FORECASTING THE PHILIPPINE PESO-DOLLAR EXCHANGE RATE: STRUCTURAL VERSUS TIME SERIES MODELS

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This paper compares the predictive power of different models of the peso-dollar exchange rate. Structural and time series models were estimated using monthly data from 1980 to 1998; out-of-sample forecasts for the period 1999 and 2000 were generated from the different models.

Using root mean square error as the principal criterion, findings show that in the short term (i.e., three-, six- and twelve-month forecasts), the random walk model outperforms all the alternative models considered in this study. In contrast, the structural monetary model had the worst performance despite the fact that these were based on the actual realized values of the independent variables.

For the 24-month forecast, the structural monetary model had a marked improvement in forecast accuracy. Yet, it continues to pale in comparison to the performance of the models that are based on the random walk, the random walk with drift, and the purchasing power parity model.

I. INTRODUCTION

The importance of forecasting the foreign exchange rate can never be overemphasized. At the macro level, foreign exchange rate projections serve as a key input in determining the probable level of foreign trade and the corresponding government revenues from tariffs. Foreign exchange rate projections also shape fiscal and monetary policies as they affect the domestic value of interest and principal payments of foreign-denominated government loans which, in turn, affect the distribution of government expenditures and financing requirements.

At the micro level, foreign exchange rate forecasts are a vital input in the operational and strategic decisions of firms. Projections of the foreign exchange rate determine the pricing decisions of firms, especially those that import a significant portion of their inputs and/or compete with goods produced by other economies. Foreign exchange rate forecasts are also important in determining the economic viability of a firm's investment project that is based in another economy and/or will import its equipment and key inputs.

Foreign exchange rate projections are also important in assessing the spending ability of consumers. While foreign exchange rate movements are generally associated with price changes, they may also determine consumer income. This is especially true for an economy like the Philippines that derives substantial

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income from the remittances of overseas Filipino workers.

Projecting foreign exchange rates, however, remains a formidable task. Obstfeld and Rogoff (1996) noted the dismal performance of monetary models in predicting short-term nominal exchange rates. They cited empirical studies that compared structural models and time series models of foreign exchange rates and concluded that the latter's predictive power is better.

Meese and Rogoff (1983a) evaluated the forecasting performance of several monetary models of exchange rate determination such as the Dornbusch model and the flexible-price monetary model using major nominal exchange rates against the dollar. Their results showed that at short-term horizons (i.e., one- to twelve-month period), a random-walk model performs better than any of the structural models. This is true even if the structural-model forecasts are based on actual values of their explanatory variables.

There are attempts to explain the structural models' poor performances. Meese and Rogoff (1983b) consider several explanations such as the breakdown of money demand functions and prolonged deviations from long-run purchasing power parity. However, a decisive explanation has yet to be reached. Nonetheless, they find that the structural models may outperform the random walk at two- to three-year horizons.

Chinn and Meese (1995) and Mark (1995) provide more conclusive evidence, showing the statistical significance of the superior performance of various monetary models at very long horizons.

Do the general findings on forecasting foreign exchange rates apply to the peso-dollar rate? Which has a greater predictive power, a structural model or a time series model? This study examines the predictive power of different models of the logarithm of the peso-dollar exchange rate. Using monthly data from 1980 to 1998, structural and time series models were developed and out-of-sample forecasts for the period 1999 to 2000 were generated from each model. Then the forecasting power of each model were ranked using the root mean square error as the principal criterion.

The following section contains a brief description of the models considered in this study. Section three presents a discussion on measuring the predictive power of the models. Finally, section four presents the empirical results, analysis, and conclusion.

II. MODELS OF FOREIGN EXCHANGE RATE

Structural Models

Model 1: Monetary Model. Different monetary models of exchange rates can be expressed in the following reduced form equation (Meese and Rogoff, 1983a):

$$e = \alpha_0 + \alpha_1(m - m^*) + \alpha_2(y - y^*) + \alpha_3(r - r^*) + \alpha_4(\pi - \pi^*) + \alpha_5 TB + \alpha_6 TB^* + \varepsilon$$

where:

e	:	logarithm of the exchange rate
$m - m^*$	:	logarithm of the ratio between domestic money supply and foreign money supply
$y - y^*$	:	logarithm of the ratio between domestic income with foreign income
$r - r^*$	:	interest rate differential[1]
$\pi - \pi^*$	:	inflation rate differential[2]
TB, TB^*	:	cumulated domestic and foreign trade balances
ε	:	residual or disturbance term

Empirical tests of the above model take various forms. For instance, the Frenkel-Bilson model imposes the following constraints: $\alpha_4 = \alpha_5 = \alpha_6 = 0$ and assumes that the purchasing power parity holds. In contrast, the Dornbush-Frankel model specifies $\alpha_5 = \alpha_6 = 0$ and provides for a slow domestic price adjustment and deviations from purchasing power parity. The Hooper-Morton model, on the other hand, does not restrict any of the parameters to zero.

In this study, no a priori restrictions were imposed on the parameters of the reduced form equation specified above. OLS estimates were made using all the candidate explanatory variables, including their possible lag effects. Explanatory variables that are not statistically significant were dropped from the model.

Based on the in-sample fit of the regression equation, the best estimate of the monetary model is the one that relates the foreign exchange rate with the logarithm of the domestic money supply.

Model 2: Purchasing Power Parity. The purchasing power parity (PPP) is a theory which states that exchange rates adjust to offset inflation differentials across countries. There are two versions of PPP: the absolute PPP and the relative PPP. The former predicts that the real exchange rate should be equal to 1.

Equivalently, this version of the PPP suggests that:

$$e = p - p^*$$

The relative PPP is a weaker assertion on the relationship between exchange rates and prices. It predicts that the exchange rate moves proportionately to national price levels. Thus,

$$e = \alpha\,(p - p^*), \text{ where } \alpha \text{ is a constant.}$$

This study uses the relative PPP version to develop a forecasting model. The constant α is estimated using OLS. The logarithm of the US consumer price index (CPI) is used to represent p^*. The logarithm of the Philippines' CPI is represented by p. Using these price indicators, Chart 1 shows the proportionate movement of the peso-dollar rate and the relative prices, supporting the relative PPP theory.

Model 3: Expectations Theory of Exchange Rate. The expectations theory of exchange rate predicts that the expected spot exchange rate is equal to the forward rate, the price of a foreign currency at

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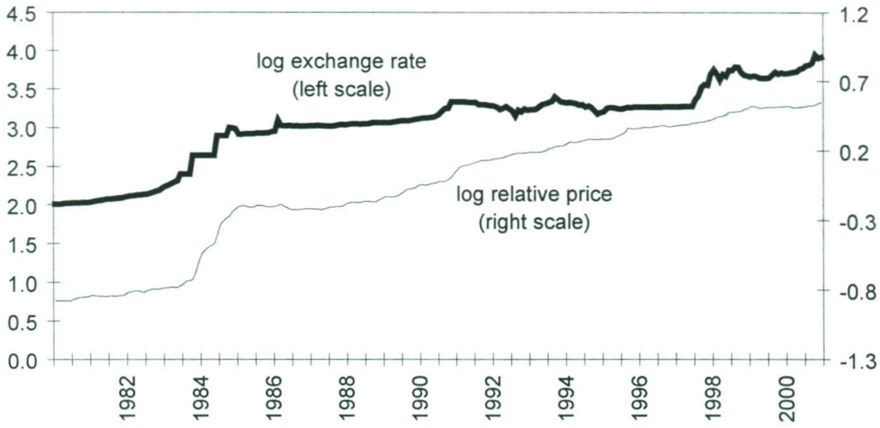
[1] The domestic interest rate is represented by the average 91-day treasury bill rate in the Philippines; foreign interest rate is represented by the average 91-day treasury bill rate in the US.

[2] Inflation rates were based on the consumer price index in the Philippines and the US.

Chart 1
Log Exchange Rate versus Relative Log Prices



some specified future date.[3] Thus,

$$E[e_{t+1}] = f_t$$

where E is the expectations operator and f_t is the logarithm of the forward rate.

While appealing, the relationship between the expected spot rate and future rate is rather naïve considering Jensen's inequality. Nonetheless, there have been empirical tests on the prediction bias in the forward rate. For instance, the forward premium defined as $f_t - e_t$ may be tested by estimating the following equation:

$$e_{t+1} - e_t = \alpha_0 + \alpha_1(f_t - e_t) + \varepsilon_t$$

where ε_t is the residual

The standard tests are used in accepting or rejecting the null hypothesis that $\alpha_0 = 0$ and $\alpha_1 = 1$.

Results vary: a number of findings show that α_1 is less than 1. Some estimates of α_1 are below 0.5; others are even negative. Regardless of the results, empirical estimates of the above equation serve as a tool in predicting exchange rates. In this regard, estimating an empirical model based on forward rates serves the purpose of this study.

Time Series Models

Model 4: Random Walk. In the random walk model, the current exchange rate serves as the predictor of the future exchange rate. Thus,

$$e_{t+1} = e_t + \varepsilon_t,$$

where e_{t+1} is the logarithm of the exchange rate in the next period. Requiring no estimation, the basic random walk model predicts that there is no change in the exchange rate, i.e., there is

[3] Based on the interest rate parity, the forward rate may be expressed as the logarithm of the exchange rate times the ratio $(1+r^*)/(1+r)$.

zero depreciation rate since

$E[\varepsilon_t] = 0.$[4]

Model 5: Random Walk With Drift. A variation of the basic random walk model is the random walk with drift. This model predicts that the future exchange rate is equal to the sum of the current exchange rate and a constant drift parameter. Thus,

$$e_{t+1} = \mu + e_t + \varepsilon_t$$

where μ is the drift parameter which is equal to the average change in the logarithm of the exchange rate. This implies a constant depreciation rate equal to μ.

Model 6: AR(1) Model. The first-order autoregressive model, or AR(1) model, is a specific form of the pure autoregressive model:

$$e_t = \alpha_0 + \Sigma\, \alpha_t\, e_{t-i} + \varepsilon_t.$$

In an AR(1) model, $p = 1$. Thus, the abovementioned general form of the autoregressive model becomes:

$$e_t = \alpha_0 + \alpha_t\, e_{t-1} + \varepsilon_t.$$

It can be noted that the AR(1) model has similarities with the random walk. The parameter α_0 represents the drift parameter and α_{t-1} is equal to one. The difference of the AR(1) is that α_{t-1} need not be equal to one. In this sense, the random walk model is a special case of the AR(1) model where α_{t-1} is equal to one.

III. COMPARING PREDICTIVE POWER: A METHODOLOGY

In this study, the predictive power of the models is measured using three statistics: mean error (ME), mean absolute error (MAE) and root mean square error (RMSE). These are computed as follows:

$$\text{ME} = \Sigma(e^A - e^f)/N$$
$$\text{MAE} = \Sigma\, |e^A - e^f|\, /N$$
$$\text{RMSE} = \{\Sigma\, (e^A - e^f)^2/N\}^{1/2}$$

where Σ is the summation operator over the forecast periods 3, 6, 12, and 24 months; e^A is the actual logarithm of the exchange rate; e^f is the forecast of the logarithm of the exchange rate and N is the total number of forecasts in the projection period.

RMSE is used as the principal criterion in evaluating the predictive power of the models; ME and MAE are used to check whether each model systematically underpredicts or overpredicts the actual logarithm of the exchange rate and to complement RMSE.

IV. EMPIRICAL FINDINGS, ANALYSIS AND CONCLUSION

Table 1 compares the predictive power of the models considered in this study. Table 2 summarizes the ranking of the different models. In the short term (i.e., three-, six- and twelve-month forecasts), the random walk model outperforms all the alternative models considered in this study. In contrast, the structural monetary model had the worst performance despite the fact that these were

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[4] The depreciation rate is approximately equal to the first difference of the logarithm of the exchange rate.

based on the actual realized values of the independent variables. The model that is based on the relative purchasing power parity theory recorded the second best performance in both the three- and twelve-month forecasts. The model that is based on the expectations theory got the second best in the six-month forecast.

For the 24-month forecast, the structural monetary model had a marked improvement in forecast accuracy. Yet, it continues to pale in comparison to the performance of the random walk model, the random walk with drift, and the purchasing power parity model.

Table 1
Predictive Power of Foreign Exchange Rate Models: A Comparison

	Actual	Model 1	Model 2a	Model 2b	Model 3	Model 4	Model 5	Model 6
Average Depreciation Rate								
3-mo	–0.25	0.96	0.83	–0.41	–0.42	0.00	1.08	–0.29
6-mo	–0.44	–0.21	0.96	–0.51	–0.92	0.00	1.08	–0.57
12-mo	0.28	0.35	0.70	0.29	–0.04	0.00	1.08	0.29
24-mo	1.07	0.43	0.41	0.97	0.87	0.00	1.08	0.97
Mean Error								
3-mo		–1.21	–1.08	0.16	0.18	–0.25	–1.32	0.05
6-mo		–0.24	–1.40	0.07	0.47	–0.44	–1.52	0.13
12-mo		–0.07	–0.42	–0.01	0.32	0.28	–0.79	–0.01
24-mo		0.64	0.66	0.10	0.21	1.07	0.00	0.10
Mean Absolute Error								
3-mo		2.46	1.08	1.65	1.06	0.90	1.32	1.27
6-mo		2.08	1.40	1.43	1.16	0.84	1.52	1.25
12-mo		2.71	1.67	2.10	2.09	1.50	1.74	1.99
24-mo		2.71	2.16	2.97	2.71	2.01	1.90	2.88
Root Mean Square Error								
3-mo		3.11	1.26	1.85	1.29	0.90	1.58	1.52
6-mo		2.54	1.57	1.60	1.41	1.02	1.78	1.47
12-mo		5.29	2.06	3.41	3.59	1.79	2.06	3.30
24-mo		6.38	4.78	9.32	8.32	4.57	4.00	9.18

Model 1 : Monetary Model
Model 2a : Purchasing Power Parity
Model 2b : Purchasing Power Parity with first order serial correlation
Model 3 : Forward Exchange Rate
Model 4 : Random Walk without drift
Model 5 : Random Walk with drift
Model 6 : AR(1) Model

Table 2
Ranking of the Foreign Exchange Rate Models' Predictive Power*

	Model 1	Model 2a	Model 2b	Model 3	Model 4	Model 5	Model 6
3-mo	7	2	6	3	1	5	4
6-mo	7	4	5	2	1	6	3
12-mo	7	2	5	6	1	3	4
24-mo	4	3	7	5	2	1	6

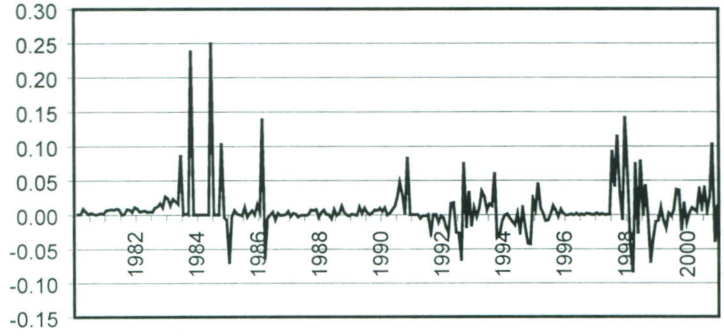
* 1: lowest RMSE; 7: highest RMSE

Inasmuch as actual values of the independent variables were used in projecting the logarithm of the exchange rate, the shortcomings of the structural models can be traced only to the limitations of its specification.

One of the key limitations of the models considered in this study is the assumption that the parameter estimates that relate the different variables remain the same regardless of the state of nature. However, it could be that there are parametric shifts when a different state sets in. (The Appendix shows graphs of selected indicators that exhibit changes in volatilities.) This is particularly true for the out-of-sample forecast period 1999-2000 when there was an increased volatility in foreign exchange rate movements (refer to Chart 2 below).

The results of this study highlight the importance of further research in regime switching models of foreign exchange rates. With the increase in the computing power of personal computers, more complex models are now easier to develop. It is worth examining the gains in forecast accuracy if the different states are acknowledged in the model.

Chart 2
First Difference of Log Exchange Rates



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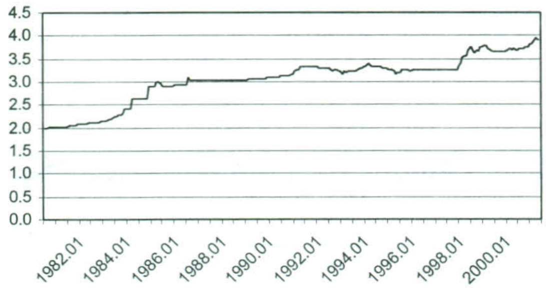
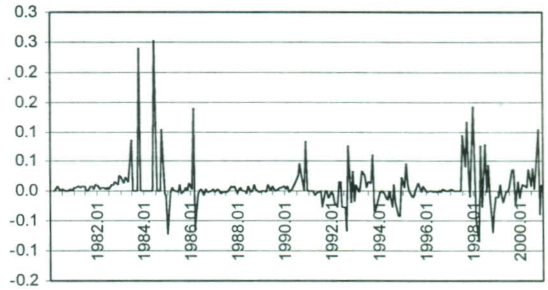
Appendix
Graphs

Log Exchange Rate

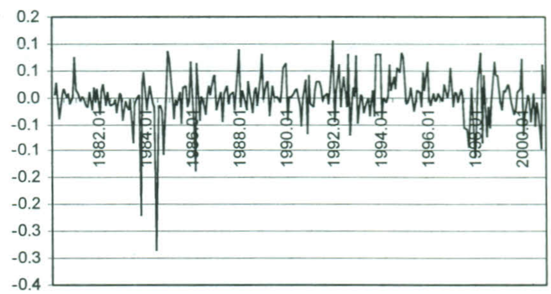


First Difference of Log Exchange Rate

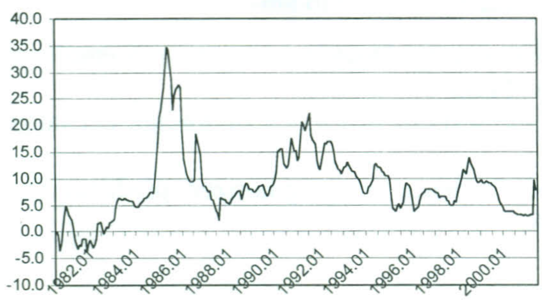


Log RPM3 - Log USM3

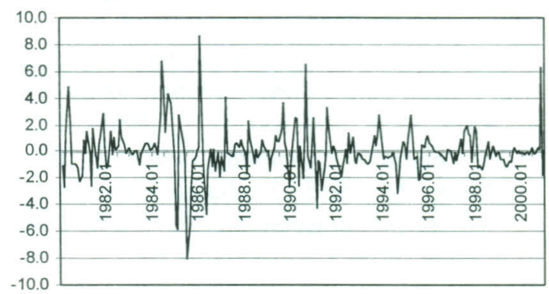
First Difference: Log RPM3 - Log USM3



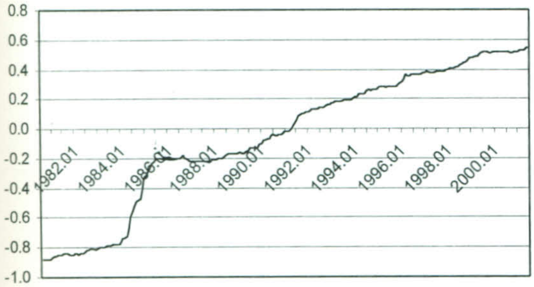
RP Interest Rate - US Interest Rate



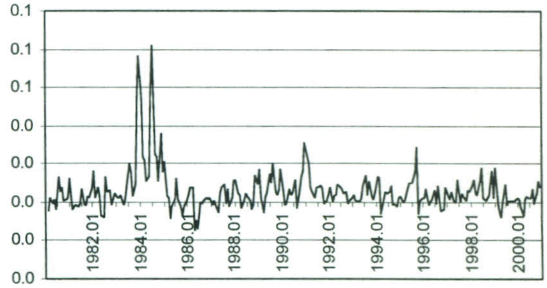
First Difference: RP Interest Rate - US Interest Rate



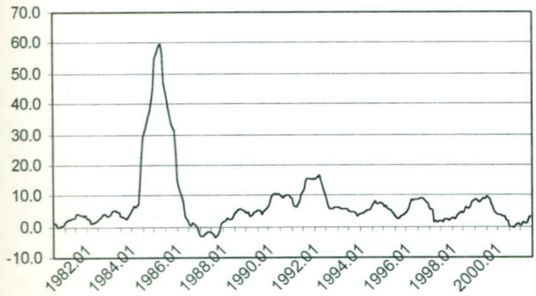
Log RPCPI - Log USCPI



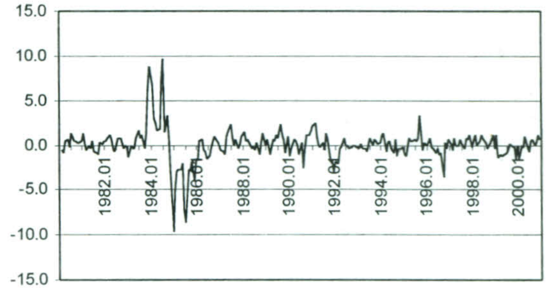
First Difference: Log RPCPI - Log USCPI



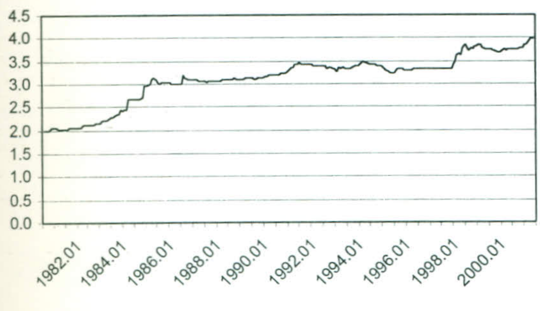
RP Inflation - US Inflation



First Difference: RP Inflation - US Inflation



Log Forward Rate: Php per US Dollar



First Difference: Log Forward Rate