This paper is a modest attempt at analyzing the exchange rate and interest rate differential dynamics in the Philippines using the Vector Error Correction (VEC) approach. Selected Asian and US Treasury rates were considered in the construction of interest rate differentials included in the VEC model. The selection of relevant foreign interest rate was made on the basis of their cointegrating relationship with Philippine Treasury rates.

Given the broad spectrum of interest rates with equally diverse term structure, this study made use of three-month Treasury bill rates and five-year Treasury bond rates. Most analyses on interest rate differential were anchored on the US interest rate as the de facto foreign interest rate. However, as emphasized by Bautista (2006), regime shifts in exchange rate policy among developing countries were the norm. Among Asian countries, dramatic shifts transpired after the 1997 Asian crisis, which drove most of the East Asian countries to a freely falling status.

Continuing interest on exchange rate-interest rate differential dynamics also has to do with the consequent impact of exchange rate movements on domestic inflation. In fact, Amato et al (2005) notes that among industrial economies, exchange rate generally enters into the decisions of policymakers only by the magnitude of its impact on expected inflation. In contrast, exchange rate can play an important role in emerging economies and this is not just limited to countries with currency boards or explicit exchange rate objectives but also extends to those that target inflation.

1. Background

Explaining and forecasting the exchange rate behavior is an arduous task, laden with measurement errors. Hence, different modeling approaches were used in analyzing the exchange rate behavior. Among these methods are the portfolio balance and monetary approach, the uncovered interest rate parity, long-term purchasing power parity model, and general-equilibrium open economy macroeconomic models (Amato, 2005).

Specifically, one of the most empirically studied concepts in understanding exchange rate behavior pertains to its relationship with interest rate differential. In analyzing the exchange rate-interest rate differential nexus, the uncovered interest rate parity (UIRP) condition, which posits that a country should expect its exchange rate to depreciate when the nominal interest rate differential widens, is the most commonly employed theoretical framework. However, the study recognizes that the choice of relevant interest rate could also be a delimiting factor given the wide array of interest rates (with different term structure) to consider. In addition, the direction of causality is not always as neat as what the theory predicts.

Empirically, under the assumption of rational expectations, UIRP is always tested in a form of equality between actual change in spot exchange rate and interest rate differential where the coefficient of the latter is expected to be positive with a value of one (Flood and Rose, 2001). Most of the empirical findings based on unbiased forward rate hypothesis point to negative relationship, implying violation of the UIRP in the data.

The UIRP relationship also predicts that for a given foreign interest and expected level of exchange rate, an increase in domestic interest rates leads to an actual appreciation of the exchange rate. This portfolio substitution effect is what motivates the interest rate defense of the currency. With an assumption of no shocks on expected level of exchange rate, the UIRP actually predicts a negative relationship. Thus, analysis using the UIRP condition has to do with whether a policy-induced rise in the interest rate leads to the (desired) exchange rate appreciation or if it leads to what is termed in the literature as the “perverse” effect of depreciating the currency (Bautista, 2004).

An important point was raised by McCallum (1992) in his re-examination of the outstanding issues
and evidence on the UIRP relation. McCallum averred that while the evidence from much of the representative studies is inconsistent with the unbiasedness of the forward rate, such evidence does not automatically translate into rejection of the UIRP. Accordingly, he pointed out that the most convincing explanation for the failure of the unbiasedness test is actually consistent with the UIRP itself, i.e., systematically irrational expectations and policy response hypothesis, which reflects the tendency of policymakers to resist rapid changes in the exchange rates by manipulating the main monetary policy instrument, the short-term interest rate. When the exchange rate tends to rise, policy will be a bit more expansionary. This policy response will manifest as a fall of domestic interest rate. This rationale is considered as having provided the most convincing conceptual appeal for the consistency between UIRP and the failure of the unbiasedness test.

The UIRP framework, therefore, implies that if the hypothesized relationships hold, any policy-induced hike in domestic interest rate under the scenario of speculative pressure is ineffectual as it is offset by larger expected currency depreciation. Since rational investors are aware of such policy maneuver, there is no advantage to domestic securities (Flood and Rose, 2005). Bautista (2004), citing the revisionist view, explained that currency depreciation results when a very high interest rate leads to widespread firm bankruptcies that disrupt overall economic activity, thereby, raising the country risk premium. The ensuing capital flight then leads to a depreciation of the currency.

In addition, interest on exchange rate-interest rate differential dynamics also has to do with the consequent impact of exchange rate movements on domestic inflation. The weight of exchange rate in monetary policy has been noted to be largely defined by the magnitude of the pass-through impact on domestic inflation such that countries that experience high pass-through typically tend to put greater emphasis on the exchange rate in their monetary policy framework. The observed weakening of exchange rate pass-through in an environment with low and stable inflation led to a shift of emphasis towards interest rate channels and the influence of the output gap. However, the exchange rate remains an important, though less significant, transmission channel for monetary policy in the medium-term orientation of monetary policy (Amato, 2005). In contrast, the findings of Kapur (Reserve Bank of India, 2004) support the usefulness of using monetary policy in stabilizing foreign exchange markets (i.e. monetary tightening generates a large exchange rate appreciation).

Recognizably, even among countries with low pass through, monetary policy intervention may be justifiable in reducing exchange rate volatility in certain circumstances, that is, when it is clearly inconsistent with the fundamentals and when intervention does not pose a threat to achieving the inflation target.\(^4\)

II. Empirical Methodology

For the empirical analysis undertaken, the Vector Error Correction (VEC) methodology was chosen over Ordinary Least Squares (OLS) method. In view of the inherent simultaneity between exchange rate and interest rate, the VEC has the novelty of conveniently dispensing with the strong \textit{a priori} distinction between exogenous and endogenous variables required in the usual structural models.\(^5\)

The VEC is a restricted Vector Autoregression (VAR) designed for use with non-stationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustments. The cointegrating term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. The ordering is given by the UIP specification: exchange rate depreciation, short-term interest rate differential (3-month Treasury bill rate) and long-term interest rate differential (5-year Treasury bond).

The long run relationship is expressed in reduced form where each variable is regressed on lagged values of both itself and all other variables in the system. Hence, the system is modeled by Vector Autoregression (VAR) procedure where individual equation is estimated using ordinary least squares.:

\[
Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \ldots + A_k Z_{t-k} + \varepsilon_t
\]

for \( t = 1, 2, \ldots, k \)

where \( Z_t \) is a vector of non-stationary variables, then all terms expressed in differences \( \nabla Z_t \) are I(0) while \( \nabla Z_{t-k} \sim I(0) \) if there exists up to \( (n-1) \) cointegrating relationships such that \( D \) has a reduced rank \( r < (n-1) \).
\[ \mathbf{V} \mathbf{Z}_t = \Gamma_1 \mathbf{V} \mathbf{Z}_{t-1} + \Gamma_2 \mathbf{V} \mathbf{Z}_{t-2} + \ldots + \Gamma_k \mathbf{V} \mathbf{Z}_{t-k} + \Pi (\mathbf{Z}_{t-k}) + \mu_t \]

where \( \mathbf{Z}_t = \begin{pmatrix} 3 \times 1 \end{pmatrix} \) vector consisting of change in exchange rate depreciation (DLEXRATE), short-term interest rate differential (DINT) and long-term interest rate differential (DBOND); and \( \mu_t \sim N(0, \Sigma) \).

The system above contains information on both the short-run and long-run adjustment to changes in \( \mathbf{Z}_t \) thru estimates of \( \Gamma_i \) and \( \Pi \), respectively. Once the long-run relations has been achieved using the Johansen, it is then possible to reformulate the model using the VEC with error correction terms explicitly included:

\[ \mathbf{V} \mathbf{Z}_t = \Gamma_1 \mathbf{V} \mathbf{Z}_{t-1} + \Gamma_2 \mathbf{V} \mathbf{Z}_{t-2} + \ldots + \Gamma_k \mathbf{V} \mathbf{Z}_{t-k} + \alpha (\mathbf{e}_{t-k}) + \mu_t \]

In operational terms, the groundwork for VEC estimation entailed the following procedures:

(i) Establishing if the series of interest (i.e., exchange rate depreciation, short-term interest rate differential and long-run interest rate differential) have unit root.

(ii) Specifying the unrestricted VAR to identify appropriate number of lags.

(iii) Based on the unit root test and identified number of lags, establish presence of cointegrating relationship.

(iv) If cointegrating relationship exists, proceed to analyzing short-term dynamics via Vector Error Correction (VEC) estimation method.

Description of Data used in the Analysis

In view of the theoretical precept that purchasing power parity (PPP) relationship is a long-run phenomenon, hence, not likely to hold in the short-run, exchange rate movement was analyzed vis-à-vis nominal interest rate differential. While the UIRP serves as the theoretical framework, the actual specification of the VEC model used in this study is not a strict UIRP specification as it contains both short-run and long-run interest rate differentials. This modification is intended to capture, though in a limited scope, the recent variants of UIRP specification (e.g. Lothian and Wu (2002) and Chinn and Meredith (2004) that looked into long-run UIRP relationship using long-run interest rates over longer time horizon. The paucity of long-run Philippine Treasury rate data limits this study to an examination of only the more recent data, which, incidentally, capture the policy shift to inflation targeting framework.

Monthly series for exchange rate, domestic interest rate and foreign interest rates, spanning the period 2001-2005, were used. Short-term interest rates were represented by 91-day Treasury bill rate. Long-term interest rates were represented by the five-year government bond yield series.

The choice of 2001 as the beginning date was due to the availability of a more complete series for five-year Philippine Treasury bond rate.

III. Estimation Results

In using the VEC approach, it is essential to establish first the stationarity of variables. Both the Augmented Dickey Fuller and Philips Perron tests of stationarity showed that only the exchange rate depreciation series (DLEXRATE) is stationary whereas all measures of interest rate differential have unit root or are integrated of order one, I(1).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Augmented Dickey Fuller Test</th>
<th>Philips-Perron Test</th>
<th>Order of Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLEXRATE</td>
<td>-7.284371***</td>
<td>-7.26019 ***</td>
<td>I(0)</td>
</tr>
<tr>
<td>DINT_US</td>
<td>-1.053437</td>
<td>-1.125834</td>
<td>I(1)</td>
</tr>
<tr>
<td>DINT_LIBOR</td>
<td>-1.171434</td>
<td>-1.107885</td>
<td>I(1)</td>
</tr>
<tr>
<td>DINT_HK</td>
<td>-1.502195</td>
<td>-1.54845</td>
<td>I(1)</td>
</tr>
<tr>
<td>DINT_MAL</td>
<td>-2.05206</td>
<td>-2.766271</td>
<td>I(1)</td>
</tr>
<tr>
<td>DINT_TH</td>
<td>-1.676859</td>
<td>-1.335634</td>
<td>I(1)</td>
</tr>
<tr>
<td>DINT_SG</td>
<td>-1.148631</td>
<td>-1.100351</td>
<td>I(1)</td>
</tr>
<tr>
<td>DBOND_US</td>
<td>-2.571029</td>
<td>-2.587771</td>
<td>I(1)</td>
</tr>
<tr>
<td>DBOND_HK</td>
<td>-3.539165**</td>
<td>-2.991734**</td>
<td>I(1)</td>
</tr>
<tr>
<td>DBOND_MAL</td>
<td>-2.147506</td>
<td>-2.099529</td>
<td>I(1)</td>
</tr>
<tr>
<td>DBOND_TH</td>
<td>-1.555376</td>
<td>-1.430168</td>
<td>I(1)</td>
</tr>
<tr>
<td>DBOND_SG</td>
<td>-2.269547</td>
<td>-1.913559</td>
<td>I(1)</td>
</tr>
</tbody>
</table>

* significant at 10% level of significance
** significant at 5% level of significance
*** significant at 1% level of significance

Sources of data: CEIC database, various central banks, Bloomberg

Since the VEC specification applies only to cointegrated series, Johansen cointegration test was conducted. The trace and maximum eigenvalue tests indicated the presence of cointegrating relations at the five percent level of significance with the US and original ASEAN member countries. This could be a reflection of the investors’ herd behavior.
Impulse Response Function

In general, the impulse response functions (IRF) from the VEC shows that a rise in both short-term and long-term interest rate gaps results in negligible appreciation that bottoms out on the second month and reverses itself afterwards (Figure 1, first row). This suggests that an interest rate defense of the exchange rate is futile even during normal times. Moreover, the results seem to support the contention made by Lothian and Wu (2002) that large interest rate differentials have stronger forecasting powers for currency movement than small differentials.

Table 2
Results of Johansen Cointegration Test with UIP Specification Using Different Measures of Interest Rate Differentials

<table>
<thead>
<tr>
<th>Interest Rate Differential</th>
<th>Lag Structure</th>
<th>Trace Statistic</th>
<th>Maximum Eigenvalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HongKong</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Singapore</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thailand</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Cholesky Ordering: DLEXRATE DINT DBOND

On the other hand, interest rate differentials respond more strongly to shocks on the exchange rate as shown by steeper response of short-term interest rate differentials to a shock on exchange rate. The same response is observed in long-term interest rates, except when measured vis-à-vis Indonesia’s Treasury bond rates (Figure 1, second and third rows). This probably reflects the extent of foreign debt service requirements of the national government whenever there is a currency depreciation, requiring higher borrowings from the market.

Figure 1
Impulse Response Functions

UNITED STATES
Response of Cholesky One S.D. Innovations

[Graphs showing impulse response functions for the United States]
MALAYSIA

Response of Cholesky One S.D. Innovations

Response of DLERATE to DINT MAL

Response of DINT MAL to DLERATE

Response of DINT MAL to DBOND MAL

Response of DBOND MAL to DINT MAL

INDONESIA

Response of Cholesky One S.D. Innovations

Response of DLERATE to DINT IND

Response of DINT IND to DLERATE

Response of DINT IND to DBOND IND

Response of DBOND IND to DINT IND
Interestingly, there appears to be an apparent substitution between assets with short-term and long-term maturity, except for Indonesia. Specifically, shock on Philippine government bond yield leads to lagged increase in short-term interest differential beginning the second month and lasts until the fourth month. In contrast, a shock on short-term interest rate differential brings about an immediate rise in long-term interest rate differential, which immediately narrows down thereafter. This seems to indicate that a rise in long-term rate reflects more strongly the expectation of an exchange rate depreciation whereas the opposite holds for a rise in short-term rate. In this aspect, the long-term bond rates reflect more expectations about future risks. The atypical response of long-term rate differential measured vis-à-vis Indonesia’s may be due to differing fundamentals that are driving expectations about future risks.

**Variance Decomposition**

The above observation is supported by the results of variance decomposition analysis which shows the relative importance of each random shock in affecting the endogenous variables. Variation in exchange rate is due mostly to own innovations whereas variance in the interest rate differentials is explained by shock on the exchange rate (refer to Figure 2 for DLEXRATE, Figure 3 for DINT and Figure 4 for DBOND).

![Figure 2: Variance Decomposition-Exchange Rate Depreciation (DLEXRATE)](image-url)
Figure 3
Variance Decomposition-Short-Term Interest Rate Differentials (DINT)

Figure 4
Variance Decomposition-Long-Term Interest Rate Differentials (DBOND)
IV. Conclusion/Main Findings

Given the inherent simultaneity between the interest rate and exchange rate, VEC has the advantage of not having to specify *a priori* distinction between exogenous and endogenous variables.

Preliminary results indicate broad validity of the UIRP condition for the Philippines where the expectation of a depreciation leads to higher interest rate differentials. With regard to the response of the exchange rate to a shock on interest rate differential, an increase in domestic interest rate, holding foreign interest rate constant, results in negligible appreciation that bottoms out on the second month and reverses afterwards. The implication is that an interest defense of the exchange rate is effective only if it is credible and if the shock on the differentials is large.

Nonetheless, as the nuances of exchange rate determination remain complicated, the initial results will have to be validated by further tests before concrete policy implications can be drawn definitively. It may be important to note that the exchange rate movement has been observed to exhibit greater volatility than the economic variables on which they depend such as domestic and foreign money supplies, price levels, real incomes and balance of payments. In addition, short-run exchange rate movement is highly susceptible to economic and political noises.

A possible extension to the analysis is to include other variables that affect the exchange rate. Specifically, an examination of how the exchange rate responds to changes in the determinants of money demand and money supply, as embodied in the monetary approach to exchange rate determination, may be looked into.

Further, since the short-run horizon is observed to be characterized by non-flexible prices, the sticky price assumption may have to be built into the monetary framework for exchange rate determination. With these assumptions, the monetary approach predicts the coefficients of money supply and inflation to be positive and that of real income to be negative. The coefficient of interest rate differential depends on the interaction among the various economic variables included in the model. If the country is experiencing a high inflationary process, the sign is expected to be positive whereas a relatively low inflation in a capital market that is highly sensitive to interest rate changes, the coefficient of interest rate differential is expected to be negative (Tucker, 1992). One limitation though in the use of the VEC approach is that it would require a large sample size since there will be more parameter values that need to be estimated.
This preliminary paper is part of the working paper series of the BSP Center for Monetary and Financial Policy (CMFP). The authors would like to thank CMFP OIC-Director Dr. Francis Dakila and Dr. Carlos Bautista of the College of Business Administration, University of the Philippines for their insightful comments. Nonetheless, the views expressed herein and errors are solely those of the authors.

1 Amato et al. (2005) identified key factors that underpin the weight of exchange rate in the monetary policy framework. These include the impact of exchange rate movements on domestic inflation, the source of shocks, credibility, the volatility of capital flows, and financial and structural reforms. However, concern has largely been focused on the impact of exchange rate on domestic inflation.

2 The existence of a forward premium bias in the usual UIRP test specification was traced to the risk averse behavior of economic transactors (Fama, 1984). Studies by Fama (1984), Frankel and Froot (1989), Froot and Thaler (1990), Lewis (1995), Engel (1996) and Malliaropulos (1997) underscored the existence of time-varying risk premium as compensation for the speculative position in the foreign currency. Chaboud (2003) ascribed UIRP’s empirical failure to “peso problems, learning effects, expectational errors and the existence of risk premium.” On the other hand, the study by Francis and Hasan (2002) examined the impact of emerging market liberalization on the UIRP. Their findings indicate that generally, deviation from UIRP in emerging markets is systematic in nature, and that a significant part of emerging market currency excess returns is attributed to time-varying risk premium. Steele and Wright (2000) attributed the empirical failure of UIRP to both foreign exchange risk premium and forecasting errors. Interestingly, a growing number of literature that lend credence to the validity of UIRP have emerged in the more recent past. Another variant of the UIRP literature examined the proposition that UIRP is a long-run relationship, characterized by temporary short-run exogenous shocks. Among the approaches used to extract long-run relationship were long horizon regressions (Lothian and Wu, 2002) and Chinn and Meredith, 2004), cointegration analysis (Moosa and Bhatti 1995), and stationarity test on ex-post UIRP deviations (Tanner and Evan, 1998).

3 Citation made by Amato et al and attributed to an unpublished paper of Munro and Spencer (2004) of the Reserve Bank of New Zealand.

4 Estimation was done using E-views 5.0

5 The money demand function is positively affected by prices and real income and negatively affected by interest rates.
REFERENCES


