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Evaluation of exchange rate point and density forecasts: An application to Brazil

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ABSTRACT

This paper constructs multi-step-ahead point and density forecasts of the exchange rate. The approaches considered vary from statistical to economics-driven models, using financial and macroeconomic data and adopting either parametric or nonparametric distributions. We employ a range of statistical tools from different strands of the literature to identify which models work in practice, in terms of forecasting accuracies across different data frequencies and forecasting horizons. We propose a novel full-density/local analysis approach for collecting the many test results, and deploy a simple risk-based decision rule for ranking models. An empirical exercise with Brazilian daily and monthly data reveals that macro fundamentals are important when modeling the risk of exchange rate appreciation, whereas models that use survey information or financial data are the best way to account for the depreciation risk. These findings are relevant for econometricians, risk managers or policymakers who are interested in evaluating the accuracy of competing exchange rate models.

1. Introduction

The foreign exchange (FX) rate market is one of the most important in the financial system. According to a report from the Bank for International Settlements (BIS, 2013), trading in foreign exchange markets averaged US$5.3 trillion per day in April 2013.[1] Besides its huge trading volume, it also represents the highest liquidity asset class. It is a high-volatility market with a potentially wide range of factors that can affect the exchange rate level (e.g., economic fundamentals, speculative transactions and currency interventions, among others).

The forecasting of exchange rates is of great importance to economic agents, especially investors and policymakers. For instance, accurate forecasts of FX rates allow investors to design adequate trading strategies and to hedge against market risk. On the other hand, central banks worldwide monitor daily FX movements closely, since they impact future price dynamics, and thus, help in setting appropriate interest rate policies (Groen & Matsumoto, 2004). In addition, exchange rates also provide useful information for central bankers who need to decide on interventions.

In practical terms, though, forecasting the FX rate accurately has proved to be a non-trivial exercise. The failure of standard economic theory to explain foreign exchange rate behavior using key economic fundamentals (such as the money supply, trade balance and national income) has been shown in the international economics literature since the classic papers by Meese and Rogoff (1983a,b). They investigated the out-of-sample forecasting performances of standard exchange rate models during the post-Bretton Woods period and concluded that such models

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[1] According to the same report, this was up from US$4.0 trillion in April 2010 and US$3.3 trillion in April 2007.

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perform no better than a naïve random walk (RW) forecast.[2] While macroeconomic theory has proposed several potential predictors of exchange rates (usually based upon the purchasing power parity (PPP) hypothesis, the uncovered interest rate (UIP) parity condition and the monetary model), the forecasting contributions of such approaches have been under question since the highly influential findings of Meese and Rogoff. In this sense, Bacchetta and van Wincoop (2006) describe the RW paradigm as "*… the major weakness of international macroeconomics*".[3]

Consequently, an extensive body of literature has studied the forecasting performances of empirical exchange rate models, and several (potential) explanations have been put forward. To mention just a few papers: Mark (1995) found evidence of a greater predictability of economic exchange rate models over longer horizons, although these findings were questioned by Kilian (1999). Kilian and Taylor (2003) argued that exchange rates can be predicted with economic models after the possibility of nonlinear exchange rate dynamics is taken into account. Cheung, Chinn, and Pascual (2005) examined the out-of-sample performances of interest rate parity, monetary, productivity-based and behavioral exchange rate models and ultimately agreed that none of these models consistently beats the RW forecast for any horizon. The authors argued that even if a particular macroeconomic "fundamental" has some level of predictive power for a bilateral exchange rate over a certain horizon, the same variable may show no predictive power over different horizons or for other bilateral exchange rates. On the other hand, Engel and West (2005) argued that it is not surprising that a random walk forecast should outperform fundamental-based models under some circumstances. Their argument is based on the behavior of the exchange rate as an asset price within a rational expectation present-value (Taylor rule) model, among others, with a discount factor near one. Finally, there is a large and growing body of literature that aims to explain currency movements in a cross-sectional rather than a time series framework (e.g., Burnside, Eichenbaum, Kleshchelski, & Rebelo, 2011; Lustig, Roussanov, & Verdelhan, 2011; Menkhoff, Sarno, Schmeling, & Schrimpf, 2012; Verdelhan, 2013). Its main findings have been used to address exchange rate predictability in a broad sense based on multiple currencies.[4]

In a distinct but complementary approach, several papers in the late 1990s started to investigate the RW paradigm from a different perspective: that of out-of-sample density forecasting. For instance, Diebold, Hahn, and Tay (1999) used the RiskMetrics model to compute half-hour-ahead density forecasts for deutschmark–dollar and yen–dollar returns. Christoffersen and Mazzotta (2005) constructed option-implied density and interval forecasts for four major exchange rates. Clews, Panigirtzoglou, and Proudman (2000) described a nonparametric way to forecast risk-neutral densities, from the smile interpolation of option prices. Boero and Marrocu (2004) obtained one-day-ahead density forecasts for the euro nominal effective exchange rate using self-exciting threshold autoregressive (SETAR) models. Sarno and Valente (2005) used information from the term structure of forward premia to evaluate the FX rate density forecast performance of a Markov-switching vector error correction model. Hong, Li, and Zhao (2007) constructed half-hour-ahead density forecasts for the euro–dollar and yen–dollar rates using univariate time series models that capture fat tails, time-varying volatility and regime switches.

Most of these previous studies on exchange rate density forecasting used high frequency data, which are not available for most conventional economic fundamentals. In addition, these studies often did not consider multi-step-ahead forecasts, and generally assumed that conditional densities are constructed analytically (i.e., based on parametric densities). Wang and Wu (2012) tackled these issues by using a semiparametric method, applied to a group of exchange rate models, to generate out-of-sample exchange rate interval forecasts. They suggested that economic fundamentals might provide useful information for (out-of-sample) forecasting of FX rate distributions. Based on forecast intervals for ten OECD exchange rates, the authors found that, in general, FX models generate tighter forecast intervals than the random walk, while their intervals cover the out-of-sample exchange rate realizations equally well. Moreover, the results suggest that there is a connection between exchange rates and fundamentals: economic variables do contain information that is useful for forecasting distributions of exchange rates. In this sense, the Taylor rule model (Molodtsova & Papell, 2009) performs better than the monetary, PPP and forward premium models, and its advantages are more pronounced for longer horizons.

This paper also goes beyond point forecasting and follows the literature on density forecasting. We address the subject by considering statistical approaches (such as GARCH), economics-driven models, and a financial data setup (treating the exchange rate as an asset price). We employ both monthly and daily data. This enables us to investigate standard macroeconomic models for point and density forecasting, constructed here using parametric, nonparametric and semiparametric setups.

In addition, based on a set of density forecasts, generated for horizons of one to twelve months (or one to twenty working days), we go a step further and ask the question, which is the best forecasting model for a given forecast horizon and a given part of the conditional distribution of the FX rate? The objective here is to investigate a set of FX rate models and determine which are the most useful for point and/or density forecasting.

Moreover, we aim to increase our understanding of exchange rate dynamics from a risk-analysis perspective. Our main motivation for this is the fact that macroeconomic fundamentals may vary in their predictive content for different parts of the distribution of the FX rate. In

[2] The random walk forecast is for the (log) level of the nominal exchange rate to remain at the current (log) level (also known as the "no change" forecast).

[3] See Rossi (2013a) for more on the work of Meese and Rogoff and the recent literature on exchange rate forecasting.

[4] For complementary lines of research, see also the papers by Chen and Tsang (2009), Della-Corte, Sarno, and Tsiakas (2009), Engel, Wang, and Wu (2009), Fratzscher, Sarno, and Zinna (2012), Molodtsova and Papell (2009), Morales-Arias and Moura (2013) and Wu (2008).