Exchange rate expectations since the financial crisis: Performance evaluation and the role of monetary policy and safe haven

Joscha Beckmann* Robert Czudaj†

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Abstract

We analyze and evaluate novel data on exchange rate expectations after the collapse of Lehman Brothers for more than 60 economies over different horizons. At a first stage, we establish a potential discrepancy between statistical and economic measures. Market expectations are superior compared to trend and carry trade strategies based on economic evaluation criteria despite a weak statistical performance. We then turn to determinants of both expectations and resulting forecast errors. We find that monetary policy effects on expectations are time-varying and identify substantial international spillovers over the recent period of unconventional monetary policy. Our results also indicate that markets have been surprised by monetary policy effects on the exchange rates and point to an unexpected safe haven status of the US dollar after 2009.

Keywords: Exchange rates, expectations, financial crisis, monetary policy
JEL classification: F31, G15

*Ruhr University of Bochum, Chair for International Economics, D-44801 Bochum, e-mail: joscha.beckmann@rub.de, University of Duisburg-Essen, Department of Economics, Chair for Macroeconomics, D-45117 Essen and Kiel Institute for the World Economy, Hindenburgufer 66, D-24105 Kiel.

†Chemnitz University of Technology, Department of Economics, Chair for Empirical Economics, D-09126 Chemnitz, e-mail: robert-lukas.czudaj@wirtschaft.tu-chemnitz.de, phone: (0049)-371-531-31323, fax: (0049)-371-531-831323 and FOM Hochschule für Oekonomie & Management, University of Applied Sciences, Herkulesstr. 32, D-45127 Essen.

1 Introduction

The notable discrepancy between theoretical exchange rate models and empirical results remains one of the major puzzles in international economics. Several explanations for the weak and unstable link between exchange rates and fundamentals, i.e. the exchange rate disconnect puzzle, have been discussed (Sarno, 2005). One frequent finding in this regard is that exchange rate expectations are detached from actual future exchange rates, contradicting a common assumption embedded in models such as uncovered interest rate parity (Jongen *et al.*, 2008). Expectations are also of crucial importance if exchange rates are not free floating. Fixed exchange rate arrangements which are considered not to be credible by markets participants potentially suffer speculative attacks, require central bank interventions and are hard to obtain in the long-run.

Moreover, it is often argued that monetary policy is an important driver of both financial market expectations and spot exchange rates. Many theoretical models rely on interest rate and money supply changes as a determinant of exchange rate fluctuation.[1] At the same time, several studies have demonstrated that the conducted and announced path of monetary policy affects expectations on financial markets (Conrad and Lamla, 2010). Since unconventional monetary policy has emerged due to the zero lower bound, such expectation effects have become of crucial importance.[2] Recent evidence also suggests that the exchange rate transmission channel for monetary policy has become more important after 2008, with monetary policy surprises significantly affecting the value of the US dollar (Glick and Leduc, 2015).

It is therefore somehow surprising that the effect of monetary policy on aggregated exchange rate expectations has not been explicitly addressed. Instead, most approaches use disaggregated data on exchange rate expectations to explain characteristics of exchange rate markets, such as heterogeneity across expectations and the microstructure of currency markets (Jongen *et al.*, 2008). While previous studies have argued that the adequacy of professional forecasters varies both over the horizon and for emerging and industrial economies based on a small subset of currencies (Ince and Molodtsova, 2013), neither minor currencies with flexible exchange rates nor the recent crisis

[1] Monetary exchange rate models were introduced after the breakdown of Bretton Woods and rest on the assumption that supply and demand for currencies are a result of transactions in international financial markets, relying on purchasing power parity (PPP) as equilibrium condition for goods markets (Dornbusch, 1976a; Frenkel, 1976). Dornbusch (1976b) introduces a sticky-price version of the monetary model to explain overshooting behavior of exchange rates. Recent models by Molodtsova *et al.* (2008) rely on a Taylor rule approach which states that a central bank adjusts the short-run nominal interest rate in order to respond to inflation and the output gap.

[2] The famous "whatever it takes" speech by Mario Draghi on July 2012 has highlighted the importance of policy announcements for the paths of exchange rates. In addition, policy announcements have already been identified as a potential driver of exchange rate volatility in the previous literature (Conrad and Lamla, 2010).

period has yet been examined.

Against this background, our study provides two major contributions based on a novel data set of exchange rate forecasts for 30 major and 35 minor currencies (classified by *FX4casts*) for the period after the start of the financial crisis.[3] We start by comparing expected and realized exchange rates after the collapse of Lehman Brothers for currencies with both fixed and flexible exchange rate arrangements over five different forecasting horizons (i.e. 1, 3, 6, 12, and 24 months), also evaluating the capacity of professionals to forecast exchange rate changes above a specific threshold under different regimes. Our first main contribution stems from a comparison between statistical and economic evaluation criteria. After conducting statistical tests for unbiasedness, we analyze the capacity of professionals to manage cross-country currency portfolios and compare their performance with usual benchmarks in terms of economic utility.

Second, our analysis focuses on potential driver of exchange rate expectations and the resulting forecast errors. We also address the time-varying role of unconventional monetary policy conducted by four major central banks. In this regard, we provide a new perspective on monetary transmission effects to exchange rates during and after the global financial crisis by disentangling expected and unexpected monetary policy effects based on the consideration of shadow policy rates in the spirit of Wu and Xia (2016). Finally, we determine which currencies are expected to serve as 'safe havens' relative to the US dollar in the aftermath of the financial crises.[4]

The rest of this paper is organized as follows. Section 2 summarizes theoretical considerations and previous literature which builds the foundation for our empirical framework. Section 3 describes our data set, while Section 4 presents our empirical results. We start by summarizing descriptive evidence and evaluate forecasts under fixed and managed exchange rates. We then turn to an economic evaluation of professional exchange rate expectations before analyzing drivers of expectations and forecast errors in the context of monetary policy and uncertainty. Section 5 concludes.

[3] Ang *et al.* (2007) have demonstrated the usefulness of macroeconomic survey data for inflation forecasts. Although previous studies such as Fratzscher *et al.* (2015), Bacchetta *et al.* (2009) and Cavusoglu and Neveu (2015) also base their analysis on survey FX data, we are the first to analyze the full data set of exchange rate expectations which includes both minor and major currencies after the collapse of Lehman Brothers.

[4] A safe haven is usually defined as an asset whose returns are negatively correlated to global stock market returns in times of market turmoil (Hossfeld and MacDonald, 2015).

2 Theoretical background and literature review

2.1 Exchange rate expectations

The literature on exchange rate expectations can be roughly divided into studies evaluating the adequacy of professional forecasts and explaining the formulation of expectations on an aggregated and disaggregated level. We start this section by a reconsideration of theoretical frameworks which deal with determinants of exchange rate expectations. We then turn to the evidence on adequacy of exchange rate expectations.

Going back to the seminal work of Frankel and Froot (1986, 1987), the most common theoretical framework to explain exchange rate expectations is build up on the idea that two kinds of market participants should be distinguished: Fundamentalists, which rely on a fundamental model when building expectations and chartists which extrapolate past exchange rate behavior for forecasting. A simple benchmark model for exchange rate expectations which incorporates both groups can be summarized as follows (Goldbaum and Zwinkels, 2014):

$$E_t(s_{t+1}) - s_t = (E_{t-1}(s_t) - s_t) + \gamma(f_t - s_t) + \Delta s_t + v_t, \tag{1}$$

where s_t denotes the natural logarithm of the spot exchange rate and $E_t(s_{t+1})$ represents the expected exchange rate at t for $t+1$. The first two components on the right hand side reflect the expectation building of fundamentalists. The expected exchange rate change is built on the forecast error of the previous period, denoted as $E_{t-1}(s_t) - s_t$, and the deviation from a fundamental model $f_t - s_t$ with the perceived rate of reversion γ. Δs_t captures chartists behavior by incorporating previous exchange rate changes while v_t is an innovation term. While the fundamental value is frequently modeled based on PPP, it is important to emphasize that participants are unaware of the actual fundamental value. Instead of relying on past fundamentals, it can therefore be argued that participants use expected fundamentals which are also subject to stochastic shocks, for example as a result of policy decisions (Goldbaum and Zwinkels, 2014). In this vein, the framework of Engel and West (2005) argues that the exchange rate reflects a discounted sum of observable and unobservable fundamentals. Applying their framework to the expected exchange rate provides the

following equation

$$E_t(s_{t+1}) = (1-b)\sum_{j=0}^{\infty} b^j E_t(f_{1,t+j} + u_{1,t+j}) + b\sum_{j=0}^{\infty} b^j E_t(f_{2,t+j} + u_{2,t+j}), \tag{2}$$

where $f_{1,t+j}$ and $f_{2,t+j}$ denote observable fundamentals and $u_{1,t+j}$ and $u_{2,t+j}$ unobservable factors while b is the discount factor. Based on these considerations monetary policy shocks potentially affect expectations via a direct or indirect influence on fundamentals. Interest rate and money supply as monetary policy instruments are part of the set of observable fundamentals $f_{1,t+j}$ itself but also affect the path of other fundamentals such as GDP or inflation. Unobservable components are by definition hard to identify but uncertainty measures represent one possible proxy.[5] Building on the idea of Bacchetta and Van Wincoop (2004), Engel and West (2005), Bacchetta *et al.* (2009) and Bacchetta and van Wincoop (2013) have also shown that different fundamentals matter at different points in time with some fundamentals, so-called 'scapegoats', blamed for unexpected exchange rate movements by market participants.

When analyzing expectation building mechanisms, recent research has emphasized the importance of information rigidities (Coibion and Gorodnichenko, 2015). Under bounded rationality, agents use the available set of information efficiently but struggle to provide adequate forecasts due to imperfect information. Coibion and Gorodnichenko (2012, 2015) have highlighted the importance of such information rigidities when it comes to macroeconomic expectations, such as inflation. Professional forecasters frequently show a delayed response to macroeconomic shocks and are subject to expectation errors. In the context of exchange rates, expectation errors potentially reflect the notorious Meese and Rogoff (1983) puzzle and the established link between the predictability of returns on financial markets and expectation errors of professionals and do not contradict rationality (Bacchetta and van Wincoop, 2006). Against this background, it seems important to consider both expectations and expectation errors. The pattern that professionals frequently switch between different forecasting techniques and also the 'scapegoat' idea mentioned above requires a switching coefficient framework since the weights of the determinants may vary over time (Jongen *et al.*, 2012).

The importance of considering expectation errors is also important once the evidence for survey-based exchange rate expectations is taken into account. Such measures are mostly unable to predict

[5] See Beckmann and Czudaj (2016) for an analysis of different uncertainty measures and their impact on expectations based on the discounted value approach.

future spot rates. A conventional test in this context is based on the following regression (Jongen *et al.*, 2008)

$$s_{t+h} - s_t = \alpha + \beta(E_t(s_{t+h}) - s_t) + u_{t+h}, \tag{3}$$

where h denotes the forecasting horizon. The joint null hypothesis $\alpha = 0$ and $\beta = 1$ has been rejected in various studies such as Blake *et al.* (1986), Chinn and Frankel (1994), MacDonald and Marsh (1996) and Jongen *et al.* (2008). In line with the general evidence on exchange rates, the findings depend on evaluation criteria, forecasting horizon and currency choices (Ince and Molodtsova, 2013).[6]

While several studies analyze the dispersion of forecasts for a specific currency, less is known about the determinants of aggregated expectations and the resulting forecast errors. The frequent rejection of unbiased expectations has been attributed to different factors such as time-varying risk premia or irrational expectations (Jongen *et al.*, 2008).[7]

Marsh and Power (1996) and Elliott and Ito (1999) were the first to argue that statistical adequacy is not necessarily an effective evaluation measure of exchange rate expectations.[8] Even biased expectations which fail to beat a random walk benchmark are potentially still useful for an investor. In this spirit, other studies have considered different approaches for evaluating and analyzing exchange rate expectations based on trading strategies. This takes into account the fact that traders on currency markets manage a portfolio and are more interested in the overall return which depends on the accuracy of direction forecasts rather than point forecasts. The finding $E_t(s_{t+h}) \neq s_{t+h}$ therefore potentially reflects different scenarios and is not equivalent to a general failure of professional forecasts.

2.2 Safe haven currencies and modeling framework

The financial crisis has also changed the dynamics across worldwide currency markets. While negative news resulted in a depreciation of the US dollar prior to the crisis, they coincided with an appreciation of the dollar during the crisis. One explanation is that market participants consider news about a weakening of the US economy to have even worse effects for other countries

[6] Cavusoglu and Neveu (2015) provide slightly more encouraging results by also considering the most optimistic and pessimistic forecasts but also fail to overturn the overall pattern.

[7] A formal test for rational expectations based on orthogonality is built on the idea that forecast errors should not be affected by previous forecast errors and the forward discount if expectations are formed rational (Jongen *et al.*, 2008; Frankel and Froot, 1986, 1987).

[8] A similar point has been raised in the context of uncovered interest rate parity (UIP) where rejections of UIP do no imply profitability of carry trades (Olmo and Pilbeam, 2011).

(Fratzscher, 2009). Despite reaching the zero lower bound, monetary policy has been an important driver of financial markets and the corresponding expectations. For this reason, we explicitly incorporate monetary policy shadow rates.

Hossfeld and MacDonald (2015) define a safe haven (hedge) as a currency whose effective returns are negatively related to global stock market returns in times of financial stress (on average). Fundamental drivers of currency appreciations in times of financial stress include net foreign asset positions and the size of stock markets (Habib and Stracca, 2012). Since we focus on exchange rate expectations via the US dollar, we argue that a safe haven currency is expected to appreciate against the US dollar in times of uncertainty while a hedge currency is expected to appreciate on average. A general link between uncertainty and expectations can be derived based on the idea of bounded rationality. Market expectations are vulnerable to and significantly affected by uncertainty which reflects a stochastic component and results in forecast errors even if expectations regarding the mean (and possible the variance of such a shock) are correct (Heiner, 1983; Conlisk, 1996). Such uncertainty effects often vary over time (Beckmann and Czudaj, 2016). Uncertainty also arises in the context of monetary policy policy decisions, for example around FOMC meetings (Ahn and Melvin, 2007).

Hossfeld and MacDonald (2015) have shown that safe haven characteristics of effective exchange rates can be characterized by threshold dynamics which depend on the level of financial stress. Considering the focus of our sample on the recent crisis period which includes several changes in the stance of monetary policy, we adopt a framework which allows for a time-varying impact of uncertainty. Although this does not enable us to identify a specific threshold, we are able to access effects over the recent period. In addition, we rely on the idea of using a shadow policy rates to calibrate monetary policy at the zero lower bound (Wu and Xia, 2016).

Taking the considerations of the previous section into account, we argue that both expected exchange rate changes $E_t(s_{t+h}) - s_t$ and the resulting forecast errors $E_{t-h}(s_t) - s_t$ are driven by fundamentals, uncertainty, monetary policy rates and past forecast errors. In this spirit, we adopt the following equation for the expected exchange rate change

$$E_t(s_{t+h}) - s_t = \theta_{0,t} + \theta_{1,t}(r_t - r_t^*) + \theta_{2,t}(\pi_t - \pi_t^*) + \theta_{3,t}\mathrm{pr}_t^{\mathrm{ECB}} + \theta_{4,t}\mathrm{pr}_t^{\mathrm{FED}}$$

$$+\theta_{5,t}\mathrm{pr}_t^{\mathrm{BOE}} + \theta_{6,t}\mathrm{pr}_t^{\mathrm{BOJ}} + \theta_{7,t}\mathrm{VIX}_t + \theta_{8,t}\varepsilon_{t-h} + \eta_t, \tag{4}$$

and for the forecast error, respectively,

$$E_{t-h}(s_t) - s_t = \theta_{0,t} + \theta_{1,t}(r_t - r_t^*) + \theta_{2,t}(\pi_t - \pi_t^*) + \theta_{3,t}\text{pr}_t^{\text{ECB}} + \theta_{4,t}\text{pr}_t^{\text{FED}}$$

$$+\theta_{5,t}\text{pr}_t^{\text{BOE}} + \theta_{6,t}\text{pr}_t^{\text{BOJ}} + \theta_{7,t}\text{VIX}_t + \theta_{8,t}\varepsilon_{t-h} + \eta_t, \tag{5}$$

where the interest rate $(r_t - r_t^*)$ and inflation differential relative to the US $(\pi_t - \pi_t^*)$ are included in each model as fundamentals. The federal funds rate was close to zero after 2008 while the Federal Reserve conducted unconventional policy, such as asset purchases, to affect the economy. Wu and Xia (2016) introduce a shadow rate measure based on a nonlinear term structure model to account for effects near the zero lower bound for interest rates. They find that such a measure reflects the underlying information of unconventional monetary policy at the zero lower bound. We therefore rely on shadow rates in the United States pr_t^{FED}, the Eurozone pr_t^{ECB}, the UK pr_t^{BOE} and Japan pr_t^{BOJ} to account for an impact stemming from unconventional monetary policy. Finally, we also include the VIX (VIX_t) to account for CBOE stock market volatility as a conventional measure of uncertainty and the h-period lagged forecast error ε_{t-h} (i.e. $E_{t-2h}(s_{t-h}) - s_{t-h}$) to allow for extrapolative expectations.

3 Data and empirical framework

3.1 Data

Survey data on exchange rate expectations are obtained from *FX4casts* formerly known as *The Financial Times Currency Forecaster*. The consensus is based on 42 individual responses and is calculated as the geometric mean in order to reduce distortions due to extreme outliers. Spot rates and their expectations are measured in units of domestic currency per one unit of the US dollar (i.e. a decrease corresponds to an appreciation of the domestic currency) and are provided for 30 major and 35 minor currencies according to the *FX4casts* classification.[9] Forecasts are provided for 1, 3, 6, 12 and 24 month horizons and our full data set of expectations including all horizons runs from 2008:10 until 2016:03.[10] Table 7 in the Appendix summarizes the whole data set under observation which also includes the regressors mentioned in the previous subsection. Whenever available, we

[9]The classification into major and minor currencies relies on the trading volume of the currencies and has no effect on the results of our study. The currencies have been separated according to this definition for illustrative purpose. The full list of currencies included in our study can be found e.g. in Tables 8 and 9 in the Appendix.

[10]Data on 3, 6 and 12 months horizons is also available prior to 2008:10.

use real time data provided by the OECD for the inflation rate.

The large number of currencies we are analyzing implies that we also cover a wide range of exchange rate regimes against the US dollar. Our data set includes managed, fixed and flexible exchange rates. Tables 12 and 13 in the Appendix summarize the exchange rate regimes of the countries under investigation according to the IMF classification. The fact that we also consider long-term forecasts enables us to address expected changes of the exchange rate regime, for example if long-run expectations exceed announced fluctuation bands of the exchange rates. This part of our analysis is therefore related to the credibility of fixed exchange rate regimes.

4 Empirical results

4.1 Descriptive analysis

Throughout the analysis, we distinguish between major and minor currencies. For both sets of currencies, we analyze the longest available sample period. The full sample period for major currencies starts in October 2001 while the sample for most of the minor currencies begins in December 2003.[11] To achieve comparability between major and minor currencies, we have often synchronized the sample period.

A natural starting point for our analysis is a comparison of expected and actual future exchange rates. A full analysis of this issue and the corresponding results discussed below are available in the Appendix. A general finding is that the performance of professional forecasters has worsened significantly after the onset of the global financial crisis. Figure 1 illustrates this pattern for four major currencies. Correlations between expected and realized exchange rates are for example never below 80% over the full sample period running from 2002/10 to 2016/03 but decrease significantly if we focus on the subsample period from 2010/07 to 2016/03. This pattern intensifies for 12 and 24 month forecasts where the correlation becomes less pronounced and partly even negative for the second sample period. We have also conducted a formal test for expectations unbiasedness as introduced in Eq. (3) to assess the explanatory power of expectations for realized exchange rates in a statistical way. Unsurprisingly and in line with previous findings, expectations are found to be biased in most cases. As outlined previously, this is not surprising and potentially reflects the

[11] The sample periods of several minor currencies start later. In addition, the calculation of e.g. forecast errors at the 24 month horizon results in a loss of two years of data. Therefore, the effective sample period is shorter and also varies to some extend due to the issue of observation. The exact effective sample period can be found below each table and figure.

unpredictability of exchange rates in terms of point predictions. The next section will focus on the question whether the weak statistical performance is also related to the capacity of professionals to generate portfolio returns.

A graphical inspection for both major and minor currencies shows that 24 month forecasts are strongly disconnected from the current spot rate while short-term forecasts are closely linked to the current exchange rate. If we focus on the period after 2008 most major currencies were expected to depreciate against the US dollar after the crisis emerged, pointing to a possible status of the dollar as a safe haven currency. However, this pattern has somehow reversed after 2012 when the dollar is expected to depreciate against most major currencies over all horizons. The same pattern becomes evident for most minor currencies which can be explained based on their exchange rate peg in many cases.

*** Insert Figure 1 about here ***

4.2 Expectations across regimes and crisis expectations

Due to the large number of currencies analyzed, we also incorporate different exchange rate regimes. The IMF classification provided in Tables 12 and 13 in the Appendix shows that most currencies allow for floating exchange rates with many of them classified as floating in the context of inflation targeting.[12] For those currencies, future expectations are directly related to the credibility of the exchange rate arrangement. Some economies have pegged their exchange rate, giving up monetary independence to earn credibility.

Expectations have a prominent role in the literature on currency crisis since the traditional model has been proposed by Krugman (1996). In a nutshell, expectations and resulting speculations can potentially force authorities to give up a non-credible exchange rate peg which is not in accordance with macroeconomic fundamentals. To analyze the performance of forecasters in the context of exchange rate regimes and large exchange rate changes, we will summarize the empirical findings of correctly and falsely expected devaluations across all currencies and horizons in the following. We choose a somehow arbitrary benchmark of depreciations above 5%. This allows us to disregard

[12]Some exchange rates are fluctuating against the US dollar due to the fact that they are fixed against other currencies. IMF 'Conventional pegs to composite' classifications have been defined as fixed in this paper. However, our findings described in the following are not affected by the classification of these currencies.

comparably small actual and expected depreciations.[13] Panel A and B of Table 1 report expected and actual depreciations above 5% for 3 and 6 as well as 12 and 24 months, respectively, for major and minor currencies and also separated into both fixed and flexible regimes. Panel (c) provides additional findings for the 15% benchmark.[14]

We focus on cases where a depreciation of above 5% is expected correctly and label the resulting conditional relative frequency as the success rate. This is the case in less than 5% of the periods for the 3 and 6 months horizon for both major and minor currencies. The picture for the 12 and 24 months horizon is quite different with around 7-24% of correctly expected devaluations for both major and minor currencies. In contrast, a large number of unexpected depreciations can be observed. The findings for the 12 and 24 month horizons display an overall success rate above 50% for both major and minor currencies. Only fixed exchange rate regimes for minor currencies display a success rate below 50% while nearly 60% in case of fixed exchange rate regimes for major currencies is observed. Hence, expectations are significantly more but still only moderately successful over the long-run.

This pattern is confirmed if depreciations of at least 15% over a two year horizon are considered. Such cases constitute less than 4% of all observations but display a success rate around 80% for both major and minor currencies under fixed exchange rates.

*** Insert Table 1 about here ***

Two findings stand out for economies which operate under fixed exchange rates: On the one hand, professionals hardly expect exchange rate changes beyond the announced exchange rate regime. In addition, they frequently fail to provide adequate forecasts under fixed exchange rates regimes over the short- and medium-run. Most depreciations against the US dollar above a specific threshold happen to be unexpected. This uncertainty has increased significantly for most minor currency forecasts after the financial crisis. However, the encouraging news is that fixed exchange rate regimes have prevailed in many cases despite depreciation expectations, in particular in case of emerging markets. An issue which is not explicitly covered here is the loss of monetary autonomy and the possible need for capital controls, i.e. the costs of adopting a fixed exchange rate regime.

[13] Several other configurations which include alternative benchmarks and/or both depreciations and appreciations are available upon request.

[14] Crawling peg to composite and currency board to euro are defined as floating relative to the US dollar.

4.3 On the economic value of professional forecasts

Our analysis of point forecast adequacy has so far examined forecasts from a single currency perspective based on statistical tests. However, the findings of our previous section have demonstrated that professionals do a better job in forecasting large exchange rate changes which raises the question whether their knowledge is potentially useful from an investor's perspective. Elliott and Ito (1999) show that a weak statistical forecasting performance is potentially still valuable in terms of generating profits compared to simple benchmarks. This reflects the general argument raised by Leitch and Tanner (1991) that statistical evaluation and economic gains from survey forecasts potentially contradict each other. The reason is that conventional statistical measures rely on narrow assumptions about a forecasters' loss function while trading rules take the economic gains and the practical use of forecasts into account. We therefore turn to the question whether exchange rate forecasts are useful from an economic perspective based on trading rules and start with a very simple question: Are professionals doing a better job in predicting exchange rate changes than recent history? To answer this question from an economic perspective, we compare the performance of expectations over different horizons relative to a simple trend following strategy. In the first scenario, the investor buys a currency which is expected to appreciate over the forecast horizon ($E_t(s_{t+h}) - s_t < 0$) and sells a currency which is expected to depreciate ($E_t(s_{t+h}) - s_t > 0$). The corresponding return based on professional forecasters expectations can thus be calculated as

$$r^E_{t,t+h} = I(E_t(s_{t+h}) - s_t > 0)(s_{t+h} - s_t)/h - I(E_t(s_{t+h}) - s_t < 0)(s_{t+h} - s_t)/h, \tag{6}$$

where $I(.)$ represents a Heaviside indicator function, $E_t(.)$ stands for expectation formed in t, and s_t denotes the natural logarithm of the spot exchange rate measured in units of domestic currency per one unit of the US dollar (i.e. a decrease of s_t means an appreciation of the domestic currency). h gives the forecast horizon.

In the second scenario, the investor uses a simple momentum strategy and buys a currency which has appreciated over the last month ($s_t - s_{t-1} < 0$) while he sells a currency which has depreciated over the last month ($s_t - s_{t-1} > 0$). The return of a momentum strategy can be expressed as

$$r^M_{t,t+h} = I(s_t - s_{t-1} > 0)(s_{t+h} - s_t)/h - I(s_t - s_{t-1} < 0)(s_{t+h} - s_t)/h. \tag{7}$$

In addition, wherever available we also extend both trading rules by the inclusion of interest rate

differentials between the domestic economy and the US ($i_t - i_t^*$) as an additional setting.[15]

Tables 2 and 3 compare returns of expectation based trading with the simple momentum strategy for 30 major currencies. The findings clearly show that professional expectations outperform momentum trading in most of the cases. This is in particular true for longer horizons where momentum trading partly accumulates significant losses but is successful in case of the Venezuelan bolivar and the Argentine peso. Interestingly, the findings for the Japanese yen are mixed with expectations being more successful over the short-run and momentum strategy being superior over longer horizons. Overall, expectations outperform momentum trading in roughly 70% of all cases and not solely referring to the simple mean return but also in respect to the risk-adjusted mean return provided by the Sharpe ratio. Furthermore, as opposed to momentum returns the standard deviations of professional expectations based returns decrease substantially for higher forecasting horizons. This clearly demonstrated the superiority of the professional forecasts. Although we disregard trading costs[16] and assume that all currencies are tradable, this exercise discovers a significant discrepancy between statistical measures such as the unbiasedness test and economic measures. Table 4 confirms this finding for selected economies by taking the interest rate differential into account where expectation trading again outperforms momentum in 9 out of 14 cases. Due to data availability, we perform this analysis solely for the 3 months horizon. Trading rules have also been analyzed for countries under capital controls and in particular expectation based trading exploits arbitrage opportunities. The example of China shows that (hypothetical) trading strategies generate significant returns and clearly outperform the other benchmarks, in particular over longer horizons. The latter becomes also evident in case of Russia where the 24 month return for professionals is around 9% while momentum trading generates a negative return of -40%. Unsurprisingly, momentum trading pays off in case of currencies which experience a continuous depreciation, such as Argentina.

[15] In this case the returns given in Eqs. (6) and (7) can be expressed as

$$r_{t,t+h}^{E,i} = I(E_t(s_{t+h}) - s_t > i_t - i_t^*)((s_{t+h} - s_t)/h - (i_t - i_t^*)) - I(E_t(s_{t+h}) - s_t < i_t - i_t^*)((s_{t+h} - s_t)/h - (i_t - i_t^*)), \quad (8)$$

and

$$r_{t,t+h}^{M,i} = I(s_t - s_{t-1} > i_t - i_t^*)((s_{t+h} - s_t)/h - (i_t - i_t^*)) - I(s_t - s_{t-1} < i_t - i_t^*)((s_{t+h} - s_t)/h - (i_t - i_t^*)), \quad (9)$$

where i_t and i_t^* gives the domestic interest rate and its US counterpart, respectively. Due to data availability we only analyze selected major currencies at a 3 months horizon where adequate three months interest rates are available.

[16] As a robustness check, we have re-run the whole analysis by accounting for transaction costs (0.1%, 0.5%, and 1%, respectively) and the corresponding results reported in the Appendix (see Tables 14 to 19) generally confirm our findings.

*** Insert Tables 2 to 4 about here ***

4.4 Portfolio trading

Having looked at individual currency forecasts with and without interest rate differentials, we turn to a portfolio perspective looking at an US investor who manages a portfolio based on aggregated expectations in the following. We again include interest rate differentials relative the US to calculate returns based on trading strategies. However, comparable interest rates over three months are not available for some countries under observation, in particular in the case of most minor currencies. In addition, some currencies are not fully tradable or not de facto used for investments and trading. For this reason, we only use currencies where adequate interest rates are available. As already done in Table 4, we therefore only rely on a basket of 14 major currencies for which three month interest rates are available. Forward rates are linked to interest rate differentials through covered interest rate parity, so that we implicitly include information in the forward rates as well (Taylor and Sarno, 2004; Sarno, 2005).

We compare a portfolio based on expectations with trend and carry trade portfolios as two alternative benchmarks. The expected return from investing in each of the risky assets is equal to the domestic riskless rate plus the currency return. In the spirit of Melvin *et al.* (2013), we generate a trend portfolio as follows:

1. Currencies are ranked by spot exchange rate appreciation (or depreciation) versus US dollar minus interest rate differential over the previous 3 months

2. For the next month hold a portfolio of +30% of the three currencies that are highest ranked instep 1 and -30% of the three currencies that are ranked lowest.

In a similar vein, the investor rebalances his portfolio on a monthly basis by taking a long position on the three currencies expected to appreciate most while reducing those who are expected to depreciate most. The choice of 30% positions is somewhat arbitrary but a standard choice. The findings are insensitive regarding assumptions related to the size and structure of the original portfolio (Melvin *et al.*, 2013).

Table 5 compares expectation based portfolio sorting, momentum trading and a carry trade strategy based on returns and risk-adjusted returns calculated by the Sharpe ratio. Professionals once

again do a better job, generating a significant return and outperforming both a momentum and a carry trade strategy in terms of the Sharpe ratio. However, one has to take into account that the result relative to carry trades reflects the low interest rate differentials over the recent sample period and the well-known fact that carry trades have become less profitable as a result. In addition, Sharpe ratios for both momentum and expectation based trading are small, reflecting the turbulence on currency markets over the sample period. One has to keep in mind, however, that Sharpe ratios underestimate the performance of dynamic strategies since they overestimate the conditional risk an investor faces at each point in time due to the full sample standard deviation they consider (Marquering and Verbeek, 2004; Han, 2006; Della Corte *et al.*, 2012). Nevertheless, the results confirm that expectations are useful from an economic perspective despite their weak statistical performances illustrated before. We also observe that the findings are quite different across horizons. The standard deviation becomes much smaller for trading based on exchange rate expectations while the opposite is observed for momentum trading.

*** Insert Table 5 about here ***

4.5 Expected exchange rate changes, monetary policy and safe haven

In the following we turn to the identification of potential drivers of exchange rate expectations and resulting forecast errors over the recent sample period. To tackle this question, we adopt the time-varying coefficient models already discussed in Section 2.2 (see Eqs. (4) and (5)) for the expected exchange rate change and the forecast error. We therefore adopt a rolling-window regression approach with a window size of 30 months to account for the overwhelming evidence of a time-varying and unstable relationship between exchange rates and fundamentals (Sarno and Taylor, 2002). All variables are stationary according to unit root tests, so that standard OLS provides consistent estimates. Putting both expectations and expectation errors under closer scrutiny enables us to address expected and unexpected effects due to financial stress, monetary policy and macroeconomic fundamentals.[17]

Table 6 summarizes the full sample results under the assumption of constant coefficients for both expected exchange rate changes as well as forecast errors for major currencies.[18] Many estimates

[17] Alternative specifications which include other uncertainty measures and a dummy variable for policy announcements, respectively, are available in the Appendix (see Tables 20 and 21) but do not change the main findings.

[18] The corresponding findings for minor currencies are provided in the Appendix (see Table 22).

turn out to be insignificant over the full sample. This is hardly surprising considering the various political and economic events throughout the entire sample period we consider. A clear pattern is that expectation errors are more frequently affected than expectations. This becomes for example evident for the Fed's shadow rate effect and points to surprise effects stemming from monetary policy. When evaluating these findings, we generally take into account that we are dealing with impacts on point forecasts over the full sample period rather than effects on the portfolio performance. As a next step, we therefore consider time-varying estimates to disentangle determinants of expectations and forecast errors. The Appendix provides currency-specific time-varying estimates while Figures 2 and 3 provide an illustrative and intuitive summary of our findings for a horizon of three months for major and minor currencies.[19] For each coefficient, we illustrate the percentage of significance at the 10% level across currencies over time together with the sign of the coefficient. Panel (a) displays findings for expected exchange rate changes while Panel (b) focuses on forecast errors. In both cases eight determinants are considered: Inflation and three month interest rates relative to the US, four monetary policy shadow rates, the VIX as an uncertainty measure and the three-periods lagged forecast error. It should be noted that a positive effect on forecast errors reflects an unexpected depreciation against the US dollar.

*** Insert Table 6 and Figures 2 and 3 about here ***

When analyzing the role of inflation and interest rate differentials via the US, we expect that currencies with higher inflation rates are expected to depreciate if forecasters believe in PPP. The impact of interest rates is less clear with uncovered interest rate parity (UIP) suggesting that higher interest rate currencies depreciate while the established forward premium puzzle indicates a reversed pattern. There is also evidence that it might pay off to bet against the validity of UIP through carry trades based on the forward premium puzzle (Jongen *et al.*, 2008).

In addition, we examine the role of monetary policy shocks in the US and the Eurozone based on the consideration of shadow policy rates. Finally, we focus on a possible time-varying impact on stock market volatility to identify expected and unexpected effects of uncertainty on expectations. We focus on the period from 2004 until the end of 2015 to include a large number of currencies and account for the period before the financial crisis. An obvious observation is that the drivers of both

[19] Findings for other horizons do not change the main conclusions and are available upon request. Figure 3 starts at a later point in time due to data availability for minor currencies.

expectations and forecast errors are time-varying and different across currencies. While a detailed discussion of all currency effects is beyond the scope of our paper, we discuss some main patterns in the following starting with drivers of expectations before analyzing the resulting forecast errors where a positive value mirrors an unexpected appreciation against the US dollar.

Interest rate and inflation differentials A first common pattern across currencies is that the interest rate differential is an important driver of expectations in major economies after the onset of the global financial crisis between 2009 and 2011. In line with theory, currencies of economies with higher interest rates are expected to depreciate which suggests that forecasters do not incorporate the forward premium puzzle when building expectations and stick with UIP instead. Effects on forecast errors displayed in Figure 2 (b) are not substantial during this first sub-period but unexpected appreciations against the US dollar are observed in case of higher interest rates between 2011 and 2013. Minor currencies are also mostly expected to depreciate in case of higher interest rates but are overall less affected. Effects on forecast errors are also less significant but unexpected depreciations are observed in 2015.

Currencies of economies with higher inflation rates should depreciate according to PPP. Unsurprisingly, this long-run belief is hardly reflected in short-run expectations. The inflation differential is rarely significant and partly displays a reversed sign.[20] Effects for minor currencies are overall slightly more in line with PPP which implies that inflation differentials are more important in case of higher inflation rates. According to our theoretical considerations in Section 2, we frequently find that forecasters attach different weights to different fundamentals (Jongen *et al.*, 2012).

Uncertainty and safe haven currencies In the following we turn to the role of uncertainty and the safe haven status. The negative impact of uncertainty measured by the VIX on exchange rate expectations according to Panel (a) in Figures 2 and 3 suggests that the US dollar was mostly expected to depreciate against many major currencies between 2008 and 2015. The strong positive impact on forecast errors according to Panel (b) in Figure 2 shows that he in-fact unexpectedly appreciated against many currencies between 2009 and 2016 except for a brief period at the end of 2011. This demonstrates an unexpected safe haven status of the US dollar after the subprime crisis, a finding which is in line with the observation of Fratzscher (2009) that currency markets have undergone

[20] When discussing the effects of inflation on expectations, our framework does not consider some country-specific effects, such as the importance of consumption tax hikes on inflation due to data availability.

substantial changes after 2009. Minor currencies are often expected to depreciate against the US dollar except in 2013. However, they have often experienced an unexpected appreciation against the dollar according to Figure 3 (b). This possibly reflects imported credibility rather than expected safe haven status. Another explanation is that some minor currencies are simply determined by cross-rates and co-movements with major exchange rates due to their low trading volume.

Monetary policy, shadow rates and expectations The final effects we are analyzing stem from monetary policy shocks reflected by shadow rates. Starting with effects of unconventional monetary policy of the US Fed, there is a strong impact on expectations when unconventional monetary policy and the zero lower bound emerged after the collapse of Lehman Brothers in 2008. Figures 2 and 3 show that monetary policy in the Eurozone had strong effects on expectations between 2009 and 2012. The aggregated negative significance suggests that lower interest rates raised substantial expectations about depreciations against the US dollar. Such an effect diminishes for major currencies around 2012 but is continuously observed for minor currencies. Monetary policy rates of the UK and Japan show a reversed effect between 2008 and 2012 and from 2008 until 2010, respectively, with lower policy rates generating expected US dollar appreciations for major currencies. Monetary policy conducted by the Federal Reserve had different effects over time, triggering both expected depreciations and appreciations.

The findings for forecast errors point to somehow unexpected effects stemming from monetary policy. Keeping in mind that we have analyzed the three month horizon, our results reflect the unpredictability of exchange rates over short-run horizons. A decrease in ECB shadow rates resulted in unexpected depreciations against the US dollar, at least to some degree, over the full sample period for major economies according to Panel (b) in Figure 2. Once again, opposite effects are observed for policy rates in the UK and in particular in Japan where a decrease coincides with unexpected appreciations against the US dollar between 2010 and 2012. While such effects reverse for the UK afterwards, effects of unconventional monetary policy in Japan displays a similar and even stronger effect after 2013 when the Bank of Japan extended the policy of quantitative and qualitative easing.[21] Contrary to that many minor currencies experienced an unexpected depreciation according to Figure 3 (b). Overall, our findings point to substantial effects of unconventional monetary policy, in particular in terms of international spillovers beyond usual co-movements of

[21] See Korniyenko and Loukoianova (2015) for a general discussion of unconventional monetary policy effects and the timeline of conducted actions.

exchange rates which affect a large share of economies. In line with previous findings by Glick and Leduc (2015) market participants are surprised by monetary policy effects. The results also suggest a significant degree of switching across models with the determinants changing across the sample period. Ahn and Melvin (2007) have illustrated that a distinction between informed and not-informed traders is necessary when evaluating the effects of monetary policy announcements after FOMC meetings. That might also explain why aggregated expectations do not consistently react to changes in shadow rates. Unexpected effects might also trigger scapegoat effects on exchange rates stemming from monetary policy as first pointed out by Bacchetta and Van Wincoop (2004).

For major and in particular for minor currencies, forecast errors also display an autoregressive component according to the coefficient of the lagged forecast error. However, our previous findings have demonstrated that even short-run expectations often outperform past values based on economic criteria. Against this background, observed unexpected effects do not imply that expectations are irrational or inefficient.

5 Conclusion

This study has analyzed and evaluated exchange rate expectations data for more than 60 currencies over different forecasting horizons. Forecast errors have increased significantly after the collapse of Lehman Brothers. A comparison across countries with different regimes suggests that professionals do a slightly better job in forecasting large exchange rate changes. Countries with managed exchange rate flexibility or fixed exchange rates often seem to be successful in importing market credibility, anchoring expectations and avoiding currency turbulence over the recent period, even if depreciations are expected.

In terms of performance, we find that statistical and economic evaluation measures of expectations potentially contradict each other. Conventional unbiasedness tests which focus on point forecasts suggest a weak performance of expectations over all horizons. On the other hand, expectation based trading strategies outperform momentum and carry trade benchmarks in terms of portfolio performance, in particular due to lower standard deviations and over longer horizons. This is in also in line with our finding that professionals are more successful at forecasting larger exchange rate changes.

Our second stage analysis has illustrated the time-varying impact of fundamentals, uncertainty

and central bank interest rates on expectations and forecast errors. Monetary policy shadow rates of major central banks turn out to be important drivers of expectations, generating substantial international spillovers over the recent period of unconventional monetary policy. Most of those effects turn out to be unexpected by professionals, pointing to surprise effects from monetary policy which are in line with the findings by Glick and Leduc (2015) who adopt surprise measures and find strong effects on the US dollar over the recent period. We also find that the safe haven status of the US dollar after 2009 was largely unexpected.

The time-varying impact on expectation building and forecast errors does not contradict market efficiency and is perfectly in line with the forward looking nature of exchange rates, the idea of bounded rationality and the theoretical idea of scapegoat effects when forming expectations. The unpredictability of exchange rates in the short-run makes it more efficient to rely on the current exchange rate for predictions. For monetary policy transmission this represents a major task when aiming at influencing expectations, also implying the potential need of cooperation across central banks to lower uncertainty arising from monetary policy. The unpredictability of exchange rates in the short-run also explains the potential returns of expectation based trading even if statistical tests point to biased expectations. Even expectations which generate significant prediction errors are useful as long as they add value compared to solely relying on the current exchange rate which should incorporate all available information.

The current study can be extended in various ways. Our evaluation of expectation based trading could easily be conducted over a different sample period. In terms of monetary policy, a more disaggregated perspective on individual expectations for selected currencies could be quite useful to understand monetary transmission over the recent period of unconventional monetary policy. Another open issue in the context of exchange rate regimes is the importance of currency reserves, their relationship to public debt and the resulting impact on expectations and exchange rate stability under fixed exchange rates.

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Tables

TABLE 1 **Expected vs. unexpected devaluation**

Panel A: Major currencies				
	3+6 months		**12+24 months**	
	Expected devaluation of 5%	Unexpected devaluation of 5%	Expected devaluation of 5%	Unexpected devaluation of 5%
Overall				
Devaluation of 5%	76 (0.87%)	1536 (17.61%)	537 (9.04%)	1461 (24.59%)
No devaluation	129 (1.48%)	6980 (80.04%)	487 (8.20%)	3456 (58.17%)
Floating				
Devaluation of 5%	10 (0.14%)	1418 (19.25%)	370 (7.37%)	1364 (27.19%)
No devaluation	45 (0.61%)	5893 (80.00%)	358 (7.14%)	2925 (58.30%)
Fixed				
Devaluation of 5%	66 (4.87%)	118 (8.71%)	167 (18.07%)	97 (10.50%)
No devaluation	84 (6.20%)	1087 (80.22%)	129 (13.96%)	531 (57.47%)
Panel B: Minor currencies				
	3+6 months		**12+24 months**	
	Expected devaluation of 5%	Unexpected devaluation of 5%	Expected devaluation of 5%	Unexpected devaluation of 5%
Overall				
Devaluation of 5%	97 (1.08%)	1412 (15.78%)	930 (14.04%)	1728 (26.08%)
No devaluation	118 (1.32%)	7320 (81.82%)	791 (11.94%)	3177 (47.95%)
Floating				
Devaluation of 5%	67 (1.78%)	888 (23.65%)	675 (23.98%)	739 (26.25%)
No devaluation	74 (1.97%)	2726 (72.60%)	451 (16.02%)	950 (33.75%)
Fixed				
Devaluation of 5%	30 (0.58%)	524 (10.09%)	255 (6.69%)	989 (25.95%)
No devaluation	44 (0.85%)	4594 (88.48%)	340 (8.92%)	2227 (58.44%)
Panel C: 24 months				
	Major currencies		**Minor currencies**	
	Expected devaluation of 15%	Unexpected devaluation of 15%	Expected devaluation of 15%	Unexpected devaluation of 15%
Overall				
Devaluation of 15%	56 (3.11%)	420 (23.36%)	35 (1.45%)	616 (25.51%)
No devaluation	16 (0.89%)	1306 (72.64%)	23 (0.95%)	1741 (72.09%)
Floating				
Devaluation of 15%	1 (0.07%)	392 (25.96%)	15 (1.41%)	348 (32.68%)
No devaluation	0 (0.00%)	1117 (73.97%)	17 (1.60%)	685 (64.32%)
Fixed				
Devaluation of 15%	55 (19.10%)	28 (9.72%)	20 (1.48%)	268 (19.85%)
No devaluation	16 (5.55%)	189 (65.63%)	6 (0.44%)	1056 (78.22%)

Note: The table shows the absolute (relative) frequencies for the matrix consisting of expected and unexpected devaluation as well as actually observed devaluation and no devaluation. Panel A (Panel B) reports the results for devaluations of at least 5% for major (minor) currencies with aggregated forecast horizons 3 and 6 as well as 12 and 24. Panel C shows the corresponding findings for devaluations of at least 15% for major and minor currencies and forecast horizon 24. The currencies have also been separated into floating and fixed exchange rates.

TABLE 2 **Descriptive statistics for professional expectations based annualized returns for major currencies in % (without transaction costs)**

	$h=1$			$h=3$			$h=6$			$h=12$			$h=24$		
	Mean	**SD**	**Sharpe**	**Mean**	**SD**	**Sharpe**	**Mean**	**SD**	**Sharpe**	**Mean**	**SD**	**Sharpe**	**Mean**	**SD**	**Sharpe**
GBP/USD	1.4787	24.1090	0.0613	1.0037	13.8411	0.0725	0.2186	9.7183	0.0225	0.4259	5.7108	0.0746	-0.3867	3.7113	-0.1042
CZK/USD	3.8897	41.8127	0.0930	3.8370	22.4701	0.1708	2.3550	14.5916	0.1614	3.5978	10.4072	0.3457	3.3066	6.2290	0.5308
DKK/USD	1.1251	31.7649	0.0354	3.6567	17.4501	0.2096	1.8227	13.1411	0.1387	2.4989	9.9403	0.2514	1.8637	5.0963	0.3657
EUR/USD	1.9044	31.9514	0.0596	3.3350	17.6608	0.1888	2.1058	13.2123	0.1594	2.4084	10.0097	0.2406	1.8240	5.1387	0.3549
HUF/USD	5.7659	44.3383	0.1300	4.8287	24.8660	0.1942	3.4093	17.0596	0.1998	4.5928	11.5081	0.3991	4.1742	6.9927	0.5969
NOK/USD	10.7576	35.8473	0.3001	8.9897	18.8494	0.4769	5.6830	15.1797	0.3744	6.4041	10.8985	0.5876	1.6473	8.8527	0.1861
PLN/USD	8.4833	44.4359	0.1909	4.4158	23.1518	0.1907	2.2260	16.1386	0.1379	2.7171	10.9711	0.2477	2.2329	7.2100	0.3097
RUB/USD	15.0488	72.2611	0.2083	12.8885	48.2130	0.2673	10.9918	31.2383	0.3519	10.5318	20.7416	0.5078	8.5219	15.2358	0.5593
SEK/USD	8.5964	35.3082	0.2435	8.0491	18.1711	0.4430	5.1164	14.1079	0.3627	5.3042	10.3696	0.5115	1.8582	7.8439	0.2369
CHF/USD	-0.6932	37.5327	-0.0185	1.0074	20.8701	0.0483	-1.2675	14.1171	-0.0898	-1.3869	9.8351	-0.1410	-0.3356	6.2000	-0.0541
TRY/USD	13.6676	38.4659	0.3553	10.0918	22.5921	0.4467	8.7532	15.5983	0.5612	9.1339	11.3266	0.8064	7.0142	8.3873	0.8363
AUD/USD	9.7043	39.1462	0.2479	4.2198	21.5168	0.1961	2.5966	15.6654	0.1658	2.8897	11.6994	0.2470	-0.9806	10.5855	-0.0926
CNY/USD	2.0652	8.9151	0.2316	2.5112	5.0490	0.4974	2.3687	3.2722	0.7239	2.1862	2.1841	1.0010	2.1388	1.2100	1.7676
INR/USD	-9.5151	36.4287	-0.2612	-8.1451	18.1051	-0.4499	-1.7433	13.2197	-0.1319	-1.2572	9.6676	-0.1300	-2.9206	6.8929	-0.4237
IDR/USD	3.2345	28.6904	0.1127	-0.3410	17.4111	-0.0196	-1.3956	13.8078	-0.1011	0.5558	10.8226	0.0514	0.2394	9.7905	0.0245
JPY/USD	4.4977	29.2960	0.1535	2.6602	20.6203	0.1290	3.2111	16.0470	0.2001	4.2742	11.7212	0.3647	2.9068	9.8042	0.2965
NZD/USD	7.5836	43.0646	0.1761	0.5802	22.1330	0.0262	1.2052	14.3851	0.0838	1.1546	10.3225	0.1119	-1.8343	8.0193	-0.2287
PHP/USD	0.5851	18.8937	0.0310	1.8080	10.2105	0.1771	1.2653	6.7992	0.1861	2.1130	4.6692	0.4526	2.1575	2.8881	0.7470
SGD/USD	3.2313	21.2663	0.1519	3.2885	10.7640	0.3055	3.3668	7.2428	0.4649	3.5567	4.8458	0.7340	3.0748	3.5017	0.8781
KRW/USD	4.4012	30.7166	0.1433	4.3851	15.0781	0.2908	2.6231	9.4204	0.2784	2.4859	5.8031	0.4284	2.6852	4.2895	0.6260
TWD/USD	2.0121	16.5542	0.1215	2.9698	9.8803	0.3006	2.2520	6.7600	0.3331	2.5986	3.9431	0.6590	2.0914	2.9596	0.7066
THB/USD	-1.1800	22.1024	-0.0534	-0.5560	12.8175	-0.0434	3.0276	8.3740	0.3616	3.0632	5.4884	0.5581	2.0336	3.7544	0.5417
ARS/USD	22.0304	58.6843	0.3754	22.7388	36.4339	0.6241	19.3849	21.7032	0.8932	17.2603	14.4869	1.1914	16.4413	9.7960	1.6784
BRL/USD	9.8045	58.2658	0.1683	6.9851	32.7691	0.2132	-1.8573	25.1751	-0.0738	0.8437	20.2489	0.0417	0.4203	14.3749	0.0292
CAD/USD	6.3183	27.9087	0.2264	4.7108	14.5527	0.3237	0.5780	10.9603	0.0527	1.1513	8.1530	0.1412	-1.8064	6.7429	-0.2679
CLP/USD	9.5831	33.4795	0.2862	8.5185	17.4763	0.4874	1.0723	13.7756	0.0778	1.6853	10.4453	0.1613	2.1158	8.6532	0.2445
COP/USD	8.1813	47.1640	0.1735	11.0562	26.8042	0.4125	3.5683	20.7717	0.1718	3.7643	16.1465	0.2331	1.8775	11.1458	0.1684
MXN/USD	0.4095	36.1598	0.0113	-2.5942	20.6636	-0.1255	-2.6786	14.1801	-0.1889	-1.7352	10.6554	-0.1628	-1.8735	6.6652	-0.2811
VEF/USD	14.6777	87.1366	0.1684	9.3208	38.2915	0.2434	7.9816	24.1119	0.3310	13.4393	23.0256	0.5837	16.0682	13.8816	1.1575
ZAR/USD	10.7947	48.4639	0.2227	11.1145	24.3658	0.4562	9.6186	17.1525	0.5608	8.0257	13.0606	0.6145	6.4718	11.1767	0.5790

Note: The table reports the means, standard deviations (SD) and Sharpe ratios (=mean/SD) for professional expectations based returns formed 1- ($h=1$), 3- ($h=3$), 6- ($h=6$), 12- ($h=12$) or 24-months ($h=24$) before for the following exchange rates (sample period 2010/07-2016/03): British Pound (GBP/USD), Czech Koruna (CZK/USD), Danish Krone (DKK/USD), Euro (EUR/USD), Hungarian Forint (HUF/USD), Norwegian Krone (NOK/USD), Polish Zloty (PLN/USD), Russian Rouble (RUB/USD), Swedish Krona (SEK/USD), Swiss Franc (CHF/USD), Turkish Lira (TRY/USD), Australian Dollar (AUD/USD), Chinese Renminbi (CNY/USD), Indian Rupee (INR/USD), Indonesian Rupiah (IDR/USD), Japanese Yen (JPY/USD), New Zealand Dollar (NZD/USD), Philippine Peso (PHP/USD), Singapore Dollar (SGD/USD), South Korean Won (KRW/USD), Taiwan Dollar (TWD/USD), Thai Baht (THB/USD), Argentine Peso (ARS/USD), Brazilian Real (BRL/USD), Canadian Dollar (CAD/USD), Chilean Peso (CLP/USD), Colombian Peso (COP/USD), Mexican Peso (MXN/USD), Venezuelan Bolivar (VEF/USD), and South African Rand (ZAR/USD). Professional expectations based returns have been calculated based on the following trading rule: $r^E_{t,t+h} = I(E_t(s_{t+h}) - s_t > 0)(s_{t+h} - s_t)/h - I(E_t(s_{t+h}) - s_t < 0)(s_{t+h} - s_t)/h$, where $I(.)$ represents a Heaviside indicator function, $E_t(.)$ stands for expectation formed in t, and s_t denotes the natural logarithm of the spot exchange rate measured in units of domestic currency per one unit of the US dollar (i.e. a decrease of s_t means an appreciation of the domestic currency).

TABLE 3 **Descriptive statistics for momentum strategy based annualized returns for major currencies in % (without transaction costs)**

	$h=1$			$h=3$			$h=6$			$h=12$			$h=24$		
	Mean	**SD**	**Sharpe**	**Mean**	**SD**	**Sharpe**	**Mean**	**SD**	**Sharpe**	**Mean**	**SD**	**Sharpe**	**Mean**	**SD**	**Sharpe**
GBP/USD	2.0542	24.0661	0.0854	7.6530	40.9141	0.1870	11.9757	57.0638	0.2099	-5.4709	68.5012	-0.0799	-7.5992	89.2321	-0.0852
CZK/USD	-2.4003	41.9262	-0.0572	-10.3950	67.5941	-0.1538	-8.0364	88.3287	-0.0910	-23.0198	130.1934	-0.1768	-44.2965	163.5482	-0.2708
DKK/USD	2.8444	31.6557	0.0899	4.5475	53.3076	0.0853	5.4732	79.4210	0.0689	-8.6861	122.7371	-0.0708	-35.6221	125.3108	-0.2843
EUR/USD	3.3799	31.8273	0.1062	6.5939	53.5219	0.1232	8.4424	79.8376	0.1057	-2.6908	123.5642	-0.0218	-35.4733	126.0057	-0.2815
HUF/USD	-0.8380	44.7091	-0.0187	0.1915	76.0117	0.0025	-0.1801	104.4112	-0.0017	-14.4466	148.1253	-0.0975	-25.9644	194.0751	-0.1338
NOK/USD	1.9882	37.3958	0.0532	4.2524	62.5891	0.0679	6.4264	97.1243	0.0662	-2.2011	151.9595	-0.0145	-1.4710	216.1596	-0.0068
PLN/USD	3.2898	45.1286	0.0729	11.4123	69.7851	0.1635	7.6808	97.4550	0.0788	-0.0608	135.6880	-0.0004	-14.8744	180.6455	-0.0823
RUB/USD	19.7815	71.0943	0.2782	22.9230	148.0009	0.1549	11.2196	198.5338	0.0565	22.6469	278.6346	0.0813	-39.3883	417.8258	-0.0943
SEK/USD	3.1184	36.2186	0.0861	10.3679	58.7732	0.1764	16.7812	88.5193	0.1896	13.3102	139.3383	0.0955	-20.0258	192.4844	-0.1040
CHF/USD	-1.6378	37.5029	-0.0437	-0.2115	62.6839	-0.0034	-5.4835	84.8689	-0.0646	-7.2824	118.9799	-0.0612	-29.2724	146.0751	-0.2004
TRY/USD	4.9549	40.5496	0.1222	5.8562	74.0871	0.0790	10.9519	106.9400	0.1024	12.6511	174.6483	0.0724	-5.6593	263.1412	-0.0215
AUD/USD	-0.6493	40.3430	-0.0161	1.1710	65.7874	0.0178	7.3967	95.0015	0.0779	2.9045	144.6437	0.0201	20.7614	254.2962	0.0816
CNY/USD	1.5285	9.0242	0.1694	1.5830	16.8663	0.0939	1.6851	24.2393	0.0695	-1.7269	37.1785	-0.0464	-9.7901	58.4767	-0.1674
INR/USD	-0.1078	37.6684	-0.0029	0.5658	59.6296	0.0095	1.0385	80.0079	0.0130	1.1650	116.9963	0.0100	1.0224	179.8645	0.0057
IDR/USD	3.8934	28.6073	0.1361	7.5998	51.6795	0.1471	22.5777	80.1095	0.2818	45.7739	121.5961	0.3764	71.9469	223.5899	0.3218
JPY/USD	1.0778	29.6244	0.0364	8.0811	61.8476	0.1307	7.0949	97.9583	0.0724	16.6018	148.9079	0.1115	32.4071	243.3913	0.1331
NZD/USD	-4.9901	43.4471	-0.1149	-5.5134	66.1896	-0.0833	-9.3282	86.1064	-0.1083	0.4589	124.6523	0.0037	-12.2065	197.1232	-0.0619
PHP/USD	0.8759	18.8823	0.0464	2.5637	31.0075	0.0827	2.3341	41.4390	0.0563	6.1877	61.2612	0.1010	3.3035	86.6840	0.0381
SGD/USD	-0.8630	21.4964	-0.0401	2.0086	33.7260	0.0596	6.5210	47.5333	0.1372	11.3422	71.4097	0.1588	10.8936	111.6613	0.0976
KRW/USD	-0.7606	31.0255	-0.0245	-2.2410	47.0814	-0.0476	-6.1637	58.3744	-0.1056	-2.7333	75.7946	-0.0361	-25.3767	118.9917	-0.2133
TWD/USD	3.3137	16.3404	0.2028	3.3527	30.7851	0.1089	1.3530	42.7612	0.0316	5.8410	56.4887	0.1034	-0.5504	87.1860	-0.0063
THB/USD	3.1711	21.9026	0.1448	2.5588	38.4028	0.0666	3.6690	53.3448	0.0688	0.8585	75.5515	0.0114	-2.6720	102.6091	-0.0260
ARS/USD	22.1908	58.6229	0.3785	67.4310	109.7951	0.6142	112.9169	133.2151	0.8476	198.0632	184.2456	1.0750	349.9454	298.3335	1.1730
BRL/USD	5.8926	58.7981	0.1002	1.7947	100.5319	0.0179	17.6994	150.4141	0.1177	31.6638	241.1002	0.1313	25.4376	344.1936	0.0739
CAD/USD	-1.4210	28.5894	-0.0497	7.1340	45.3547	0.1573	10.4931	65.0005	0.1614	21.6382	96.3869	0.2245	21.3469	166.2343	0.1284
CLP/USD	-1.4171	34.8141	-0.0407	3.6398	58.2925	0.0624	10.2589	82.2605	0.1247	18.3960	125.6287	0.1464	32.2280	211.4057	0.1524
COP/USD	7.1356	47.3359	0.1507	4.9646	86.9339	0.0571	6.6215	126.3066	0.0524	26.0994	197.2858	0.1323	37.8343	268.6322	0.1408
MXN/USD	2.8002	36.0520	0.0777	9.6741	61.7199	0.1567	15.3390	85.2177	0.1800	13.8843	128.8161	0.1078	-1.2346	166.2488	-0.0074
VEF/USD	14.6777	87.1366	0.1684	27.9624	114.8746	0.2434	31.8186	149.0958	0.2134	161.2718	276.3067	0.5837	385.6367	333.1585	1.1575
ZAR/USD	-2.8884	49.5835	-0.0583	-3.2564	80.3780	-0.0405	-3.7810	118.1380	-0.0320	-15.2491	183.6823	-0.0830	-17.5204	310.0356	-0.0565

Note: The table reports the means, standard deviations (SD) and Sharpe ratios (=mean/SD) for momentum strategy based returns formed 1- ($h=1$), 3- ($h=3$), 6- ($h=6$), 12- ($h=12$) or 24-months ($h=24$) before for the following exchange rates (sample period 2010/07-2016/03): British Pound (GBP/USD), Czech Koruna (CZK/USD), Danish Krone (DKK/USD), Euro (EUR/USD), Hungarian Forint (HUF/USD), Norwegian Krone (NOK/USD), Polish Zloty (PLN/USD), Russian Rouble (RUB/USD), Swedish Krona (SEK/USD), Swiss Franc (CHF/USD), Turkish Lira (TRY/USD), Australian Dollar (AUD/USD), Chinese Renminbi (CNY/USD), Indian Rupee (INR/USD), Indonesian Rupiah (IDR/USD), Japanese Yen (JPY/USD), New Zealand Dollar (NZD/USD), Philippine Peso (PHP/USD), Singapore Dollar (SGD/USD), South Korean Won (KRW/USD), Taiwan Dollar (TWD/USD), Thai Baht (THB/USD), Argentine Peso (ARS/USD), Brazilian Real (BRL/USD), Canadian Dollar (CAD/USD), Chilean Peso (CLP/USD), Colombian Peso (COP/USD), Mexican Peso (MXN/USD), Venezuelan Bolivar (VEF/USD), and South African Rand (ZAR/USD). Momentum strategy based returns have been calculated based on the following trading rule: $r^M_{t,t+h} = I(s_t - s_{t-1} > 0)(s_{t+h} - s_t)/h - I(s_t - s_{t-1} < 0)(s_{t+h} - s_t)/h$, where $I(.)$ represents a Heaviside indicator function and s_t denotes the natural logarithm of the spot exchange rate measured in units of domestic currency per one unit of the US dollar (i.e. a decrease of s_t means an appreciation of the domestic currency).

TABLE 4 **Descriptive statistics for annualized returns at $h = 3$ for selected currencies when accounting for interest rate differentials in %**

	No transaction costs						0.1% transaction costs						0.5% transaction costs						1% transaction costs					
	Profess. expectations			Momentum strategy			Profess. expectations			Momentum strategy			Profess. expectations			Momentum strategy			Profess. expectations			Momentum strategy		
	Mean	SD	Sharpe	Mean	SD	Sharpe	Mean	SD	Sharpe	Mean	SD	Sharpe	Mean	SD	Sharpe	Mean	SD	Sharpe	Mean	SD	Sharpe	Mean	SD	Sharpe
GBP/USD	-0.1758	16.8661	-0.0104	1.9441	16.7532	0.1160	0.1995	16.8658	0.0118	2.8929	16.6140	0.1741	1.0796	16.8320	0.0641	1.5686	16.7930	0.0934	0.6499	16.8543	0.0386	0.1473	16.8664	0.0087
EUR/USD	3.0866	19.7091	0.1566	3.8772	19.5672	0.1981	1.7234	19.8767	0.0867	2.8338	19.7475	0.1435	-1.1108	19.9209	-0.0558	-1.5446	19.8916	-0.0777	-1.5517	19.8910	-0.0780	-1.2969	19.9095	-0.0651
NOK/USD	2.3557	22.0972	0.1066	2.4533	22.0864	0.1111	1.2458	22.1885	0.0561	2.7879	22.0462	0.1265	1.2458	22.1885	0.0561	3.0761	22.0074	0.1398	1.2458	22.1885	0.0561	2.3118	22.1019	0.1046
SEK/USD	7.5582	21.7726	0.3471	1.6441	23.0029	0.0715	6.4537	22.1294	0.2916	0.6544	23.0528	0.0284	2.5123	22.9233	0.1096	-1.7769	22.9929	-0.0773	2.0895	22.9662	0.0910	-0.0602	23.0622	-0.0026
CHF/USD	0.9107	20.8805	0.0436	0.7658	20.8864	0.0367	1.0032	20.8762	0.0481	0.7780	20.8859	0.0372	5.4382	20.1718	0.2696	0.5954	20.8920	0.0285	1.3464	20.8567	0.0646	-0.3582	20.8975	-0.0171
AUD/USD	10.7078	25.8395	0.4144	8.0190	26.8076	0.2991	10.3502	25.9866	0.3983	6.9064	27.1193	0.2547	10.3699	25.9786	0.3992	8.5095	26.6541	0.3193	10.3699	25.9786	0.3992	10.7473	25.8229	0.4162
IDR/USD	14.7301	19.6027	0.7514	12.8514	20.8977	0.6150	14.7301	19.6027	0.7514	12.8514	20.8977	0.6150	14.7301	19.6027	0.7514	12.7421	20.9654	0.6078	14.7301	19.6027	0.7514	13.2549	20.6411	0.6422
JPY/USD	-0.5115	19.3161	-0.0265	3.5012	18.9992	0.1843	0.7449	19.3084	0.0386	4.1015	18.8772	0.2173	-3.7831	18.9444	-0.1997	-2.0312	19.2146	-0.1057	-2.8163	19.1141	-0.1473	-2.0245	19.2153	-0.1054
NZD/USD	2.2277	20.0933	0.1109	5.7294	19.3788	0.2957	3.4456	19.9185	0.1730	8.4271	18.3543	0.4591	5.8164	19.3525	0.3006	7.0216	18.9436	0.3707	6.0889	19.2675	0.3160	6.3412	19.1850	0.3305
SGD/USD	2.2996	10.7246	0.2144	0.1361	10.9705	0.0124	2.1360	10.7588	0.1985	0.0939	10.9709	0.0086	0.3842	10.9645	0.0350	0.3235	10.9665	0.0295	1.2424	10.8999	0.1140	1.1983	10.9049	0.1099
KRW/USD	7.7757	18.8199	0.4132	3.7927	20.0207	0.1894	7.7757	18.8199	0.4132	6.5098	19.3001	0.3373	9.1214	18.1982	0.5012	6.2536	19.3856	0.3226	8.5676	18.4686	0.4639	5.6999	19.5577	0.2914
TWD/USD	1.2130	10.1516	0.1195	0.1831	10.2230	0.0179	2.1291	9.9978	0.2130	0.5760	10.2083	0.0564	1.7351	10.0746	0.1722	0.7071	10.1999	0.0693	1.7351	10.0746	0.1722	1.0576	10.1692	0.1040
CAD/USD	0.7540	16.5608	0.0455	0.2976	16.5755	0.0180	1.2024	16.5340	0.0727	-0.8810	16.5545	-0.0532	0.8624	16.5555	0.0521	-0.7921	16.5590	-0.0478	0.6763	16.5642	0.0408	-1.0060	16.5473	-0.0608
ZAR/USD	9.3380	27.7858	0.3361	6.7456	28.5351	0.2364	9.7834	27.6302	0.3541	6.7604	28.5315	0.2369	9.3252	27.7901	0.3356	8.6877	27.9985	0.3103	9.3252	27.7901	0.3356	9.0346	27.8871	0.3240

Note: The table reports the means, standard deviations (SD) and Sharpe ratios (=mean/SD) for professional expectations based returns and momentum strategy based returns at a 3-months ($h = 3$) horizon for the following exchange rates (sample period 2009/05-2016/03): British Pound (GBP/USD), Euro (EUR/USD), Norwegian Krone (NOK/USD), Swedish Krona (SEK/USD), Swiss Franc (CHF/USD), Australian Dollar (AUD/USD), Indonesian Rupiah (IDR/USD), Japanese Yen (JPY/USD), New Zealand Dollar (NZD/USD), Singapore Dollar (SGD/USD), South Korean Won (KRW/USD), Taiwan Dollar (TWD/USD), Canadian Dollar (CAD/USD), and South African Rand (ZAR/USD). Professional expectations based returns have been calculated based on the following trading rule: $r^{E,i}_{t,t+h} = I(E_t(s_{t+h}) - s_t > i_t - i^*_t)((s_{t+h} - s_t)/h - (i_t - i^*_t)) - I(E_t(s_{t+h}) - s_t < i_t - i^*_t)((s_{t+h} - s_t)/h - (i_t - i^*_t))$, where $I(.)$ represents a Heaviside indicator function, $E_t(.)$ stands for expectation formed in t, and s_t denotes the natural logarithm of the spot exchange rate measured in units of domestic currency per one unit of the US dollar (i.e. a decrease of s_t means an appreciation of the domestic currency). i_t and i^*_t gives the domestic interest rate and its US counterpart, respectively. Momentum strategy based returns have been calculated based on the following trading rule: $r^{M,i}_{t,t+h} = I(s_t - s_{t-1} > i_t - i^*_t)((s_{t+h} - s_t)/h - (i_t - i^*_t)) - I(s_t - s_{t-1} < i_t - i^*_t)((s_{t+h} - s_t)/h - (i_t - i^*_t))$, where $I(.)$ represents a Heaviside indicator function and s_t denotes the natural logarithm of the spot exchange rate measured in units of domestic currency per one unit of the US dollar (i.e. a decrease of s_t means an appreciation of the domestic currency).

TABLE 5 **Descriptive statistics for annualized returns at $h = 3$ for portfolio strategies in %**

	Professional expectations	Momentum strategy	Carry trade strategy
Mean	2.60	2.77	-5.92
SD	6.72	8.08	6.35
Sharpe ratio = Mean/SD	0.39	0.34	-0.93
Skewness	-0.37	0.32	0.71
Kurtosis	2.99	3.22	3.79

Note: The table reports the means, standard deviations (SD), Sharpe ratios (Mean/SD), Skewness and Kurtosis for portfolio returns based on professional expectations, momentum strategy and interest rate differentials at a 3-months ($h = 3$) horizon (sample period 2009/05-2016/03). The portfolios have been constructed from the following exchange rates: British Pound (GBP/USD), Euro (EUR/USD), Norwegian Krone (NOK/USD), Swedish Krona (SEK/USD), Swiss Franc (CHF/USD), Australian Dollar (AUD/USD), Indonesian Rupiah (IDR/USD), Japanese Yen (JPY/USD), New Zealand Dollar (NZD/USD), Singapore Dollar (SGD/USD), South Korean Won (KRW/USD), Taiwan Dollar (TWD/USD), Canadian Dollar (CAD/USD), and South African Rand (ZAR/USD). For the portfolio construction currencies have been ranked based on the three strategies: (1) $E_t(s_{t+h}) - s_t - (i_t - i_t^*)$, (2) $s_t - s_{t-1} - (i_t - i_t^*)$ and (3) $-(i_t - i_t^*)$. For the next month the portfolio is constructed by buying the three highest ranked currencies and selling the three lowest ranked currencies.

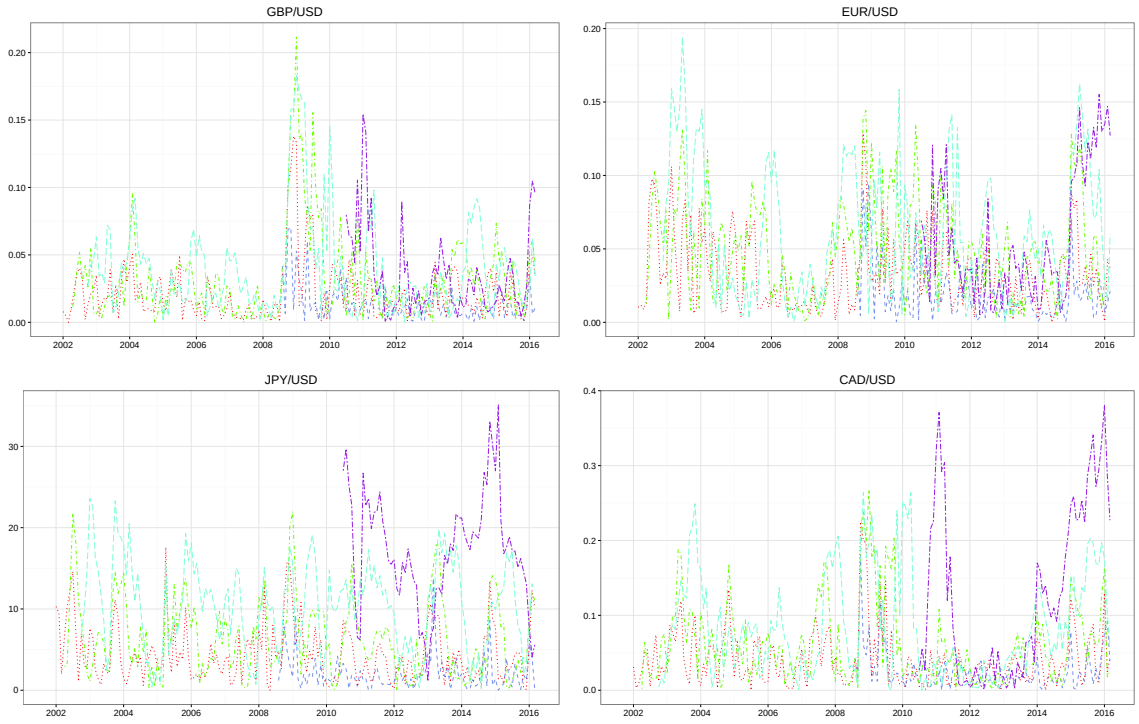
TABLE 6 **Coefficient estimates for major currencies**

	Expected exchange rate change $E_t(s_{t+h}) - s_t$								**Forecast error** $E_{t-h}(s_t) - s_t$							
	$r_t - r_t^*$	$\pi_t - \pi_t^*$	pr_t^{ECB}	pr_t^{FED}	pr_t^{BOE}	pr_t^{BOJ}	VIX_t	ε_{t-h}	$r_t - r_t^*$	$\pi_t - \pi_t^*$	pr_t^{ECB}	pr_t^{FED}	pr_t^{BOE}	pr_t^{BOJ}	VIX_t	ε_{t-h}
GBP/USD	-0.1862	-0.0734	-0.0020	-0.0021	-0.0006	0.0035*	-0.0002	-0.0644***	-7.8407***	-0.0717	-0.0099**	-0.0022	-0.0032	0.0198***	-0.0019***	-0.4379***
CZK/USD	-0.9552	0.0517*	-0.0022	-0.0038*	0.0005	0.0026	-0.0004**	-0.0515**	0.9473	0.2343*	-0.0184***	0.0133	-0.0020	0.0117	-0.0015*	-0.1931**
DKK/USD	0.7955	-0.2487*	-0.0031*	0.0002	-0.0023	0.0021	-0.0004*	-0.0657**	-10.0546***	0.6164	-0.0107**	-0.0087	0.0006	0.0258***	0.0003	-0.1855**
EUR/USD	1.6309	-0.1667***	-0.0022	0.0008	-0.0026*	0.0010	-0.0004**	-0.0694***	-5.0607	-0.0340	-0.0150***	-0.0017	-0.0019	0.0229***	-0.0004	-0.1903**
HUF/USD	-0.0689	0.0339***	-0.0012	-0.0031**	-0.0001	0.0023	-0.0006***	-0.0485***	-0.8394	0.0760	-0.0185**	0.0057	-0.0050	0.0231**	-0.0019**	-0.2189**
NOK/USD	0.9471	-0.1014	0.0018	0.0036*	-0.0031**	-0.0035*	-0.0003*	-0.0617***	-7.7483**	0.0529	-0.0165***	-0.0087	0.0016	0.0292***	0.0004	-0.0956
PLN/USD	-0.2108	0.0372***	-0.0024	-0.0031	0.0010	0.0020	-0.0007***	-0.0539***	2.8765	0.1737**	-0.0157*	0.0197*	-0.0071	0.0086	-0.0031***	-0.2612***
RUB/USD	0.4703***	0.0088***	-0.0013	-0.0010	0.0001	0.0015	-0.0004**	0.0009	0.1232	-0.0165	-0.0290***	-0.0036	0.0063	0.0472***	-0.0029**	-0.1423
SEK/USD	-0.0515	-0.2235***	0.0011	0.0005	-0.0027	0.0004	-0.0003	-0.0466**	-1.6885	-0.2838	-0.0222***	0.0094	-0.0071	0.0231**	-0.0010	-0.1266
CHF/USD	-0.6102	-0.1068**	-0.0004	-0.0033	-0.0022	0.0036	-0.0004**	-0.0434*	1.4015	-0.2931**	-0.0002	0.0054	-0.0137***	0.0137	-0.0009	-0.1824**
TRY/USD	0.6122**	-0.0037	-0.0018	-0.0014	0.0005	0.0004	-0.0004**	-0.0527***	2.9475**	-0.0065	-0.0281***	0.0066	0.0019	0.0149	-0.0004	-0.0093
AUD/USD	-0.4600	-0.0641**	-0.0023	-0.0050**	-0.0003	0.0079***	-0.0010***	-0.0273	-0.4087	0.2202*	-0.0240***	0.0088	-0.0019	0.0211*	0.0003	-0.1227
CNY/USD	-0.1948	0.0134*	-0.0003	0.0010	-0.0011***	-0.0013**	0.0000	-0.0229	0.5710	0.0291	-0.0004	0.0028	0.0007	-0.0004	0.0000	-0.0820
INR/USD	0.8615***	-0.0208**	-0.0014	0.0032***	0.0001	0.0003	0.0000	-0.2613	0.1706*	-0.0036	-0.0003	0.0006	-0.0000	0.0004	0.0001	-0.3365***
IDR/USD	1.1009***	-0.0423**	-0.0011	0.0013	0.0008	-0.0018	-0.0001	-0.0029	-1.8897	0.2505***	-0.0062	0.0098**	-0.0046	-0.0013	0.0003	0.0759
JPY/USD	0.6868	-0.0581**	0.0027	-0.0009	-0.0048***	0.0021	-0.0001	-0.0180	3.5827	0.1774**	-0.0142**	0.0211**	-0.0045	0.0025	0.0007	-0.1948**
NZD/USD	-0.3421	-0.1072***	-0.0007	-0.0023	-0.0033*	0.0062***	-0.0010***	0.0481*	1.7229	-0.1499	-0.0019	-0.0113**	-0.0060	0.0353***	-0.0008	-0.1822*
PHP/USD	0.1953	0.0244	0.0003	0.0007	0.0013	-0.0041***	0.0002	-0.0373***	-0.7869	0.0380	-0.0220***	0.0082	-0.0091	0.0246***	-0.0011	-0.0836
SGD/USD	0.0922	0.0062	-0.0009	0.0020**	-0.0004	-0.0031***	0.0003**	-0.0087	-1.0517	-0.0057	-0.0034	0.0096***	-0.0027	-0.0051	0.0005	-0.0761
KRW/USD	-0.1105	0.0295	0.0001	0.0014	0.0002	-0.0034*	0.0002	-0.0491	-4.6875*	0.0492	-0.0103***	-0.0072	0.0032	0.0154***	-0.0004	-0.1421
TWD/USD	1.6534**	-0.0039	0.0008	0.0041***	-0.0013**	-0.0035***	0.0003***	-0.0355***	-14.4185**	0.1759*	-0.0208***	-0.0106	-0.0027	0.0107	-0.0005	-0.1718**
THB/USD	-1.6900**	-0.0427*	0.0013	-0.0026	-0.0010	0.0014	-0.0002	-0.1232***	-4.2236**	0.0208	-0.0069**	-0.0078**	0.0025	0.0101**	-0.0003	-0.3048***
ARS/USD	0.2686	0.0038	0.0079***	0.0007	-0.0035**	-0.0133***	-0.0001	0.0107	-0.4394	-0.0390	-0.0046	0.0093**	-0.0077**	0.0060	-0.0002	-0.1102
BRL/USD	0.6282***	-0.0199	-0.0006	-0.0011	0.0014	-0.0004	-0.0008***	-0.0658**	-1.0551	-0.1235*	0.0178***	-0.0091	0.0053	-0.0113	-0.0003	0.0666
CAD/USD	0.3125	0.0251	0.0005	-0.0009	0.0009	0.0003	-0.0004***	-0.0317**	19.9267*	2.9081***	-0.0233***	0.0384***	0.0009	0.0081	0.0009	0.0998
CLP/USD	0.1486	0.0177	0.0004	0.0003	0.0000	-0.0015	-0.0002*	-0.0534***	1.8801**	0.1062	-0.0107**	0.0143***	-0.0044	0.0049	-0.0003	-0.1178
COP/USD	0.8183**	0.0250	-0.0017	-0.0001	0.0005	-0.0000	-0.0005***	-0.0441**	-5.8554***	0.1809*	-0.0172***	0.0092	0.0093	-0.0114	0.0042***	0.0141
MXN/USD	0.9873***	-0.0059	-0.0014	0.0012	0.0009	0.0014	-0.0005***	-0.0219	0.2723	-0.0659	-0.0153**	0.0029	-0.0005	0.0261**	-0.0003	-0.0844
ZAR/USD	1.1369*	0.0353	-0.0005	-0.0025	0.0009	0.0022	-0.0010***	-0.0790***	-3.0962*	-0.2514***	-0.0196***	-0.0019	0.0093*	0.0171**	-0.0001	-0.1212

Note: The table reports OLS estimates for the sample period running from 2004/09-2015/11 based on the following regression equation (for $h = 3$): $(E_t(s_{t+h}) - s_t) = \theta_0 + \theta_1(r_t - r_t^*) + \theta_2(\pi_t - \pi_t^*) + \theta_3 \text{pr}_t^{\text{ECB}} + \theta_4 \text{pr}_t^{\text{FED}} + \theta_5 \text{pr}_t^{\text{BOE}} + \theta_6 \text{pr}_t^{\text{BOJ}} + \theta_7 \text{VIX}_t + \theta_8 \varepsilon_{t-h} + \eta_t$, where the expected exchange rate change $(E_t(s_{t+h}) - s_t)$ and the forecast error $E_{t-h}(s_t) - s_t$, respectively, is regressed on domestic-US differentials of the three-month interest rate $(r_t - r_t^*)$ and the inflation rate $(\pi_t - \pi_t^*)$ as well as shadow rates of the ECB, the US Fed, the Bank of England and the Bank of Japan pr_t^{ECB}, pr_t^{FED}, pr_t^{BOE} and pr_t^{BOJ}, respectively, the CBOE volatility index VIX_t, and the h-period lagged forecast error ε_{t-h} (i.e. $E_{t-2h}(s_{t-h}) - s_{t-h}$). Coefficient estimates for the intercept are not reported to save space. *, **, and *** indicate significance at the 10, 5, and 1% level, respectively. Both regressions are applied for the following currencies: British Pound (GBP/USD), Czech Koruna (CZK/USD), Danish Krone (DKK/USD), Euro (EUR/USD), Hungarian Forint (HUF/USD), Norwegian Krone (NOK/USD), Polish Zloty (PLN/USD), Russian Rouble (RUB/USD), Swedish Krona (SEK/USD), Swiss Franc (CHF/USD), Turkish Lira (TRY/USD), Australian Dollar (AUD/USD), Chinese Renminbi (CNY/USD), Indian Rupee (INR/USD), Indonesian Rupiah (IDR/USD), Japanese Yen (JPY/USD), New Zealand Dollar (NZD/USD), Philippine Peso (PHP/USD), Singapore Dollar (SGD/USD), South Korean Won (KRW/USD), Taiwan Dollar (TWD/USD), Thai Baht (THB/USD), Argentine Peso (ARS/USD), Brazilian Real (BRL/USD), Canadian Dollar (CAD/USD), Chilean Peso (CLP/USD), Colombian Peso (COP/USD), Mexican Peso (MXN/USD), and South African Rand (ZAR/USD).

Figures

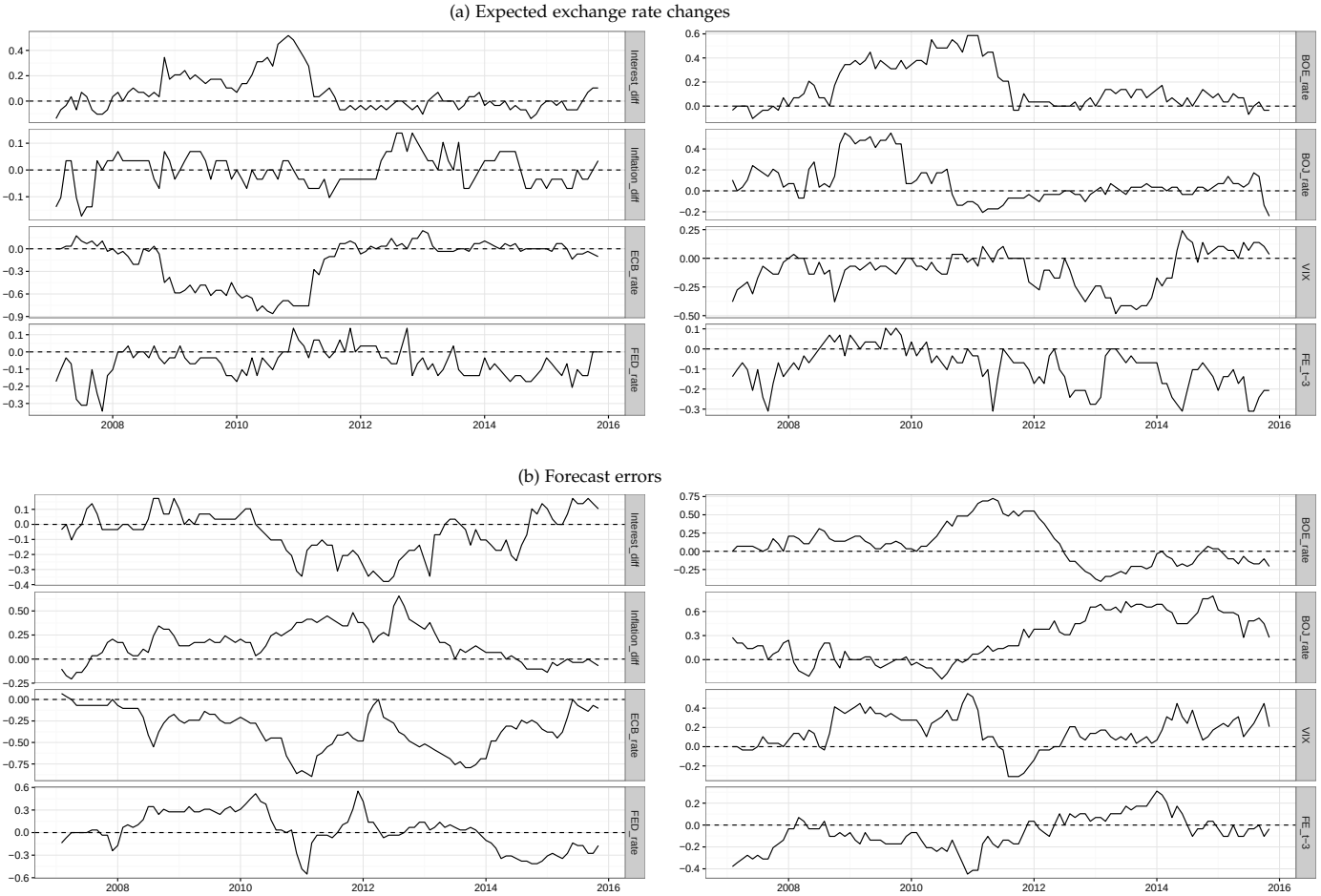
FIGURE 1 **Forecast errors for four main currencies**



Note: The figure shows forecast errors for expectations formed 1- (blue), 3- (red), 6- (green), 12- (cyan) or 24-months (violet) before for four main currencies (sample period 2002/10-2016/03): British Pound (GBP/USD), Euro (EUR/USD), Japanese Yen (JPY/USD), and Canadian Dollar (CAD/USD).

FIGURE 2 **Aggregated significance of the time-varying coefficients for major currencies**

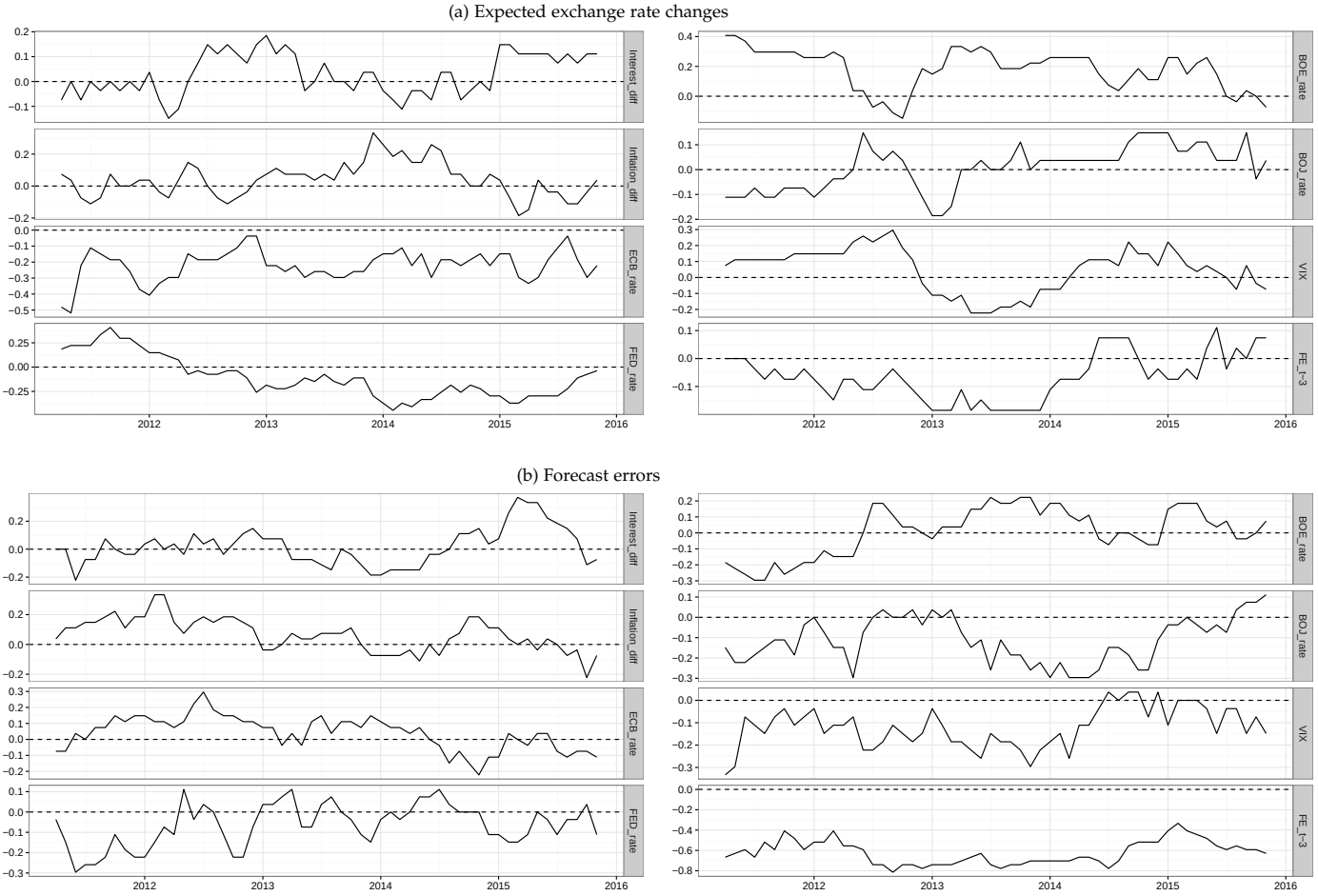
($h = 3$)



Note: The graphs show the share of significant rolling window regression estimates (at the 10% level) for the sample period running from 2004/09-2015/11 based on the following regression equation (for $h = 3$):
$(E_t(s_{t+h}) - s_t) = \theta_{0,t:t+30} + \theta_{1,t:t+30}(r_t - r_t^*) + \theta_{2,t:t+30}(\pi_t - \pi_t^*) + \theta_{3,t:t+30}\text{pr}_t^{\text{ECB}} + \theta_{4,t:t+30}\text{pr}_t^{\text{FED}} + \theta_{5,t:t+30}\text{pr}_t^{\text{BOE}} + \theta_{6,t:t+30}\text{pr}_t^{\text{BOJ}} + \theta_{7,t:t+30}\text{VIX}_t + \theta_{8,t:t+30}\varepsilon_{t-h} + \eta_t$,
where the expected exchange rate change $(E_t(s_{t+h}) - s_t)$ and the forecast error $E_{t-h}(s_t) - s_t$, respectively, is regressed on domestic-US differentials of the three-month interest rate $(r_t - r_t^*)$ and the inflation rate $(\pi_t - \pi_t^*)$ as well as shadow rates of the ECB, the US Fed, the Bank of England and the Bank of Japan pr_t^{ECB}, pr_t^{FED}, pr_t^{BOE} and pr_t^{BOJ}, respectively, the CBOE volatility index VIX_t and the h-period lagged forecast error ε_{t-h}. The share of significant rolling window regression estimates has been computed as fraction of significant coefficient to the total number of equations containing this coefficient (= 29 major currencies excluding the Venezuelan Bolivar (VEF/USD) due to the fixed exchange rate during a long period of time). The sign indicates positive and negative significance of the corresponding coefficient for each time period. The individual rolling window regression estimates are shown in Figures 12 to 21 in the Appendix.

FIGURE 3 **Aggregated significance of the time-varying coefficients for minor currencies**

($h = 3$)



Note: The graphs show the share of significant rolling window regression estimates (at the 10% level) for the sample period running from 2008/11-2015/11 based on the following regression equation (for $h = 3$):
$(E_t(s_{t+h}) - s_t) = \theta_{0,t:t+30} + \theta_{1,t:t+30}(r_t - r_t^*) + \theta_{2,t:t+30}(\pi_t - \pi_t^*) + \theta_{3,t:t+30}\text{pr}_t^{\text{ECB}} + \theta_{4,t:t+30}\text{pr}_t^{\text{FED}} + \theta_{5,t:t+30}\text{pr}_t^{\text{BOE}} + \theta_{6,t:t+30}\text{pr}_t^{\text{BOJ}} + \theta_{7,t:t+30}\text{VIX}_t + \theta_{8,t:t+30}\varepsilon_{t-h} + \eta_t$,
where the expected exchange rate change $(E_t(s_{t+h}) - s_t)$ and the forecast error $E_{t-h}(s_t) - s_t$, respectively, is regressed on domestic-US differentials of the three-month interest rate $(r_t - r_t^*)$ and the inflation rate $(\pi_t - \pi_t^*)$ as well as shadow rates of the ECB, the US Fed, the Bank of England and the Bank of Japan pr_t^{ECB}, pr_t^{FED}, pr_t^{BOE} and pr_t^{BOJ}, respectively, the CBOE volatility index VIX_t and the h-period lagged forecast error ε_{t-h}. The share of significant rolling window regression estimates has been computed as fraction of significant coefficient to the total number of equations containing this coefficient (= 27 minor currencies reported in Table **??**). The sign indicates positive and negative significance of the corresponding coefficient for each time period. The individual rolling window regression estimates are available upon request.