

Insper



Testing the Taylor Model Predictability for Exchange Rates in Latin America

Marcelo L. Moura

Insper Working Paper

WPE: 126/2008



Copyright Insper. Todos os direitos reservados.

É proibida a reprodução parcial ou integral do conteúdo deste documento por qualquer meio de distribuição, digital ou impresso, sem a expressa autorização do Insper ou de seu autor.

A reprodução para fins didáticos é permitida observando-se a citação completa do documento

Testing the Taylor Model Predictability for Exchange Rates in Latin America

Marcelo L. Moura

Ibmec São Paulo

Rua Quatá 300, São Paulo-SP – Brazil – CEP:04546-042

Tel.: 4504-2435

marcelom@isp.edu.br

ABSTRACT

Exchange rates forecasting performance is tested by a model which incorporates endogenous monetary policy through a Taylor rule reaction function. Other usual monetary and equilibrium empirical exchange rate models are also evaluated for comparison purposes. Predictability is tested by comparing the models to a benchmark random-walk specification. We contribute to the recent literature in many ways. First, we include models of forward looking endogenous monetary policy to the exchange rate forecasting exercise, the Taylor Model. Second, our data, set across countries, is uniform in terms of economies adopting both inflation targeting and flexible exchange rate. Third, our study sheds light on exchange rate determinants for emerging economies: Brazil, Chile, Colombia, Peru and Mexico. Despite the increasing economic importance of this group of countries, studies about them are in relatively short supply. Our results show strong predictability evidence for the Taylor Model and indicate that assuming models of endogenous monetary policy and present value of expected fundamentals is a rewarding strategy to model exchange rate determination.

Key-Words: Exchange Rates, Taylor Rule model, Monetary model, Interest Rate Parity; Purchasing Power Parity; Unit Root, Cointegration; Forecasting performance.

JEL Codes: F31, F41, F47.

1 – Introduction

Brazil, Chile, Colombia, Peru and Mexico are all Latin America Emerging Economies that have shared free floating exchange rate arrangements and inflation targeting monetary frameworks since late 90's. These homogeneous characteristics allow us to evaluate one important question that has constituted an active field of research over the past few years. When the question comes to exchange rate forecasting, is it possible to beat a random walk guess?

What is new in this study? First, much of the recent literature looks at just a few models that are in general old vintage monetary models of the 1970s and 1980s with an unrealistic assumption of exogenous monetary policy. Instead, we use an up-to-date endogenous monetary model based on a Taylor rule reaction function. We compare the predictability of this model against a benchmark random-walk. We also contrast the Taylor predictability results with a wider set of models: (i) the traditional monetary model from the 1970s; (ii) models based on productivity differentials and equilibrium relationships from the 1980s and

1990s, and (iii) known relationships such as the uncovered interest parity arbitrage restrictions and the power purchasing parity equilibrium conditions.

Second, in a plethora of papers about exchange rate forecasting performance just a few cover emerging economies, and an even smaller number of studies are about Latin America economies. Among the few references are Ferreira (2005), Paiva (2006) and Uz and Ketenci (2007). In view of that, we try to shed some light on the issue of economies where the exchange rate can show a different pattern of response to economic fundamentals from that of the industrialized economies. Finally, our study covers a period in which a homogeneous set of countries shared similar terms of monetary policy arrangements and free floating exchange rates¹.

The question of exchange rate predictability has a milestone in the work of Meese and Rogoff (1983). Their landmark paper concluded that macroeconomic models are unable to produce forecasts that are better than a naive random walk specification. Since then, many other studies have followed with controversial results. For instance, the exchange rate is predictable by using macroeconomic models by Schniasi and Swamy (1989) Kalman-Filter estimation of time-varying models and Mark (1995) mean correction error formulation of the monetary model.

There are also some mixed results. Cheung, Chinn and Pascual (2005) updates the classic paper of Meese and Rogoff (1983, 1988) using a wider set of models². Their results do not indicate better performance in general for the 1990s models and their answer to “is it possible to beat the random walk?” is a “bold perhaps”. At least, they think, it is in terms of the U.S. Dollar, Yen, Canadian Dollar, Swiss Franc and Deutsche Mark.

Some authors further investigate the results with skepticism. Kilian (1999) and Berkowitz and Giorgianni (2001) raise questions about the use of nonparametric bootstrapping technique by Mark (1995) to evaluate out-of-sample significance. Basically, the authors show that predictability results crucially depend on the assumed data generating process for the bootstrapping exercise. Sarno and Taylor (2002) in an extensive survey of the literature of the 1980s and 1990s conclude that the empirical results tended to be fragile in the sense that they were hard to replicate in different samples or countries.

Despite all the controversy, a large volume of studies have recently shown increasing evidence of exchange rate predictability. In particular, models assuming endogenous monetary policy present interesting results. Molodtsova and Papell (2007) employ an error correction formulation for a model that incorporates a Taylor rule reaction function. Their empirical estimation, with monthly data from 1973:12 to 1998:12 for a set of 12 industrialized countries, finds significant predictability when Clark and West (2006, 2007) statistics for testing nested models is utilized.

¹ Those definitions of monetary policy arrangements and exchange rate frameworks follow the classification adopted by the IMF, and available at <http://www.imf.org/external/np/mfd/er/index.asp>

² Our study resembles the study of Cheung, Chinn and Pascual (2005), since both test exchange rate predictability for a wider set of models. However, we see important value added in ours. First, we include a more realistic model, the Taylor model, which assumes an endogenous monetary policy, and they do not. Second, we carefully selected our sample based on countries with similar characteristics, free floating exchange rates, and during the same monetary policy regime. Third, statistical significance use Clark and West (2006, 2007) statistics which corrects the Diebold Mariano (1995) statistic used by them. Finally, our study is focused on emerging economies while theirs was focused on industrialized economies.

Mark (2005) builds up an endogenous monetary model based on interest rates set by independent reaction functions for each central bank and uncovered interest parity. His model is successful in capturing the real Dollar-Deutsche Mark exchange rate dynamics from 1976 to 2003. Engel and West (2006) study the equilibrium value for the real exchange rate from a similar setup and find support for the model using German data. Besides the Taylor models, pooling information with cointegration tests seems to add considerable forecasting performance. Groen (2005), Rapach and Wohar (2005) and Mark and Sul (2001) find evidence of predictability for the monetary model, especially over longer horizons.

Motivated by those new developments and trying to build up on the recent results, we incorporate Latin America economies in the exchange rate predictability analysis. Our focus is to test for cointegration relationships and apply a mean correction error formulation to the Taylor rule model and a broad set of models in the literature of exchange rate determination. We also improve forecasting evaluation techniques by using Clark and West (2006, 2007) statistic rather than that in Diebold and Mariano (1995), which is subject to some strong criticism, see Kunst (2003) and Clark and West (2006, 2007).

This paper is organized in three additional sections. Following this introduction we expose the selected economic models together with a detailed description of the Taylor model. In section 3, we apply some diagnostic tests, namely, we test for unit root in the employed series and evaluate if there is cointegration in each model. Section 4 describes the forecasting methodology and exhibits the predictability results. The final section explores the main conclusions, limitations and possible extensions of this study.

2 – Specification of the models

As pointed out by Engel, Mark and West (2007), two important characteristics of monetary policy are ignored in many macroeconomic exchange rate models. First, it is endogenous. Second, since the mid-1980s central banks have used interest rate as the policy instrument rather than money supply.

Instead, we assume a Taylor rule reaction function, meaning that interest rates respond positively to lagged interest rates, the current output gap, and the difference between the expected inflation and their respective target. If we also make use of the uncovered interest parity relationship, we can obtain the exchange rate as a function of the expected values of future interest rates, output gaps and interest rates.

In order to visualize this, assume initially that a Taylor's rule function for the selected country is:

$$i_t = \gamma_q q_t + \gamma_\pi E_t \pi_{t+1} + \gamma_y y_t + \delta i_{t-1} + u_t$$

Where, i_t is the log of one plus the instantaneous short-term interest rate, q_t is the log of the real exchange rate, π_t is the log of one plus the inflation rate less the inflation target and u_t is a random term. For the parameters, we assume $\gamma_q > 0, \gamma_\pi > 0, \gamma_y > 0, 0 \leq \delta < 1$. Using asterisks to describe similar variables for the foreign country, we can write a similar Taylor reaction function for the benchmark country,

$$i_t^* = \gamma_\pi^* E_t \pi_{t+1}^* + \gamma_y^* y_t^* + \delta^* i_{t-1}^* + u_t^*$$

Notice that we assumed that the benchmark country does not react to the real exchange rate. Since we are comparing countries with emerging economies with the United States as the benchmark country, this assumption seems plausible. The final equation of the system is the uncovered interest rate arbitrage condition,

$$i_t - i_t^* = E_t s_{t+1} - s_t + \rho_t,$$

where s_t is the nominal interest rate, E_t is the conditional expectation operator and ρ_t is a risk premium.

Using those three equations above and assuming that the home and benchmark countries have similar parameters, we can write:

$$s_t = E_t s_{t+1} - (\gamma_q q_t + \gamma_\pi E_t (\pi_{t+1} - \pi_{t+1}^*)) + \gamma_y (y_t - y_t^*) + \delta (i_{t-1} - i_{t-1}^*) + u_t - \rho_t + u_t^*$$

This expression can be further simplified and solved forward yielding:

$$s_t = p_t - p_t^* + b \sum_{j=0}^n b^j X_{t+j} + \xi_t \quad (2.1)$$

Where:

$$\begin{aligned} b &\equiv \frac{1}{1 + \gamma_q} \\ X_{t+j} &= \left[(\gamma_\pi - 1) E_t (\pi_{t+1+j} - \pi_{t+1+j}^*) + \gamma_y (y_{t+j} - y_{t+j}^*) + \delta (i_{t-1+j} - i_{t-1+j}^*) \right] \\ \xi_t &= b \sum_{j=0}^n b^j (u_{t+j} - u_{t+j}^* - \rho_t) \end{aligned}$$

Empirical estimation of equation (2.1) requires that we know all the future expected values of inflation, production gap and interest rates, which is not reasonable. Further, the discount parameter, b , has to be estimated beforehand.

One alternative is to make simplifying assumptions about market expectations. We presume that expectations for a near future can closely approximate the series of future expected values. Formally, we will assume that we can approximate expectations for all future date $j=1,2,3,\dots$, by expectations at a fixed data K :

$$\begin{aligned} E_t (\pi_{t+1+j} - \pi_{t+1+j}^*) &\simeq E_t (\pi_{t+K} - \pi_{t+K}^*), \\ E_t (y_{t+j} - y_{t+j}^*) &\simeq E_t (y_{t+K} - y_{t+K}^*), \\ E_t (i_{t-1+j} - i_{t-1+j}^*) &\simeq E_t (i_{t+K} - i_{t+K}^*), \\ \xi_t &\simeq v_t + \lambda v_{t-1} - \rho_t. \end{aligned} \quad (2.2)$$

Plugging (2.2) into (2.1) and selecting $K=12$ conducts us to

$$s_t = p_t - p_t^* + \frac{b}{1-b} E_t X_{t+12} + v_t - \lambda v_{t-1} - \rho_t,$$

and to their respective empirical specification,

$$s_t = \alpha + p_t - p_t^* + \beta_1 E_t (\pi_{t+12} - \pi_{t+12}^*) + \beta_2 E_t (y_{t+12} - y_{t+12}^*) + \beta_3 E_t (i_{t+12} - i_{t+12}^*) + \beta_4 emb_i + \beta_5 q_{t-1} + v_t. \quad (2.3)$$

Equation (2.3) is represented in the last column of table 1. For expectations, we use Economics Consensus Forecast Survey historical data.

Comparing the Taylor specification with every possible model would make the exercise unnecessarily cumbersome. Therefore, we selected a manageable set of models based on the criteria of having a parsimonious specification form and being a well known model in the literature of exchange rate modeling.

By parsimonious specification forms it is meant that we can nest all models in the same basic block. In particular, for every model we tested, the exchange rate is a linear function of economic fundamentals³. In mathematical terms, the log of nominal exchange rate, s_t , can always be modeled as a linear function of k economic fundamentals:

$$s_t = \alpha + \beta \hat{X}_t \quad (2.4)$$

Notice that we define the economic fundamental in logarithmic values and always as the difference of the home country (Brazil, Chile, Colombia, Mexico and Peru) against the benchmark country (the United States).

Table 1 shows all the models used in this study with the economic fundamentals in the rows and the selected models in the columns. In mathematical terms, the comparison models, second to sixth columns in table 1, can be considered versions of the nested specification:

$$s_t = \alpha + I_{1t} (p_t - p_t^*) + \beta_1 (m_t - m_t^*) + \beta_2 (y_t - y_t^*) + \beta_4 (i_t - i_t^*) + \beta_5 (z_t - z_t^*) + \beta_6 \varpi_t + \beta_7 (r_t - r_t^*) + \beta_8 (ngd_t - ngd_t^*) + \beta_9 tot_t + \beta_{10} nfa_t + \beta_{11} emb_i + I_{2t} s_{t-k} + v_t \quad (2.5).$$

Where the I_t 's are indicator variables, taking the value one if the variable is included in the model and zero otherwise, and the β 's are the estimated parameters. The definition of the variables is given in Table 1.

The first comparison model is the Flexible Price Monetary Model (FPMM) which became very representative in the 1970s, after the emergence of the Bretton Woods system in 1973, and the adoption of floating exchange rates by the main industrialized economies. The FPMM assumes that, in each country, the equalization of currency supply and demand determines the price level in each country. Furthermore, relative prices in each country and

³ For simplicity sake, we have excluded nonlinear models from our analysis. This may sound too restrictive as, in fact, assuming nonlinearities can enhance the exchange rate predictability, see for instance Hnatkovska, Lahiri and Vegh (2008). A similar study allowing for nonlinear models would be an interesting next step.

exchange rates are connected by the purchasing power parity relationship. In its reduced form, the exchange rate is a function of the relative money supplies, production levels, and interest rates.

The next two specifications, in the third and fourth columns respectively, are the Productivity Differential and the Composite Model. They follow a more recent set of exchange rate determination models in the Balassa-Samuelson tradition. The Productivity Differential Model includes in the monetary model the productivity gap between tradable and non-tradable sectors, which is measured by the respective inverse ratios of price level of each sector. The Composite model includes other well-known familiar effects of the exchange rate: the relative price of non-tradables, the real interest rate differential, net government debt, terms of trade, and net foreign asset position. As pointed out by Cheung, Chinn and Pascual (2005), this formulation is quite similar to the behavioral equilibrium exchange rate (BEER) model of Clark and MacDonald (1999).

The fifth and sixth columns display specifications based respectively on the uncovered interest rate parity arbitrage condition and the power purchasing parity equilibrium assumptions. Uncovered interest parity assumes that the change on real exchange rates will only be influenced by the interest rate differential. The power purchasing parity condition establishes that the nominal exchange rate is proportional to the price levels of each country.

3 – Unit root and cointegration diagnostic tests

The general empirical estimation of the models in section 2 implies the following specification:

$$s_t = \beta_0 + X_t \Pi + \varepsilon_t \quad (3.1).$$

Where X_t denotes the vector of explanatory variables, Π is a vector of parameters and ε_t is a random term.

However, since we are dealing with macroeconomic variables, it is very likely that the exchange rate and many of the explanatory economic fundamentals are non-stationary. Following the seminal work of Engle and Granger (1987), unless $[s_t, X_t]$ has a long-run relationship, estimating (3.1) can lead to spurious regressions. Therefore, before running the models specified in section 2, we proceed with some diagnostic tests of non-stationarity (unit root) and cointegration relationship in our series.

We run two unit root tests: the Augmented Dickey-Fuller (1979) test, herein after ADF, and the Phillips-Perron (1988) test, in both, the null assumes that the series has a unit root. Both tests aim to correct the serial correlation problem on a basic Dickey-Fuller specification test. For the ADF, the test regression is given by:

$$\begin{aligned} \Delta y_t &= \alpha y_{t-1} + x_t' \delta + \lambda_1 \Delta y_{t-1} + \lambda_2 \Delta y_{t-2} + \dots + \lambda_p \Delta y_{t-p} \\ H_0 &: \alpha = 0 \\ H_1 &: \alpha < 0 \end{aligned}$$

The exogenous variables x_t can be included or not in the regression and allows for the inclusion of a constant or a constant and a trend. The ADF test makes use of Schwarz

information criteria to select the lag length p automatically. The Phillips and Perron (1988) test uses a test regression similar to the ADF without the p lagged difference terms; they modify the t-ratio of the α coefficient in order to correct for serial correlation of the test statistic.

For fundamentals that are expected to grow over time, we specify the unit root tests with a constant and a time trend. Those series are the price level, the money supply and the industrial production level. For all the other series, we expect a long - run equilibrium value which does not grow over time and we specified the test with a constant but no time trend.

Table 2.1 displays augmented Dickey-Fuller tests, for the macroeconomic variables used in our models. In most of the cases, 60 out of 80, we fail to reject the null of unit root at using 90% confidence intervals. Table 2.2 shows the Phillips-Perron tests where we reject the null of unit root more often, 25 out of 80 cases. Looking at both tests, we see strong evidence of stationarity for the industrial production levels, real interest rates and expected industrial production gap. Since our data span, 1999:01 to 2007:12, comprehends a period of low industrial production growth in Latin-America economies (1999-2001), we do not take the last results too literally.

In general, we have strong empirical evidence to believe that the estimating equation (3.1) involves non-stationary $[s_t, X_t]$ series. Therefore, we now test if $[s_t, X_t]$ co-integrate by using the Engle-Granger two-step procedure, as described in Davidson and MacKinnon (1993)⁴.

The test is based on firstly regressing (3.1) by ordinary least squares. For each country, empirical estimation uses monthly data from January 1999 to December 2007, a full sample of 108 observations. From these estimated regressions, the second step of the procedure consists in generating estimated residuals series, $\hat{\varepsilon}_t$, for each model, running the auxiliary regressions

$$\Delta \hat{\varepsilon}_t = \gamma \hat{\varepsilon}_{t-1} + u_t \tag{3.2}$$

and testing for the null of no-cointegration of $\gamma = 0$. The intuition behind the test is that if $[s_t, X_t]$ displays a long-run relationship, although those variables are non-stationary, they will produce stationary residuals and the parameter γ will be zero. As pointed out by Engle and Granger (1987), t-statistics for γ under the null will have no standard distribution, depending on the sample size and the number of parameters. For this reason, we use Davidson and MacKinnon (1993) reported asymptotic critical values for this test.

Table 3 shows results for the cointegration tests. They show strong co-integration evidence for both the uncovered interest parity model, for all countries, and for the Taylor model, for Brazil, Chile and Mexico. For Colombia, there is also some evidence of cointegration in the productivity differential and in the power purchasing parity model. Recall that unless the model has a cointegration relationship, its estimation in levels will lead

⁴ Note that we could test for more than one cointegration relationship as suggested by the Johansen (1995) approach suggests. However, the exchange rate economic models described in section 2 predict just one relationship among the variables and that is what we want to test in this study. This justifies our option for a simpler procedure of testing only the cointegration relationship using the Engle and Granger (1987) method.

to spurious regressions. Therefore, we expect to obtain robust and meaningful estimates leading to exchange rate predictability only for the models that passed the cointegration tests. This verification will be explained in the following section.

4 - Forecasting Exercise

The out-of-sample forecasting analysis followed the mean correction error methodology used by Cheung, Chinn and Pascual (2005). Firstly, we estimate specification (3.1) for each model obtaining the fundamental value for the exchange rate:

$$F_t = \hat{\beta}_0 + X_t \hat{\Pi} \quad (3.3).$$

The second step is to estimate the following mean correction equation:

$$s_{t+k} - s_t = \phi(F_t - s_t) + v_t \quad (3.4).$$

The estimated parameters of equation (3.4) are used to forecast future values of the exchange rate at the horizons of $k = 1, 3, 6$ and 12 months ahead. Note that, by using (3.4) to predict future exchange rate, we have true *ex-ante* forecasts. Only information available at time t is used to estimate the future exchange rate at $t+k$.

Forecasting is done according to *rolling regressions* on (3.3) and (3.4). First we divide the total sample of size T into two subsets: one for estimation, and the other for forecasting. The estimation sub-sample has a fixed size of D with $T < D$. Using data up to observation D , we first estimate the exchange rate mean correction model, equations(3.1), (3.3), and (3.4). From (3.4) we obtain one-, three-, six- and twelve-month exchange rate predictions for each model. Next, we displace the estimation sample one period ahead, to $t=2$ to $t= D + 1$ keeping the size of the initial sample fixed on D observations. Again, we predict the exchange rate for one-, three-, six- and twelve-month ahead. We repeat this procedure until the exhaustion of the sample. In the end, for each model, we will have a series of exchange rate predictions of one-, three-, six- and twelve-month ahead of respective sizes $T-D-1$, $T-D-3$, $T-D-6$ and $T-D-12$.

The predicted exchange rates are then compared with those forecast by a drift less random walk specification where:

$$s_{t+k} = s_t \quad (3.5).$$

Table 4 displays Theil's ratio of the Root Mean Squared Predicted Error⁵ (RMSPE) for each model in table 1, divided by the RMSPE of the random walk. To check for robustness, the table reports results for two different forecasting samples, Nov/04 to Dec/07

⁵ $RMSPE = \sqrt{\sum_{i=t-D+k}^T (s_i - \hat{s}_i)^2}$ where \hat{s}_i is the estimated and s_i is the actual value of the exchange rate, T is the sample size and k is the forecasting horizon.

($D = 70$) and Jan/04 to Dec/07 ($D = 60$). To test the statistic significance of this ratio, we used the statistic proposed by Clark and West (2006, 2007), in which, under the null hypothesis, there is no difference between the two estimations forecasting performance, that is, the forecasting generated by the economic models is as good as the forecasting generated by a driftless random walk. Values of the Theil's ratio below one indicate that the economic models under evaluation had a lower RMSPE than those generated by the random walk model.

As expected by the theory, models that presented better out-of-sample predictability exhibit empirical evidence of cointegration between the exchange rate and the macroeconomic fundamentals. Particularly, the best forecasting performance is obtained when the Taylor model is used, which shows evidence of predictability for all the selected countries. The evidence is particularly strong for Brazil, Colombia, Chile and Mexico; the Taylor Model outperforms the random walk in 21 out of 28 cases. For these countries, we emphasize forecastability at longer horizons. The Taylor model outperforms the random walk in 7 out of 8 cases at 12-months-ahead predictions.

Interestingly enough, the other economic models also present some predictability. Nevertheless, they outperform the random walk in a much less expressive way than the Taylor model; besides it is more difficult to find a pattern across countries or horizons for those models. These results go in the direction of many others in the literature where comparison models can have some predictability, but it is not very robust, see Sarno and Taylor (2002). Another fact to point out is the excellent performance of the PPP model for Colombia. It may indicate that the Colombian central bank targets its monetary policy to keep the purchasing power level of its exchange rate constant.

4 – Conclusions

Engel and West (2005) nest all exchange rate models in a rational expectations present-value framework and show that beating a random-walk can be too strong a benchmark, even if the model is true. Standard models imply near random walk behavior in the exchange rates and the power to beat the random walk in out-of-sample forecasts is low. That is clearly the case in our exercise. Even though we found strong predictability evidence in favor of the Taylor model, it is a tight win; the lowest Theil's ratio is 0,843.

We find the predictability results for an endogenous monetary policy model very promising for new research. Not surprisingly, we found that using more plausible assumptions, such as the central bank following an endogenous monetary policy and exchange rates responding to expectation fundamentals, is probably a rewarding research strategy. For instance, recent studies like Engel and West (2005) and Chen, Rogoff and Rossi (2008) show that exchange rates are influenced by the present value of economic fundamentals.

The linear and simple formulation of the Taylor rule model confers some limitations to this study. Recent results for monetary policy, see Qin and Enders (2007) and Cukierman and Muscatelli (2008), demonstrate that non-linear Taylor rules are better suited to model the central bank reaction function. We also ignored the fact that pooling information across countries generally improves predictability, see Engel, Mark and West (2007). Future research should look to non-linear Taylor rule models and pooling estimation.

References

CHEN Y-C.; ROGOFF, K.; ROOSI, B. **Can Exchange Rates Forecast Commodity Prices?**, NBER Working paper Series, WP 13901, March, 2008.

CHEUNG, Y; CHINN, M.D.; PASCUAL, A.G. Empirical exchange rate models of the nineties: are any fit to survive?. **Journal o International Money and Finance**, v. 24, p. 1150-1175, 2005.

CLARK, T. E.; WEST, KENETH, D. Using out-of-sample mean squared prediction errors to test the martingale difference hypothesis, Comparing Predictive Accuracy. **Journal of Econometrics**, v. 135, p. 155-86, 2006.

CLARK, T. E.; WEST, KENETH, D. Approximately Normal Tests for Equal Predictive Accuracy in Nested Models. **Journal of Econometrics**, v. 138, p. 291-311, 2007.

CUKIERMAN, A.; MUSACTELLI, A. Nonlinear Taylor Rules and Asymmetric Preferences in Central Banking: Evidence form the United Kingdom and the United States. **The B.E. Journal of Macroeconomics**, v.8 issue 1, p. 1-29, 2008.

DAVIDSON, R.; MACKINNON, J.G. **Estimation and Inference in Econometrics**, Oxford University Press, 1993..

DIEBOLD, F. X.; MARIANO, M. Comparing Predictive Accuracy. **Journal of Business and Economic Statistics**, v. 13, p. 253-65, 1995.

DICKEY, D.A.; FULLER, W.A. **Distribution of the Estimators for Autoregressive Time Series with a Unit Root**, **Journal of the American Statistical Association**, 74, 427-431, 1979.

ENGEL, C; WEST, K.D. Exchange rates and Fundamentals **Journal of Political Economy**, v. 113, p. 485-517, 2005.

ENGEL, C.; MARK, N. C.; WEST, K.D. Exchange rate models are not as bad as you think. **NBER Working Paper Series**, w13318, 2007.

ENGLE, R.F.; GRANGER, C.W.J. Co-integration and error correction: representation estimation and testing. **Econometrica**, v.55, p. 251-276, 1987.

FERREIRA, J.E.A. **Effects of Fundamentals of the Exchange Rate: A Panel Analysis for a Sample of Industrialized and Emerging Economies**, manuscript, 2005.

GROEN, J.J.J. **Exchange Rate Predictability and Monetary Fundamentals in a Small Multi-Country Panel**, **Journal of Money, Credit and Banking** 37, 495-516, 2005.

KILIAN, L. Exchange rates and monetary fundamentals: evidence on long-horizon predictability. **Journal of Applied Econometrics**, v. 14, p. 491-510, 1999.

KUNST, R. M. Testing for relative predictive accuracy: A critical viewpoint. **Reihe Okonomie Economics Series**, v. 130, 2003.

MACKNINNON, J. D. Critical values for cointegration tests. In: ENGLE, R.F.; GRANGER, C.W.J. (Eds.), **Long-run Economic Relationships: Readings in Cointegration**. Oxford University Press., 1992, P. 267-276.

MACKNINNON, J. G. Numerical Distribution Function for Unit Root Tests. **Journal of Applied Econometrics**, v. 11, p. 601-618, 1996.

MARK, N. C. Exchange rates and fundamentals: evidence on long-horizon predictability. **American Economic Review**, v. 85, p. 201-218, 1995.

MARK N. A.; SUL, D. **Nominal Exchange Rates and Monetary Fundamentals: Evidence from a Small Post-Bretton Woods Sample**, Journal of International Economics 53, 29-52, 2001.

MEESE, R.; ROGOFF, K. Empirical exchange rate models of the seventies: do they fit out of the sample?. **Journal of Finance**, v. 43, p. 933-948, 1983.

MOLODTSOVA, T.; PAPELL, D. Out-of-sample exchange rate predictability with Taylor Rule Models. **University of Houston Working Paper**, 2007.

PHILLIPS, P.C.B.; PERRON P. **Testing for a Unit Root in Time Series Regression**, Biometrika, 75, 335–346, 1988

PAIVA, C. **External Adjustment and Equilibrium Exchange Rate in Brazil**, IMF Working Paper, WP/06/221, 2006.

QIN, T.; ENDERS, W. **In-sample and out-of-sample properties of linear and nonlinear Taylor rules**, Journal of Macroeconomics, v. 30, p. 428-443, 2007.

RAPACH, D. E.; WOHAR M. E.. Testing the Monetary Model of Exchange Rate Determination: A Closer Look at Panels. **Journal of International Money and Finance**, 23, pp. 867-895, 2004.

SARNO, L.; TAYLOR, M.P. **The economics of exchange rates**. Cambridge: Cambridge University Press, 2002, cap. 4, p. 104-107, 115-118.

SCHINASI, G. J.; SWAMY, P.A.V.B. **The Out-of-Sample Forecasting Performance of Exchange Rate Models When Coefficients Are Allowed to Change**. Journal of International Money and Finance, 8(3), pp. 375-90, September, 1989.

UZ, I.; NATALYA, K. **Panel Analysis of the Monetary Approach to Exchange Rates: Evidence from the new EU members and Turkey**. Emerging Markets Review, vol. 9, p. 57-69, 2008.

TABLES

Table 1- Exchange Rate Models

Independent Variables	Notation	Models - Nominal Exchange Rate is the Dependent Variable					
		Taylor	Monetary	Prod. Dif.	Composite	U.I.P.	P.P.P.
Constant	α	✓	✓	✓	✓	✓	✓
Expected Inflation - Target	$E(\pi - \pi^*)$	✓					
Expected Ind. Prod. Gap	$E(y - y^*)$	✓					
Expected Interest Rates	$E(i - i^*)$	✓					
Real Exchange Rate	q	✓					
EMBI+	$embi$	✓					
Price Level	$p - p^*$				✓		✓
Money Supply - M1	$m - m^*$		✓	✓	✓		
Industrial Production	$y - y^*$		✓	✓			
Interest Rates	$i - i^*$		✓	✓		✓	
Productivity Differential	$z - z^*$			✓			
Relative Price of Tradables	$w - w^*$				✓		
Real Interest Rate	$r - r^*$				✓		
Government Debt	$ngd - ngd^*$				✓		
Terms of Trade	$tot - tot^*$				✓		
Net Foreign Assets	$nfa - nfa^*$				✓		
Lagged Interest Rate	s						✓

Note: The nominal exchange rate is the logarithm of end of the month market rates in country's currency by U.S. Dollars. Each independent variable series is defined as the logarithm of the ratio of their respective nominal values for the reference country and the United States, except for EMBI+, which is already defined as a spread against the United States Treasury bonds.

Table 2.1 - Unit Root Augmented ADF Tests - Individual Series

Series	Brazil	Chile	Colombia	Mexico	Peru
Exchange Rate	-0,927	-1,349	-2,576	-1,003	0,421
Expected Inflation - Target	-3,270**	-2,754*	-1,993	-3,595***	-2,639*
Expected Ind. Prod. Gap	-3,028**	-3,068**	-1,602	-2,770*	-1,970
Expected Interest Rates	-1,605	-2,197	-1,763	-1,646	-1,563
Real Exchange Rate	-0,427	-1,153	-1,515	-3,119**	-0,787
EMBI+	-0,947	-1,474	-1,134	-2,066	-1,145
Price Level (a)	-0,584	-1,639	-0,835	-2,021	-3,44*
Money Supply - M1 (a)	-1,252	-1,810	-2,459	-2,927	0,056
Industrial Production (a)	-3,567**	-3,275*	-1,848	-10,835***	-2,432
Interest Rates	-1,265	-1,906	-1,582	-1,455	-1,017
Productivity Differential	-1,418	-2,370	-1,126	-1,854	-3,293**
Relative Price of Tradables	-2,130	-3,919***	-2,476	-2,005	-1,734
Real Interest Rate	-3,036**	-1,728	-5,345***	-4,240***	-1,28
Government Debt	-2,231	-2,768*	-1,838	-3,697***	-0,898
Terms of Trade	-0,411	-1,932	-1,032	-1,218	-0,053
Net Foreign Assets	-0,041	-1,171	0,123	-4,472***	-2,120

Note: The table reports the t-statistics of the augmented Dickey-Fuller tests assuming a constant and no-time trend except on cases (a), which assumes a constant and a time trend. The test regression uses the Schwarz information criteria for automatic lag length selection. The asterisks at the right of the numbers, ***, ** and * denote statistical significance at 1%, 5% and 10% respectively using MacKinnon (1992, 1996) asymptotical values.

Table 2.2 - Unit Root Phillips Perron Tests - Individual Series

Series	Brazil	Chile	Colombia	Mexico	Peru
Exchange Rate	-1,910	-1,534	-2,477	-0,998	0,538
Expected Inflation - Target	-2,480	-2,640*	-1,978	-4,934***	-2,457
Expected Ind. Prod. Gap	-2,909**	-5,441***	-4,684***	-7,540***	-5,623***
Expected Interest Rates	-1,105	-2,045	-1,805	-1,797	-1,321
Real Exchange Rate	-0,874	-1,335	-1,151	-3,229**	-1,078
EMBI+	-0,971	-1,510	-0,892	-2,097	-1,046
Price Level (a)	-0,294	-1,713	-1,465	-2,981	-2,887
Money Supply - M1 (a)	-1,367	-2,542	-2,353	-2,924	0,026
Industrial Production (a)	-3,468**	-5,692***	-7,661***	-10,827***	-7,673***
Interest Rates	-0,755	-1,931	-1,625	-1,600	-1,040
Productivity Differential	-2,775*	-2,051	-1,056	-1,990	-3,328**
Relative Price of Tradables	-2,900**	-4,911***	-2,760*	-9,561***	-2,017
Real Interest Rate	-3,857***	-2,244	-4,883***	-4,390***	-1,113
Government Debt	-2,195	-3,101**	-2,281	-4,696***	-0,750
Terms of Trade	-0,642	-1,558	-0,506	-1,258	0,001
Net Foreign Assets	0,578	2,830	1,557	-3,613***	-2,092

Note: The table reports the p-values of the Phillips-Perron (1988) nonparametric test assuming a constant and no-time trend except on cases (a), which assumes a constant and a time trend. The test estimates a non-augmented Dickey-Fuller equation and modifies the t-ratio of the test statistic in order to correct for serial correlation. The asterisks at the right of the numbers, ***, ** and * denote statistical significance at 1%, 5% and 10% respectively using MacKinnon (1992, 1996) asymptotical values.

Table 3 - Engle and Granger Two-Step procedure - Augmented ADF cointegration test of residuals.

Model	Countries					# of dep. variables	Asympt. Critical Values		
	Brazil	Chile	Colombia	Mexico	Peru		1%	5%	10%
Taylor	-6,93***	-5,231**	-3,249	-4,897**	-2,483	6	-5,25	-4,71	-4,42
Monetary	-3,83	-2,852	-2,811	-2,676	-4,058	5	-4,96	-4,42	-4,13
Prod. Dif.	-2,952	-3,879	-4,373*	-3,007	-3,792	5	-4,96	-4,42	-4,13
Composite	-3,248	-3,877	-3,91	-3,404	-2,643	6	-5,25	-4,71	-4,42
U.I.P.	-9,624***	-7,241***	-6,54***	-8,849***	-9,184***	1	-3,43	-2,86	-2,57
P.P.P.	-0,699	-1,667	-3,19**	-1,266	0,623	1	-3,43	-2,86	-2,57

Note: This table presents ADF tests of the residuals generated by OLS estimates of each model for each country. Asterisks denote rejection of the null of no-cointegration at a 5% significance level, asymptotical critical values were obtained from Davidson and Mackinnon (1993).

Table 4 - RMSPE Ratios

Model	Horizon	Brazil	Chile	Colombia	Mexico	Peru
<i>Forecasting Sample: Nov/04 to Dec/07</i>						
Taylor	1	1,058	1,018	0,971*	0,987	0,993**
	3	0,915***	1,011	0,886***	0,958**	1,043
	6	0,880***	1,019	0,833***	0,937***	1,079
	12	0,843***	0,985**	1,016	0,964**	1,001
Monetary	1	1,106	0,969***	1,053	0,991	1,058
	3	1,45	0,995	1,18	0,955**	1,171
	6	1,789	1,168	1,356	0,759***	1,262
	12	1,428	1,354	1,208	0,685***	0,938***
Prod. Dif.	1	1,076	0,973**	1,018	0,991	1,061
	3	1,345	0,914***	1,073	0,949***	1,194
	6	1,674	1,079	1,268	0,791***	1,317
	12	1,390	1,442	1,355	0,73***	1,196
U.I.P.	1	1,000	1,009	0,973**	1,006	1,015
	3	0,900***	1,002	1,056	0,973*	0,997
	6	1,178	1,021	1,019	1,040	1,055
	12	0,903***	0,982**	1,086	0,989**	1,026
P.P.P.	1	1,027	1,053	0,971**	1,004	1,049
	3	1,234	1,204	0,930***	1,037	1,182
	6	1,596	1,452	0,895***	1,157	1,375
	12	1,630	1,688	0,865***	1,181	1,489
<i>Forecasting Sample: Jan/04 to Dec/07</i>						
Taylor	1	1,049	0,987*	1,055	0,992	1,026
	3	0,961**	0,992*	0,985**	0,952***	1,113
	6	0,927***	1,015	0,804***	1,018	1,146
	12	0,877***	0,988*	0,829***	0,950***	1,068
Monetary	1	1,106	1,013	1,053	1,034	1,078
	3	1,394	1,033	1,167	1,111	1,179
	6	1,813	1,118	1,402	1,206	1,200
	12	1,442	1,399	1,407	1,161	1,040
Prod. Dif.	1	1,084	0,995	1,015	1,035	1,076
	3	1,329	1,045	1,062	1,127	1,187
	6	1,713	1,239	1,187	1,221	1,237
	12	1,413	1,520	1,201	1,187	1,199
U.I.P.	1	1,006	0,990**	0,955***	1,019	0,990
	3	0,920***	1,040	1,045	0,988*	1,006
	6	1,133	1,010	0,981*	1,048	1,049
	12	0,946***	1,141	1,058	0,953***	1,036
P.P.P.	1	1,064	1,049	0,987	1,017	1,064
	3	1,247	1,179	0,931***	0,973**	1,195
	6	1,588	1,367	0,857***	1,023	1,334
	12	1,536	1,669	0,711***	1,074	1,364

Note: The number in each cell is the ratio of root mean square predict errors (RMSPE) of the selected model divided by the RMSPE of a benchmark driftless random-walk for horizons of 1, 3, 6 and 12 months ahead. Numbers below unit indicate that the selected model had a lower forecasting error than the random walk. The asterisks at the right of the numbers, ***, ** and * denote statistical significance at 1%, 5% and 10% respectively using Clark and West (2006, 2007) statistics. Forecasting errors are based on rolling regressions with a fixed sample size. The total sample size has a total of 108 observations and goes from Jan/99 through Dez/07.