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ALTERNATIVE EXCHANGE RATE THEORIES:
AN EMPIRICAL INVESTIGATION

By

Joon-Ho Lee
Basudeb Biswas
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An Empirical Investigation

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&

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Session 153, Wednesday, June 23, 1993
2:30-4:15 p.m. Exchange Rate Models
I. INTRODUCTION.

During the fixed exchange rate regime which ended in 1973, maintenance of external balance was one major concern of policy makers. With the shift to a system of floating exchange rates among major currencies in 1973, there was a shift of emphasis from the external balance to the exchange rate determination. There is substantial evidence about the greater variability of both the nominal and the real exchange rate after 1973.

As an example, Figure 1 shows quarterly change in the bilateral real and nominal dollar-Deutsche mark exchange rate for the period 1959 to 1991. The observed volatility in the movement of both real and nominal exchange rate since early 1970s is generally attributed to the floating exchange rate system. The dollar was increased by 40-50 percent over the period 1973 to 1985. Accordingly, the volatility of the exchange rate has become a dominant theme in policy discussions. Economists have been trying to explain the fluctuation of the exchange rate without much success.

Dornbusch (1990) asserts that "the dollar movements of the 1980s are to open economy macroeconomics what the Great Depression has been to Macroeconomics - a baffling, largely unexplained phenomenon". Attempts have been made to explain the movement of the exchange rate both theoretically and
empirically over the last 20 years. But most of the models could not give a satisfactory explanation of the real exchange rate movement. Different approaches give different explanation and suggest different policies. The purpose of this paper is to test the competing models of different approaches.

The paper is organized as follows. Section 2 reviews the
theories of exchange rate determination. Of the alternative models explaining the volatility of the exchange rate, we briefly mention the monetary approach and the Mundell-Fleming model. Section 3 discusses the econometric issues associated with the empirical testing in the time series model and reports the results. Conventional econometric modeling (structural model), based on some theory suffers from a priori restrictions on the model. One "atheoretical" model that we use in this paper is the vector autoregression (VAR) model. Before examining the relationship among the variables, we need to test for stationarity of individual variables. After testing for stationarity, we look into the long-run relationship by testing for cointegration. Cointegration identifies the long-run relationship among the variables. Next, we consider a class of models known as the error correction model to study the short-run dynamics. We will use variance decomposition to determine how much of the variation in the data can be attributed to innovations in the different variables. Impulse response of the model to a one standard deviation shock can be drawn to identify the dynamics of the model. Section 4 gives the concluding remarks.
II. A BRIEF REVIEW OF TWO MODELS OF EXCHANGE RATE DETERMINATION: THE MUNDELL-FLEMING MODEL AND THE MONETARY MODEL

The Mundell-Fleming model introduced capital mobility to the Keynesian approach to the balance of payments. According to the Mundell-Fleming model, any increase in the money supply translates into real output changes. The higher level of income and capital outflow leads to a trade deficit at a given exchange rate. The exchange rate must depreciate to generate the equilibrium in the balance of payments equation.

Fiscal expansion induces an increase in the interest rate which generates an incipient capital inflow and the trade deficit because of the increase in income but the overall balance will be in deficit. Trade deficit requires the exchange rate to depreciate.¹

One particular specification of the monetary approach to the exchange rate determination (Frankel, 1983) is given below. Assuming the PPP condition and uncovered interest rate parity condition, the monetarist equation of the exchange rate determination can be identified as:²

---

¹ With the assumption of perfect capital mobility the capital inflow will result in over all trade surplus.

² Early monetarist model has been developed by Frenkel(1976), Mussa(1976) and Dornbusch(1976).
\[ e = (m - m^*) - \Phi(y - y^*) + \lambda(\psi \Delta p - \psi \Delta p^*) \]  \hspace{1cm} (1)

where \( e \) is the log of the exchange rate, \( m \) is the log of the domestic money supply, \( p \) is the log of the domestic price level, \( y \) is the log of domestic real income, \( i \) is the domestic interest rate, \( \Phi \) is the money demand elasticity with respect to income and \( \lambda \) is the money demand semielasticity with respect to the interest rate. Asterisks represent foreign variables. Other things constant, the relative increase in the supply of money \((m - m^*)\) and increase in expected inflation rate \((\Psi \Delta p - \Psi \Delta p^*)\) depreciate the exchange rate. The relative increase in the domestic level of income \((y - y^*)\) will appreciate the exchange rate.

One variant of above model is the over-shooting model of Dornbusch (1976). In the contracting approach, stickiness of nominal prices resulting from existing nominal contracts may necessitate "overshooting" of nominal exchange rate in response to unanticipated monetary changes. In the long run, given increase in the money supply raises the exchange rate proportionately as in the monetarist model. In the short run, the interest rate falls, generating an incipient capital outflow, which causes the currency to depreciate
instantaneously more than the long run level.³

In explaining the movement of the bilateral exchange rate between two currencies, changes in the relative income and the interest rate differential are regarded as the two important macroeconomic variables. However, from the theoretical point of view, their impact on the exchange rate is quite different and it depends on the model of the exchange rate that is used for the purpose. For example, in the Mundell-Fleming model, an increase in the domestic income level causes a depreciation of the currency. This result follows from the positive relation between the domestic income and the demand for imports. An increase in the domestic income causes an increase in imports. The demand for foreign currency increases and this results in the depreciation of the currency. In the monetary model, an increase in income means that the demand for money increases and hence there is less demand for goods. A reduction for imports causes a decrease in demand for foreign currency. As a result, the domestic currency appreciates. An increase in the interest rate differential, in the context of the monetary model, will cause investors to shift out of the domestic currency because of the increased expected depreciation; thus causing the exchange rate to depreciate. In this context, a high interest rate is

³ This model can be regarded as the Mundell-Fleming model in the short-run and the monetary model in the long-run.
not a sign of strength of a currency, rather it reflects expected future depreciation and is thus a sign of weakness. Within the frame work of the Mundell-Fleming model, an increase in the interest rate differential will cause the incipient capital inflow and thus the trade surplus. Trade surplus requires the exchange rate to appreciate.

In view of the divergent theoretical results, we use the VAR model to see what light the empirical results shed on the issues.

III. METHODOLOGY.

A. ECONOMETRIC ISSUE.

Conventional dynamic simultaneous equations models suffer from arbitrary classification of endogenous and exogenous variables and have to impose some constraints on the parameters to achieve identifications. As an alternatives, we use a vector autoregression model\(^5\) which expresses the current values of the endogenous variables solely as a function of the lagged values of the endogenous variables. This implies that all variables are endogenous and that the only equations that can

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\(^5\) For further discussion of VAR, see Sims (1980) and Cooley & Leroy (1985).
be estimated are reduced form equations in which the exogenous variables are all lagged values of the endogenous variables.

We select five variables for the empirical study of nominal exchange rate. Those are the money supply, the level of income, the price level, the interest rate and the balance of trade. We mainly concentrate on the effects of four variables, namely the money supply, the level of income, the level of price and the interest rate.

We adopt a slightly modified variation of the empirical model of "real interest rate differential equation" used by Frankel (1979, 1983), and present our model in the vector autoregression form:

\[ Y_t - A_1 Y_{t-1} + \cdots + A_l Y_{t-l} + \epsilon_t \]  \hspace{1cm} (2)

where \( l \) is number of lags, \( \epsilon_t \) is 5x1 vector and \( A_1, \ldots, A_l \) are 5x5 matrices of constants to be estimated. \( Y_t \) is a 5x1 vector, 

\[ Y_t = ( Y_{1t}, Y_{2t}, Y_{3t}, Y_{4t}, Y_{5t} ), \]

where

\( Y_{1t} = \log \) of exchange rate (e),
\( Y_{2t} = \log \) of relative national income (y),
\( Y_{3t} = \log \) of relative money supply (m),
\( Y_{4t} = \log \) of relative price level (p),
\( Y_{5t} = \) interest rate differential (i).
We have chosen U.S. and Germany as our countries of case study. We will use quarterly data starting from the third quarter of 1973 ending the fourth quarter of 1991. All data sets are obtained from various issues of International Financial Statistics (IMF). The nominal exchange rate used is the end of period U.S. Dollar per Deutsche Mark spot rate. The money supply is obtained from the seasonally adjusted M1 for both country. The price level used is the consumer price index with 1985=100 as the base year for both country. The index of gross national product (GNP) is used for the level of national income. We used long-term government bond interest rate for interest rate.

B. EMPIRICAL TESTING.

Unit-Root and Cointegration.

The concept of stationarity and co-integration is an important one in constructing the VAR model. The co-integration test gives a theoretical basis for imposing some restrictions on the VAR model whether they should be in levels or in first differences or in both with some restrictions.
Economic time series are often modeled as having a unit root in their autoregressive representation or (equivalently) as containing a stochastic trend. But both casual observation and economic theory suggest that many series might contain the same stochastic trends so that they are cointegrated. If each of n series is integrated of order 1, I(1), but can be jointly characterized by k<n stochastic trends, the vector representation of these series has k unit roots and n-k distinct stationary linear combinations. The cointegrated variables represent the long-run relationship and the short-run dynamics can be described by the vector error correction model.\(^6\) If some of the variables in VAR model are cointegrated, this implies that we need to impose that restrictions on that model. It has been found that predictions from the VAR model improved with the restrictions imposed according to cointegrating relations.\(^7\)

A simple method of testing unit root is the augmented Dickey-Fuller test. In the general case this regression can be written as:

\[
\Delta Y_t - \alpha_0 + \alpha_1 T + \alpha_2 Y_{t-1} + \sum_{i=0}^{p} \beta_i \Delta Y_{t-i} + \varepsilon_t, \tag{3}
\]

\(^6\) See Engle and Granger(1987) for Granger representation theorem.

\(^7\) For more discussion, see Phillips(1991) and Engle and Yoo(1987)
where $\epsilon_t$ are assumed to be identically and independently distributed random variables. The various test statistics proposed in Fuller (1976, P373) and Dickey-Fuller (1979, 1981) are reported in Table.1 for all series.

The statistic $\hat{\xi}_t$ is proposed in Dickey-Fuller (1979) for testing $\alpha_0=0$ in equation 3 and the table is proposed in Fuller (1976). The statistic $\hat{\phi}_2$ and $\hat{\phi}_3$ are proposed in Dickey-Fuller (1981, P1063) for testing the hypotheses $(\alpha_0=\alpha_1=\alpha_2=0)$ and $(\alpha_1=\alpha_2=0)$ in equation 3. For all of the series, the results indicate that we fail to reject the null hypothesis of a unit root at a significance level of 10%. Based on these results, we conclude that all series are non-stationary and are characterized as random walk.

**TABLE 1**

Results are reported for a lag truncation parameter=4.

<table>
<thead>
<tr>
<th>variables</th>
<th>$\hat{\xi}_t$</th>
<th>$\hat{\phi}_2$</th>
<th>$\hat{\phi}_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>-2.3066</td>
<td>1.9603</td>
<td>2.6629</td>
</tr>
<tr>
<td>y</td>
<td>0.57324</td>
<td>2.6429</td>
<td>2.7365</td>
</tr>
<tr>
<td>i</td>
<td>-1.6859</td>
<td>3.5941</td>
<td>5.3414</td>
</tr>
<tr>
<td>p</td>
<td>-1.4539</td>
<td>1.5004</td>
<td>1.6452</td>
</tr>
<tr>
<td>m</td>
<td>-1.4285</td>
<td>0.97973</td>
<td>1.2680</td>
</tr>
</tbody>
</table>

The 90% point of the distribution for $\hat{\xi}_t$ for the sample size 69 falls between -1.19 and -1.22. The 90% point of the distribution for $\hat{\phi}_2$ and $\hat{\phi}_3$ fall between (4.31 and 4.16) and (5.61 and 5.47).
Although individual series that contain stochastic trends are nonstationary in their levels, if the stochastic trends are common across series there will be stationary linear combination of the levels. Several different strategies are available for uncovering long-run relationships in a set of time series. Engle and Granger (1987) suggest to estimate the cointegrating vector by ordinary least square and test for the unit root in residual of that relationship. Another possible strategy is to employ the method using maximum-likelihood estimation in the context of the vector error correction model (Johansen 1988, Johansen and Juselius 1990).

Because the results of the Engle-Granger can change with the variables chosen as dependent variable, we performed the test with each variable on the right-hand side. The test result reject the hypothesis of any cointegration between any combination of the variables with and without trend term. TABLE 2 and TABLE 3 report the results of the loglikelihood ratio test based on the eigen value and the trace of the stochastic matrix. It is not clear how one decides the number of cointegrating vectors based on these results. From the results of the test based on eigenvalue, we may conclude that there's at least one cointegrating relationship. The test based on the trace accepts the null hypothesis that the number of cointegrating vector is smaller than equal to two ($r \leq 2$) at 95% critical value. The null hypotheses $r \leq 3$ and $r \leq 4$ can not
be rejected at 90% critical value. Based on these results, we could conclude that there's at least one and up to three

**TABLE 2**

Test Based on Maximal Eigenvalue of the Stochastic Matrix

<table>
<thead>
<tr>
<th>List of variables included in the cointegrating vector:</th>
<th>EXCH</th>
<th>M1</th>
<th>Y</th>
<th>P</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of eigenvalues in descending order:</td>
<td>.41014</td>
<td>.29469</td>
<td>.18055</td>
<td>.13878</td>
<td>.035160</td>
</tr>
<tr>
<td>Null Alternative</td>
<td>Statistic</td>
<td>95% Critical</td>
<td>90% Critical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r = 0</td>
<td>r = 1</td>
<td>36.9511</td>
<td>33.4610</td>
<td>30.9000</td>
<td></td>
</tr>
<tr>
<td>r &lt;= 1</td>
<td>r = 2</td>
<td>24.4382</td>
<td>27.0670</td>
<td>24.7340</td>
<td></td>
</tr>
<tr>
<td>r &lt;= 2</td>
<td>r = 3</td>
<td>13.9384</td>
<td>20.9670</td>
<td>18.5980</td>
<td></td>
</tr>
<tr>
<td>r &lt;= 3</td>
<td>r = 4</td>
<td>10.4582</td>
<td>14.0690</td>
<td>12.0710</td>
<td></td>
</tr>
<tr>
<td>r &lt;= 4</td>
<td>r = 5</td>
<td>2.5055</td>
<td>3.7620</td>
<td>2.6870</td>
<td></td>
</tr>
</tbody>
</table>

Maximum lag in VAR=4.

**TABLE 3**

Test Based on Trace of the Stochastic Matrix

<table>
<thead>
<tr>
<th>List of variables included in the cointegrating vector:</th>
<th>EXCH</th>
<th>M1</th>
<th>Y</th>
<th>P</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of eigenvalues in descending order:</td>
<td>.41014</td>
<td>.29469</td>
<td>.18055</td>
<td>.13878</td>
<td>.035160</td>
</tr>
<tr>
<td>Null Alternative</td>
<td>Statistic</td>
<td>95% Critical</td>
<td>90% Critical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r = 0</td>
<td>r &gt;= 1</td>
<td>88.2914</td>
<td>68.5240</td>
<td>64.8430</td>
<td></td>
</tr>
<tr>
<td>r &lt;= 1</td>
<td>r &gt;= 2</td>
<td>51.3403</td>
<td>47.2100</td>
<td>43.9490</td>
<td></td>
</tr>
<tr>
<td>r &lt;= 2</td>
<td>r &gt;= 3</td>
<td>26.9021</td>
<td>29.6800</td>
<td>26.7850</td>
<td></td>
</tr>
<tr>
<td>r &lt;= 3</td>
<td>r &gt;= 4</td>
<td>12.9638</td>
<td>15.4100</td>
<td>13.3250</td>
<td></td>
</tr>
<tr>
<td>r &lt;= 4</td>
<td>r = 5</td>
<td>2.5055</td>
<td>3.7620</td>
<td>2.6870</td>
<td></td>
</tr>
</tbody>
</table>

Maximum lag in VAR=4.
conointegrating vectors. We obtained results based on the hypothesis that there are three (r=3) conointegrating vectors.

The conointegrating vectors based on the Johansen test are obtained and reported in TABLE 4. If there is only one conointegrating vector, it is easy to interpret. When there are more than one conointegrating vectors, it causes problems in interpretation and it is hard to give plausible economic meaning on that relationship. According to Maddala (1992, p596) --"this is not surprising because conointegration is purely statistical concept based on properties of the time series considered -- conointegrated relationship need not have any economic meaning". However, "conointegrating vectors can be thought of as representing constraints that an economic system imposes on the movement of the variables in the system in the long-run. Consequently, the more conointegrating vectors there

<table>
<thead>
<tr>
<th>variables</th>
<th>vector 1</th>
<th>vector 2</th>
<th>vector 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>m</td>
<td>-.52391</td>
<td>.15307</td>
<td>-3.9802</td>
</tr>
<tr>
<td>y</td>
<td>-1.3318</td>
<td>-1.9377</td>
<td>10.8248</td>
</tr>
<tr>
<td>p</td>
<td>2.8475</td>
<td>.85452</td>
<td>-8.6105</td>
</tr>
<tr>
<td>i</td>
<td>-.017305</td>
<td>.092903</td>
<td>-.06838</td>
</tr>
</tbody>
</table>

9 However, Johansen and Juselius (1990) note that one would expect the maximum eigenvalue test to produce more clear cut results.
are, the "more stable" the system." Hence, it could be a good sign for the economic system because the multiple cointegrating vector can be thought as the multiple direction of the economy to the long-run stable equilibrium.

We obtained residuals of each cointegrating relationship and test for the stationarity of those residuals. We could not reject the null hypothesis of unit root for the three series of residuals. Since cointegration relationship greatly improved the predictive power of VAR model, it was decided to use another strategy to identify cointegrating vectors. A priori reasoning was used to search for linear combinations of the series with economically meaningful interpretations. We test for PPP condition \((e=p)\), interest parity condition \((i=p)\) and money demand relationship \((m-p=y-i)\). The results of the tests reject the null hypothesis that there is at least one cointegrating vector for the PPP condition and the interest rate parity condition. We could identify one cointegrating vector in money demand relationship, but could not pass the unit root test with the residuals of that relationship. If a set of unit root variables, say \(n\) variables, satisfy \(r\) cointegrating relation it is appropriate to model the VAR system with \(r\) stationary relation and \(n-r\) difference of the variables. If the variables are all integrated of order one and no cointegration exists then it is appropriate to model

the VAR system as an unrestricted one with first differenced series.\textsuperscript{11} We proceed our test with unrestricted VAR model with first differenced series.

**Variance Decomposition and Impulse Response Function.**

One of the objectives of this study is to determine the relative importance of different variables in explaining the exchange rate behaviour. Variance decomposition gives the percent of the forecast error variance of the dependent variables in a VAR (for a given forecasting horizon) model attributable to innovations in another variable in the system. It is important that the VAR residuals need to be decomposed into orthogonal time series to give precise meaning. The approach proposed by Bernanke(1986) is less restrictive than the traditional Choleski decomposition. Assume that the dynamic behavior of $Y_t$ (nx1 vector) can be represented by following structural model:

$$Y_t = \sum_{i=0}^{P} B_i Y_{t-i} + \varepsilon_t$$

(4)

\textsuperscript{11} See Maddala (1992, P597).
where the structural disturbance $\epsilon_t$ is serially uncorrelated and $E(\epsilon_t\epsilon_t') = \Sigma$, a diagonal matrix. $A$ is a $n \times n$ nonsingular matrix. Under certain conditions, a reduced form of above equation relating $Y_t$ to its lagged values can be written as:

$$Y_t = \sum_{i=1}^{p} C_i Y_{t-i} + u_t$$  \hspace{1cm} (5)

where $C_i = (I-B_0)^{-1} B_i$ and $u_t$ is a serially uncorrelated vector of residuals. The vector satisfies

$$u_t = Bu_t + A\epsilon_t$$ \hspace{1cm} (6)

The conventional method of orthogonalization based on Choleski decomposition is equivalent to assuming a model of the form where $A=I$ and, from a specified ordering of the variables, $B$ is a lower triangular matrix of projection coefficient. This condition achieves orthogonalization of residuals, and we are assuming that the structural model for $y$ is strictly recursive.\(^{12}\) The last term $\epsilon_t$ is uncorrelated and can be associated with innovations in the variables of VAR, meaningful variance decomposition can be derived. The equation (6) is referred as the contemporaneous structural model because the elements of $B$ are structural parameters showing the contemporaneous relationship among the model.

The contemporaneous structural model allows the use of

\(^{12}\) This fact is criticized by Bernanke (1986).
the VAR to forecast the response of a given variable to an unanticipated one time innovation in another variable via the impulse response function. Since we didn't impose any structural restrictions on our model, we will use Choleski factorization method. Orthogonalized innovations have advantages over non-orthogonalized ones. First, it is easy to compute the variances of linear combinations of them. Secondly, it takes account of the co-movement of the other variables in the system when there is a shock to a single variable.

Table 5 reports the result of variance decomposition of a series exchange rate into the parts attributable to each of a set of innovations. Most of the variation in the exchange

<table>
<thead>
<tr>
<th>Step</th>
<th>y</th>
<th>p</th>
<th>i</th>
<th>exch</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00250</td>
<td>0.00352</td>
<td>78.58431</td>
<td>21.40653</td>
<td>0.00314</td>
</tr>
<tr>
<td>2</td>
<td>0.00578</td>
<td>0.00169</td>
<td>98.38726</td>
<td>1.56700</td>
<td>0.03828</td>
</tr>
<tr>
<td>3</td>
<td>0.01235</td>
<td>0.00165</td>
<td>98.44479</td>
<td>1.50371</td>
<td>0.03751</td>
</tr>
<tr>
<td>4</td>
<td>0.00702</td>
<td>0.00123</td>
<td>99.10587</td>
<td>0.85750</td>
<td>0.02837</td>
</tr>
<tr>
<td>5</td>
<td>0.00615</td>
<td>0.00116</td>
<td>99.21542</td>
<td>0.75249</td>
<td>0.02478</td>
</tr>
<tr>
<td>6</td>
<td>0.00598</td>
<td>0.00112</td>
<td>99.24218</td>
<td>0.72681</td>
<td>0.02391</td>
</tr>
<tr>
<td>7</td>
<td>0.00707</td>
<td>0.00121</td>
<td>99.24794</td>
<td>0.71992</td>
<td>0.02386</td>
</tr>
<tr>
<td>8</td>
<td>0.00800</td>
<td>0.00138</td>
<td>99.24446</td>
<td>0.72010</td>
<td>0.02606</td>
</tr>
<tr>
<td>9</td>
<td>0.00823</td>
<td>0.00142</td>
<td>99.24357</td>
<td>0.72001</td>
<td>0.02676</td>
</tr>
<tr>
<td>10</td>
<td>0.00825</td>
<td>0.00142</td>
<td>99.24403</td>
<td>0.71879</td>
<td>0.02751</td>
</tr>
<tr>
<td>11</td>
<td>0.00852</td>
<td>0.00144</td>
<td>99.24244</td>
<td>0.71969</td>
<td>0.02791</td>
</tr>
<tr>
<td>12</td>
<td>0.00888</td>
<td>0.00150</td>
<td>99.24112</td>
<td>0.72024</td>
<td>0.02827</td>
</tr>
</tbody>
</table>
rate is explained by the interest rate differential. At the first step, about 21% of the variance of the exchange rate is explained by its own innovations. From the second quarter, almost 99% of the variance is entirely explained by the interest rate differential. We now turn our attention to the impulse response of the variables to a specified set of shocks. Figures 2 through 5 show the expected response of individual series to the other shocks.

These figures suggest that an innovation in the money supply is associated with sharp appreciation of exchange rate, increase in the price level and an increase in the interest rate. The exchange rate then sharply depreciates at the third quarter and then it appreciates again to its long-run level. The innovation in the interest rate differential is associated with the appreciation of the exchange rate, decrease in the money supply and increase in the price level in the short-run. In the long-run, money supply increases and the price level decreases. The exchange rate will still remain low though it will depreciate somewhat before reaching its long-run level. The innovation in the level of relative income is associated with the appreciation in the exchange rate and increase in the price level. The exchange rate depreciates during the third quarter but it will appreciate again and remain low until it reaches its long-run level. The level of price and the interest rate remain high until they reach their long-run
Figure 1.

Figure 2.
Figure 3.

Figure 4.
level. The innovation in the level of price causes an appreciation of the exchange rate and an increase of the interest rate. The sharp decrease in the level of money supply is accompanied by the appreciation of the exchange rate and decrease in the interest rate. These three variables fluctuate around their long-run level, moving quite closely together, until they reach their long-run level.

One interesting phenomenon is that the adjustment of the exchange rate to its long-run level is not monotonic rather it shows the pattern of fluctuating or oscillating adjustment. The process of nonmonotonic adjustment to its long-run level does not support the view of the Dornbusch model (1976). After an increase in the money supply, the exchange rate depreciates in the first quarter by a greater amount than the long-run level. This is in support of the view of the short-run over-shooting. But the expected adjustment of the exchange rate is nonmonotonic and fluctuating. Above results coincide with the results obtained by Driskill (1981). However, depreciating exchange rate is consistent with the general view of the monetary model and contradicts the view of Mundell-Fleming model.

The expected response of exchange rate to innovation in the interest differential is consistent with the prediction of Mundell-Fleming model. In the Mundel-Fleming model with high degree of capital mobility, high interest differential
required an appreciation of the currency. In the monetarist model, through the uncovered interest parity condition, interest differential can be regarded as expected depreciation. When the expectation of depreciation is high, it causes the currency to depreciate. But even within the asset market view, this result coincides with the view of sticky price version, Dornbusch model and the real interest differential model, which is based on the Keynesian theory in the short-run.

The expected response of the exchange rate to the change in the level of income supports the view of monetarist approach to the exchange rate determination. In the monetarist model, where price is perfectly flexible and the output is in full employment level, all changes in output are changes in potential output. This change is the sign of improvement in the economy and it tends to appreciate the exchange rate. In contrast, the increase in income will increase the demand for output and this will lead to current account deficit, therefore it requires the exchange rate to depreciate in the Mundell-Fleming model. The increase in the price level is associated with the depreciation of the exchange rate as we expected.
IV. BRIEF CONCLUSION.

We test the basic model of exchange rate determination with five variables namely the exchange rate, relative money supply, relative price level, relative income level and the interest differential. All these variables are found to follow the random walk process. We could find the cointegrating vector through Johansen test but the residuals of those cointegrating relation could not pass the hypothesis of stationarity. We proceed to model un-restricted VAR with first differenced variables. Even though the result of variance decomposition was not satisfactory, we could identify a few interesting relationship between those variables through impulse response function.

The apparent contradiction between the monetarist model and the Mundell-Fleming model is about the effects of the interest differential and the national income level on the exchange rate. The test results support the view of the monetarist model in case of the increase in national income while the case of increase in the interest differential support the view of Mundell-Fleming model. But the overall result of this study generally supports the view of monetarist or, more broadly, the asset market view of exchange rate determination.
REFERENCES


