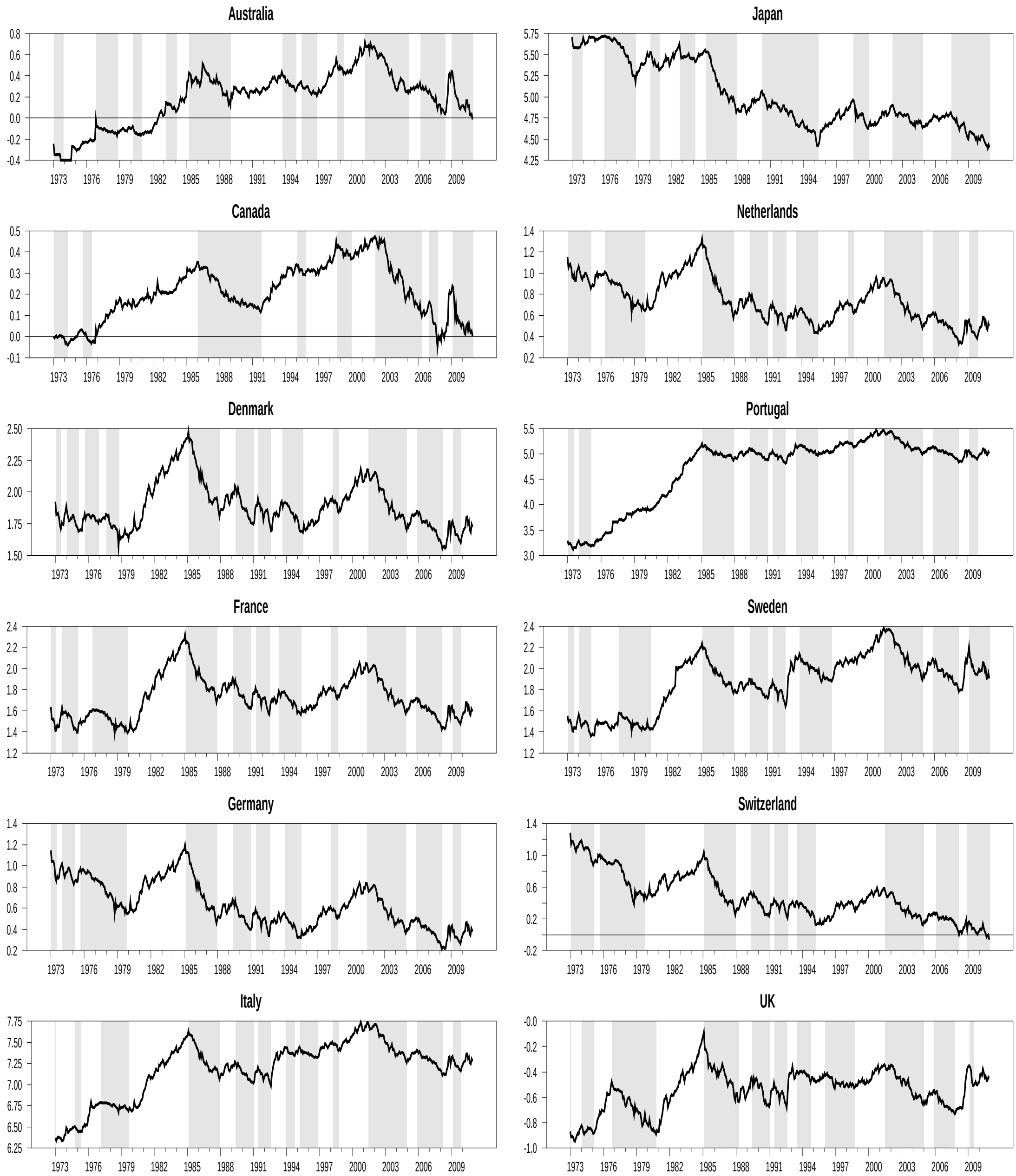
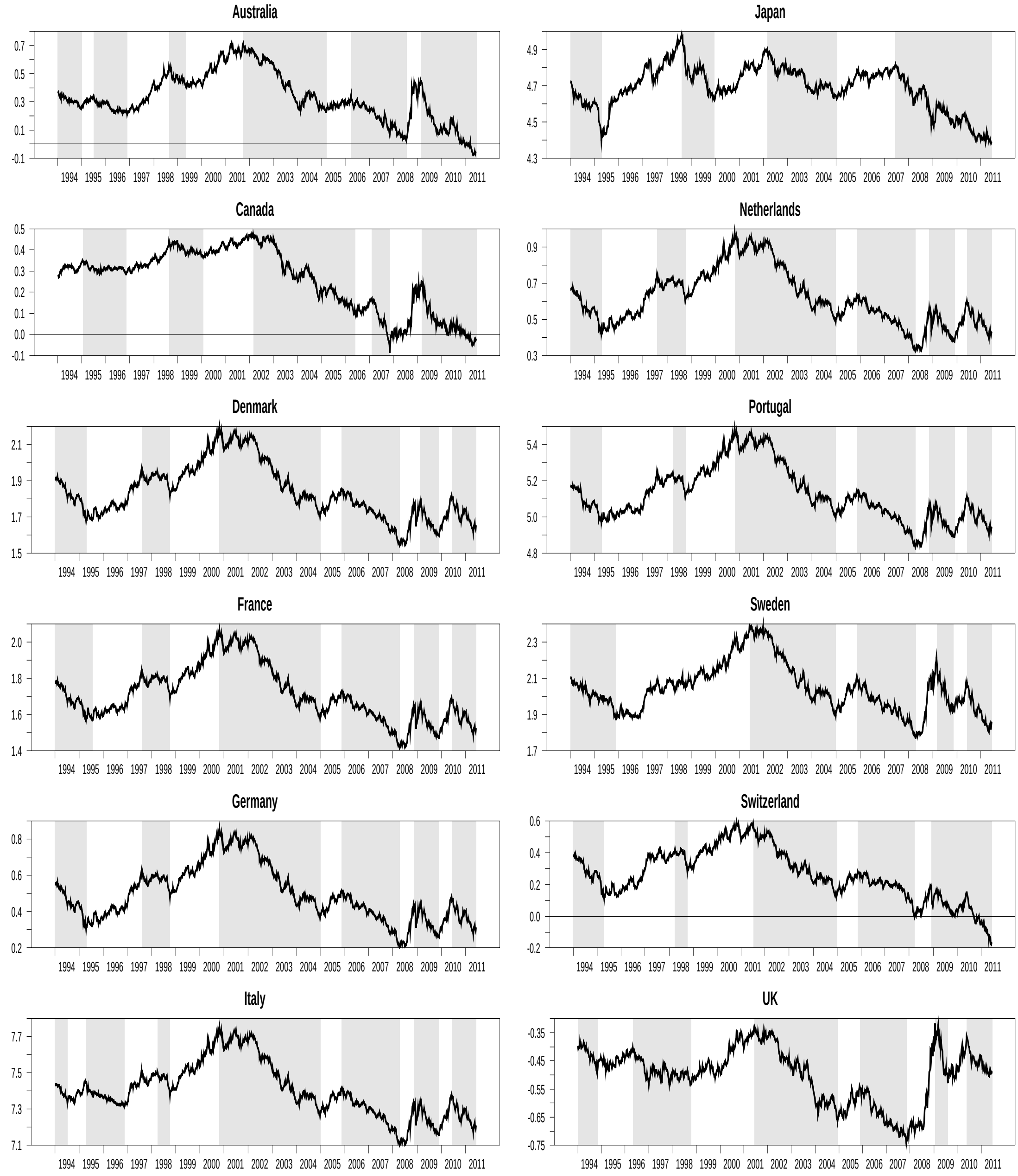


Figure 2: Weekly Exchange Rate Swings (shading areas indicate appreciation-trend periods): 1994:1:5–2011:6:15



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