Exchange rate forecasting with Excel

Michele Ca' Zorzi
European Central Bank

Michał Rubaszek
SGH Warsaw School of Economics
Narodowy Bank Polski

Abstract

This paper shows that there are two regularities in foreign exchange markets in advanced countries with flexible regimes. First, real exchange rates are mean-reverting, as implied by the Purchasing Power Parity model. Second, the adjustment takes place via nominal exchange rates. These features of the data can be (easily) exploited to generate nominal exchange rate forecasts that outperform the random walk. The secret is to avoid estimating the pace of mean reversion and the evolution of relative inflation.

Keywords: Exchange rate forecasting; Purchasing Power Parity; mean reversion.

JEL classification: C32; F31; F37; F41.

Non-technical summary

The international finance literature has documented two important regularities in foreign exchange markets. First, there is ample evidence that for developed countries real exchange rates are reverting to the level implied by the Purchasing Power (PPP) theory. Second, for flexible currency regimes the adjustment process is predominantly driven by the nominal exchange rate. At the same time most of the recent articles remain very skeptical that one can outperform the RW in nominal exchange rate forecasting.

In this paper we claim that the two above in-sample regularities of foreign exchange markets can be exploited to infer out-of-sample movements of major currency pairs. To prove this thesis we proceed as follows:

1. We begin by presenting robust (in-sample) evidence that long-run PPP holds and that the nominal exchange rate is the main driver of this adjustment process. Both these empirical regularities validate modern and traditional exchange rate models.

2. We then evaluate a battery of models that aim to exploit these in-sample regularities. We find that reasonably calibrated models outperform the RW at all horizons. It is enough to assume that the real exchange rate gradually returns to its past sample mean and that relative prices play no role in this adjustment. This can be done easily with an Excel worksheet.

3. We highlight that severe problems arise, instead, when attempting to estimate the pace of mean reversion of the real exchange rate or forecasting relative inflation. Among the estimated approaches, we find that it is preferable to rely on direct rather than indirect forecasting methods. In the case of direct methods and medium-term horizons the estimation error is less acute, hence one can beat the RW in real and nominal exchange rate forecasting.

4. This analysis highlights that equilibrium exchange rate analysis matters. Simple measures of exchange rate disequilibria, not only signal economic imbalances, but also in which direction the exchange rate might go.

Our paper highlights that it is misleading to exclusively rely on the out-of-sample evidence and think of the nominal exchange rate as a RW. The time has come to reappraise exchange rate theory.

1 Introduction

Not for the first time in the history of the exchange rate (ER) literature there is a clear dichotomy between the ”in” and ”out” of sample evidence. Comprehensive writings have shown that the most popular ER models of our times, albeit successful in explaining what drives them in-sample, cannot consistently beat the random walk (RW) out-of-sample (Cheung et al., 2005, 2016). Building on the results of Ca' Zorzi et al. (2016, 2017), we find that there are however two empirical regularities helping us to beat the RW in a forecasting race. The first one is that Purchasing Power Parity (PPP) holds over the medium run. The second one is that in flexible regimes the nominal ER (NER) drives most of the real ER (RER) adjustment process. This is re-assuring as these regularities feature also in the classic Dornbusch (1976) model and in state-of-the-art DSGE models (Eichenbaum et al., 2017). These results immediately prompt the question: why didn't previous analyses exploit these features in the data and beat the RW?

The principal contribution of this paper is to provide an exhaustive and, in our eyes conclusive, answer to this apparent dichotomy. This is achieved in three steps. First, we present robust evidence for the aforementioned two regularities for major bilateral ER pairs of the US dollar. Second, we explain why previous studies, which relied on estimated models, could not systematically beat the RW. Third, we show that calibrating the half-life RER adjustment to three years and a RW for relative inflation is, at least for advanced countries, a better option than the RW or relying on estimated models. The conclusion that we draw is that the ER forecasting problem is dual, i.e. an estimation error problem and a failure to understand what drives relative inflation across countries. Once these difficulties are appropriately accounted for, beating the RW is (almost) trivial. This analysis also reveals that the out-of-sample evidence, on which the ER literature has dwelled for so long, can be misleading from the policy perspective more than the in-sample regularities of foreign ER markets.

2 In-sample regularities on the FX markets

From the IMF-IFS and BIS databases we have taken monthly end-of-period NER against the USD and consumer price index (CPI) data over the period 1975:1-2017:5 for the following countries: Australia (AUD), Canada (CAD), Japan (JPY), New Zealand (NZD), Switzerland (CHF), the United Kingdom (GBP), the euro area (EUR), Korea (KRW), Norway (NOK), Sweden, (SEK) and the United States (US).[1] Using these times series, we have calculated the bilateral RERs as:

$$rer \equiv ner + rpi, \tag{1}$$

where $rpi = p - p^*$ is the relative price index. Following this definition, an increase in the RER and NER represents an appreciation of the domestic currency with respect to the USD.

The first regularity in the data is that RERs are mean reverting over medium-term horizons. A particularly neat way to illustrate this is to scatter plot changes of real bilateral ER of the euro at different horizons relative to its starting level (top panel, Figure 1). The negative correlation, already visible at the six-month, gets progressively stronger at longer horizons, proving that there is a powerful self-adjusting mechanism at play. The second regularity is illustrated by the middle and bottom panels of Figure 1, which show that the NER and not the RPI drives this adjustment. This stylized fact is entirely intuitive, if we think that ERs play an important role in absorbing atypical movements in price competitiveness. This in-sample empirical regularity has recently been emphasized by Eichenbaum et al. (2017) and compared to the properties of DSGE models to validate them. However, it matches perfectly also one of the standard equations in the Dornbusch model and hence equally validates the open-economy models of the 1970s and 1980s.

Particularly remarkable is how robust these results are to all currency pairs in our dataset. To show this we have estimated the following regressions:

$$\Delta rer_{t,h} = \alpha_h + \beta_h rer_{t-h} + \epsilon_t \tag{2a}$$

$$\Delta ner_{t,h} = \alpha_h + \beta_h \Delta rer_{t,h} + \epsilon_t \tag{2b}$$

$$\Delta rpi_{t,h} = \alpha_h + \beta_h \Delta rer_{t,h} + \epsilon_t, \tag{2c}$$

where $\Delta y_{t,h} = y_t - y_{t-h}$. If the RER is mean reverting, then in model (2a) β_h should converge to -1. In turn, if the adjustment in RER is driven by NER rather than the RPI then in model (2b) $\beta_h = 1$ and in model (2c) $\beta_h = 0$. This is exactly what we have found in the data for all analyzed currencies, as reported in the three panels of Table 1.

[1] For the euro area over the pre-monetary union period we have taken either a composite of the eleven legacy currencies of the euro (EA11) or Germany (DE). For ease of exposition we report only the results for the EA11 composite measure since the alternative set of results are almost identical.

3 Out-of-sample evidence

The above in-sample analysis suggests that real and nominal ER rates do not behave like random walks. But is this assessment compatible with the out-of-sample evidence? In this section we will assess the accuracy of the forecasts generated by three simple models and compare it to that of the RW benchmark by running a rolling monthly forecast, in which the length of the estimation window is set to 15 years. The performance is evaluated with the root mean squared forecast errors (RMSFEs) statistics calculated with the forecasts formulated for the period 1990:1-2017:5. In particular, we have 329 1-month-ahead forecasts, 328 2-month-ahead forecasts and so forth.

In general, we will consider the three following models:

$$
\begin{array}{lll}
\text{Autoregression (AR):} & y_t = \mu + \rho(y_{t-1} - \mu) + \epsilon_t; & y^f_{t+h} = \hat{\mu} + \hat{\rho}^h(y_t - \hat{\mu}). \\
\text{Half-life (HL):} & y_t = \mu + \rho(y_{t-1} - \mu) + \epsilon_t; & y^f_{t+h} = \overline{\mu} + \overline{\rho}^h(y_t - \overline{\mu}). \\
\text{Direct forecast (DF):} & \Delta y_{t,h} = \alpha_h + \beta_h(x_{t-h}) + \epsilon_t; & y^f_{t+h} = y_t + (\hat{\alpha}_h + \hat{\beta}_h x_t).
\end{array}
$$

The first two models are mean-reverting autoregressions of order one with the only difference that, in one case, the parameters are estimated, and in the other, calibrated. For the RER, following Ca' Zorzi et al. (2016), we have calibrated $\overline{\rho}$ and $\overline{\mu}$ so that half of the adjustment of the RER toward 15-year average takes 3 years. For relative inflation (Δrpi) we set $\overline{\mu}$ to 0 and, building on the results of Faust and Wright (2013), we calibrate $\overline{\rho}$ so that the half-life is six months. The last competitor is a simple direct forecast, in which the adjustment in y at the h horizon depends on the initial level of x.

3.1 Real exchange rate

The results for the RER are presented in the upper panel of Table 2. They confirm that the AR model fails to beat the RW. Only at the five-year horizon, when the mean-reverting forces are sufficiently strong to outweigh the estimation error problem, the outcome tends to flip in favor of the AR model. The DF model, which exploits the regularities reported in the top panels of Figure 1 and Table 1, becomes more competitive at the 2 year horizon, suggesting that with direct forecasting the "estimation error" problem is less acute. Finally, the HL model overwhelmingly beats the RW at all horizons. We conclude that the difficulties encountered with RER forecasting in previous analyses is mainly caused by estimator error.

3.2 Relative price index

If the RER is forecastable so should be the NER, if we can reasonably extrapolate what drives the RPI. This is tautological if we think in terms of the accounting identity $\Delta ner \equiv$

$\Delta rer - \Delta rpi$. But is forecasting relative inflation easy? Not at all. For example the euro area has shown, for several consecutive years, a tendency to record lower inflation rates than the US. While the direction of the movement has been almost always the same, this (relative) deflationary process has decelerated in a way that was difficult to forecast ex-ante.

Let us explore this issue in a more formal setting. Our benchmark model is again the RW, which assumes constant RPI. This simple approach could be motivated by the importance of global inflation in determining domestic inflation, as suggested by Ciccarelli and Mojon (2010). The results for the AR, DF and HL model are presented in the middle panel of Table 2 and prove the difficulty to forecast the RPI. The AR model extrapolates too much past trends. The DF model is not helpful, as the RPI does not play a significant role in the RER adjustment. A marginally better performance than the RW is given by the HL model, as it exploits some short-run persistence of inflation differentials out of sample.

3.3 Nominal exchange rate

We finally turn to the NER. We do not report the results for the AR model as they are, similarly to the case of the RER, imprecise. There are three competitors left to challenge the RW. The first is the DF model, in which we exploit directly the empirical regularity that the NER adjusts to restore PPP. For the remaining two, the future path of the NER is calculated as the difference in the forecast of the RER (HL model) and RPI (RW or HL model), bypassing entirely the estimation error problem. As before the DF model is competitive above the 2-year horizon (Table 2). The two calibrated models are extremely competitive, instead, at all horizons. The slightly more accurate, between the two, is the model that assumes a (three-year) HL process for the RER and a constant for the RPI. The corresponding ER forecasts are then given by the following formula:

$$\Delta ner^{f}_{t+h,h} = \rho^{h}(rer_t - \overline{\mu}) \tag{3}$$

Although computable easily with a spreadsheet, such projections are much more accurate than just to assume a constant exchange rate. Simple variants of this model, by changing the calibration of the half-life adjustment within reasonable values (i.e. between 2 and 5 years), or changing the methodology for calculating the RER equilibrium $\overline{\mu}$ would, in general, not change this positive outcome. These variants equally beat the RW by exploiting the mean reversion of the RER while avoiding the common pitfalls described in this paper.

4 Conclusions

Our data suggest that there are two regularities in foreign exchange markets in advanced countries with flexible regimes, i.e. the mean reversion of the RER and the tendency of the NER to drive such adjustment. There are different ways to capitalize on these findings, either with estimated or calibrated models, to forecast ERs. The preferable option is to employ a calibrated approach, i.e. to assume a gradual adjustment for the RER toward PPP and be agnostic about the evolution of the RPI. Among the estimated approaches, it is clearly better to rely on "direct" rather than "indirect" forecasting techniques, as they at least outforecast the RW at medium-term horizons. The prime intention of this paper was to show how out-of-sample evidence can be misleading. It is indeed not true that nothing can be said about ERs. They act as shock absorbers. The secret to beat the RW is to impose a reasonable pace at which PPP is restored and assume that relative inflation is zero.

References

Ca' Zorzi, M., Kolasa, M., Rubaszek, M., 2017. Exchange rate forecasting with DSGE models. Journal of International Economics 107 (C), 127–146.

Ca' Zorzi, M., Muck, J., Rubaszek, M., 2016. Real exchange rate forecasting and PPP: This time the random walk loses. Open Economies Review 27 (3), 585–609.

Cheung, Y.-W., Chinn, M. D., Pascual, A. G., 2005. Empirical exchange rate models of the nineties: Are any fit to survive? Journal of International Money and Finance 24 (7), 1150–1175.

Cheung, Y.-W., Chinn, M. D., Pascual, A. G., 2016. Empirical exchange rate models of the 'teens: Are any fit to survive?, unpublished manuscript (version: July 2016).

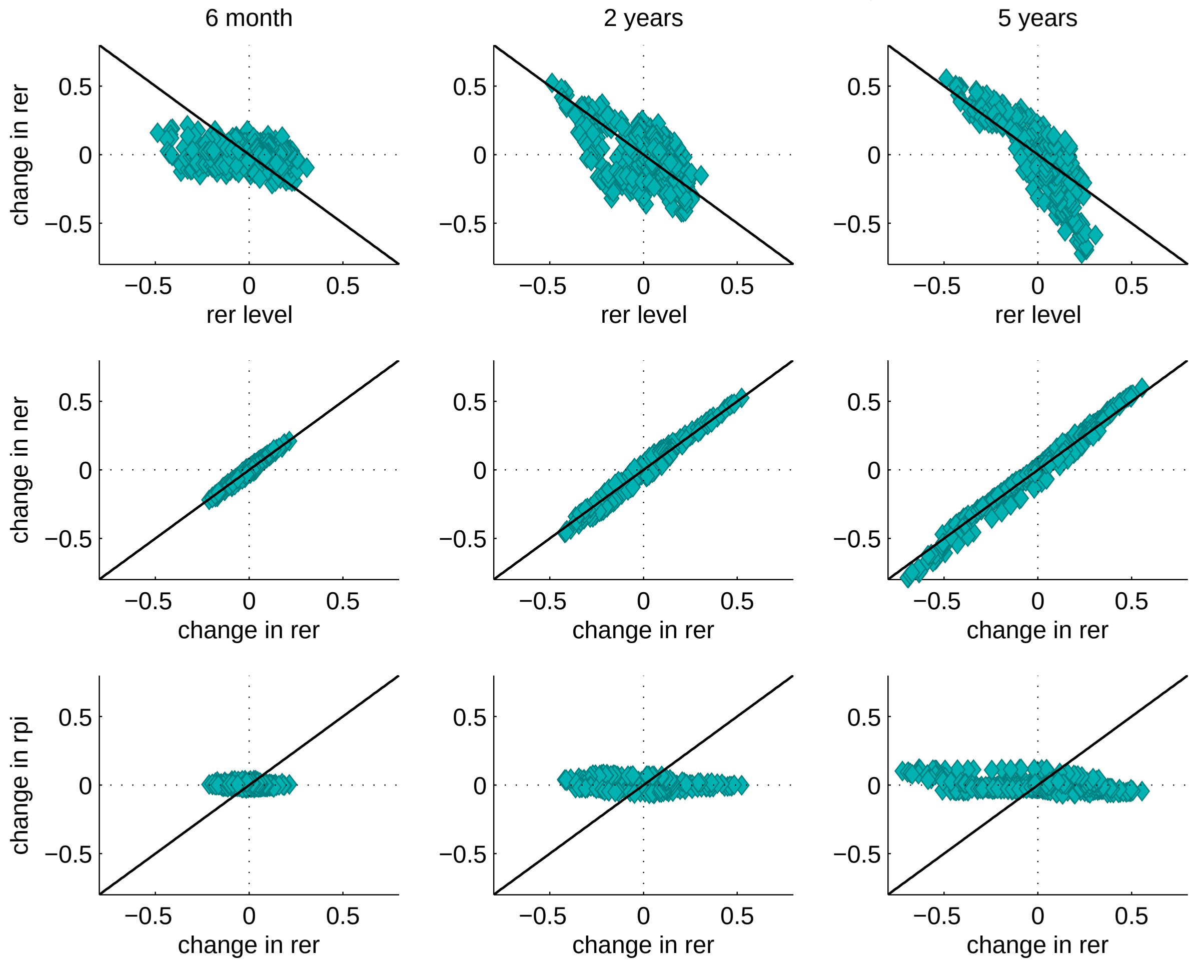
Ciccarelli, M., Mojon, B., 2010. Global inflation. The Review of Economics and Statistics 92 (3), 524–535.

Dornbusch, R., 1976. Expectations and exchange rate dynamics. Journal of Political Economy 84 (6), 1161–1176.

Eichenbaum, M., Johannsen, B. K., Rebelo, S., 2017. Monetary policy and the predictability of nominal exchange rates. NBER Working Papers 23158, National Bureau of Economic Research, Inc.

Faust, J., Wright, J. H., 2013. Forecasting inflation. In: Elliott, G., Timmermann, A. (Eds.), Handbook of Economic Forecasting. Vol. 2. Elsevier, Ch. 1, pp. 2–56.

Figure 1: Illustration of ER regularities for the EUR/USD rate



Notes: Changes are expressed as the value of expression $y_{t+h} - y_t$, where $y_t = \log(Y_t)$. The rer level is equal to $rer_t - \overline{rer}$, where $\overline{rer}$ is the sample mean.

Table 1: Regressions for ER regularities

	6 months			**2 years**			**5 years**		
	α_h	β_h	R^2	α_h	β_h	R^2	α_h	β_h	R^2
	Estimates of $\Delta rer_{t,h} = \alpha_h + \beta_h rer_{t-h} + \epsilon_t$								
AUD	0.00	-0.11	0.06	-0.01	-0.41	0.22	-0.02	-0.92	0.44
CAD	0.00	-0.08	0.04	-0.01	-0.38	0.21	-0.02	-0.98	0.51
JPY	0.00	-0.12	0.06	0.01	-0.52	0.27	0.02	-0.85	0.43
NZD	0.00	-0.11	0.05	0.01	-0.51	0.25	0.00	-1.07	0.48
CHF	0.00	-0.14	0.07	0.01	-0.57	0.29	0.00	-1.05	0.52
GBP	0.00	-0.20	0.09	0.00	-0.84	0.39	0.00	-1.41	0.69
EUR	0.00	-0.13	0.06	-0.01	-0.59	0.29	-0.02	-1.35	0.70
KRW	0.00	-0.17	0.08	0.00	-0.63	0.31	-0.01	-1.16	0.62
NOK	0.00	-0.15	0.07	-0.01	-0.58	0.26	-0.01	-1.36	0.65
SEK	-0.01	-0.09	0.04	-0.02	-0.45	0.21	-0.04	-1.04	0.55
	Estimates of $\Delta ner_{t,h} = \alpha_h + \beta_h \Delta rer_{t,h} + \epsilon_t$								
AUD	-0.01	1.01	0.96	-0.02	0.99	0.93	-0.04	1.00	0.92
CAD	0.00	1.00	0.96	0.00	0.97	0.94	0.00	0.98	0.95
JPY	0.01	0.97	0.98	0.04	0.98	0.97	0.12	0.99	0.97
NZD	-0.01	0.99	0.94	-0.03	0.91	0.87	-0.08	0.94	0.76
CHF	0.01	1.00	0.98	0.04	0.99	0.95	0.09	0.93	0.91
GBP	0.00	1.02	0.96	-0.01	1.01	0.95	-0.02	1.01	0.93
EUR	0.00	1.02	0.98	0.00	1.03	0.98	0.01	1.05	0.98
KRW	-0.01	1.03	0.94	-0.04	1.04	0.89	-0.09	1.05	0.81
NOK	0.00	1.01	0.96	-0.01	1.01	0.93	-0.02	1.00	0.90
SEK	0.00	1.01	0.97	-0.01	0.99	0.95	-0.02	0.97	0.91
	Estimates of $\Delta rpi_{t,h} = \alpha_h + \beta_h \Delta rer_{t,h} + \epsilon_t$								
AUD	0.01	-0.01	0.00	0.02	0.01	0.00	0.04	0.00	0.00
CAD	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.02	0.01
JPY	-0.01	0.03	0.05	-0.04	0.02	0.02	-0.12	0.01	0.00
NZD	0.01	0.01	0.00	0.03	0.09	0.06	0.08	0.06	0.01
CHF	-0.01	0.00	0.00	-0.04	0.01	0.00	-0.09	0.07	0.05
GBP	0.00	-0.02	0.01	0.01	-0.01	0.00	0.02	-0.01	0.00
EUR	0.00	-0.02	0.02	0.00	-0.03	0.04	-0.01	-0.05	0.13
KRW	0.01	-0.03	0.01	0.04	-0.04	0.01	0.09	-0.05	0.01
NOK	0.00	-0.01	0.00	0.01	-0.01	0.00	0.02	0.00	0.00
SEK	0.00	-0.01	0.00	0.01	0.01	0.00	0.02	0.03	0.01

Table 2: RMSFE for RER, RPI and NER with respect to the RW

	1 months			**6 months**			**2 years**			**5 years**		
	real exchange rate											
	AR	DF	HL	AR	DF	HL	AR	DF	HL	AR	DF	HL
AUD	1.01	1.01	1.00	1.03	1.04	1.00	1.02	1.11	0.96	0.97	1.08	0.92
CAD	1.01	1.01	1.00	1.05	1.05	1.01	1.07	1.15	0.99	1.16	1.15	0.88*
JPY	1.01	1.01	1.00	1.04	1.05	1.00	1.05	1.15	0.97	1.01	1.19	0.88*
NZD	1.01	1.01	1.00	1.05	1.05	0.99	1.03	0.96	0.90*	0.87**	0.98	0.81**
CHF	1.01	1.01	1.00	1.06	1.06	0.98	1.04	1.04	0.90*	0.85**	1.01	0.75**
GBP	1.01	1.01	1.00	1.01	1.02	0.97*	0.85**	0.76**	0.85**	0.66**	0.68**	0.71**
EUR	1.02	1.01	1.00	1.07	1.07	0.97	1.03	0.92	0.87**	0.76**	0.67**	0.69**
KRW	1.00	1.00	0.99	1.01	0.98	0.96**	1.05	0.87*	0.86**	1.60	0.79**	0.75**
NOK	1.01	1.01	1.00	1.05	1.05	0.97	0.99	0.93	0.89**	0.78**	0.71**	0.73**
SEK	1.01	1.01	1.00	1.04	1.05	0.98	1.05	0.93	0.88*	0.94	0.91	0.79**
	Relative price indices											
	AR	DF	HL	AR	DF	HL	AR	DF	HL	AR	DF	HL
AUD	1.04	1.05	1.01	1.22	1.39	1.06	1.71	2.42	1.07	2.52	3.49	1.08
CAD	1.01	1.03	1.02	1.06	1.19	1.09	1.21	1.73	0.93	1.34	2.23	0.95
JPY	0.92**	0.94**	0.93**	0.76**	0.78**	0.76**	0.58**	0.66**	0.77**	0.39**	0.49**	0.87**
NZD	1.19	1.12	1.02	1.80	1.75	1.08	3.23	3.71	1.03	5.00	6.52	1.03
CHF	0.97*	1.01	0.96**	0.88	1.10	0.79**	0.79*	1.09	0.77**	0.59**	0.79*	0.90**
GBP	1.01	1.01	1.00	1.05	1.06	0.99	1.23	1.32	0.91*	1.57	1.70	0.96
EUR	1.02	1.00	1.01	1.01	1.05	1.08	1.02	1.07	1.04	1.12	1.31	1.01
KRW	0.91*	0.99	0.98	0.91	0.94	0.95	0.78*	0.88	0.87*	0.76*	0.89	0.88**
NOK	1.01	1.02	1.02	1.10	1.11	1.04	1.40	1.66	1.02	1.92	2.83	1.05
SEK	1.00	1.02	0.99	1.09	1.16	0.94	1.42	1.49	0.85**	1.80	2.22	0.94**
	nominal exchange rate											
RER		HL	HL		HL	HL		HL	HL		HL	HL
RPI		RW	HL		RW	HL		RW	HL		RW	HL
NER	DF			DF			DF			DF		
AUD	1.01	1.00	1.01	1.04	0.99	1.01	1.05	0.95	0.97	0.99	0.89*	0.90*
CAD	1.01	1.00	1.01	1.05	1.01	1.03	1.08	1.00	1.01	0.94	0.87*	0.87*
JPY	1.01	1.00	1.00	1.05	1.01	1.00	1.12	0.97	0.98	1.08	0.89	0.88*
NZD	1.01	1.00	1.00	1.04	0.99	1.01	0.98	0.91*	0.92	1.28	0.80**	0.81**
CHF	1.01	1.00	1.00	1.04	0.99	0.99	0.93	0.94	0.93	0.80*	0.87*	0.85**
GBP	1.01	1.00	1.00	1.03	0.97*	0.99	0.78**	0.85**	0.84**	0.86*	0.75**	0.74**
EUR	1.02	1.00	1.00	1.07	0.97	0.99	0.91	0.87**	0.88**	0.68**	0.68**	0.68**
KRW	1.00	0.99	1.00	0.97	0.97**	0.97*	0.85*	0.88**	0.88**	0.63**	0.80**	0.78**
NOK	1.01	1.00	1.00	1.05	0.98	0.98	0.93	0.91**	0.91**	0.77**	0.75**	0.76**
SEK	1.01	1.00	1.00	1.05	0.97	1.00	0.88	0.86**	0.88*	0.67**	0.69**	0.71**

Notes: The table shows the ratio of RMSFE from a given model in comparison to the RMSFE from a RW. Asterisks ** and *denote the 1% and 5% significance levels of the one-sided Diebold-Mariano test with the alternative that RMSFE from a given model is lower than that from the RW.

Exchange rate forecasting with Excel

Michele Ca' Zorzi

European Central Bank, Sonnemannstrasse 20, 60314 Frankfurt, Germany.

E-mail: michele.cazorzi@ecb.europa.eu

Michał Rubaszek

SGH Warsaw School of Economics, Al. Niepodległości 162, 02-554 Warsaw, Poland

Narodowy Bank Polski, ul. Świętokrzyska 11/21, 00-919 Warsaw, Poland

E-mail: michal.rubaszek@sgh.waw.pl