"Forecasting emerging market currencies: Are inflation expectations useful?"

Alberto Fuertes and Simón Sosvilla-Rivero

UBIREA Institut de Recerca en Economia Aplicada Regional i Pública

Abstract

This paper investigates the empirical relevance of inflation expectations in forecasting exchange rates. To that end, we use an expectation version of purchasing power parity (EVRPPP) based on the differential of inflation expectations derived from inflation-indexed bonds for Brazil, Colombia, Chile, India, Mexico, Poland, South Africa, South Korea and Turkey. Using monthly data on exchange rates and on the inflation expectations, we find that our predictors are not significantly better than the random walk model, although, with the exception of the South Korean Won, they outperform the random walk when considering the sign of the rate of change. We also find strongly support Granger causality running from exchange rate to the forecasts based on EVRPPP and only partial evidence of Granger causality running the other way around. Finally, our results suggest that 1-year, 5-year and 10-year inflation expectations are mutually consistent.

JEL classification: C22, F30.

Keywords: Forecasting, Purchasing power parity, Exchange rates, Inflation expectations.

Alberto Fuertesa: Banco de España. Email: alberto.fuertes@bde.es

Simón Sosvilla-Rivero: Complutense Institute for Economic Analysis, Universidad Complutense de Madrid. Email: sosvilla@ccee.ucm.es

Acknowledgements

This work has been carried out within the research project ECO2016-76203-C2-2-P directed by Montserrat Guillen.

1. Introduction

The past 50 years have been characterized by increasing internationalization of economic activity. The relentless advances that have taken place in areas such as transport and communications, together with the progressive liberalization of international economic relationships, have given rise to unprecedented increases in trade in goods and services as well as in financial assets.

This increase has gone hand in hand with the spectacular development that has been experienced in foreign exchange markets, since the use of different national currencies makes conversions from one to another a necessary aspect of each international transaction. Naturally, this puts what are universally known as 'foreign exchange markets' at the forefront as mechanisms of multilateral conversion.

The foreign exchange market is the world's most important financial market, both due to its daily trade volume as well as its incidence in the behaviour of other markets, both for financial assets and for goods and services. Average daily global turnover in in foreign exchange spot and OTC derivatives markets rose to $6.6 trillion in April 2019, with emerging market currencies progressively gaining market share reaching 25% of overall global turnover (Bank for International Settlements, 2019).

Due to the extreme importance of foreign exchange markets for international economic activity, it is common to see in the financial market literature attempts to predict exchange rates. This has proven to be a most difficult task, due to the high volatility experienced by exchange markets, as well as the complex data-generating process governing its underlying dynamic behaviour (see, for example, Sarno and Taylor, 2002). Following on from the influential paper by Meese and Rogoff (1983) on the poor predictive capacity of exchange rate determination models compared to a random walk, there has been an immense amount of effort dedicated to analysing the causes of the extreme difficulties experienced when attempting to predict exchange rates, as well as attempts to design alternative procedures that offer improvements in predictions. Later, Cheung *et al.* (2005) evaluated the predictability of a wide variety of models that have been proposed over the past decade, and they conclude that these models are still unable to improve a random walk.

Sosvilla-Rivero and García (2005) use an Expectations Version of Relative Purchasing Power Parity (EVRPPP) to generate expected short-run variations in the dollar/euro exchange rate. With few exceptions, their predictors, based on the differential of inflation expectations derived from inflation-indexed bonds for the euro area and the USA, behave significantly better than a random walk.

This paper hopes to contribute to the wide and active research programme on predictability in financial markets by evaluating the empirical relevance of EVRPPP for the exchange rate of eight major emerging countries. The rest of the paper is organized as follows. Section 2 presents an overview of the theoretical framework used to generate the predictions. Section 3 describes the database used, and offers a statistical evaluation of the predictors. Section 4 examines the consistency properties of the formation process underlying the inflation expectations. Section 5 performs some robustness checks to asses if the uncovered rate parity condition could be useful in predicting the foreign exchange. Finally, Section 6 summarizes the findings and offers some concluding remarks.

2. Theoretical framework

Following Sosvilla-Rivero and García (2005), we make use of the EVRPPP, that integrates the parity conditions of both commodity and financial markets. This version, known as the efficient market approach (see Roll, 1979), is based on Fisher's hypothesis and the assumption of uncovered interest rate parity.

Fisher's hypothesis postulates that a country's nominal interest rate should be equal to its real interest rate plus the expected rate of inflation. Therefore:

$$i = r + \pi^e \tag{1a}$$

$$i^* = r^* + \pi^{*e} \tag{1b}$$

where i is the nominal interest rate, r is the real interest rate, π^e is the expected rate of inflation, and an asterisk denotes a foreign variable.

Uncovered interest rate parity requires that the nominal interest differential between a domestic currency investment and a foreign currency investment be equal to the expected change in the exchange rate:

$$\sigma^e = i - i^* \tag{2}$$

where σ^e is the expected rate of depreciation.

Since international investors are concerned with real rather than nominal returns on their financial assets, in order to maximize the real returns of their assets, they transfer capital from a low interest rate country to one with a higher real rate. Thus, in absence of transactions costs, specific asset risks and taxation, this process of arbitrage will result in the real rates of interest over the two countries being equated:

$$r = r^* \tag{3}$$

By substracting (1b) from (1a), using (2) and (3), and rearranging, we obtain:

$$\sigma^e = \pi^e - \pi^{*e} \tag{4}$$

which is the EVRPPP, in which all of the variables are expressed in expected values instead of incurrent values. In this way, given economic agents' expectations of the future rates of inflation in both the national and the foreign economies, we can derive a measure of market expectations on the future behaviour of the exchange rate which, compared to the rate actually observed at any given moment, will allow us to calculate the market's expected exchange rate for the following period:

$$S_{t+1}^{e} = (1+\sigma^{e})S_{t} \tag{5}$$

where *S* denotes the exchange rate (expressed as the number of units of local currency that are exchanged for one unit of foreign currency). Note that this exchange rate prediction generator process is based on market expectations of the future evolution of the inflation rates. In order to make it effective, we need to have proxy variables for the expected rates of inflation in the national and foreign economies.

In this paper, in contrast with the generally accepted approach in the empirical literature in this area which consists of using observed values for inflation rates, or predictions for these rates based on univariate models, we use inflation expectations for emerging markets obtained using the affine model employed by Fuertes *et al.* (2018).

Given the mixed results obtained by the literature testing the Purchasing Power Parity (PPP) condition (see for example He et al. (2014) and Bahmani-Oskooee et al. (2014)), we do not claim that PPP needs to hold for the sample period and currency pairs used in our exercise. Our goal is to test whether inflation expectations have any forecasting power over the exchange rate even if PPP does not hold. Actually, if deviations from PPP are not large enough valuable information about the future behaviour of the exchange rate could still be part of inflation expectations.

3. Data and empirical results

3.1. Data

We consider data for Brazil, Colombia, Chile, India, Mexico, Poland, South Africa, South Korea and Turkey.

The data on exchange rates consist of monthly averages of daily figures against the US dollar series for the Brazilian Real (BRL), the Colombian Peso (COB), the Chilean Peso (CLP), the Indian Rupee (INR), the Mexican Peso (MXN), the Poland Zloty (PLN), the South African Rand (ZAR), the South Korean Won (KRW) and the Turkish Lira (TRY) offered by the Federal Reserve Economic Data (FRED), a database maintained by the Research division of the Federal Reserve Bank of St. Louis[1].

As for the inflation expectations, one common way of obtaining them is to use market prices of financial instruments used to hedge against inflation such as inflation-linked bonds, inflation swaps or inflation options. Unfortunately, there are not many markets of inflation-linked securities in emerging economies and because of that we have followed Fuertes et al. (2018) to calculate them[2]. They use an affine model that takes as factors the observed inflation and the parameters generated in the zero-coupon yield curve estimation of nominal government bonds. The data on government bonds prices and inflation rates is obtained from IFS-DataStream.

Our sample spans from February 2007 to September 2017 for Brazil, from February 2005 to October 2017 for Colombia, from July 2012 to October 2017 for Chile, from February 2001 to April 2018 for India and Poland, from May 2001 to August 2018 for Mexico, from

[1] https://fred.stlouisfed.org/

[2] For the case of the U.S. we have used inflation linked swaps to obtain inflation expectations as there is a depth and liquid market available for those securities. Even for some emerging countries such as Chile, where inflation-linked securities exists, it is not reliable to use them as a proxy for inflation expectations given that the low liquidity of the market introduces large premiums (see Fuertes *et al.*, 2018).

February 2001 to October 2018 for South Africa and South Korea, and from November 2007 to April 2018 for Turkey. The sample size has been conditioned by the availability of inflation-expectations data.

3.2. Forecasting accuracy

Based on the inflation expectations for 1-. 5- and 10-year ahead, we compute exchange rate expectations using equation (4) and then, using equation (5), we compute recursive exchange rate forecasts that we denote EX1, EX5 and EX10, respectively[3].

Figure 1 and Figure 2 displays the observed and predicted exchange rates. As can be seen, the predicted exchange rates closely track the evolution of the observed exchange rates and the predicted values are very similar no matter the inflation expectations horizon used.

[Insert Figure 1 here]

To formally evaluate the forecasting performance of the forecast accuracy, we fist consider the root mean square error (RMSE), the mean absolute percentage error (MAPE) and the Theil inequality coefficient (*U*).

Suppose the forecast sample is *j=T+1, T+2,..., T+k*, and denote the actual and forecasted value in period *t* as y_t and $\hat{y}_t$, respectively. The RMSE statistic is computed as follows:

$$RMSE = \sqrt{\sum_{t=T+1}^{T+k} (\hat{y}_t - y_t)^2 / k} \qquad (6)$$

[3] Note that in equation (4) we are imposing that π^e and π^{e*} have the same coefficient (1), allowing us to combine them forming a differential in expected inflations. To assess the robustness of our results, we assumed that the coefficients are different, estimating the following equation:

$$\sigma^e = \alpha + \beta\pi^e - \beta^* \pi^{*e} + \varepsilon_t$$

where ε_t is the error term, and where α is also introduce to capture the existence of some factors such as government control on prices, restrictions on international trade and transportation costs that could account for deviations from EVRPPP. The results (not shown here to save space, but they are available from the authors upon request.) render the same qualitative conclusions.

and the *U* statistic is computed as follows:

$$U = \frac{\sqrt{\sum_{t=T+1}^{T+k} (\hat{y}_t - y_t)^2 / k}}{\sqrt{\sum_{t=T+1}^{T+k} \hat{y}_t^{\,2} / k} + \sqrt{\sum_{t=T+1}^{T+k} y_t^{\,2} / k}} \qquad (7)$$

As can be seen, these statistics all provide a measure of the distance of the true from the forecasted values. The RMSE statistics depend on the scale of the dependent variable (the smaller the error, the better the forecasting ability), while the Theil inequality coefficient is scale invariant (lying between zero and one, where zero indicates a perfect fit).

As for the MAPE, it is computed as follows:

$$MAPE = 100 \sum_{t=T+1}^{T+k} \left| \frac{\hat{y}_t - y_y}{y_y} \right| / k \qquad (12)$$

One of the main advantages of MAPE as a measure of forecast accuracy is that it can be implemented independently of the series' magnitude or unit of measurement. This tool has been used by many studies for comparing different methods and for forecasting accuracy as Makridakis et al. (1979), Karamouzis and Lombra (1989) or Deschamps and Mehta (1980), among others. Alternatively, we also use the SMAPE (symmetric mean absolute percentage error), another measure of forecast accuracy that in contrast to the MAPE has both an upper and a lower bound.[4]

$$SMAPE = 100 \sum_{t=T+1}^{T+k} \frac{|\hat{y}_t - y_t|}{|\hat{y}_t| + |y_t|} / k \qquad (13)$$

[4] For forecasts which are too high there is not an upper bound for the MAPE percentage error.

Table 1 reports the forecast accuracy

[Insert Table 1 here]

For all currencies but the Chilean peso, the forecasts obtained from the random walk show lower predicting errors independently of the measure used. Regarding the forecast errors among the predictors obtained using inflation expectations, those calculated from the10-year horizon expectations perform better for most currencies, with the exception of the Chilean peso, the South Korean won, the Polish zloty and the Colombian peso. In the case of the Chilean peso, the lowest error is obtained using 1-year horizon inflation expectations, while for the Polish zloty the lowest error corresponds with 5-year inflation expectations. Regarding the South Korean won and the Colombian peso, the results depend on the error measure used.

Finally, we further compare the performance of the predictors with respect to a random walk using the test statistic proposed by Diebold and Mariano (1995) that analyses whether two competing forecasts have equal predictive accuracy. Let $\hat{y}_t^1$ and $\hat{y}_t^2$ denote alternative predictors of a given variable y_t , let e_{1t} and e_{2t} denote the corresponding prediction errors ($e_{1t} = \hat{y}_t^1 - y_t$ and $e_{2t} = \hat{y}_t^2 - y_t$, respectively), and let $d_t = (e_{1t})^2 - (e_{2t})^2$ denote the loss differential, then the Diebold and Mariano (DM) test involves a test of the hypothesis that the mean loss differential $\bar{d}$ is zero with an appropriate correction for serial correlation in the series d_t:

$$DM = \frac{\bar{d}}{s_d} \qquad (13)$$

where $\bar{d}$ and s_d are the mean and sample standard deviation of d_t. Following Harvey *et al.* (1997), we calculate the standard deviation using a small-sample bias corrected variance calculation. The test-statistic follows a Student's t-distribution with T-1 degrees of freedom. Thus, a significant and positive (negative) value for DM indicates a significant difference between the prediction errors generated by the two predictors, indicating that the most accurate predictor is $\widehat{y_t^2}$ ($\widehat{y_t^1}$).

The results from the Diebold and Mariano test in Table 2 indicate that our predictors perform worse than a random walk with the exception of the Chilean peso. For this currency, the predictors obtained using inflation expectations perform better than the random walk. In the cases of the Colombian peso and the South Korean won, the difference between the two predictors is not significant. One possible explanation of these results is that inflation expectations are better suited for predicting the foreign exchange in countries where the risk premium with respect to US government debt is lower.

[Insert Table 2 here]

3.2. Directional forecast

As Boothe and Glassman (1987) observe, a further test of forecasting performance relative to the forecasts of a random walk is the accuracy in the direction of movements in the exchange rate of the emerging economies under study. This is because getting the right sign in the prediction matters in markets with low transaction costs, like foreign exchange markets. Therefore, we calculated the correct percentage appreciations and depreciations, the results of which are presented in Table 3. As can be seen there, with the exception of KRW, the forecasts based on EVRPPP offer a value that is greater than 50%, which indicates an improvement over the random walk in terms of directional prediction.

[Insert Table 3 here]

3.4. Causality

Engel and West (2005) argue that the use of Granger-causality tests can help to assess if fundamental variables such as relative inflation provide help in predicting changes in floating exchange rates. In this sense, one variable Granger-causes some other variable, given an information set, if past information about the former can improve the forecast of the latter based only in its own past information. Therefore, the knowledge of one series evolution reduces the forecast errors of the other, suggesting that the latter does not evolve independently of the former (Granger, 1969: and Sims, 1972).

The resulting statistics are reported in Table 4. As can be seen, with the exception of the Colombian and the Mexican peso when using EVRPP based on 10-year expected inflation differentials, our results suggest that Granger causality runs from exchange rate to the forecasts based on EVRPPP suggesting the former contains useful information for forecasting the latter that is not contained in its own past observations. Additionally, we find evidence of bidirectional Granger-causality in the cases of the KRW and the TRY for all EVRPPP forecasts and for the PLN when using the EVRPP based on 1-year expected inflation differentials. Finally, we find some weak evidence (at 10 percent) in favour of additional Granger causality running from EVRPP based on 5-year expected inflation differentials to exchange rates in the cases of COB, and PLN.

[Insert Table 4 here]

4. Expectation formation

To assess if the expectations are rational one necessary requirement to be met is that of consistency. Consistency is weaker than rationality, since it is not required that the prediction process match the stochastic process generating the actual series. Following Froot and Ito (1989), consistency of expectations built at the same moment in time dominate if we obtain the same result when we compare the expectation about the inflation rate for the entire time period with the expectations about inflation rate changes during shorter time periods.

We assume the same model used by Frankel and Froot (1987a, b) and Frenkel et al. (2012) in which the agents build their expectations using an extrapolative model which can, in its simplest form, be expressed as a distributed lag function with one lag:

$$\pi_k^e - \pi_t = \alpha_k + \beta_k(\pi_{t-1} - \pi_t) + \zeta_t \tag{15}$$

where π_t and π_k^e denote, respectively, the inflation rate at time *t* and the expected inflation rate at time *t+k* made at time *t*. Subscript *k* denotes the forecast horizon (1-, 5- and 10-years in our case) and ζ_t is the error term.

An estimated positive value for β_k would indicate that with a slowdown in price growth during the period preceding the time of the forecast leads market participants to expect an opposite effect for the next period. Therefore, they will expect that the inflation rate in period *t+k* exceed that registered in *t*, expectations being in this case stabilising. On the contrary, if $\hat{\beta}_k$ is negative, and in the preceding period market participants observe a reduction in the rate at which prices growth then they expect that the inflation rate in period *t+k* will be lower than that in *t*, expectations being in this case destabilising.

Note that our inflation expectations data gathers market participants' expectations at different horizons at the same point of time, the information set available to the agents being the same, therefore allowing us to formally estimate equation (15) for such forecasting horizons. Table 5 reports the results. As can be seen, $\hat{\beta}_k$ are positive in all cases except for South Africa. Therefore, our results indicate that the inflation expectations on Brazil, Colombia, Chile, India, Mexico, Poland, South Korea and Turkey are formed by market participants in a stabilising way, while in the case of South Africa there is evidence of destabilising expectations. Therefore, our results suggest that we should not reject the null hypothesis that 1-year, 5-year and 10-year inflation expectations are consistent.

[Insert Table 5 here]

5. Robustness Checks

We have already documented running the Diabold and Mariano (1995) that inflation expectations cannot beat the random walk in predicting the foreign exchange for most of the currencies pairs analyzed. Sosvilla-Rivero and Garcia (2005) show on the contrary that for the euro area and the U.S. inflation expectations do behave significantly better than a random walk in predicting the foreign exchange.

One of the reasons why in this case the performance of inflation expectations is poorer, with some exceptions such as Chile, could be that the real rates of interest over the two countries are not equated as it is required by equation (4). This could be a plausible assumption for two developed economic areas such as the euro zone and the U.S. but it may fail to hold for emerging economies as the interest rates of these countries use to include, for example, a credit risk premium. In order to analyze this issue we have recover equation (3) as our main specification without imposing the equality in the real rates of the emerging economy and the U.S. That's it, we have simply used the uncovered interest rate parity condition to asses it usefulness in predicting the foreign exchange.

Table 6 show the results of the Diabold and Mariano (1995) test that compares the forecasting power of the difference between the nominal rates and a random walk in predicting the foreign exchange. The results show that for most cases the differential in the nominal interest rates cannot outperform the random walk. Only in predicting the Turkish lira and the South African Rand it is possible to outperform the random walk. These results point out that there are other factors apart from the interest rate differentials that make inflation expectations not being able to outperform the random walk. It is reasonable to conclude that departures from the uncovered interest rate parity seem to be affecting the capacity of inflation expectations to forecast the foreign exchange.

Finally we have also asses the forecasting performance of the differential in the nominal interest rates in terms of the direction of movements in the exchange rate. We calculate the correct percentage of appreciations and depreciations. The results are slightly better than those obtained using only inflation expectations, outperforming the random walk in all cases. By these metrics, we conclude that there is some role played by the interest rate differential in augmenting the forecasting power of the directions of movements in the exchange rate for the currency pairs anlayzed. Table 7 show the results.

6. Concluding remarks

We have evaluated the empirical relevance of an expectations version of Purchasing Power Parity (PPP) for explaining the behaviour of the exchange rate in a sample of representative emerging economies. The PPP model used is based on the difference between equivalent inflation rates, an approximation to expected inflation in financial markets, for Brazil, Colombia, Chile, India, Mexico, Poland, South Africa, South Korea and Turkey with respect to the United States.

Using monthly data on exchange rates and on the inflation expectations, we have obtained the result that our predictors are not significantly better than the random walk model for forecasting based on 1-year, 5-year and 10-year inflation expectations. Nevertheless, with the exception of the South Korean Won, they outperform the random walk when considering the sign of the rate of change.

To further evaluate the role of fundamental variables as potential determinants of the short-run behaviour of exchange rates in emerging economies, we have also evaluate the Granger-causality between exchange rates and expected inflation differentials. Our results strongly support Granger causality running from exchange rate to the forecasts based on EVRPPP and only partial evidence of Granger causality running the other way around.

As for the consistency properties of the inflation expectation process, with the exception of South Africa, we find that market participants form stabilising expectations suggesting that 1-year, 5-year and 10-year inflation expectations are mutually consistent.

We consider that our findings may provide useful insight into the file of exchange rate forecasting that could be useful to portfolio managers, risk strategists and international traders.

Founding

This paper is based on work supported by the Spanish Ministry of Economy and Competitiveness [grant ECO2016-76203-C2-2-P].

References

Bank for International Settlements (2016). *Triennial Central Bank Survey: Foreign exchange turnover in April 2016*. Bank for International Settlements, Basel.

Bahmani-Oskooee, M., Chang, T. and Wu, T.-P. (2014) Revisiting purchasing power parity in African countries: panel stationary test with sharp and smooth breaks, *Applied Financial Economics,* 24: 1429–38.

Boothe, P. and Glassman, D. (1987). Comparing exchange rate forecasting models: accuracy versus profitability. *International Journal of Forecasting* 3: 65-79.

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

Deschamps, B. and Mehta, D. R. (1980). Predictive ability and descriptive validity of earnings forecastings models. *Journal of Finance* 35: 933-950.

Engel, C. and West, K. D. (2005). Exchange rates and fundamentals. *Journal of Political Economy* 113: 485-517.

European Central Bank (2002). Economic fundamentals and the exchange rate of the euro. *Monthly Bulletin* Jan: 41–53.

Frankel, J. A. and Froot, K. A. (1987a) Using survey data to test standard propositions regarding exchange rate expectations. *American Economic Review* 77: 133-153.

Frankel, J. A. and Froot, K. A. (1987b) Short-term and long-term expectations of the yen/dollar exchange rate: evidence from survey data. *Journal of the Japanese and International Economies* 1; 249–74.

Frenkel, M., Rülke, J .C., and Stadtmann, G. (2012). Twisting the dollar? On the consistency of short‐ run and long‐ run exchange rate expectations. *Journal of Forecasting* 31: 596‐ 616

Froot, K. A. and Ito, T. (1989). On the consistency of the short and long run exchange rate expectations. *Journal of International Money and Finance* 8: 487-510.

Fuertes, A., Gimeno, R. and Marques, J. M. (2018) Extraction of inflation expectations from financial instruments in Latin America. Working Paper 1819, Bank of Spain, Madrid.

Granger, C. W. J (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica* 37: 24-36.

Harvey, D., Leybourne, S. Newbold, P. (1997). Testing the equality of prediction mean squared errors. *International Journal of Forecasting* 13: 281-291.

He, H., Chou, M. and Chang, T. (2014) Purchasing power parity for 15 Latin American countries: panel SURKSS test with a Fourier function, *Economic Modelling*, 36: 37–43.

Karamouzis, N., and Lombra, N. (1989. Federal Reserve policymaking: An overview and analysis of the policy process. *Carnegie Rochester Conference Series on Public Policy* 30: 7-62.

Makridakis, S., Hibon, M. and Moser, C. (1979). Accuracy of forecasting: An empirical investigation. *Journal of the Royal Statistical Society. Series A* 142: 97-145.

Meese, R.A. and Rogoff, K. (1983). Empirical exchange rate models for the seventies: do they fit out of sample? *Journal of International Economics* 14: 3–24.

Roll, R. (1979). Violations of purchasing power parity and their implications for efficient international commodity markets. In *International Finance and Trade*, Vol. 1, Sarnat, M. and Szego, G. P. (eds). Ballinger: Cambridge, MA; 133–176.

Sarno, L, and Taylor M. P. (2002). *The Economics of Exchange Rates*. Cambridge University Press: Cambridge.

Sims, C. A. (1972). Money, income, and causality. *American Economic Review* 62: 540-552.

Sosvilla-Rivero, S. and García, E. (2005). Forecasting the dollar/euro exchange rate: Are international parities useful? *Journal of Forecasting* 24: 369-377.

Table 1. Forecast accuracy

Forecast	RMSE	MAPE	SMAPE	Theil U
Brazilian Real				
EX1	0.1511	4.8091	4.6701	0.0307
EX5	0.1406	4.4198	4.3098	0.0286
EX10	0.1359	4.3342	4.2334	0.0277
Random walk	0.0969	2,8364	2.8652	0.0201
Colombian Peso				
EX1	78.7756	2.4338	2.4444	0.0175
EX5	78.9238	2.4326	2.4444	0.0175
EX10	78.9677	2.4288	2.4415	0.0175
Random walk	78.7503	2.4111	2.4247	0.0174
Chilean Peso				
EX1	14.5580	1.9779	1.9806	0.0121
EX5	14.7907	2.0182	2.0222	0.0123
EX10	14.8460	2.0266	2.0313	1.0121
Random walk	14.7832	2.0017	2.0106	1.0120
Indian Rupee				
EX1	5.8080	10.6135	9.9418	0.0539
EX5	4.6980	9.1999	8,7592	0.0439
EX10	4.3328	8.2595	8,1557	0.0406
Random walk	0.8829	1.1989	1.2034	0.0086
Mexican Peso				
EX1	2.7246	17.6266	15.8083	0.0927
EX5	1.9033	13.6860	12.7408	0.0660
EX10	1.5886	11.5549	10.8885	0.0556
Random walk	0.3555	1.7433	1.7553	0.0138
Poland Zloty				
EX1	0.1301	3.3460	3.3307	0.0201
EX5	0.1224	3.0510	3.0681	0.0190
EX10	0.1268	3.0588	3.1012	0.0198
Random walk	0.1048	2.4360	2.4440	0.0154
South African Rand				
EX1	0.5083	4.1709	4.0561	0.0256
EX5	0.4411	3.5892	3.5201	0.0223
EX10	0.3985	3.2205	3.1825	0.0202
Random walk	0.3819	2.8880	2.9049	0.0199
South Korean Won				
EX1	28.5425	1.6457	1.6498	0.0130
EX5	28.7024	1.6441	1.6494	0.0130
EX10	28.7361	1.6415	1.6473	0.0131
Random walk	27.7056	1.6091	1.6132	0.0123
Turkish Lira				
EX1	0.1522	5.9853	5.7726	0.0319
EX5	0.1397	5.4824	5.3068	0.0294
EX10	0.1339	5.1885	5.0308	0.0282
Random walk	0.0744	2.4355	2.4689	0.0162

Notes:

EX1, EX5 and EX10 are exchange-rate forecasts based on EVRPPP using relative 1-year, 5-year and 10-year inflation expectations, respectively

We have shaded the forecast that performed the best under each of the evaluation statistics.

Table 2. Diebold Mariano predictability tests

	BRL	COB	CLP	INR	MXN	PLN	ZAR	KRW	TRY
EX1 *vs* RW	3.4747 (0.0007)	-0.8042 (0.4225)	-1.4375 (0.0000)	14.0730 (0.0000)	7.8879 (0.0000)	4.3322 (0.0000)	3.5999 (0.0004)	-0.8556 (0.3934)	5.9161 (0.0000)
EX5 *vs* RW	3.1663 (0.0019)	-0.6014 (0.5485)	-0.9052 (0.0000)	22.2971 (0.0000)	15.8452 (0.0000)	4.0508 (0.0001)	2.4790 (0.0142)	-0.8719 (0.3845)	5.5095 (0.0000)
EX10 *vs* RW	3.1024 (0.0024)	-0.5904 (0.5558)	-0.7475 (0.0000)	24.7583 (0.0000)	17.7432 (0.0000)	4.4554 (0.0000)	1.3809 (0.1691)	-1.2025 (0.2309)	5.1628 (0.0000)

Notes:

BRL, COB, CLP, INR, MXN, PLN, ZAR, KRW and TRY stand for Brazilian Real, Colombian Peso, Chilean Peso, Indian Rupee, Mexican Peso, Poland Zloty, South African Rand, South Korean Won, and Turkish Lira respectively.

EX1, EX5 and EX10 are exchange-rate forecasts based on EVRPPP using 1-year, 5-year and 10-year inflation expectations, respectively. RW stands for exchange-rate forecasts based on a random walk

p-values in parenthesis

Table 3. Directional forecast

Forecast	EX1	EX5	EX10
BRL	96.00	97.60	99.20
COB	65.18	65.21	65.77
INR	57.96	62.42	61.15
CLP	57.45	61.30	62.03
MXN	55.41	59.95	58.41
PLN	59.87	61.15	60.51
ZAR	52.35	54.12	52.94
KRW	47.06	45.88	47.58
TRY	55.62	57.26	57.81

Notes:

BRL, COB, CLP, INR, MXN, PLN, ZAR, KRW and TRY stand for Brazilian Real, Colombian Peso, Chilean Peso, Indian Rupee, Mexican Peso, Poland Zloty, South African Rand, South Korean Won, and Turkish Lira respectively.

EX1, EX5 and EX10 are exchange-rate forecasts based on EVRPPP using 1-year, 5-year and 10-year inflation expectations, respectively.

Total number of appreciations and depreciations correctly predicted by EVRPPP

Table 4. Granger causality tests

	F-Statistic		F-Statistic
	Brazilian Real		
BRL → EX1	2730.13 (0.0000)	**EX1 → BRL**	1.6890 (0.1891)
BRL → EX5	7456.87 (0.0000)	**EX5 → BRL**	1.7169 (0.1840)
BRL → EX10	11405.70 (0.0000)	**EX10 → BRL**	1.8347 (0.1642)
	Colombian Peso		
COB → EX1	95.5770 (0.0000)	**EX1 → COB**	0.6766 (0.5129)
COB → EX5	785.4280 (0.0000)	**EX5 → COB**	2.4863 (0.0927)
COB → EX10	0.1041 (0.9013)	**EX10 → COB**	0.3898 (0.6791)
	Chilean Peso		
CLP → EX1	30197.80 (0.0000)	**EX1 → CLP**	1.1261 (0.3318)
CLP → EX5	240334 (0.0000)	**EX5 → CLP**	1.1671 (0.3198)
CLP → EX10	393347 (0.0000)	**EX10 → CLP**	0.6923 (0.5048)

Table 4. (continued)

	F-Statistic		F-Statistic
		Indian Rupee	
INR → EX1	109.9530 (0.0000)	**EX1 → INR**	0.2263 (0.7977)
INR → EX5	762.0390 (0.0000)	**EX5 → INR**	0.7718 (0.4640)
INR → EX10	2020.42 (0.0000)	**EX10 → INR**	0.8338 (0.4364)
		Mexican Peso	
MXN → EX1	95.5770 (0.0000)	**EX1 → MXN**	0.6766 (0.5129)
MXN → EX5	785.4280 (0.0000)	**EX5 → MXN**	2.4863 (0.0927)
MXN → EX10	0.1041 (0.9013)	**EX10 → MXN**	0.3898 (0.6791)
		Poland Zloty	
PLN → EX1	2106.74 (0.0000)	**EX1 → PLN**	3.4102 (0.0356)
PLN → EX5	3772.34 (0.0000)	**EX5 → PLN**	2.8097 (0.0634)
PLN → EX10	4504.64 (0.0000)	**EX10 → PLN**	2.6545 (0.0736)

Table 4. (continued)

	F-Statistic		F-Statistic
South African Rand			
ZAR → EX1	4215.09 (0.0000)	**EX1 → ZAR**	1.3245 (0.2688)
ZAR → EX5	9620.60 (0.0000)	**EX5 → ZAR**	1.2195 (0.2980)
ZAR → EX10	12989.90 (0.0000)	**EX10 → ZAR**	1.1893 (0.3070)
South Korean Won			
KRW → EX1	241532 (0.0000)	**EX1 → KRW**	9.5748 (0.0001)
KRW → EX5	1327771 (0.0000)	**EX5 → KRW**	8.8175 (0.0002)
KRW → EX10	2643987 (0.0000)	**EX10 → KRW**	9.3024 (0.0001)
Turkish Lira			
TRY → EX1	1769.57 (0.0000)	**EX1 → TRY**	4.5090 (0.0130)
TRY → EX5	13563.50 (0.0000)	**EX5 → TRY**	4.1244 (0.0186)
TRY → EX10	28724 (0.0000)	**EX10 → TRY**	3.4656 (0.0345)

Notes:

BRL, COB, CLP, INR, MXN, PLN, ZAR, KRW and TRY stand for Brazilian Real, Colombian Peso, Chilean Peso, Indian Rupee, Mexican Peso, Poland Zloty, South African Rand, South Korean Won, and Turkish Lira respectively.

EX1, EX5 and EX10 are exchange-rate forecasts based on EVRPPP using 1-year, 5-year and 10-year inflation expectations, respectively.

p-values in parenthesis

Table 5: Expectation formation processes

Forecast	1-year ahead	5-year ahead	10-year ahead
Brazil			
$\hat{\alpha}_k$	-0.1849 (0.0000)	-0.1068 (0.0832)	0.0794 (0.3580)
$\hat{\beta}_k$	0.1435 (0.0527)	0.4310 (0.0238)	0.5649 (0.0351)
Colombia			
$\hat{\alpha}_k$	1.0906 (0.0000)	0.6947 (0.0000)	0.2690 (0.0000)
$\hat{\beta}_k$	0.5117 (0.0000)	0.5104 (0.0000)	0.5089 (0.0000)
Chile			
$\hat{\alpha}_k$	-0.0810 (0.3181)	0.0412 (0.0761)	0.1283 (0.0396)
$\hat{\beta}_k$	0.1451 (0.0044)	0.4768 (0.0014)	0.5235 (0.0013)
India			
$\hat{\alpha}_k$	-0.2188 (0.1715)	-0.0526 (0.7828)	-0.0071 (0.9725)
$\hat{\beta}_k$	0.7621 (0.0001)	0.894 (0.0108)	0.5523 (0.0258)
Mexico			
$\hat{\alpha}_k$	3.6881 (0.0000)	3.6896 (0.0000)	3.6951 (0.0000)
$\hat{\beta}_k$	0.5764 (0.0001)	0.5240 (0,0000)	5.5119 (0.0000)
Poland			
$\hat{\alpha}_k$	-0.0268 (0.8006)	-0.3051 (0.0024)	-0.7910 (0.0000)
$\hat{\beta}_k$	1.8965 (0.0000)	1.7017 (0.0000)	1.6379 (0.0000)
South Africa			
$\hat{\alpha}_k$	0.0104 (0.8813)	-0.5554 (0.0000)	-1.1541 (0.0000)
$\hat{\beta}_k$	-0.4967 (0.0000)	-0.3941 (0.0041)	-0.2855 (0.0068)
Korea			
$\hat{\alpha}_k$	-0.0886 (0.0162)	-0.1021 (0.0592)	-0.1060 (0.0794)
$\hat{\beta}_k$	0.1409 (0.0143)	0.3455 (0.0154)	0.4050 (0.0110)
Turkey			
$\hat{\alpha}_k$	-0.2363 (0.0045)	-0.1626 (0.2529)	-0.1483 (0.3351)
$\hat{\beta}_k$	0.2624 (0.0051)	0.4549 (0.0051)	0.4924 (0.0051)

Note: p-values in parenthesis

Table 6. Diebold Mariano predictability tests

	BRL	COB	CLP	INR	MXN	PLN	ZAR	KRW	TRY
EX1 *vs* RW	1.0572 (0.2933)	3.4873 (0.0006)	1.4980 (0.1392)	2.8867 (0.0044)	10.3905 (0.0000)	2.8464 (0.0050)		9.8000 (0.0000)	-5.3948 (0.0000)
EX5 *vs* RW	1.0642 (0.2902)	5.4683 (0.000)	1.4767 (0.1450)	2.8870 (0.0044)	14.7877 (0.0000)	2.8465 (0.0050)	1.1572 (0.2488	3.9093 (0.0001)	-5.0149 (0.0000)
EX10 *vs* RW	1.0826 (0.2820)	6.5103 (0.0000)	1.4692 (0.1468)	2.8872 (0.0044)	13.1643 (0.0000)	2.8464 (0.0050)	-2.0583 (0.0416)	4.2310 (0.0000)	0.1496 (0.8814)

Notes:

BRL, COB, CLP, INR, MXN, PLN, ZAR, KRW and TRY stand for Brazilian Real, Colombian Peso, Chilean Peso, Indian Rupee, Mexican Peso, Poland Zloty, South African Rand, South Korean Won, and Turkish Lira respectively.

EX1, EX5 and EX10 are exchange-rate forecasts based on risk-premium augmented-EVRPPP [equation (2)], using 1-year, 5-year and 10-year inflation expectations, respectively. RW stands for exchange-rate forecasts based on a random walk

p-values in parenthesis

Table 7. Directional forecast

Forecast	EX1	EX5	EX10
BRL	68.65	68.35	68.60
COB	65.24	65.30	65.35
CLP	60.82	63.17	65.92
INR	59.77	62.73	63.37
MXN	61.84	62.34	63.15
PLN	60.23	63.17	62.34
ZAR		55.94	56.17
KRW	51.17	53.47	51.49
TRY	58.06	58.24	59.19

Notes:

BRL, COB, CLP, INR, MXN, PLN, ZAR, KRW and TRY stand for Brazilian Real, Colombian Peso, Chilean Peso, Indian Rupee, Mexican Peso, Poland Zloty, South African Rand, South Korean Won, and Turkish Lira respectively.

EX1, EX5 and EX10 are exchange-rate forecasts based on risk-premium augmented-EVRPPP [equation (2)] using 1-year, 5-year and 10-year inflation expectations, respectively.

Total number of appreciations and depreciations correctly predicted by on risk-premium augmented-EVRPPP [equation (2)]

Figure 1. Plot of observed and predicted exchange rates

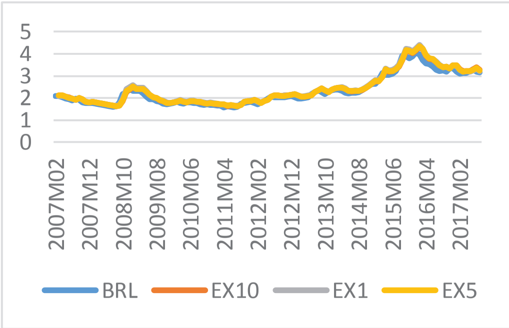
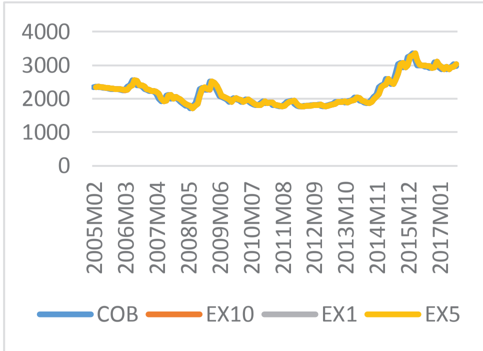
Brazil	Colombia	Chile
		

Figure 1. (cont)

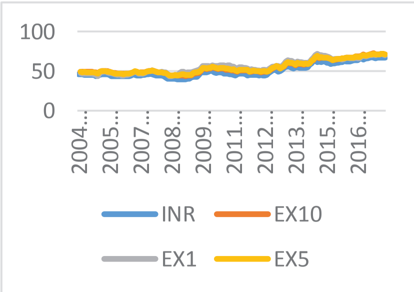
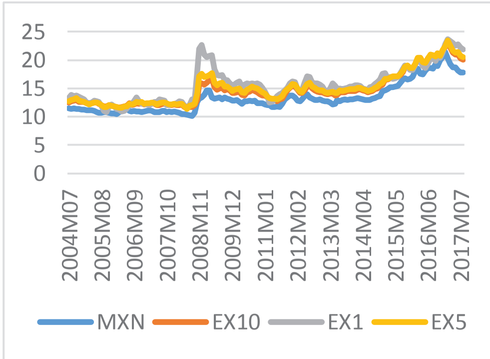
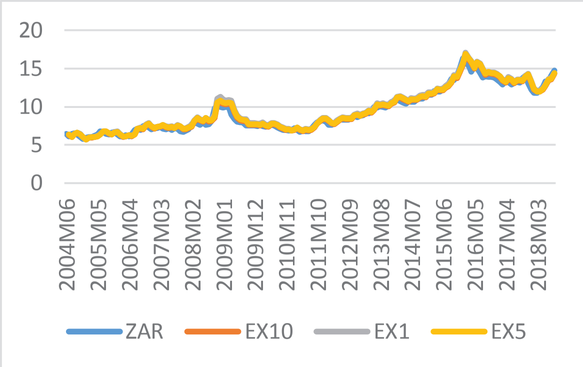
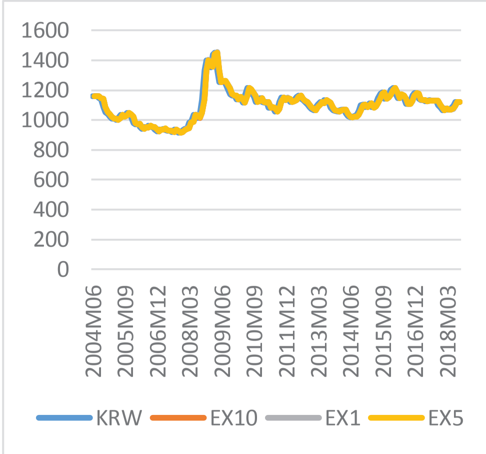
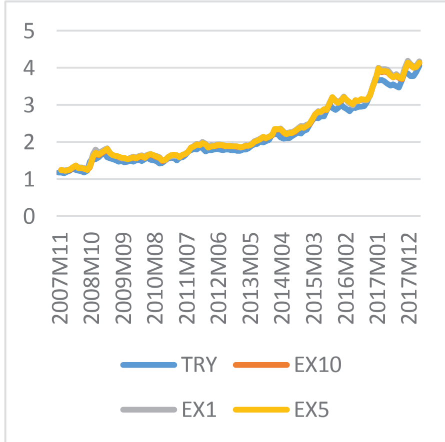
India	Mexico	Poland
		

Figure 1. (cont)

South Africa	South Korea	Turkey
		

Appendix 1: Definition of the variables and data sources

Variable	Description	Source
Exchange rates	National currency to one U.S. Dollar Averages of daily figures.	FRED (Federal Reserve Economic Data)
Inflation rates	Inter-annual inflation rate calculated form Consumer Price Index: All Items	FRED (Federal Reserve Economic Data)
Inflation expectations	Rate of expected inflation at different horizons obtained following Fuertes *et al*. (2018)	Own calculations and IFS-DataStream

UBIREA
Institut de Recerca en Economia Aplicada Regional i Pública
Research Institute of Applied Economics
Universitat de Barcelona
Av. Diagonal, 690 • 08034 Barcelona

WEBSITE: www.ub.edu/irea/ • **CONTACT:** irea@ub.edu