AN EMPIRICAL NOTE ON VARIOUS EXCHANGE RATE MODELS

by

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ABSTRACT

Three econometric models of exchange rate determination are constructed and used to compare the monetary and components approach to exchange rate determination. The statistical results, including dynamic multiplier analysis, tend to support the monetary approach against the components approach.
1. Introduction

Beginning with Johnson's (1968) seminal paper, and continuing through the work of Mundell (1968), Dornbusch (1973) and others, there has been a phenomenal proliferation of theoretical and empirical articles on the topic of the monetary approach to the balance of payments and exchange rate determination.\(^1\) On the one hand, the monetary approach to the balance of payments and exchange rate determination suggests that the balance of payments and the exchange rate are essentially monetary phenomena and should be analyzed as such. Like Keynes' resurrection of Malthus in the General Theory, the monetarists trace their intellectual forerunners back through Cassel and Ricardo to David Hume and his "specific flow" theory. On the other hand, one has what Magee (1976) has termed the various components approaches, which emphasize that money is usually demanded to buy some real good and, therefore, the more appropriate foci of analysis are the determinants of the demand for goods and services. Both sides of the controversy agree, however, that a general equilibrium approach taking into account the interaction of all markets is the most appropriate forum for the discussion of the determination of the exchange rate. Therefore, aside from some fundamental differences over stocks vs. flows, the main bone of contention relates to which theory does a better job of explaining exchange rate fluctuation.

The present study is an attempt to combine elements of both the monetary and components approaches to exchange rate analysis in a simple model that is flexible enough to serve as a general case of both the "pure" monetary and "pure" components models of exchange rate determination. This
is accomplished by combining a simple model already in the literature with a relationship relating the level of the exchange rate to the balance of payments. Alternate models are estimated and tested in an attempt to determine which approach is most appropriate. Finally, the general model is subjected to dynamic multiplier analysis. The results suggest that monetary factors play a key and, perhaps, even dominant role in exchange rate determination.

2. A Conceptual Model

The approach in modeling exchange rate determination here begins with an essentially monetarist model and then adds some important generalizations. However, no reliance is placed on the purchasing-power-parity hypothesis as has been the case with some earlier monetarist studies (see e.g. Frenkel (1976)). Samuelson (1964) has provided a strong criticism of the concept in all but the most trivial cases and recent empirical work, particularly that by Isard (1977), has suggested that the law of one price may not hold at the aggregate level.

First of all, the model explicitly allows for a deficit or surplus in the balance of payments. Disequilibrium in the balance of payments is, of course, dictated by the realities of the market situation. The fundamental assumption of the model is that the exchange rate responds to disequilibrium in the balance of payments. To explain why it does not move to clear the balance of payments, it should be noted that at present the floating rate regime is characterized by regulated floating of rates with governmental policy playing a key role in exchange rate determination.

To take government influence into account, it is supposed that the government has at every point in time some desired level for the exchange
rate that is a function of the overall balance of payments \( (BOP_t) \), i.e.

\[
De_t = h(BOP_t)
\]  

(1)

where \( De_t \) is the desired exchange rate and \( BOP_t \) is the balance of payments at time \( t \). To relate the unobservable desired exchange rate to observable phenomena, a Nerlovian partial adjustment process may be specified as

\[
\Delta e_t = bh(BOP_t) - be_{t-1}
\]  

(2)

where \( b \) is the factor of adjustment.

To complete the monetarist model of exchange rate determination, equation (2) is integrated into a modified version of a model originally developed by Kouri and Porter (1974), Hodlera (1976) and Artus (1976) have recently estimated variants of the original model. The model can be written as

\[
r_t = r(C_t, r^d_t)
\]  

(3)

\[
M^d_t = M^d(r_t, M_t, \gamma_t)
\]  

(4)

\[
BOP_t = BOC_t + C_t = \Delta R_t
\]  

(5)

\[
M^s_t = D_t + R_t
\]  

(6)

\[
M^s_t = M^d_t
\]  

(7)

\[
\Delta e_t = bh(BOP_t) - be_{t-1}
\]  

(8)

where \( r_t \) is the market rate of interest,

\( C_t \) is the balance on capital account,

\( r^d_t \) is the discount rate,

\( M^d_t \) is money demand,

\( R_t \) is international reserves,
BOC_t is the balance on current account,

D_t is the level of domestic credit,

M^S_t is money supply,

P_t is the general price level,

M_t is income.

Equation (3) hypothesizes that the market rate of interest is determined by the level of the capital account and governmental policy as reflected by the discount rate. Equation (4) is a simple money demand function which presumes that money demanded at time t is a function of the general price level, the market rate of interest, and income. It is essentially identical in nature, though not necessarily in functional form, to money demand functions specified in Frenkel (1976) and Magee (1976). Equation (5) recognizes the equality of the various components of the overall balance of payments with the change in international reserves while expression (6) recognizes the two sources of money supplied to the market. Equation (7) requires equality of money demand and money supply. The model as constructed by Kouri and Porter (1974) was originally intended to provide an explanation of international capital movements and as such C_t was considered as endogenous while BOC_t and, indeed, the whole real portion of the economy (therefore P_t and M_t) were considered as exogenous. These assumptions will be maintained here.

The jointly dependent variables of the model are M^d_t, M^S_t, R_t, C_t, r and the exchange rate. Since the actual coefficients of the money demand relationship and of the interest rate equation are of little intrinsic interest in the present study, the model as outlined above can be solved
to obtain a reduced form expression for the exchange rate. In principle, of course, it is possible to do this for each of the jointly dependent variables but this seems unnecessary for the purposes of the present study. The reduced form equation for the exchange rate can be written as

$$
\Delta e_t = h^1(BOC_t, D_t, P_t, r^d_t, e_{t-1}, M_t)
$$  \hfill (9)

As noted above, the topic of interest is not the money market per se, but the money market's effect on the exchange rate, and this effect should be adequately captured by the reduced form of the model.

Interestingly, the exchange rate determination equations derived from both a simple components approach and a simple monetarist model can be shown to be special cases of equation (9). First, consider the components model defined by the system of equations consisting of

$$
BOP_t = C_t + BOC_t
$$  \hfill (10)

$$
C_t = C(r_t)
$$

$$
r_t = r(C_t, r^d_t)
$$

and equation (2). Assuming BOC is determined recursively, the reduced form equation for the exchange rate can be written as

$$
\Delta e_t = g(BOC_t, r^d_t, e_{t-1})
$$  \hfill (11)

Similarly, the basic monetarist model of exchange rate determination can be represented by the system of equations consisting of

$$
r_t = r(r^d_t)
$$

$$
M^d_t = M(r_t, P_t, M_t)
$$  \hfill (12)

$$
M^d_t = D_t + R_t
$$

$$
M^d_t = M^g_t$$
and equation (2). The reduced form model for the exchange rate can then be written as

$$\Delta e_t = g^1(r_t, P_t, M_t, D_t, e_{t-1}).$$

(13)

Assuming a linear form for equations (9), (11) and (13) and making the appropriate distributional assumptions, it is clear that the parameter sets of (11) and (13) are subsets of the parameter set of (9). Therefore, it is possible to use standard statistical testing procedures to decide which of the proposed exchange rate models is most appropriate.

3. Empirical Results

For convenience, the respective models will be referred to as the mixed, pure components and pure monetary models. The results of the estimation of these equations are presented in Table 1. The mixed and components models were estimated as a function of an inverted V lag on the balance on current account. The pure monetary model, of course, is not a function of the balance on current account. For the two null hypotheses of pure monetary and components versus the alternative hypothesis of the mixed model a standard F test was carried out to determine if either of the null hypotheses was rejectable. The computed F statistics were, respectively, .0764526 and .61795 so that at the 5% confidence level neither of the null hypotheses could be rejected in favor of the alternative hypothesis. Nevertheless, the statistical evidence tends to favor the monetary approach and, at a somewhat higher critical level, is sufficient to reject the components approach. In all the estimated equations all signs conform to a priori expectations with the sole exception of the coefficient for the discount rate in the components model. A possible explanation for the sign is that rates of return on foreign capital have been rising faster than the domestic rate of interest thus leading to a
negative capital flow. It should be noted, however, that the sign of this coefficient is consistent with the monetary approach. Given the lack of clear statistical evidence for discrimination between the three alternative models the properties of the most general (i.e. the mixed) model are further investigated in the following dynamic analysis.

Table 1 about here

4. Dynamic Analysis

The dynamic multipliers corresponding to the credit variable are tabulated in Table 2. The one period lag multiplier suggests that a one billion dollar decrease in the level of domestic credit will increase the exchange rate by approximately .0003 SDR/dollar. The lagged multipliers drop over the whole period suggesting that the major adjustments will occur over a very short time horizon. The cumulative and equilibrium multipliers reported in Table (2) suggest that a sustained change in the level of credit has little more than an 8 quarter adjustment period after which a new equilibrium level would be reached and the adjustment would be about .002 SDR/dollar for each sustained billion dollar decrease in the level of domestic credit. Therefore, the response of the exchange rate to a contraction of the domestic money supply would be quite rapid. In light of the current downward pressure on the dollar, these results suggest that a contractionary monetary policy might provide an effective brake against the slide of the dollar in world markets.

These multipliers can be compared with the corresponding multipliers for the variable BOC. The BOC multipliers are extremely small suggesting that the impact of the balance on current account might be negligible. Although the equilibrium multiplier indicates that a one billion dollar improvement in the balance on current account will appreciate the exchange
Table 1: The Estimated Model

**Mixed**

\[
SDR_t = 0.302515 + 0.723764 \cdot SDRL_t + 0.00000248BOC_t + 0.00000288BOC_t \\
(1.352947) \quad (3.9898) \\
+ 0.0000028BOCL2_t + 0.0000014BOCL3_t - 0.000457189 \cdot CREDIT_t \\
(-1.80778) \\
- 0.00258441 \cdot RD_t + 0.00108307WHSP_t + 0.000113492DT_t \\
(-.573982k) \quad (1.65516) \quad (.712973) \\
+ 0.0125208FALL_t + 0.0082028WINT_t - 0.00580550SPR_t \\
(1.56556) \quad (1.04417) \quad (-.614378) \\
R^2 = .9584873 \quad D.W. = 1.9527194
\]

**Components**

\[
SDR_t = 0.0719610 + 0.924228 \cdot SDRL_t + 0.0000066BOC_t \\
(1.244713) \quad (18.76339) \\
+ 0.00000132BOCL_t + 0.00000132BOCL2_t + 0.0000066BOCL3_t \\
- 0.000958559RD_t + 0.00829778FALL_t + 0.00407352WINT_t \\
(-.28756) \quad (.98397) \quad (.499514) \\
- 0.0148164SPR \quad (-1.82712) \\
R^2 = .9491726 \quad D.W. = 1.6416006
\]

**Pure Monetary**

\[
SDR_t = 0.352498 + 0.683286 \cdot SDRL_t - 0.000514908 \cdot CREDIT_t \\
(2.1080812) \quad (5.02976) \quad (-2.769602) \\
- 0.00302582RD_t + 0.00115967WHSP_t + 0.000130641 \cdot DI_t \\
(-.70132) \quad (1.88733) \quad (.86490) \\
+ 0.0131966FALL_t + 0.00894195WINT_t - 0.00443088SPR_t \\
(1.70175) \quad (1.18359) \quad (-.51926) \\
R^2 = .9583462 \quad D.W. = 1.9267517
\]
Table 1: Continued

* t - statistics are reported in parentheses

† Variable definitions are as follows where L indicates lag operator
e.g. $SDR_t = SDR_{t-1}$

$SDR_t = \text{special drawing rights/dollar exchange rate}$

$\text{CREDIT} = \text{domestic credit (billion dollars)}$

$RD_t = \text{discount rate at the N.Y. Federal Reserve}$

$\text{WHISP}_t = \text{wholesale price index, 1967 = 100}$

$DI_t = \text{disposable income, (billion dollars)}$

$BOC_t = \text{balance on trade (millions of dollars)}$

$\text{FALL, WINT, SPR} = \text{seasonal indicators}$

rate by .0032 SDR/dollar, one must bear in mind that a one billion dollar increase in BOC_t is proportionately a much larger change than a one billion dollar decrease in the money supply.

The last set of dynamic multipliers to be investigated are those that detail the responsiveness of the exchange rate to fluctuations in the level of interest rate. By raising the discount rate and, thereby, deflating the demand for dollars, the government appears to have the power to control the exchange rate to a substantial degree. For example, a one percent drop in the discount rate has a long run effect of increasing the exchange rate by approximately .009 SDR/dollar as a result of the increased demand for dollars. The exchange rate adjustment process, however, appears to take more than two years before a new stationary state is reached. Interestingly, these results suggest that recent rises in the interest rate will tend to exacerbate the already weakened position of the dollar in world markets as the excess supply of dollars continues to rise. Strengthening the dollar would seem to require lowering the interest rate.

5. Concluding Remarks

Although there is no strong statistical support for either the pure components or pure monetary approach against the mixed model, it does appear from the reported F statistics that the level of domestic credit is a more important determinant of the level of the exchange rate than the level of the balance on current account. This finding is further supported by the relative magnitudes of the dynamic multipliers; a sustained change in the level of domestic credit would bring about an equilibrium adjustment of about .002 SDR/dollar per billion dollars change in domestic credit. In percentage terms a much smaller response is noted for a change in the balance on current account. The interest rate also appears to be an important determinant of the level of the exchange rate.
These results suggest that monetary policy provides a rather effective tool for controlling the level of the exchange rate, while policies aimed directly at influencing the balance of trade will be less effective. Furthermore, controlling the level of the money supply seems to be a more effective means of regulating the exchange rate determination than manipulating the level of interest rates.
Footnotes

1/ Many of the most influential works are contained in Johnson and Frenkel (1976).

2/ S. C. Tsiang (1977) has recently provided a vehement criticism of the appropriateness of such a specification for an aggregate money demand equation. He presents some limited empirical evidence and some heuristic arguments for the inclusion of the volume of trade in the money demand function. However, the model presented above has been validated in a number of studies and, lacking any strong verification of Tsiang's arguments, the specification of (4) seems acceptable. It should also be noted that since we shall only deal with a reduced form exchange rate equation, our model yields an identical specification of the exchange rate equation as would be obtained by using Tsiang's money demand function.
References


Table 2: Delay, Cumulative and Equilibrium Multipliers

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