

Theoretical and Empirical Exchange Rate Models: Do they aim to forecast the Quetzal?¹

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Abstract

The forecasting performance of a wide variety of theoretical and empirical exchange rate models is tested against the random walk specification to determine their assessment in predicting the quetzal's exchange rate. In effect, applying a modified version of Cheung, Chinn and García-Pascual (2004) and Meese and Rogoff (1983), the Purchasing Power Parity, the Interest Rate Parity Condition, the Monetary Models in their Flexible and Sticky-Price versions, the Portfolio Balance, and a Behavioral Empirical Exchange Rate (BEER) model are tested against the simple random walk specification. Such models are estimated using recursive regression methodology based on quarterly data for the period 1995Q1-2009Q4 for the quetzal's exchange vis-à-vis the U.S. dollar. Estimations are performed based on a trend-gap, and an error-correction specification to contrast short vs. long run prediction performance, which is evaluated up to eight period ahead forecasts for all model specifications. Different from results obtained in empirical research, forecasts provided by most specifications in the very short run (up to 2 quarters ahead), mainly the BEER specification, consistently outperform those obtained from the random walk model.

JEL Classification: E44, F31, F41

Key Words: Exchange rate, Monetary Policy, Fiscal Policy, Economic Activity, Trade Partner

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1 INTRODUCTION

Exchange rate forecasting has been an important challenge for academics and empiricists through time. Although there is a wide range of theoretical and empirical models developed over the years to estimate and predict exchange rate behavior, empirical literature suggests that such estimates are only useful to determine an exchange rate trend, because in the short run they are usually outperformed by a random walk model. We defy previous findings by testing the forecasting performance of a wide variety of theoretical and empirical exchange rate models against the random walk specification to determine their assessment in predicting the Guatemalan exchange rate (the quetzal) over short and long horizons.

In effect, based on the work of Meese and Rogoff (1983), and Cheung, Chinn and García-Pascual (2004), exchange rate forecasts obtained through the Purchasing Power Parity model, the Uncovered Interest Rate Parity Condition, the Monetary Model in its Flexible and Sticky-Price versions, the Portfolio Balanced model, and a Behavioral Empirical Exchange Rate (BEER) model are tested against forecasts generated by a random walk specification. Such models are estimated with quarterly data for the period 1995Q1-2009Q4 using a rolling regression methodology for the quetzal's exchange vis-à-vis the U.S. dollar. Estimations are performed based on a trend-gap specification, as well as in error-correction form in order to contrast short vs. long run prediction performance, which is evaluated up to eight period ahead forecasts.

Different from the results obtained in previous research, prediction estimates by most exchange rate models in the very short run (2 quarters ahead), particularly from the BEER specification, consistently outperform those obtained through the random walk model.

The remaining part of this document is divided as follows. Section 2 presents the theoretical and empirical exchange rate models used as reference in this study. Section 3 describes the data and methodology employed. Section 4 depicts the comparative forecasts of each model with respect to the random walk specification, while Section 5 concludes.

2 NOMINAL EXCHANGE RATE ESPECIFICATIONS

The quantity of models developed through time to explain and forecast exchange rates is highly numerous that it will be almost an impossible task to describe each one of them. Nevertheless, there are a finite number of models that have survived through time, and their insights are still being applied by policymakers when analyzing and predicting the exchange rate behavior, mainly in the long run. Such models are: i) the Purchasing Power Parity, ii) the Uncovered Interest Rate Parity Condition, iii) the Monetary Model, iv) the Portfolio Balance, and v) the Behavioral Empirical Exchange Rate (BEER). A description of each model along with a brief summary of its recent empirical findings is described next.

2.1 The Purchasing Power Parity Model

The purchasing power parity (PPP) approach is the most widely followed framework to assess an exchange rate value, mainly for the long run. It is also one of the oldest approaches, since its roots go back to the 16th century Spain, and it has been continuously restated in different versions. We focus on the relative version of PPP, which states that percentage changes in the quetzal's bilateral exchange rate, s_t , is determined by the difference between domestic, π_t , and the foreign, π_t^* , inflation rates. In functional form, the PPP equation can be stated as follows:

$$s_t = \rho_0 + \rho_1 (\pi_t - \pi_t^*) + \epsilon_t \quad (1)$$

It is not outrageous to assert that since its establishment, Equation (1) has been the most estimated equation in empirical financial literature around the globe. In fact, the simplicity of its formulation, and its commanding economic intuition, makes PPP a very appealing theory. Nevertheless, empirical results, such as those described in Frenkel (1980), Meese and Rogoff (1983), Dornbush (1980), Rosenberg (1996), and Froot and Rogoff (1994), have demonstrated departures from PPP, mainly over short term horizons, because of productivity shocks, terms of trade changes, resource discoveries, and structural differences in income elasticities, and growth rates. Such elements could generate current account imbalances whose correction might need significant exchange rates ad-

adjustments, even when domestic and foreign price levels remain fixed.

In recent years, the compilation of wider and longer datasets, the development of new statistical methods, and the periodic emergence of stronger computer power, have contributed to develop new forms of testing Equation (1). Such a growing body of evidence, as summarized in Taylor (2009) suggests that exchange rates do indeed converge toward their PPP values in the long run. Once again, PPP refuses to die.

2.2 The Monetary Approach

Another widely used model to estimate and forecast exchange rates is the monetary approach whose original specification is the flexible-price version established by Frenkel (1976) and Bilson (1978). According to this approach, changes in the relative supply of money lead to adjustments of prices, and hence, in the exchange rate. Its functional form states that the nominal exchange rate is a function of domestic and foreign differentials of money supply ($m_t - m_t^*$), GDP ($y_t - y_t^*$), and expected inflation ($\pi_t^e - \pi_t^{e*}$). Therefore, the nominal exchange rate in functional form can be established as:

$$s_t = \alpha_0 + \alpha_1 (m_t - m_t^*) + \alpha_2 (y_t - y_t^*) + \alpha_3 (\pi_t^e - \pi_t^{e*}) + \epsilon_t \quad (2)$$

Dornbusch (1976) argued that Equation (2) should be modified, given that the empirical evidence on PPP suggested that it does not hold continuously. Therefore, he suggested a monetary approach that relaxed the assumption of price flexibility, but that allows PPP to hold in the long run. Dornbusch's version of the monetary is known as the Sticky Price Monetary Model, which is defined as follows:

$$s_t = \beta_0 + \beta_1 (m_t - m_t^*) + \beta_2 (y_t - y_t^*) + \beta_3 (i_t - i_t^*) + \epsilon_t \quad (3)$$

Note that the interest rate differential ($i_t - i_t^*$) is assumed to reflect differences in expected inflation rates. Therefore, an increase in domestic interest rates relative to foreign interest rates should reflect a worsening of domestic inflation expectations, which will lead towards an exchange rate appreciation.

Empirical results based on the monetary models are mixed. Boughton (1988), Frankel (1984), Meese and Rogoff (1983), Alexander and Thomas (1987), Schinasi and Swamy (1989), and Eichenbaum and Evans (1993), among others, have found poor estimates when trying to estimate exchange rate forecasts based

on the monetary model. They argue that the failure of PPP to hold in the short run, the assumption of money demand stability, the reliance on fixed regression coefficients, and the overly simplified equations describing how expectations are formed, are the main reasons that explain the failure of the monetary model in practice. Nevertheless, empirical work by MacDonald and Taylor (1994), McNown and Wallace (1994), Castillo (1997), Lütkepohl and Wolters (1999), Schröder and Dornau (2001), Groen (2002), and Chin, Azali and Matthews (2007), have obtained favorable results when applying innovations, such as variable coefficients, lagged dependent variables, or cointegration techniques. These new approaches for exchange rate testing have contributed to develop a renewed interest in the monetary model in recent years.

2.3 The Portfolio Balanced Approach

The portfolio balanced approach slightly differs from the monetary model, by assuming that domestic and foreign bonds are not perfect substitutes. Therefore, the exchange rate value can be affected by relative bond supply variations, and shifts in asset preferences. Thus, besides the fundamentals described in Equation (3), the nominal exchange rate is also a function of the domestic and foreign real interest rate differential ($r_t - r_t^*$), and the percentage change between domestic and foreign bonds supply ($b_t - b_t^*$), as described below:

$$s_t = \gamma_0 + \gamma_1 (m_t - m_t^*) + \gamma_2 (y_t - y_t^*) + \gamma_3 (\pi_t^e - \pi_t^{e*}) + \gamma_4 (r_t - r_t^*) + \gamma_5 (b_t - b_t^*) + \epsilon_t \quad (4)$$

Empirical results from the portfolio balance model have been generally poor. According to Rosenberg (1996) and Taylor (2004), the failure of this model to forecast exchange rate trends is due to misspecification of asset demand functions, inadequate data on the size and currency composition of private sector portfolios, simultaneity bias between exchange rate changes and changes in the current account balance, and inadequate treatment of exchange rate expectations.

2.4 The Uncovered Interest Rate Parity (UIP) Condition

According to this specification, the exchange rate expected value, s_t^e , will differ from the current exchange rate, s , whenever there are differences between the domestic and foreign interest rate differentials ($I_t - I_t^*$), adjusted by a country

risk premium, ρ_t . Although several versions have been constructed out of this approach, in this document we test the uncovered version of the parity (UIP), which is stated as follows:

$$i_t - i_t^* = (s_t^e - s_t) + \rho_t + \epsilon_t \quad (5)$$

Equation (5) implicitly states that arbitrage opportunities arise whenever the exchange rate falls apart from the established interest rate parity. Until recently, empirical results of the UIP hypothesis had been poor. Froot and Thaler (1990), MacDonald and Taylor (1992) and Isard (1995) concluded that interest rate differentials are not predictors of future exchange rate movements. However, recent findings by Alexius (2001), Chinn and Meredith (2005), and MacDonald and Nagayasu (2000) have found supportive evidence of the UIP parity when using long term (+5 years) interest differentials. Such results show correct sign coefficients, which are closer to the predicted value of unity than to zero.

2.5 The Behavioral Equilibrium Exchange Rate (BEER) Model

The BEER model features the nominal exchange rate as a function of two main variables, both of which appear in previous models, but under a different form. The specification of the combined model is the following:

$$s_t = \phi_o + \phi_1 m_t + \phi_2 y_t^* + \phi_3 caf_t + \phi_4 rem_t + \epsilon_t \quad (6)$$

Where m_t stands for domestic money supply, y_t^* for foreign (U.S.) output, caf_t for international coffee prices, and rem_t for family remittances. The value of ϕ_s represent estimated coefficients. According to such specification, variations in the quetzal's exchange rate are a function of monetary policy actions, manifested through the money supply, U.S. economic activity, since they regulate the capital inflows to Guatemala in the form of exports, tourism, foreign direct investment, family remittances and coffee prices. Although Equation (6) resembles the original formulation established by Clark and MacDonald (1998) or its modified version described in Cheung, Chinn and Garcia-Pascual (2004), the last two terms are included explicitly since their inflows are very representative for the Guatemalan economy.

3 DATA, ESTIMATION, AND COMPARISION TESTS

3.1 Data

Estimations and forecasts are made based on quarterly data for the period 1995Q1-2009Q4 using recursive regression methodology for the quetzal's exchange vis-à-vis the U.S. dollar. Econometric estimations begin in 1995, to take into account the beginnings of a floating exchange rate system in Guatemala. The data for Guatemalan variables is obtained from the Central Bank's website, while information for foreign variables is obtained from the IMF's International Financial Statistics, and from the Federal Reserve website.

3.2 Estimation Methodology

We follow the rolling regression methodology applied by Meese and Rogoff (1983), and Cheung, Chinn and Garcia-Pascual (2004), which tends to control for parameter instability within the data sample, which is a common concern in the exchange rate literature. Estimations are performed for a trend-gap and an error-correction specification, in order to contrast short vs. long run prediction performance, which is evaluated up to 8 period ahead forecasts.

With respect to the first type of estimations, the natural log of each variable's gap was obtained through a Hodrick-Prescott filter, which gives us an approximation for a variable's percentage difference from its long run trend. Consider the following functional form that depicts the nominal exchange rate, s_t , as a function of its fundamentals, x_t :

$$s_t = Ax_t + \epsilon_t \tag{7}$$

Taking natural logs on both sides of Equation (7), decomposing each side between its trend and gap component, and rewriting such expression as a two equation system whose addition is equivalent to (7), we have:

$$s_{tnd_t} = Ax_{tnd_t} + \epsilon_{1t} \tag{8}$$

$$s_{gap_t} = Ax_{gap_t} + \epsilon_{2t} \tag{9}$$

We assume that Ax_{tnd_t} in Equation (8) can be approximated by an n order lag polynomial of its dependent variable, $L^n(s_{tnd_t})$. Therefore, the exchange

rate trend component can be estimated and forecasted outside from each model fundamental's specification. Given that the fundamental vector x_{gap_t} might contain contemporaneous variables, their forecasts are estimated through an ARMA model, which is tailored to each independent variable. Thus, both equation components are added up to obtain the exchange rate log forecast for each period. Because of the rolling regression methodology applied in the estimation, this procedure is repeated for each forecast window.

The error-correction specification is a two step procedure. In the first place, a Dickey-Fuller regression is estimated to check for the order of integration of each variable involved in the estimation. Since s_t is I(1), it is expected that the other variables have the same order of integration, a condition necessary to proceed with the second step, and which holds in most cases.

$$d\log(s_t) = \omega_0 d\log(x_t) + \omega_1 d\log(x_{t-1}) + \omega_2 (\log(s_t) - \log(x_{t-1})) + \mu_t \quad (10)$$

In the second step, Equation (10) is estimated through least squares, to take into account the short and long run effects of independent variables on the nominal exchange rate dynamics. Forecasts for exogenous variables were generated through an AR(1) specification of each variable's growth rate. A similar approach was employed in Mark (1995), Chinn and Messe (1995).

3.3 Comparison Tests

In the spirit of Meese and Rogoff (1983), and Cheung, Chinn and García-Pascual (2004), each of exchange rate forecasts produced by the model specifications described in Section 2 are tested against those produced by a random walk model. The null hypothesis of no difference in the accuracy of both forecasts is tested based on Diebold and Mariano (1994) loss differential methodology. In fact, we employ the loss differential criteria, d , to the Mean Squared Error (MSE) formulation. The statistic d is asymptotically distributed as a standard normal distribution, where a consistent standard deviation is constructed from the weighted sum of the loss differential vector sample autocovariances. A Quadratic Spectral kernel, as the one used by Andrews (1993) is employed, along with a data dependent bandwidth parameter⁴.

⁴Following Andrews (1993), the bandwidth parameter specification was the following:

$$A(1) = 4 \left[\frac{\rho}{(1-\rho)(1+\rho)} \right]^2$$

In addition, a direction of change criteria is also tested. In effect, the proportion of correct sign predictions from the random walk model is subtracted from the proportion of correct sign forecast obtained from each model specification. The result is the proportion of correct direction of change predictions that outnumber (if positive) those forecasts made by the random walk specification. The null hypothesis of a greater proportion of correct direction of change predictions resulting from the theoretical models is therefore tested based on a normal distribution.

The third test is the consistency condition developed by Cheung and Chinn (1998), which represents a more lenient criterion to evaluate a forecast, since it just concerned with the relative long run difference between forecast and actual data. Nevertheless, it requires that exchange rate forecasts be cointegrated with actual realizations, and that the elasticity of expectations be equal to one, two conditions that are difficult to achieve for model forecasts. Cointegration is tested based on the Johansen methodology for two different forecast windows: the longest size window, which includes seven years of forecasts (2002Q1-2009Q4) to take into account the period since the new financial legislation reforms, and a medium term window, that includes four years of forecasts values (2005Q1-2009Q4) which accounts for the period since the establishment of Inflation Targeting in Guatemala . In this case, the probability of finding a significant cointegration relationship is expected to be higher in the shorter forecast window.

4 FORECASTING RESULTS

In this section we present the results obtained, and provide a brief analysis of our main findings. As mentioned before, the econometric estimation and within-sample forecast of each theoretical model was performed through mobile and uniform windows to test for parameter and model robustness to changes in the sample period. Then, we tested their forecast performance through the Diebold-Mariano loss differential statistic by comparing them with those provided by a random walk specification. Three different criteria were used for forecast comparison: i) mean square error; ii) direction of change; and iii) cointegration

Where ρ is the coefficient of an AR(1) model of the nominal exchange rate series.

analysis. Again, two specifications were performed for each model. The first one is a short run representation where estimations are obtained from a trend-gap specification, as indicated by Equations (8) and (9), while the second one is a long run representation where we employed an error-correction specification for each model, as the one described in Equation (10).

Table 1 shows the results obtained from the loss differential statistic, d , which compares the Mean Squared Error (MSE) statistic generated for all of the eight period ahead forecasts produced by each model, relative to the MSE statistic produced by a random walk specification. The first column of Table 1 indicates the forecast period, while the remaining columns are divided according to the model specification used to obtain the results. The first five columns present the outcome estimated through the trend-gap specification for each of the following five models: i) the purchasing power parity (PPP) model; ii) the flexible price monetary model; iii) the sticky price monetary model; iv) the portfolio balanced model; and v) the behavioral exchange rate (BEER) model. The following six columns present the results estimated through the error-correction specification for each of the five models indicated above, and also for the uncovered interest rate parity (UIP) condition.

Ho: The loss differential of each model forecast is lower than the one produced by the random walk specification

Forecast Period	Gap Specification					Error Correction Specification					
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(6)
1	-1.06 (0.03) **	-1.06 (0.03) **	-1.06 (0.03) **	-1.06 (0.03) **	-1.07 (0.03) **	-1.06 (0.03) **	-1.06 (0.03) **	-1.07 (0.03) **	-1.06 (0.03) **	-1.06 (0.03) **	-1.03 (0.03) **
2	-1.83 (0.04) **	-1.82 (0.04) **	-1.82 (0.04) **	-1.82 (0.04) **	-1.82 (0.04) **	-1.79 (0.06) *	-1.79 (0.05) *	-1.80 (0.06) *	-1.78 (0.07) *	-1.78 (0.06) *	-1.65 (0.13)
3	-3.68 (0.43)	-3.67 (0.43)	-3.67 (0.43)	-3.67 (0.43)	-3.66 (0.43)	-3.59 (0.44)	-3.59 (0.44)	-3.60 (0.44)	-3.58 (0.44)	-3.56 (0.44)	-3.22 (0.46)
4	-4.05 (0.45)	-4.05 (0.45)	-4.04 (0.45)	-4.04 (0.45)	-4.04 (0.45)	-3.92 (0.46)	-3.89 (0.46)	-3.93 (0.46)	-3.89 (0.46)	-3.89 (0.46)	-3.19 (0.48)
5	-5.40 (0.46)	-5.40 (0.46)	-5.39 (0.46)	-5.39 (0.46)	-5.38 (0.46)	-5.24 (0.47)	-5.16 (0.47)	-5.23 (0.47)	-5.17 (0.47)	-5.17 (0.47)	-4.05 (0.48)
6	-5.75 (0.48)	-5.75 (0.48)	-5.75 (0.48)	-5.75 (0.48)	-5.74 (0.48)	-5.58 (0.49)	-5.47 (0.49)	-5.57 (0.48)	-5.48 (0.49)	-5.49 (0.49)	-3.38 (0.49)
7	-7.14 (0.48)	-7.14 (0.48)	-7.14 (0.48)	-7.14 (0.48)	-7.14 (0.48)	-6.95 (0.48)	-6.85 (0.48)	-6.95 (0.48)	-6.84 (0.48)	-6.83 (0.48)	-3.36 (0.49)
8	-6.01 (0.47)	-6.02 (0.47)	-6.01 (0.47)	-6.01 (0.47)	-6.01 (0.47)	-5.79 (0.47)	-5.74 (0.47)	-5.79 (0.47)	-5.66 (0.47)	-5.64 (0.47)	-0.33 (0.50)

Model (1): Purchasing Power Parity (PPP) Model

Model (2): Flexible Price Monetary Model

Model (3): Sticky Price Monetary Model

Model (4): Portfolio Balanced Model

Model (5): Behavioral Exchange Rate (BEER) Model

Model (6): Uncovered Interest Rate Parity Condition

*** Significant at 1% level

** Significant at 5% level

* Significant at 10% level

Table 1. Loss Differential (Mean Squared Error) Criterion

The null hypothesis states that the loss differential is lower than zero, implying that the MSE calculated through each model forecasts is lower than the MSE computed through the random walk forecasts. The statistic d is asymptotically distributed as a standard normal distribution. As mentioned before, this criterion shows how close each model forecast is from the observed value, with respect to the random walk forecasts. For instance, a value such as -1.06, a result obtained in 8 out of 11 d statistics computed for the first forecast period, indicates that the forecast produced by the random walk specification was, in average, 1.06 units more distant from the observed value, than the forecast produced by the specific model which whom it was being compared. According to the estimated sign for all of the d statistics, all model forecasts seem to be, in average, closer to the observed value than the random walk estimates. Nevertheless, the significance of such a forecast differential is relevant, for most cases, just for the first two period ahead forecasts⁵. In effect, Table 1 shows in

⁵The only exception is the forecast obtained through the UIP condition, which was more

parenthesis the p-values for each of the d statistics computed. By separating the results obtained through the trend-gap specifications from those obtained through the error-correction regressions, we observe that the d statistics are consistently significant at 5% for the first two period ahead forecasts in the first type of models, while for the second type of models, most of them are significant at the 5% level for the first period, but just at the 10% level in the second period ahead forecast. Therefore, the first kind of model specification provides better results. Forecasts for the independent variables that feed each model specification were obtained through ARIMA processes. Therefore, we also employed observed data for such variables trying to determine whether the outcome generated for each model specification could enhance over two periods ahead. However, we did not find any significant improvement in such an exercise.

We also run a comparison tests between each of the models forecasts in order to determine the more reliable nominal exchange rate specification, particularly for the two periods ahead where model forecasts appeared to outperform those obtained through the random walk model. Therefore, by using the same methodology, but taking as a reference each of the model forecasts (instead of the random walk predictions), we determined that the BEER specification is significantly better than the remaining forecasts for the period $t+1$, while the PPP specification provides more precise forecasts for the period $t+2$.

The second criterion to evaluate model forecasts is the direction of change forecast and the results obtained are presented in Table 2. This table's structure is similar to the previous table, so we won't go over it again. The null hypothesis establishes that the number of correct sign forecasts (the direction of exchange rate forecasted variations) is greater for each model forecast, relative to the number of correct sign forecasts obtained through the random walk specification. Therefore, a d statistic greater than zero implies that the average number of correct sign forecasts produced by any given model is greater than the number of right direction of change assertions provided by the random walk model.

As observed, the d statistics computed are all positive. However, they are significant just from the second to the fourth forecasting period, and for the last period ahead forecast. Results are not significant starting from the first period, since the random walk specification is also a good indicator of the direction

significant than the random walk specification just for the first period ahead forecast.

of change for the first period ahead forecast, even though the d statistic is greater than zero. By comparing each type of specification, we observe that forecasts obtained through the trend-gap type models provides better forecasts than those produced by the error-correction specification type models. However, the d statistic computed for each of those models is still positive, which implies a better performance, although not statistically significant, than the random walk specification.

Ho: The proportion of correct direction predictions is greater for each model than for the random walk specification

Forecast Period	Gap Specification					Error Correction Specification					
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(6)
1	0.19 (0.76)	0.19 (0.50)	0.16 (0.96)	0.16 (0.96)	0.25 (0.24)	0.25 (0.86)	0.25 (0.64)	0.25 (0.64)	0.25 (0.92)	0.28 (0.36)	0.16 (0.76)
2	0.39 (0.01) ***	0.39 (0.00) ***	0.29 (0.04) **	0.35 (0.02) **	0.32 (0.01) ***	0.23 (0.50)	0.35 (0.24)	0.19 (0.76)	0.23 (0.64)	0.26 (0.08) *	0.19 (0.64)
3	0.30 (0.03) **	0.27 (0.01) ***	0.27 (0.07) *	0.27 (0.14)	0.23 (0.14)	0.23 (0.50)	0.30 (0.36)	0.23 (0.86)	0.20 (0.93)	0.20 (0.36)	0.23 (0.77)
4	0.28 (0.00) ***	0.21 (0.03) **	0.28 (0.03) **	0.28 (0.01) ***	0.21 (0.07) *	0.31 (0.23)	0.31 (0.23)	0.28 (0.64)	0.28 (0.64)	0.24 (0.23)	0.24 (0.64)
5	0.21 (0.22)	0.14 (0.50)	0.14 (0.65)	0.14 (0.65)	0.18 (0.35)	0.18 (0.97)	0.18 (0.78)	0.14 (1.00)	0.21 (0.97)	0.18 (0.78)	0.18 (1.00)
6	0.19 (0.35)	0.19 (0.65)	0.15 (0.78)	0.15 (0.88)	0.19 (0.65)	0.07 (1.00)	0.15 (0.99)	0.07 (1.00)	0.11 (1.00)	0.11 (0.94)	0.15 (1.00)
7	0.27 (0.12)	0.23 (0.22)	0.27 (0.12)	0.23 (0.22)	0.27 (0.06) *	0.15 (0.94)	0.19 (0.88)	0.19 (1.00)	0.23 (0.98)	0.19 (0.50)	0.15 (0.98)
8	0.24 (0.05) **	0.28 (0.02) **	0.24 (0.05) **	0.24 (0.05) **	0.28 (0.00) ***	0.16 (0.95)	0.28 (0.66)	0.12 (0.98)	0.16 (0.98)	0.20 (0.50)	0.08 (0.99)

Model (1): Purchasing Power Parity (PPP) Model

Model (2): Flexible Price Monetary Model

Model (3): Sticky Price Monetary Model

Model (4): Portfolio Balanced Model

Model (5): Behavioral Exchange Rate (BEER) Model

Model (6): Uncovered Interest Rate Parity Condition

*** Significant at 1% level

** Significant at 5% level

* Significant at 10% level

Table 2. Direction of Change Criterion

As in the previous case, we also make an alternative exercise by including observed data for the independent variables in each of the models. Results did not change for the error-correction type models. However, for the trend-gap estimates, particularly those generated by the BEER model, they improved considerably, to the point that such forecasts are significantly better from the first to the eight period ahead forecasts than those generated by the random walk specification. As in the previous case, we compare the results obtained

by each of the model forecasts. According to the direction of change criterion, there is no model whose forecasts are consistently better off.

The third forecast comparison criterion consists of a cointegration test between each model forecast, and observed exchange rate data. In addition, following Cheung, Chinn and García-Pascual (2004), we tested whether the normalized coefficient of the cointegrating vector (if there is one) is equal to one, to check for forecast robustness. To test for cointegration we needed first to test for unit roots, in order to determine whether both series (forecasted and observed exchange rate series) have the same order of integration. Then, we employed the Johansen cointegration methodology to find a cointegrating vector, and in the cases where significant results were found, we imposed the restriction on the normalized coefficient of the cointegrating vector to check whether its value was statistically different from one. Two forecast windows were tried in this case. The first one comprehends the period 2002-2009, since the new financial legislation reforms, while the second one takes into account the period 2005-2009, since the establishment of inflation targeting in Guatemala.

The results obtained through the trend-gap specification are presented in Table 3. The first column indicates the period used to obtain the results. The rest of the table is classified into five different sections, each of them representing the results based on one particular model. In effect, sections (1)-(5) depicts the outcome obtained through each of the following five models: i) the purchasing power parity (PPP) model; ii) the flexible price monetary model; iii) the sticky price monetary model; iv) the portfolio balanced model; and v) the behavioral exchange rate (BEER) model. In addition, each section contains three main results. The first column shows the Unit Root Tests for the exchange rate series forecasted by such a model, the second column shows the Johansen Cointegration Tests between the forecasted and the observed exchange rate series, and the third column shows the statistic computed to test for a unit value cointegrating coefficient, which is distributed according to a Chi-Squared distribution. The first row depicts the estimated coefficient for each test, while the value into parenthesis represents its p-value.

Period	(1)			(2)			(3)		
	Uroot	Coint	Restr	Uroot	Coint	Restr	Uroot	Coint	Restr
2002-2009	-0.04 (0.95)	0.23 (0.36)		-0.05 (0.95)	0.22 (0.37)		-0.08 (0.94)	0.23 (0.36)	
2005-2009	-3.25 (0.03) **			-6.50 0.00 ***			-3.52 (0.02) **		
Period	(4)			(5)					
	Uroot	Coint	Restr	Uroot	Coint	Restr			
2002-2009	-0.06 (0.95)	0.22 (0.40)		0.25 (0.97)	0.26 (0.24)				
2005-2009	-5.95 (0.00) ***			-3.77 (0.01) ***					

Ho^{Uroot}: There is a unit root (the series is not stationary)

Ho^{Coint}: There is no cointegrating relationship

Ho^{Restr}: The normalized coefficient is different from one

Model (1): Purchasing Power Parity (PPP) Model

Model (2): Flexible Price Monetary Model

Model (3): Sticky Price Monetary Model

Model (4): Portfolio Balanced Model

Model (5): Behavioral Exchange Rate (BEER) Model

*** Significant at 1% level

** Significant at 5% level

* Significant at 10% level

Table 3. Cointegration and Robustness Criterion (Trend-Gap Specification)

As observed, exchange rate forecasts generated by each model for the period 2002-2009 appear to have a unit root. Since this is also the case for the observed series, we tested for cointegration. Out of the five model forecasts, none of them appear to be cointegrated with the observed series. Hence, no results appear in the unitary restriction column because no tests were made. On the other hand, all model forecasts generated for the period 2005-2009 are stationary. Therefore, there is no cointegration between the forecasted and the observed exchange rate series, and the restriction could not be tested. Thus, no results appear in such columns.

Table 4 presents the results obtained through the error-correction specification. The structure of the table is similar to that of Table 3 with the difference that it includes another section to present the results obtained through the UIP condition.

Period	(1)			(2)			(3)		
	Uroot	CoInt	Restr	Uroot	CoInt	Restr	Uroot	CoInt	Restr
2002-2009	20.99 (1.00)	0.97 (0.00) ***	48.44 (0.00) ***	-343.02 (0.00) ***			0.88 (0.99)	0.62 (0.00) ***	1.18 (0.28)
2005-2009	12.51 (1.00)	0.94 (0.00) ***	39.45 (0.00) ***	5.91 (1.00)	0.77 (0.00) ***	25.28 (0.00) ***	16.87 (1.00)	0.97 (0.00) ***	49.60 (0.00) ***
Period	(4)			(5)			(6)		
2002-2009	23.59 (1.00)	0.23 (0.36)		11.00 (1.00)	0.36 (0.05) **	1.85 (0.17)	-36.78 (0.00) ***		
2005-2009	7.49 (1.00)	0.56 (0.02) **	4.60 (0.03) **	-26.47 (0.00) ***			6.36 (1.00)	0.77 (0.00) ***	0.02 (0.90)

Ho^{Uroot}: There is a unit root (the series is not stationary)

Ho^{CoInt}: There is no cointegrating relationship

Ho^{Restr}: The normalized coefficient is different from one

Model (1): Purchasing Power Parity (PPP) Model

Model (2): Flexible Price Monetary Model

Model (3): Sticky Price Monetary Model

Model (4): Portfolio Balanced Model

Model (5): Behavioral Exchange Rate (BEER) Model

Model (6): Uncovered Interest Rate Parity Condition

*** Significant at 1% level

** Significant at 5% level

* Significant at 10% level

Table 4. Cointegration and Robustness Criterion (Error-Correction Specification)

In this case, with the exception of the forecasts obtained through the Flexible Price Monetary Model and the UIP condition, all exchange rate forecasts performed for the period 2002-2009 have a unit root. Therefore, we proceed to test for cointegration. According to the results obtained, such forecasts are cointegrated with the observed exchange rate series; the only exception being those obtained through the Portfolio Balanced model. At first glance, such results seem to contradict the conclusions followed through the results obtained with the other two criteria. However, given the signs of the d statistics presented in Table 1 and Table 2, which imply that such forecasts are better than those provided by a random walk model, we interpret their lack of statistical significance for forecasts over 2 periods ahead, as indicating that there is not a huge improvement in forecasting precision between using any of the exchange rate models previously specified through equations (1)-(6), and employing a random walk specification. Nevertheless, in the long term, such forecasts could be cointegrated with the observed exchange rate series. Finally, we proceed to test for

a unitary coefficient within the cointegration vector. The null hypothesis of a differentiated value for such a coefficient is just rejected for the PPP model at the 1% of significance.

The Unit Root Test for the forecasts obtained for the period 2005-2009 indicate that with the exception of the BEER specification, all the remaining model forecast have a unit root. Since this is also the case for the observed exchange rate series, we ran a cointegration test on those exchange rate forecasts. According to the Johansen criterion, all such series appear to be cointegrated with observed data. Thus, it was performed a unitary coefficient test for all cointegrating relationships, and we did not find enough statistical evidence to support the null hypothesis of a cointegrating coefficient different from one in all cases, with the exception of the forecasts performed through the UIP condition.

In conclusion, forecasts obtained through the exchange rate theoretical models are suitable to explain short run exchange rate fluctuations, since they are significantly better than a random walk specification within the first 2 forecast ahead periods. Nevertheless, in the long run, such forecasts are not significantly better than those generated by a random walk model. A cointegrating relationship was found between exchange rate forecasts and observed data, particularly through the error-correction specifications.

Out of the six exchange rate specifications employed to forecast the nominal exchange rate, the most suitable model appears to be the BEER. According to such a model specification, quetzal variations are mainly a function of the U.S. economic fluctuations, family remittances, coffee export prices and domestic money supply changes. Given that the U.S. is Guatemala's main trading partner, periods of U.S. economic expansion (contraction) are followed by capital inflows (outflows) to the Guatemalan economy, which are manifested in higher (lower) exports, tourism, remittances, and foreign direct investment, which in turn have an effect in the supply of foreign exchange, and hence, in the nominal exchange rate. In addition, given their geographical proximity, and their commercial and financial linkages, the American and Guatemalan economic cycles register a similar pattern. Therefore, periods of economic expansion (contraction) in the U.S. are followed by restrictive (relaxed) monetary policies in the Guatemalan economy, which affect the country's aggregate money supply, which in turn have an effect on the quetzal's exchange rate. Some other variables included, such as family remittances, and the average international price of coffee

were also found significant, but to a lower degree.

5 CONCLUSIONS

In this document we followed the empirical approaches of Meese and Rogoff (1983), and Cheung, Chinn and García-Pascual (2004) to compare nominal exchange rate forecasts for the quetzal vis à vis the U.S. dollar generated by several theoretical exchange rate models with those generated by a random walk specification. The models employed in the analysis are the Purchasing Power Parity, the Uncovered Interest Rate Parity, the Monetary Model in its Flexible and Sticky-Price versions, the Portfolio Balanced, and a Behavioral Empirical Exchange Rate (BEER) model. We generated the forecasts based on two alternative model specifications. First, we employed a trend-gap approach, where all series were separated into its trend and gap components. Therefore, the theoretical models were expressed in a gap form, while the exchange rate trend component followed an ARIMA model. The second model was an error-correction specification, following the empirical literature previously mentioned.

Forecast comparison was performed with respect to the random walk specification, and with respect to all other models forecasts. To compare among forecasts we employed three different forecast comparison criteria: i) the loss differential criteria constructed through the mean squared error statistic; ii) the direction of change criteria based on observed data; and iii) the cointegration criteria between each forecast and the observed series. We found that most models provide better forecasts than the random walk in the very short run: up to two periods (quarters) ahead. Among the different forecasts, the BEER and the PPP models estimated through the trend-gap specification were found to provide the more precise short run forecasts for $t+1$ and $t+2$, respectively, and the BEER were found to provide the better direction of change forecast up to eighth period ahead forecasts. Therefore, according to the latter specification, the quetzal's short run fundamentals are: i) domestic money supply; ii) US GDP; iii) family remittances; and, iv) the unit price of sugar exports.

Although forecasts for longer horizons do not provide a huge improvement over those generated through the random walk model, most forecasts were found to be cointegrated with observed exchange rate series, even for a longer forecast horizon. According to such results, even though forecast precision weakens for

longer horizons, their long run trend follows observed data quite well. Although further job is needed to improve forecasts precision in the long run, the quetzal's short run fundamentals were identified.

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