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THE MODELS OF EXCHANGE RATE DETERMINATION

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Abstract

During 1970s, three competing theories of exchange rate determination were developed: the flexible price monetary model, the sticky price monetary model, and the portfolio balance model. The aim of these models has been to give a plausible explanation to volatility in exchange rates, especially after the adoption of the flexible exchange rate system. The empirical findings of the models have not been supportive of the predictions of the models. The purpose of this paper is to analyze these theoretical models in a detailed form to evaluate whether they have been adequate in explaining volatility in exchange rates.

Keywords: *Exchange rates, exchange rate volatility, models of exchange rate*

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Özet

1970'li yıllarda esnek fiyat para modeli, yapışkan fiyat para modeli ve portföy denge modeli olmak üzere üç model geliştirildi. Bu modellerin amaci özellikle esnek döviz kuru sistemi kabul edildikten sonraki dönemde, döviz kurlarındaki dalgalanmaları açıklamaktı. Yapılan ampirik çalışmaların sonuçları, genellikle bu modellerin tahminlerini desteklemiyordu. Bu makalenin amacı belirtilen modelleri teorik açıdan incelemek ve modellerle ilgili yapılan ampirik çalışmaların döviz kurlarında gözlenen dalgalanmaları açıklamakta ne kadar başarılı olduklarını belirlemektir.

Anahtar Kelimeler: *Döviz kurları, döviz kuru dalgalanmaları, döviz kuru modelleri.*

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1. INTRODUCTION

The theory of exchange rate determination has evolved quite rapidly over the last three decades. Since the Bretton Woods system collapsed in 1973 because of an exchange rate crisis, experienced exchange rate volatility has been larger than expected by advocates of a floating exchange rate system. During the 1970s, the favorite idea among economists was that an elimination of inflation would bring foreign exchange market stability. Monetary authorities were to blame for unstable exchange rates since unpredictable changes in monetary policies seemed to lead to large deviations in a country's price level. Meanwhile, the existing theories of exchange rate determination, such as the Keynesian model of open economy macroeconomics, failed to give a satisfactory explanation of exchange rate movements.

Three new competing theories of exchange rate determination have been developed. The first one is the flexible-price monetary model, which was established by Jakob Frenkel (1976) and Michael Mussa (1976). The second one is the stick-price monetary (overshooting) model developed by Rudiger Dornbusch (1976). The last one is the portfolio balance model developed by Pentti Kouri (1976). Even though each of these models has very different predictions, all of them argue that the movements in exchange rates can be explained by relative demands of domestic and foreign assets and not international flows of goods and services. Therefore, these models are also known as asset market models.

The flexible-price monetary model (FPMM) can be considered as a combination of purchasing power parity (PPP) and the quantity theory of money. The model defines an exchange rate to be the relative supplies of domestic and foreign currencies so that exchange rate movements can be explained by changes in demands and supplies of domestic and foreign currencies. The most important distinguishing feature of this model is that PPP holds even in the short-run because prices are free to adjust in response to monetary disturbances.

Contrary to FPMM, the sticky-price monetary model (SPMM) assumes that prices are sticky, at least in the short-run. Because of the sticky price assumption, unanticipated monetary disturbances can cause exchange rates to change by more than its long-run equilibrium value. In other words, the model predicts that PPP does not hold in the short-run. The exchange rate, therefore, may overshoot its long-run equilibrium value.

In both the FPMM and the SPMM, the relationship between money market equilibrium and exchange rate determination is established by the assumption of a perfect substitution between domestic and foreign non-money assets. On the other hand, the portfolio balance model (PBM) abandons this assumption, by allowing an imperfect substitution between domestic and foreign non-money assets such as bonds. By doing this, the PBM emphasizes the importance of relative demands and supplies of domestic and foreign non-monetary assets or portfolio balance equilibrium into the determination of exchange rates. In general, the PBM shows how exchange rates adjust to reach portfolio balance equilibrium in the short-run and how the stock of foreign assets approaches to its new equilibrium by giving a current account surplus or capital account deficit.

The purpose of this paper is to review the literature relating to the theory and empirical evidence on the standard models of exchange rate determination- the FPMM, the SPMM, and the PBM- and to indicate how far they have gone to explain volatility in exchange rates. The empirical studies of the FPMM and SPMM can be divided into two periods. In the first period, the floating period of 1973-1978, empirical studies generally support the models while the second period, after 1978, has mixed results. Even though the PBM is much better than the other two models that explain the behavior of exchange rates, its success comes from income variables rather than from portfolio balance effect, contrary to what the PBM predicts. It is evident that these models exaggerated the importance of monetary factors in causing exchange rate volatility and failed to explain not only short-term but also medium-term volatility.

The rest of the paper is organized in following way. Section II states the basic theoretical structures of the FPMM, the SPMM, and the PBM models. Section III briefly reviews the empirical studies of the models. Concluding remarks are presented in section IV.

2. REVIEW OF THE MODELS

2.1. The Flexible-Price Monetary Model (FPMM)

The flexible-price monetary approach to exchange rates has been the one of the most popular explanations of exchange rate movements since the breakdown of the Bretton Woods system in 1973. The basic FPMM is a combination of purchasing power parity (PPP) and the quantity theory of money. PPP defines the exchange rate as the relative price of goods in two countries, while the FPMM defines it as the price of foreign currency relative to domestic currency. Since the exchange rate is the relative price of two currencies, changes in demands and supplies of these two currencies are captured by movements in the exchange rate. Money demand equations for domestic and foreign currencies are specified by[1]

$$m = p + \psi y - \varnothing i \quad (1)$$

$$m^* = p^* + \psi^* y^* - \varnothing^* i^* \quad (2)$$

where

m, m = logs of domestic and foreign money supplies,

p, p* = logs of domestic and foreign price levels,

y, y* = logs of domestic and foreign real income, and

i, i* = domestic and foreign interest rates.

The demand for money, m, depends on the price level, p, the real income, y, and the nominal interest rate and will equal the money supply which is exogenous according to the FPMM.

Recognize that equation (1) and (2) do not show how the exchange rate is determined. To show the relationship between the money market equilibrium and the exchange rate, we subtract (2) from (1) and solve for the relative price level:

$$p - p^* = m - m^* - \psi y + \psi^* y^* + \varnothing i - \varnothing^* i^* \quad (3)$$

The FPMM assumes that (PPP) holds continuously[2]:

$$e = p - p^* \quad (4)$$

where e = log of the exchange rate. Combining equation (3) and (4), we reach the exchange rate equation of the FPMM, assuming that the elasticities are identical in both countries.

$$e = (m - m^*) + \psi(y^* - y) + \varnothing(i - i^*) \quad (5)$$

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[1] See Frankel (1982), Frenkel (1976), Frenkel and Jhonson (1978), and Mussa (1976) for the detail of equations.

[2] PPP is a relationship which states an equality between domestic price level, p, and foreign price level, p*, converted into domestic currency, ep*.

From equation (5) recognize that an increase in domestic money demand relative to foreign money demand will cause an appreciation of the exchange rate. Similarly, an increase in domestic real income or a decrease in the domestic nominal interest rate relative to foreign real income or nominal interest rate will appreciate the exchange rate. The prediction of the model is that coefficient of (m - m*) is one, since the money is completely natural in the model. Also, ψ should be one.

FPMM assumes that agents form their expectations rationally. It is also assumed that there is perfect capital mobility and substitution. Therefore, uncovered interest parity holds,

$$x = i - i^* \tag{6}$$

where x is the expected rate of depreciation of the domestic currency. When the derivative of (4) is taken with respect to time, the expected rate of depreciation should be equal to the expected inflation differential:

$$x = \pi - \pi^* \tag{7}$$

Since both interest differentials and the expected inflation differentials equal the expected exchange rate, the expected inflation differential equals the interest differential,

$$i - i^* = \pi - \pi^* \tag{8}$$

Therefore, the exchange rate equation, (5), can be rewritten in the following form,

$$e = (m - m^*) + \psi(y^* - y) + \varnothing(\pi - \pi^*) \tag{9}$$

A general equilibrium is reached in an open economy if labor, goods, foreign exchange, domestic bonds, foreign bonds, and money markets are in equilibrium. As it is shown, equilibrium in the money market is reached through the money demand equation. Taylor (1995) argues that the domestic and foreign asset markets can be considered as a single market since the FPMM assumes perfect capital mobility and substitutability. The exchange rate adjusts freely to equilibrate demand and supply in the foreign exchange market. Since prices and wages are perfectly flexible, equilibrium in labor and goods markets is also reached. The equilibrium in three of the five markets is achieved. The Walras law states that in an n-market system, equilibrium in the n-th market will be reached automatically, if equilibrium in n-1 markets is reached. Therefore, one can conclude that the FPMM is a general equilibrium model in which the PPP continuously holds.

2.2. The Sticky Price Monetary Model (SPMM)

It has been observed that PPP has not held during 1970s. By introducing forward looking rational expectations into the Keynesian open economy macroeconomics model, Dornbusch (1976) and Frankel (1979) developed the stick-price monetary model or overshooting model to show that monetary policy shifts can induce disproportionate movements in exchange rates, which means that the PPP fails to hold at least in the short-run. The SPMM focuses on the short-run deviations of nominal and real exchange rates from their long-run equilibrium values. Short-run deviations of exchange rates from their long-run equilibrium values occur because under plausible assumptions, the price of goods and services are sluggish. They cannot adjust immediately after a monetary shock and thus the exchange rate must carry a disproportionate saddle of adjustment, at least in the short-run.

Dornbusch (1976) specifies exchange rates and interest rates as jump variables and the price of goods and services as sluggish variables. If a monetary shock occurs, the jump variables - the nominal exchange rate, the real exchange rate, and the interest rate- will all overshoot their long-run equilibrium values in the short-run. For example, consider the effects of loose monetary policy. Since in the short-run goods prices are sticky, an increase in the money supply raises the real money supply and decreases interest rates. The decrease in interest rates will lead to an outflow of capital and a depreciation of nominal exchange rates. The agents anticipate that the exchange rate overshoots and expect an appreciation. A short-run equilibrium should be reached when the expected appreciation of the exchange rate equals interest rate differentials. Recognize that this result is reached by the assumption of uncovered interest parity. Dornbusch (1976) states that this mechanism works because a monetary expansion leads to an immediate depreciation in a spot rate that exceeds the long-run depreciation rate. Therefore, the agents will expect an appreciation of the exchange rate in the long run and be compensated for the reduced interest on domestic assets. In the middle to long run, prices increase, thus the real money supply decreases, interest rates increase and the exchange rate appreciates. At the end, the money supply and interest rates reach their previous values, while an increase in prices and the depreciation rate of the exchange rate are in proportion to the money stock increase. Since price increases are offset by the deprecation of the currency, the PPP holds in the SPMM in the long run.

The SPMM consists of three equations: an uncovered interest parity, a money market equilibrium condition, and a price level adjustment equation which relates changes in the domestic price level to excess aggregate demand. Dornbusch establishes his model with a small open economy, which takes the world interest rate as a given. The perfect capital mobility assumption will equal the domestic interest rate to the world rate of interest plus the expected rate of depreciation of the domestic currency. This relationship is known as uncovered interest parity, which can be stated in the following form[3]

$$i = i^* + x \tag{10}$$

where i is the domestic interest rate, x is the expected depreciation of the domestic currency as in the FPMM, and i* is the world interest rate.

The formation of expectations is introduced into the model by[4]

$$x = \alpha\,(\grave{e} - e) \tag{11}$$

where α is the adjustment coefficient, e is the logarithm of the current exchange rate, and è is the logarithm of the long-run exchange rate that the exchange rate will converge in the long-run.

A money market equilibrium condition in the SPMM is the same as in the FPMM. The demand for real money balances, m, depends on the price level, p, the real income, y, and the domestic interest rate and will equal to the real money supply. The following equation states the money market equilibrium:

$$m = p + \psi y - \varnothing i \tag{12}$$

To see the relationship between the price level, the current exchange rate, and the long-run exchange rate we combine (10), (11), and (12)

$$m = p + \psi y - \varnothing i^* - \varnothing\alpha(\grave{e} - e) \tag{13}$$

If there are no unexpected changes in money supply, the current and the expected exchange rates will be equal and therefore the domestic interest

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3 See Dornbusch (1976) for the detailed explanation of the equations.

4 The perfect foresight assumption is made in the model. In other words, expectations are rational.

rate and world interest rate will be equal as well. The long-run equilibrium price level, þ, is shown in the following form:

$$þ = m + (\varnothing i^* - \psi y) \quad (14)$$

We combine (12) and (13) to determine the current exchange rate as a function of the current level of prices for the given long-run values of the exchange rate and the prices:

$$e = \grave{e} - (1/\varnothing\alpha)(p - þ) \quad (15)$$

The price level adjustment is reached through an equilibrium in the goods market. The rate of increase in the price of domestic goods, p', can be shown in the following form:

$$p' = \pi [u + \beta(e - p) + (\psi - 1) y - \varnothing i \quad (16)$$

where (e - p) is relative price of domestic goods. The equation (16), known as Phillips curve relation, states the relationship between excess aggregate demand and changes in prices. Given that the interest differential equals the expected depreciation in (11), (16) can be rewritten by the following form:

$$p' = -k (p - þ), \quad (17)$$

where $k = \pi [(\beta\alpha + \alpha\psi) / \psi\varnothing + \beta]$

(19) shows the level of output prices approaching its long-run level, þ, by a rate of k.

2.3. The Portfolio Balance Model (PBM)

Portfolio balance models (PBM) were developed to analyze movements in international reserves, interest rates, and financial capital during the fixed exchange rates period. These models were then applied to explain the variations in financial capital, exchange rates, and interest rates under the flexible exchange rates system[5]. The PBM were originally developed by Tobin and de Macedo (1980), by Branson, Masson and

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5 Branson, W. and Henderson, D. "The Specification and Influence of Asset Markets," in Ronald W. Jones and Peter B. Kenen, eds. 1985, Vol. 2, pp.749-805.

Halttunen (1977, 1979) and by Branson (1976). The PBM assumes an imperfect substitution of domestic and foreign assets. There are several reasons why domestic and foreign assets might be imperfect substitutes, such as exchange rate risk, tax rates in different countries, and political risk. However, in general, PBM concentrates on exchange rate risk. To be compensated from an exchange rate risk, investors require an exchange risk premium or some kind of discount. The PBM shows how the exchange rate adjusts to reach portfolio equilibrium in the short-run and how the stock of foreign assets approaches its new equilibrium giving the current account surplus (capital account deficit) or current account deficit (capital account surplus)[6]. The PBM assumes that the wealth or portfolio of domestic residents consists of three assets: domestic currency (M), domestic bonds (B), and foreign bonds (F) that are denominated in foreign currency. The wealth equation can thus be stated by following

$$W = M + B + EF \tag{18}$$

where E is the exchange rate.

The next equation gives the equilibrium condition in the domestic money market.

$$M = m\,(i, i^*, x)\,W \text{ and } Mi < 0,\ Mi^*,\ Mx < 0^{7} \tag{19}$$

where i is the domestic interest rate, i* is the foreign interest rate, and x is the expected rate of depreciation. Under static expectations, the expected rate of depreciation is equal to zero. On the other hand, if expectations are rational, it will be equal to the actual rate of depreciation.

$$B = b\,(i, i^*, x)\,W \text{ and } Bi > 0,\ Bi^*,\ Bx < 0 \tag{20}$$

(20) indicates the equilibrium condition in the domestic bonds market.

$$EF = f\,(i, i^*, x)\,W \text{ and } Fi < 0,\ Fi^*,\ Fx > 0 \tag{21}$$

(21) shows the equilibrium condition in internationally traded foreign bonds market. Next is the balance of payments equation:

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6 The relationship between current account and capital account is established by Dornbusch, Fischer, and Kouri (1976).

7 Yx denotes the partial derivative of Y (.) with respect to x.

$$\beta K = PT\ (EP^*/P) - E\beta F = 0 \qquad (22)$$

where T (EP*/P) denotes the sum of the trade balance, which is equal to the current account. The trade balance depends positively on the real exchange rate since depreciation improves trade balance. The balance of payments is the sum of the trade balance and capital inflow-foreign bonds- from foreign country. The capital inflow, F, is measured in terms of domestic currency when it is multiplied by E[8]. P and P* indicate domestic and foreign price levels, respectively.

Suppose that an economy is initially in equilibrium with a capital account of zero and a trade balance of zero, or an equivalent current account of zero. The home country's monetary authority conducts an expansionary open market operation or open market purchase. A decrease in domestic interest rates due to an expansionary monetary policy leads to an increase in the demand for domestic currency. In addition, the decrease in domestic interest rates raises demand for foreign bonds given that the return on foreign bonds, i*, is fixed. Since the demand for foreign bonds is higher than before, the price of foreign bond in terms of domestic currency goes up and the exchange rate depreciates. Due to the depreciation of the domestic currency, the home country’s competitiveness will increase, assuming that the Marshall-Lerner condition holds and its current account will be positive rather than zero.

The current account surplus leads to an increase in the real wealth of agents so that the agents prefer to hold bonds denominated in their currency. Therefore, the agents will start to sell some of their foreign bonds and buy domestic bonds. The higher demand for domestic bonds will lead to an appreciation of the exchange rate. In the mean time the price level will increase to its long-run equilibrium level. The trade balance will deteriorate-lose of competitiveness- due to an increase in domestic price level and an appreciation of the exchange rate. As long as agents in the home country are selling foreign bonds and buying domestic bonds, the exchange rate will continue to appreciate. In order to reach a current account balance of zero, the trade balance should be negative. By the time the price level has returned to its long-run equilibrium value, the exchange rate will also be at its long-run equilibrium. At the end, the trade deficit will be equal to the capital account surplus.

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8 See Taylor (1995) and Branson and Henderson (1985) for detailed analyze of the portfolio balance model.

3. THE EMPIRICAL STUDIES

3.1. The Empirical Studies of the FPMM

The empirical studies of monetary models can be separated into two periods. The first period of empirical studies generally support monetary models while the second period has mixed results.

The first period of empirical studies includes the inter-war floating period and the floating period of 1973-1978. Frankel (1976) estimates equation (5) for the German mark/US dollar exchange rate for the German hyperinflation period of 1920-1923 by applying an OLS technique. His empirical results support the FPMM since he finds out that PPP holds. In addition, as predicted by the model, the elasticity of the price level with respect to the money stock is close to unity and the elasticity with respect to inflation is positive. Bilson (1978) tests the German mark/U.K pound exchange rate for the period of 1972 – 1976. His findings support the FPMM.

Hodrick (1978) analyzes the German mark/US dollar exchange rate to see whether the three predictions of FPMM hold over the period of April 1973 to September 1975. The first prediction of the model is that the percentage change of the exchange rate is determined by the domestic currency's rate of growth minus the foreign currency's long-run rate of growth. Even though the empirical findings support the flexible version of this model, it is hard to interpret whether or not the percentage change of the exchange rate will overshoot or undershoot its long-run growth rate. The second prediction of the model is that a decrease in the real income depreciates the exchange rate and decreases the demand for domestic currency. These empirical results also support the second prediction of the FPMM. The third prediction of the model, which is supported by Roderick's study, is that a loose monetary policy leads to an increase in interest rates and a depreciation of the exchange rate.

Dornbusch (1980) also estimates equation (5) for the dollar/mark exchange rate over the 1973.2-1979.4 period. He finds that almost all the estimated coefficients are insignificant. He concludes that the FPMM is not able to capture movements in the dollar/mark exchange rate for the stated period.

Frankel (1979) argues that both FPMM and SPMM are not successful when the inflation differential is moderate-not high or low. He states that FPMM and SPMM assume that real interest rate differentials are constant or zero. He adds that such a modification can be true under two special cases, first with a high and variable inflation differential such as in Frenkel's model and second with a low and constant inflation differential such as Dornbusch's model. However, this is not the case during the 1970s. The following equation determines Frankel's version of the monetary model, which depends on real interest rate differentials.

$$e = (m - m) + \psi(y - y^*) + \varnothing(i - i^*) + \alpha(\pi - \pi^*) \qquad (23)$$

where m, m*, y, y*, i, and i* are as defined previously and π and π^* are the expected inflation rates in domestic and foreign countries, respectively. He finds that the $\varnothing$ is negative and α is positive. Equation (23) is estimated for the mark/dollar exchange rate over the period of July 1974 - February 1978 by using monthly data. Frankel concludes that the real interest rate differential model works very well to estimate the mark/dollar exchange rate while the alternative models -FPMM and SPMM- do not work at all.

As stated previously, the empirical studies made after 1978 do not support the FPMM. The FPMM predicts that an increase in the relative supply of domestic currency leads to a depreciation of exchange rates. Evidence after 1978 contradicts this prediction. For example, an appreciation of the mark/dollar exchange rate was observed instead of depreciation during 1978 to1979. To solve the FPMM`s shortcomings, Frankel (1982) includes wealth into money demand equations and mark/dollar exchange rate equations. He argues that it is evident that there was a decrease in demand for the dollar while there was an increase in demand for the mark. The logic behind the inclusion of wealth into the money demand function holds that a foreign current account surplus has an effect of redistribution of wealth from domestic residents to foreign residents, causing an increase in demand for foreign currency and at the same time a decrease in the demand for domestic currency. Therefore, the exchange rate appreciates. He concludes that the monetary model with wealth is much more successful than the original monetary model to estimate the behavior of a mark/dollar exchange rate.

Smith and Wickens (1986) apply the FPMM to the British pound/US dollar and German mark/US dollar exchange rates from 1973 to 1982. Their empirical results show that the coefficient on relative money supplies are significantly different from unity, contrary to what FPMM predicts. They conclude that the breakdown of the PPP and the misidentification of the money demand function are the reasons of the missepicification of this model.

Meese and Rogoff (1988) state that monetary models do not perform well because they focus on monetary disturbances to explain movements in the real exchange rate. However, if real shocks were considered to explain movements of the exchange rate, the results would be much more reliable.

Stockman (1980) argues that the FPMM is not able to explain the short-run variations of exchange rates. The reason is that the FPMM assumes that money supply is exogenous. However, it should be considered an endogenous variable to capture short-run variations in the exchange rates. Further, he compares the success of FPMM with the success of the PPP and concludes that both are failures.

3.2. The Empirical Studies of the SPMM:

The empirical evidence for the SPMM is also very weak, especially after 1978. Driskill (1981) tests SPMM to see if the predictions of the model coincide with the 1973-1977 Swiss franc/US dollar exchange rate. He finds that the exchange rate overshoots in the same quarter after a monetary innovation, the same as the prediction of the SPMM. The other prediction, which is supported by Driskill's study, states that the PPP holds in the long run. However, Backus (1983) states that even there is a prove that the money is natural; there is no overshooting of the Canada/US exchange rate from 1971 to 1980, contrary to Driskill's findings.

The SPMM predicts a strong relationship between the real exchange rate and real interest differentials. This relationship holds because unanticipated changes in money can change both variables proportionally. For example, if the German mark/ Italian lira real exchange rate exceeds its long-run value, there is an expectation that the mark will depreciate to reach its long-run value. Therefore, the real return on German assets should exceed the real return on Italian assets proportionally to the expected depreciation rate. Thus, the model predicts that there is a proportional relationship between the real exchange rate and real interest differentials.

Meese and Rogoff (1988) test the SPMM for the US dollar/German mark, US dollar/Japanese yen, and US dollar/British pound exchange rates from February 1974 to March 1986. They state that real exchange rates and interest rate differentials are not cointegrated. Therefore, they conclude that there is no evidence to support that there exists a structural model relating real exchange rates to a real interest rate differential. Furthermore, they give two explanations for the nonexistence of the relationship between the real exchange rate and interest rate differential. First, there may be an omitted variable from the relation. For example, the real shock -not the monetary shocks- might cause non-stationary in real exchange rates. However, it is difficult to determine the type of the real shock that causes variations in real exchange rates so that some work should be done in the line of real business cycles. Second, an existence of bubbles in the exchange rate might be the reason for the failure of the SPMM.

Baxter (1993) applies band-spectral methods to test the relationship between the real exchange rate and the real interest rate differential. She finds a strong relationship between real exchange rates and real interest differential at business cycle and trend frequencies. She states that other researchers could not find statically significant relationships because they use a first-difference filter, which puts too much weight on the highest frequency parts of the data, such as 2-5 quarters of the data.

Lastrapes (1992) applies vector auto regression (VAR) and moving average (MA) techniques to estimate the effects of nominal and real shocks on real exchange rates. His estimates are based on six countries - Germany, U.S, U.K, Japan, Canada, and Italy- for the period of March 1973 to December 1989. He argues that while SPMM is able to explain overshooting of the exchange rate in the short-run in response to unexpected monetary shocks, this is not observable in the empirical work. Lastrapes argues that the fluctuations in real and nominal exchange rates for the stated period are due to real shocks and not monetary shocks. Furthermore, he suggests that the existing exchange rate models should consider the importance of the real shocks to determine exchange rates.

McNown and Wallace (1989) analyze long-run predictions of the SPMM by using cointegration methods. They test US dollar vis-a-vis the currencies of Canada, Japan, Germany, the U.K, and France from April 1973 to 1989. Their empirical results do not support the SPMM since their variables have different orders and there is no cointegration.

MacDonald and Taylor (1994) point out that, because in these studies static models or limited dynamics are used, previous empirical studies are very far from supporting the SPMM. Instead of applying the Eagle-Granger two-step technique, they apply the multivariate cointegration technique since later technique can catch up to the time series properties of the data. They conclude that the SPMM is successful to estimate the long-run British pound/US dollar exchange rate once dynamic properties of the model are captured by the multivariate cointegration technique.

3.3. The Empirical Studies of the PBM

Taylor (1995) argues that the empirical studies on the PBM have two obstacles. The first is about the availability of the data on assets, which are shorted out by currency of denomination. To overcome this problem, the earlier empirical studies concentrate on the current account. The second problem is about components of the asset demand functions. Because of these problems, the empirical studies are not very supportive of the PBM.

Some researchers estimate the PBM by using quasi-reduced form equations. Branson, Halttunen, and Masson (1977) apply the PBM to the U.S dollar/German mark exchange rate using OLS and 2SLS techniques. The OLS results show that variables are either insignificant or with incorrect signs. On the other hand, 2SLS estimations support the PBM. Driskill (1981) tests Swiss franc/U.S dollar exchange rates over the 1973-1977 period by applying a modified Cochrone-Orcutt procedure. The empirical results support the PBM. Backus (1984) analyzes Canadian dollar/U.S dollar exchange rate for the period of 1971-1980. He argues that among the three models -SPMM, FPMM, and PBM- the PBM best captures variations in the exchange rate. However, he states that the success of the PBM comes from income variables instead of asset variables. They also find that the U.S current account does not have a strong affect on the exchange rate, contrary to what PBM states.

Rogoff (1984) argues that Driskill (1981) and Branson et al.'s (1977) empirical results are clearly in favor of the PBM because of their explanatory power of exchange rates, which come either from current account or from net private capital flows. This is completely acceptable since the PBM states that the appreciation of the exchange rate coincides with the current account surplus. If the supply of foreign bonds is held constant, the current account surplus raises the real wealth of agents of the country. The agents prefer to hold bonds denominated in their currency. However, Rogoff suggests two reasons why the empirical existence of the relationship between the current account or net capital flow and the exchange rate is not enough to support PBM. First, even if the bonds denominated in different currencies are perfect substitutes, a relationship can still exist. Second, not only current account but also other factors can affect real wealth. For example, capital gains or losses can change real wealth since most of the savings go into capital stock investments.

The other line of empirical studies of the PBM concentrates on risk premium or bond demand functions. Frankel (1982) estimates interest differentials between German mark denominated and U.S dollar denominated bonds. In this study, the bonds of the U.S government and German government are included as portfolio balance variables. He concludes that portfolio balance variables are either insignificant or with wrong signs.

Rogoff (1984) estimates the portfolio balance effect in the Canadian dollar/U.S dollar exchange rate risk premium over the 1973-1980 period. Rogoff explores the portfolio balance effect. He asks whether sterilized intervention is able to change the exchange rate by moving the exchange rate risk between the private sector and public portfolios, at least in the short-run, to eliminate the disturbances to exchange rate. To capture the very short-run effects of intervention, he uses weekly data. His results indicate that portfolio balance variables are insignificant and that they have incorrect signs. Therefore, Rogoff concludes that there is no evidence to support the existence of a portfolio balance effect.

4. CONCLUSION

None of the theories have been successful in capturing all the movements of the exchange rates. As stated earlier, the first period of empirical studies have been supportive of the FPMM. Equation (5) has been estimated by Frankel (1976), Hodrick (1978), and Bilson (1978). Frankel (1979) also has estimated equation (23). All of the studies have been considered successes in the sense that estimated coefficients are significant and that the predictions of the model have been proved. For example, the PPP holds continuously as a loose monetary policy increases interest rates and depreciates exchange rates. However, according to empirical results found after 1978, the FPMM is considered as a complete failure because its estimated coefficients are generally insignificant with wrong signs. Furthermore, Smith and Wickens (1986) have reported that the model has a misspecification problem concerning the money demand function.

The empirical studies of the SPMM have also not performed well. The problems concern the central predictions of the model, such as the non-existence of overshooting in data and the relationship between real exchange rate and real interest differentials. Even though the empirical work on the PBM seem much more promising than the previous two models', its success comes from income variables. It has been difficult to find evidence to support a strong portfolio balance effect as predicted by the theory.

The models seem to fit the data well within a given sample period, but they give poor result in out-of-sample tests. In sum, empirical testing of the models indicate that these models exaggerated the role of monetary factors in causing exchange rate volatility and failed to explain not only short-term but also medium-term volatility. Thus, the future line of empirical work might focus more on the effect of real shocks in explaining exchange rate volatility.

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