

"Monetary and Portfolio-Balance Models of Exchange Rate Determination"

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3 Monetary and Portfolio-Balance Models of Exchange Rate Determination

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3.1 The Asset-Market View of Exchange Rates

The theoretical literature on the "asset-market" view of exchange rates has been expanding voluminously in recent years. The popularity of this view may be attributed to the compelling realism in today's world of both its distinguishing theoretical assumption and its distinguishing empirical implication. The theoretical assumption that all asset-market models share is the absence of substantial transactions costs, capital controls, or other impediments to the flow of capital between countries, an assumption which will here be referred to as perfect capital mobility. Thus the exchange rate must adjust instantly to equilibrate the international demand for stocks of national assets—as opposed to adjusting to equilibrate the international demand for flows of national goods as in the more traditional view. The empirical implication is that floating exchange rates will exhibit high variability, variability that exceeds what one might regard as that of their underlying determinants.

But beyond this common point, the asset-market models diverge down a bewildering complexity of routes. Synthesis models and comprehensive surveys are notably lacking. Furthermore, the specific empirical implications of the various theories conflict with observed events, as well as with each other. Econometric attempts to relate the theory to recent data have

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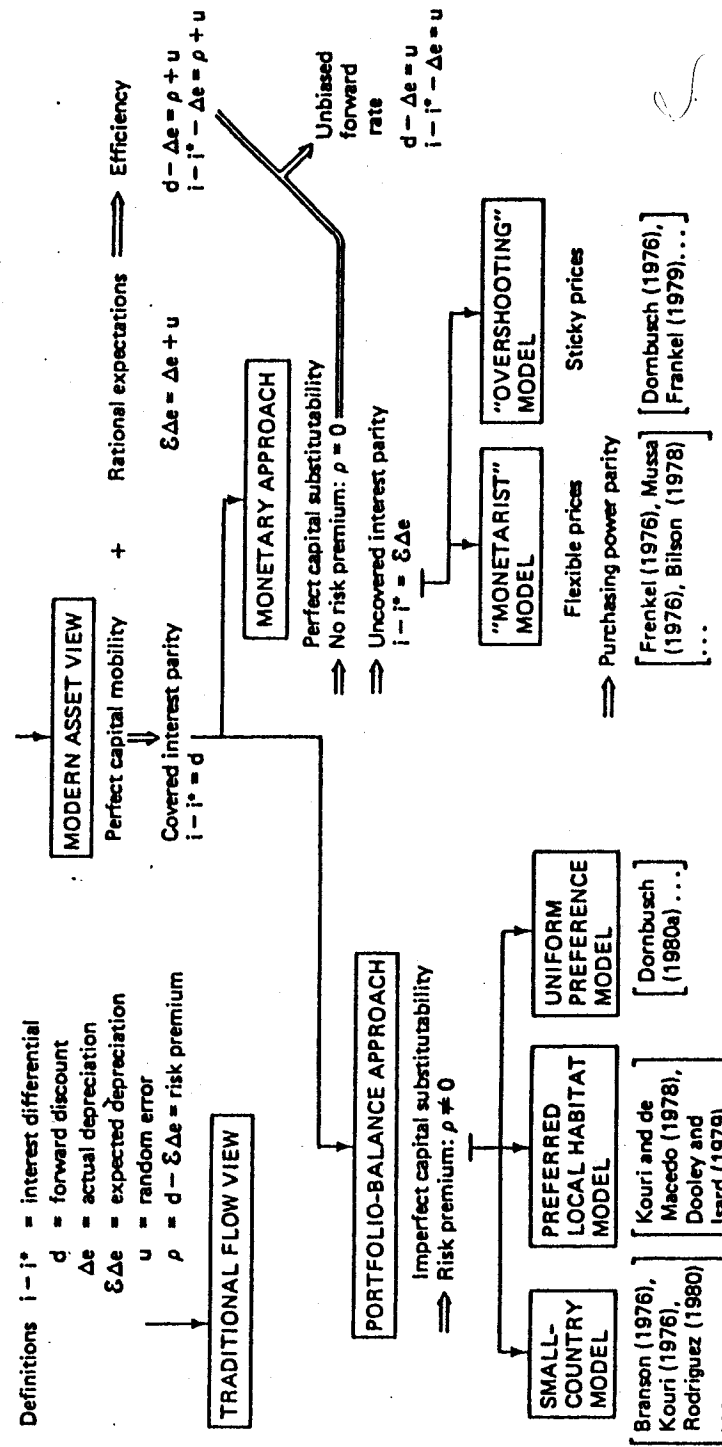


Figure 3.1 Exchange rate models and assumptions.

founded on the dollar depreciation, which, in 1977 and 1978, was too highly correlated with the US current account deficit to be explained readily by the asset-market approach, and which rather seemed to fit the more traditional approach.

This chapter proposes a taxonomy of asset-market models of floating exchange rates, as illustrated in figure 3.1. The most important dichotomy is according to whether or not domestic and foreign bonds are assumed to be perfect substitutes in asset-holders' portfolios. It is important to note the distinction between capital mobility, as the term is used here, and substitutability.¹ Perfect capital mobility between countries means that actual portfolio composition adjusts instantaneously to desired portfolio composition. Assuming no risk of default or future capital controls, perfect capital mobility implies, for example, covered interest parity: The interest rate on a domestic bond is equal to the interest rate on a similar foreign bond plus the forward premium on foreign exchange.² Perfect substitutability between domestic and foreign bonds is the much stronger assumption that asset holders are indifferent as to the composition of their bond portfolios as long as the expected rate of return on the two countries' bonds is the same when expressed in any common numeraire. It would imply, for example, uncovered interest parity: The interest rate on a domestic bond is equal to the interest rate on a foreign bond plus the *expected* rate of appreciation of foreign currency.³

In one class of asset-market models, domestic and foreign bonds are imperfect substitutes. This is the "portfolio-balance approach" to exchange rates, in which asset holders wish to allocate their portfolios in shares that are well-defined functions of expected rates of return.⁴

In the other class of asset-market models, domestic and foreign bonds are perfect substitutes: Portfolio shares are infinitely sensitive to expected rates of return. Thus uncovered interest parity must hold. But given that it does hold, bond supplies then become irrelevant. The responsibility for determining the exchange rate is shifted onto the money markets. Such models belong to the "monetary approach" to exchange rates,⁵ which focuses on the demand for and supply of money.

3.2 The Monetary Approach

3.2.1 The Flexible-Price ("Monetarist") Monetary Model

We have defined the monetary approach by the assumption that not only are there no barriers (such as transaction costs or capital controls) segmenting international capital markets, but domestic and foreign bonds

are also perfect substitutes in investor demand functions. In essence, there is only one bond in the world.

As the starting point within the monetary approach we begin with the model that also makes the analogous assumption for goods markets: Not only are there no barriers (such as transportation costs or trade controls) segmenting international goods markets, but domestic and foreign goods are also perfect substitutes in consumer demand functions. In essence, there is only one good in the world.

This assumption, of course, implies purchasing power parity: The domestic price level is equal to the foreign price level times the exchange rate. Large short-run failures of purchasing power parity have been observed empirically.⁶ But the assumption can be useful in certain contexts, for example, hyperinflation. And, in any case, the model that assumes one world good as well as one world bond is a powerfully simple prototype that will serve as a point of departure for more sophisticated models.

If perfect price flexibility is considered the crucial characteristic of monetarism, then the best name for the variety of monetary model that assumes purchasing power parity is the "monetarist model."⁷ It has been developed by Frenkel [1976, 1977, 1980], Mussa [1976], Girton and Roper [1977], Hodrick [1978], and Bilson [1980a, b].

The fundamental equation in the monetary approach is a conventional money demand function:

$$m = p + \phi y - \lambda i, \quad (1)$$

where

$m \equiv$ log of the domestic money supply,

$p \equiv$ log of the domestic price level,

$y \equiv$ log of domestic real income,

$i \equiv$ the domestic short-term interest rate,

$\phi \equiv$ the money demand elasticity with respect to income,

$\lambda \equiv$ the money demand semielasticity with respect to the interest rate.

We assume a similar money demand function for the foreign country:

$$m^* = p^* + \phi y^* - \lambda i^*$$

where asterisks denote foreign variables and the parameters are assumed the same in both countries. Taking the difference of the two equations gives us a relative money demand function:

$$(m - m^*) = (p - p^*) + \phi(y - y^*) - \lambda(i - i^*). \quad (2)$$

The one-bond assumption gives us uncovered interest parity:

$$i - i^* = \delta(\Delta e) \quad (3)$$

where $\delta(\Delta e) \equiv$ the expected depreciation of domestic currency. We combine (2) and (3) and solve for the relative price level:

$$(p - p^*) = (m - m^*) - \phi(y - y^*) + \lambda\delta(\Delta e). \quad (4)$$

The one-good assumption gives us purchasing power parity:

$$e = p - p^*, \quad (5)$$

where $e \equiv$ log of the spot exchange rate, defined as the price of foreign currency in terms of domestic. A consequence is that expected depreciation is equal to the expected inflation differential:

$$\delta(\Delta e) = \delta(\Delta p) - \delta(\Delta p^*). \quad (6)$$

We combine (5), (4), and (6) to obtain the monetarist equation of exchange rate determination:

$$e = (m - m^*) - \phi(y - y^*) + \lambda(\delta \Delta p - \delta \Delta p^*). \quad (7)$$

Equation (7) says that the exchange rate, as the relative price of currency, is determined by the supply and demand for money. An increase in the supply of domestic money causes a proportionate depreciation. An increase in domestic income, or a decrease in the expected inflation rate, raises the demand for domestic money and thus causes an appreciation. The equation has been widely estimated econometrically.

Assume that expectations are rational and the system is stable. Assume further that income growth is exogenous (for simplicity equal to zero, so $y - y^* = \bar{y} - \bar{y}^*$), as it usually is in monetarist models. Then the expected inflation rate is equal to the rationally expected monetary growth rate. A benchmark specification of the money supply process is that monetary growth follows a random walk. Then the rationally expected future relative monetary growth rate, and thus the last term in equation (7), is simply the current relative monetary growth rate, which we will represent by $\Pi - \Pi^*$:

$$e = (m - m^*) - \phi(\bar{y} - \bar{y}^*) + \lambda(\Pi - \Pi^*). \quad (8)$$

As an alternative to the benchmark specification, a very restrictive special case occurs when we specify the *level* of the money supply, rather than the change in the money supply, to be a random walk. Then the expected relative rate of monetary growth, $\Pi - \Pi^*$, is zero. The level of

the exchange rate is perfectly correlated with the level of the relative money supply. But in today's world the existence of secular inflation and its effect on money demand cannot be ignored.⁸

On the other hand, one could generalize beyond the benchmark case of a random-walk specification for money growth. More sophisticated specifications of the money supply process have appeared in monetarist exchange rate models by Mussa [1976], who distinguishes between transitory and permanent monetary disturbances, and Barro [1978], who distinguishes between anticipated and unanticipated disturbances.

3.2.2 The Sticky-Price ("Overshooting") Monetary Model

As mentioned, purchasing power parity may be a good approximation in the long run, but large deviations appear in the short run empirically. The existence of contracts, imperfect information, and inertia in consumer habits means that prices do not change instantaneously but adjust gradually over time.

We now retain the monetary approach's one-bond representation of financial markets but relax the monetarist model's one-good representation of trade. This gives us a class of models in which changes in the nominal money supply are also changes in the real money supply because prices are sticky, and thus have real effects, especially on the exchange rate.

The sticky-price class of monetary models begins with the well-known analysis of perfect capital mobility by Mundell [1963]. Mundell abstracts from expectations, so that uncovered interest parity (3) becomes a simple equality between the domestic and foreign interest rates. In a money demand equation like (1), the combination of a fixed price level and an interest rate tied to the world rate means that a monetary expansion causes a large instant depreciation in the currency: Export demand has to be stimulated sufficiently for the increased income to raise money demand to the level of the new higher money supply *without* lowering the domestic interest rate below the foreign one.

A number of authors have introduced a nonzero expected rate of depreciation into the Mundell model.⁹ They argue that as long as the expected future spot rate is less than unit-elastic with respect to the current spot rate, a monetary expansion will not cause as large an increase in the exchange rate and income as in the Mundell model. This is because it is possible for the domestic interest rate to fall below the foreign one without inducing an infinite capital outflow.

At first Argy and Porter [1972] and Dornbusch [1976a] specified

expectations adaptively. But then Dornbusch [1976b] offered a model in which expectations are specified rationally. In this model purchasing power parity does hold in the long run, so that a given increase in the money supply raises the exchange rate proportionately as in the monetarist model, but *only* in the long run. In the short run, because prices are sticky, a monetary expansion has the liquidity effects of the Mundell model. The interest rate falls, generating an incipient capital outflow, which causes the currency to depreciate instantaneously *more* than it will in the long run; it depreciates just enough so that the rationally expected rate of future *appreciation* precisely cancels out the interest differential. The phenomenon just described is known as "overshooting" of the spot rate. In its honor, this paper will use the name "overshooting model" for the sticky-price monetary approach to distinguish it from the monetarist (flexible-price monetary approach) model.¹⁰

The overshooting model retains the money demand function (1) and uncovered interest parity condition (3) essential to the monetary approach. It replaces the instantaneous purchasing power parity condition (5) with a long-run version:

$$\bar{e} = \bar{p} - \bar{p}^*, \quad (9)$$

where bars over variables signify a relation that holds in the long run. Thus the monetarist exchange rate equation (7) is replaced by a long-run version:

$$\bar{e} = (\bar{m} - \bar{m}^*) - \phi(\bar{y} - \bar{y}^*) + \lambda(\bar{\mathcal{E}}(\Delta p) - \bar{\mathcal{E}}(\Delta p^*)). \quad (10)$$

Precisely as we did in the monetarist model, we assume that expectations are rational and the system is stable; for simplicity, income growth is exogenous (or random with mean zero); and as a benchmark specification, monetary growth follows a random walk. It then follows that the relative money supply, and in the long run the relative price level and exchange rate, are all rationally expected to follow paths along which they increase at the current rate of relative monetary growth $\Pi - \Pi^*$. Equation (10) becomes

$$\bar{e} = (m - m^*) - \phi(y - y^*) + \lambda(\Pi - \Pi^*). \quad (11)$$

It remains only to specify expectations. In the short run, when the exchange rate deviates from its equilibrium path, it is expected to close that gap with a speed of adjustment θ . In the long run, when the exchange rate lies on its equilibrium path, it is expected to increase at $\Pi - \Pi^*$:¹¹

$$\mathcal{E}(\Delta e) = -\theta(e - \bar{e}) + \Pi - \Pi^*. \quad (12)$$

We combine (12) with the uncovered interest parity condition (3),

$$i - i^* = \mathcal{E}(\Delta e) \quad (3)$$

to obtain

$$\dot{e} - \bar{e} = -(1/\theta)[(i - \Pi) - (i^* - \Pi^*)]. \quad (13)$$

The gap between the exchange rate and its equilibrium value is proportional to the real interest differential. Intuitively, when a tight domestic monetary policy causes the nominal interest differential to rise above its equilibrium level, an incipient capital inflow causes the value of the currency to rise proportionately above *its* equilibrium level.

Now we combine (11), representing the long-run monetary equilibrium path, with (13), representing the short-run overshooting effect, to obtain a general monetary equation of exchange rate determination:

$$e = (m - m^*) - \phi(y - y^*) + \lambda(\Pi - \Pi^*) - (1/\theta)[(i - \Pi) - (i^* - \Pi^*)]. \quad (14)$$

As the basis for econometric estimation, equation (14) is identical to the monetarist equation (8) but for the addition of a fourth explanatory variable, the real interest differential. This variable should show up in a regression with a zero coefficient if the monetarist model is correct; the economic interpretation would be that the speed of adjustment θ is infinite.

As we did in the last section, we can depart from the benchmark specification of the money supply process by considering the simple special case when the *level* of the money supply, rather than the *change* in the money supply, is a random walk. Then the expected long-run inflation differential $\Pi - \Pi^*$ is zero. This is precisely the context in which this model was originally developed by Dornbusch. Equation (14) becomes

$$e = (m - m^*) - \phi(y - y^*) - (1/\theta)(i - i^*). \quad (15)$$

The Dornbusch equation (15), like the monetarist equation (8), can be viewed as a nested model which can be tested econometrically by estimating equation (14).

Again as in the last section, one could also depart from the benchmark specification by considering a more general money supply process. More sophisticated specifications of the money supply process have appeared in Dornbusch-type models by Rogoff [1979], who distinguishes between transitory and permanent monetary disturbances, and Wilson [1979]

and Gray and Turnovsky [1979], who distinguish between anticipated and unanticipated monetary disturbances.

3.2.3 Empirical Application of the Monetary Approach

Five years or so after exchange rates began to float in 1973, a number of empirical studies of the period appeared.¹² These studies tended generally to support the implications of the monetary approach against those of the traditional flow approach: a coefficient on the relative money supply which is positive or—more precisely—unity, and a coefficient on relative income which is negative and interpretable as the income elasticity of money demand. However, the empirical basis for a choice between the flexible-price and sticky-price variants of the monetary approach was less clear-cut. When the United Kingdom was one of the two countries whose exchange rate was studied, Bilson [1978a] and Hodrick [1978] found the interest differential to show the significant positive coefficient that is implied by the flexible-price model represented by equation (8). But Hodrick [1978] found the German interest rate to show the significant negative effect on the mark/dollar rate that is implied by the sticky-price model represented by equation (15). Estimation of equation (14)—Frankel [1979b]—supported the general monetary model for the mark/dollar rate from July 1974 to February 1978. The coefficient on the short-term interest differential was significantly less than zero, as in the sticky-price model, while the coefficient on the expected long-run inflation differential was significantly greater than zero, as in the flexible-price model.

In 1978 the dollar depreciated sharply. The depreciation prompted increasing political criticism of the noninterventionist policies of the US government and did not come to an end until the November package of increased monetary restraint and direct intervention to support the dollar. Much of the criticism, such as that appearing in repeated *Wall Street Journal* editorials, subscribed to the monetary model. In this view the declining price of dollars was simply due to the rapid increase in the supply of dollars “spewing forth from Federal Reserve printing presses.” The behavior of the Bundesbank and the performance of the mark were pointed to as paragons of monetary restraint and its rewards. Unfortunately for this theory, German monetary growth in 1978 was, and has been for some years, actually *higher* than US monetary growth. The reason for the surprisingly high rate of monetary growth in Germany, ironically, was the strength in the value of the mark against the dollar. The Bundesbank resisted this appreciation by buying dollars, without

sterilizing the reserve inflow, and thus caused the German money supply to swell.

Empirical studies that tried to update the monetary equation to include the events of 1978 and 1979 were quite unsuccessful from the viewpoint of all versions of the model.¹³ The only coefficient to appear statistically significant was that on the expected inflation differential. The coefficient on the relative money supply actually appeared with the incorrect sign, attesting to the mystery of a mark that went up in price even as it was increasing in relative supply.¹⁴

In 1980 the traditional Keynesian correlation between the interest rate and the value of the dollar strongly reemerged. Both exhibited two sharp peaks centered on April and December. Table 3.1 reports an update of the monetary equation through December 1980. When we correct for serial correlation, the coefficient on the interest differential rejoins the coefficients on the expected inflation rates in appearing statistically significant. This new evidence would tend again to support the general sticky-price form of the monetary model, equation (14). However, the insignificant (or in one case significant but of the wrong sign) coefficient on the money supplies and relative income continue to cast doubt on the monetary model in all forms.

If the money supplies are endogenous, because of either the existence of central bank reaction functions or disturbances in money demand, then the estimates reported in the first row of table 3.1 are not consistent. One remedy is to impose the constraint of a unit coefficient on the relative money supply, in effect moving the endogenous variable to the left-hand side of the regression equation. The results of such regressions (not reported here) are no better than the unconstrained regression.

3.3 The Portfolio-Balance Approach

3.3.1 The Effect of the Current Account

The other popular explanation for the decline of the dollar in 1978, besides US monetary growth, was the large US current account deficit. The old-fashioned view that the level of the exchange rate must clear the current account had been refuted by theorists who pointed to the existence of high capital mobility and by practitioners who pointed to the fact that until the end of 1977 the dollar's trade-weighted value was quite high despite a record current account deficit. But more recently, the correlation between current account deficits and exchange rates has been undeniably strong, not only in 1978 when the dollar depreciated and the currencies

Table 3.1
Estimation of monetary exchange rate equation (14): dependent variable—log of mark/dollar rate*

Sample	Technique	c.	gml - usmlb	gy	usy	gi - usi	gπ	usπ	R ²	D.W.	ρ
7401-8012	OLSQ	3.229 (0.570)	-0.835 ^b (0.158)	-0.885 ^b (0.255)	0.289 (0.195)	-0.190 (0.300)	4.717 ^a (0.813)	-3.932 ^a (0.301)	0.93	0.92	
	CORC	3.283 (1.018)	-0.770 ^b (0.268)	-0.382 (0.271)	-0.199 (0.240)	-0.698 ^a (0.328)	3.485 ^a (1.187)	-3.444 ^a (0.539)	0.95		0.67
7402-8011	FAIR	2.453 (1.217)	-0.503 (0.335)	-0.167 (0.319)	-0.222 (0.294)	-1.465 ^a (0.516)	7.244 ^a (2.081)	-4.877 ^a (0.755)	0.94		0.66

a. Definitions: gml = log of relative money supply, Germany/U.S. (M1B); gy, usy = log of real income levels (proxied by industrial production), Germany and United States, respectively; gi - usi = nominal interest differential (short-term money market rates, per annum basis); gπ, usπ = expected inflation rates (proxied by average CPI inflation over preceding twelve months); OLSQ, ordinary least squares; CORC, iterated Cochrane-Orcutt; FAIR, Fair's method of correcting for possible endogeneity of gi - usi, gπ, and usπ (instrumental variables are the German and US ratios of outstanding government bonds to monetary base, and the German and US long-term government bond interest rates) in the presence of serial correlation (current and lagged values of all endogenous and included exogenous variables are added to the list of instruments). (Standard errors are in parentheses.)
b. Significant at the 95% level and of the correct sign.
c. Significant at the 95% level and of the correct sign.

of the surplus countries, Germany and Japan, appreciated, but also in 1979 and 1980 when the pattern was reversed.

There are three main lines according to which current account developments can be argued to affect the exchange rate, without reverting to the traditional flow theory of foreign exchange. The first begins by observing that current account developments have been largely dominated by oil. One could argue within the monetary approach that, because the United States produces oil while Germany and Japan produce none, or else because world oil trade is actually transacted in dollars, the sharp increase in world oil prices that took place in 1979 raised the demand for the dollar at the expense of the mark and yen, much as did the increase that took place in late 1973. On the other hand, financial commentators have often argued more loosely that oil price increases actually hurt the dollar because the United States had not yet decontrolled domestic oil prices or else because US political prestige is at stake in the Middle East.¹⁵

The second line of argument begins by observing that the release by the government of unexpected figures on the trade balance or current account appears to have large immediate "announcement effects" on the exchange rate. In some versions the current account figures reveal new information about shifts in the long-run terms of trade. But the important point is that only the unexpected component of the current account has a large effect, the expected component having already been taken into account by the foreign exchange market.¹⁶

The third line of argument begins by observing that the counterpart of a current account surplus is a transfer of wealth from foreign residents to domestic residents. The increase in domestic wealth can, in turn, appreciate the currency through any of three channels. First, it can raise domestic expenditure as in the well-established Modigliani consumption function, and thus raise domestic income and the transactions demand for domestic money. Second, it can raise the demand for domestic money directly if wealth enters the money demand function and domestic money is not held by foreigners. Third, if domestic bonds and foreign bonds are imperfect substitutes and domestic residents have a greater tendency to hold wealth in the form of domestic bonds than do foreign residents, the increase in domestic wealth will raise the demand for domestic bonds. Each of these effects might claim a role in a comprehensive model, but we will focus on the last of the three and refer to it as the "portfolio-balance" effect, giving us the second major branch in figure 3.1.¹⁷

3.3.2 The Portfolio-Balance Equation

We retain our assumption that there are no barriers segmenting international capital markets, but we relax the assumption that domestic and foreign bonds are perfect substitutes. Thus investors allocate their bond portfolios between the two countries in proportions that are functions of the expected rates of return.

There are many reasons why two assets can be imperfect substitutes: liquidity, tax treatment, default risk, political risk, and exchange risk. However, at the level of aggregation relevant for most macroeconomic models (see note 2), and under our assumption of perfect international bond markets, the last of these is the most important. We assume that there is only one respect in which domestic and foreign bonds differ: their currency of denomination. Investors, in order to diversify the risk that comes from exchange rate variability, balance their bond portfolios between domestic and foreign bonds in proportions that depend on the expected relative rate of return (or risk premium):

$$B_j/EF_j = \beta_j(i - i^* - \delta \Delta e). \quad (16)$$

Here B_j is the stock of domestic-denominated bonds held by investor j ; F_j , the stock of foreign-denominated bonds held; and E , the exchange rate. β_j is a positive-valued function; for concreteness let it be $\exp[\alpha_j + \beta_j(i - i^* - \delta \Delta e)]$.¹⁸ An increase in the interest differential or a fall in the expected rate of depreciation induces investors to shift their portfolios out of foreign bonds and into domestic bonds. (Note that B_j and F_j can be negative, which will be the case if agent j is a debtor.)

We assume at first that all active participants in the market have the same portfolio preferences, as represented by the function β . This assumption allows us to add up individual asset demand functions into the aggregate asset demand equation (17):

$$\frac{B}{EF} = \beta(i - i^* - \delta \Delta e), \quad (17)$$

where

$$B \equiv \sum_{j=1} B_j \quad \text{and} \quad F \equiv \sum_{j=1} F_j.$$

B and F are the *net* supplies of bonds (domestically denominated and foreign denominated, respectively) in the market. If one market participant is in debt to another, the asset and liability will cancel out. All that matters are the supplies of *outside* assets in the market.

A relation like (17) between asset supplies and expected rates of return is not by itself a theory of exchange rate determination, as Dooley and Isard [1979] have pointed out. Even if the interest rates are omitted or taken as exogenous, expectations must be specified. For example, if either the expected rate of depreciation $\delta \Delta e$ or the expected future exchange rate δe_{+1} is determined, then the exchange rate is uniquely determined.¹⁹ But specifying that expectations are formed *rationally* is not sufficient to determine the exchange rate uniquely; as in so many rational expectations problems, the assumption of stability is also required. The simplest possible portfolio-balance model would specify static expectations: $\delta \Delta e = 0$. Then the exchange rate is simply determined by relative bond supplies and the interest differential:

$$e = -\alpha + \beta(i - i^*) + b - f, \quad (18)$$

where $b \equiv \log B$ and $f \equiv \log F$. Equation (18) is estimated below.²⁰

So far we have not been very precise about the definitions of B and F . If the market consists of the whole world, and residents of all countries have the same portfolio preferences, then "the supplies of outside assets in the market" include only government-issued liabilities held by the private sector.²¹ In (17) B must be interpreted as net domestically denominated government indebtedness and F as net foreign-denominated government indebtedness. B and F will be the same as domestic and foreign government debt, respectively, under the assumption that governments issue debt denominated exclusively in their own currencies.²²

The proposition that residents of all countries have the same portfolio preferences implies that the indebtedness of residents of one country to residents of the other has no effect. This proposition holds in several recent finance papers—Grauer, Litzenberger, and Stehle [1976]; Frankel [1979a]; Fama and Farber [1979]; and Dornbusch [1980a]—and is represented by the "uniform preference" branch of portfolio-balance models in figure 3.1. These papers derive the asset demand functions as the outcome of maximization of expected utility by risk-averse agents. The proposition that all agents have the same portfolio preference follows from the assumption that they all consume the same good, or basket of goods.²³

This interpretation of equation (17) contrasts with macroeconomic models of portfolio balance that take asset-demand functions as given. The majority of these models, though they maintain our assumption that no barriers discourage residents of any country from participating in the world market, make the assumption that domestic residents are the only

ones who *wish* to hold domestically denominated assets.²⁴ The domestic country is assumed to be too small for its assets to be of interest to foreign residents.

One motivation for this assumption is to simplify the accounting—it allows the identification of a capital inflow or outflow with an increase or decrease in the supply of foreign assets in the home market by assuming away the problem of currency of denomination of the capital flow. The second motivation for the assumption is that, under floating exchange rates, it leads to the result that a current account deficit causes a depreciation of the home currency, since the counterpart to the current account deficit is a capital inflow: The reduction in the supply of foreign-denominated assets in the market leads to a rise in their price in terms of domestic currency.

Thus as an alternative to (17), we aggregate (16) over all domestic residents only:

$$\frac{B_H}{EF_H} = \beta_H(i - i^* - \delta \Delta e), \quad (19)$$

where B_H is defined as the sum of all domestic bonds held by home residents (identical to B , under the small-country assumption), F_H is defined as the sum of all foreign bonds held by home residents (equal to the accumulation of past current account surpluses under the small-country assumption), and β_H is the asset-demand function shared by all home residents. Assuming static expectations, the exchange rate equation is

$$e = -\alpha_H - \beta_H(i - i^*) + b - f_H, \quad (20)$$

where $b \equiv \log B$ and $F_H \equiv \log F_H$.

The small-country assumption—the assumption that foreign residents do not hold domestic bonds—is particularly unrealistic if the domestic country is the United States. One alternative is to assume that the *foreign* country is the small country—that domestic residents do not hold foreign bonds. Then (20) is replaced by

$$e = -\alpha_F - \beta_F(i - i^*) + b_F - f, \quad (21)$$

where b_F is defined as the log of domestic bonds held by foreign residents (equal to the accumulation of past foreign current account surpluses under the small-country assumption).²⁵ Equations (20) and (21) are estimated below.

A realistic portfolio-balance model for large countries must recognize

that residents of both countries hold assets issued by both countries. But the (cumulated) current account will still have the expected effect on the exchange rate, provided domestic residents wish to hold a greater proportion of their wealth as domestic assets and foreign residents wish to hold a greater proportion as foreign assets. (Such models are classified under the name “preferred local habitat” in figure 3.1.²⁶) This is because the current account will redistribute world wealth in such a way as to raise net world demand for the surplus country’s assets, thus raising the price of its currency. We would have to specify a separate asset-demand function for foreign residents:

$$\frac{B_F}{EF_F} = \beta_F(i - i^* - \delta \Delta e), \quad (22)$$

where $\beta_H \geq \beta_F$ for all values. Equations (19) for the home country and (22) for the foreign country could each be solved independently for the exchange rate and regressed in logarithmic form, were data on B_H , B_F , F_H , and F_F available. Unfortunately, data on the four-way breakdown—who owns how much of which asset—are difficult to obtain. Only the two-way breakdowns can be attempted: between domestically and foreign-denominated bonds ($B \equiv B_H + B_F$ versus $F \equiv F_H + F_F$) and between domestically and foreign-held wealth ($W_H \equiv B_H + EF_H$ versus $W_F \equiv B_F + EF_F$).

The nonlinear nature of (19) and (22) prevents solving for the exchange rate as a function of B , F , W_H , and W_F . However, the signs to be expected in such a relation are clear. An increase in the supply of foreign bonds F lowers their relative price E . An increase in the supply of domestic bonds B raises E . An increase in foreign wealth W_F raises the overall world demand for foreign assets and thus raises their relative price E . Finally, an increase in home wealth W_H raises the overall world demand for domestic assets and thus lowers E .

Table 3.2 presents regressions of the dollar/mark exchange rate against the interest differential and bond supplies, which are tests of the portfolio-balance approach under static expectations. Calculation of the net supplies of domestically and foreign-denominated assets requires correcting outstanding treasury debt for exchange intervention by central banks—as mentioned in note 22.²⁷ In addition, each country’s monetary base is subtracted from the supply of its assets to arrive at the supply of its interest-paying bonds. Kouri [1978] argues that all nominally fixed assets should be included in the portfolio, whether interestpaying or not. Proponents of the currency-substitution model argue in effect that *only*

Table 3.2 Estimation of portfolio-balance equations—log of dollar/mark rate, January 1974–October 1978*

Asset preferences	Technique	c	usi - g	usb	gb	usf	gf	R ²	D.W.	β
1. Uniform worldwide	OLS	-0.485 (0.215)	-0.472 (0.579)	-0.798 ^b (0.122)	+0.916 ^b (0.116)			0.78	0.46	
	CORC	+0.733 (0.971)	-0.387 (0.461)	-0.343 ^b (0.173)	+0.431 ^b (0.089)			0.94		0.97
2. US bonds held only by US residents	OLS	-6.391 (0.831)	0.240 (0.643)	-0.393 ^b (0.098)	+1.255 ^b (0.217)			0.71	0.29	
	CORC	-10.312 (3.202)	-0.248 (0.525)	-0.117 (0.171)	+1.639 ^b (0.524)			0.92		0.95
3. German bonds held only by German residents	OLS	-1.530 (0.223)	1.920 ^b (0.598)		+0.224 ^b (0.062)			0.61	0.23	
	CORC	+0.632 (1.041)	-0.311 (0.426)		+0.154 (0.106)			0.94		-0.96
4. General case	OLS	-5.648 (0.881)	-1.595 ^c (0.491)	-0.607 ^b (0.105)	+0.893 ^b (0.102)	+1.330 ^b (0.226)	-0.295 ^b (0.096)	0.87	0.61	
	CORC	-5.620 (2.497)	-0.699 (0.431)	-0.188 (0.106)	+0.271 (0.147)	+1.174 ^b (0.423)	-0.463 ^b (0.149)	0.95		0.94

a. Definitions: usi - g ≡ interest differential (short-term money market rates, per annum basis); usb ≡ log of net supply of dollar bonds to the private sector, calculated as US Treasury debt + cumulative Federal Reserve sales of dollar assets in foreign exchange intervention (inferred from Fed international reserves without valuation changes) - dollar assets held by other central banks - US monetary base; gb ≡ log of net supply of mark bonds to the private sector, calculated as German Treasury debt + cumulative Bundesbank sales of mark assets in foreign exchange intervention (inferred from Bundesbank international reserves without valuation changes) - mark assets held by other central banks - German monetary base; usf ≡ log of net supply of foreign bonds to the US private sector, under the (unrealistic) assumption that dollar assets are held only by US residents and that all capital flows are denominated in marks, calculated as the cumulation of (expressed in marks) the US current account - Federal Reserve purchases of foreign assets in foreign exchange intervention + sales by other central banks of foreign assets for dollars; gf ≡ log of net supply of foreign bonds to the German private sector, under the (unrealistic) assumption that mark assets are held only by German residents and that all capital flows are denominated in dollars, calculated as the cumulation of (expressed in dollars) the German current account - Bundesbank purchases of foreign assets in foreign exchange intervention + sales by other central banks of foreign assets for marks. (Standard errors in parentheses.)

b. Significant at the 95 percent level and of the incorrect sign.

c. Significant at the 95 percent level and of the correct sign.

moneys should be included in the portfolio.²⁸ But regressions based on these alternatives were no more successful than those, based on supplies of bonds alone, reported in table 3.2.

Row 1 is an estimation of equation (18): the portfolio-balance model when residents of all countries have uniform asset preferences, so that the worldwide distribution of wealth via current accounts is irrelevant and government bond supplies are all that matter. Row 2 is an estimation of equation (20), the "domestic small-country" model, in which the relevant stock variables are the supply of domestic government bonds and the supply of foreign bonds to domestic residents, with the United States defined as the domestic country. Row 3 is an estimation of equation (21), the "foreign small-country" model, in which the relevant stock variables are the supply of foreign government bonds and the supply of domestic bonds to foreign residents, with Germany defined as the foreign country. Row 4 uses all four stock variables: the supplies of both domestic and foreign bonds and the cumulated current accounts of both countries.²⁹ This regression includes each of the first three as special cases.³⁰

The results are very poor for the portfolio-balance models. The coefficients on all four stock variables are always of the incorrect sign and usually appear significantly so.

3.4 A Synthesis of the Monetary and Portfolio-Balance Equations

In section 3.2.1 we presented the simple monetarist model of exchange rates which assumes one world bond (i.e., perfect capital substitutability, implying uncovered interest parity) and one world good (i.e., perfect price flexibility, implying purchasing power parity). The result was the monetarist equation in which the exchange rate is determined by the relative money supply, relative income, and the expected inflation differential:

$$e = (m - m^*) - \phi(y - y^*) + \lambda(\Pi - \Pi^*) \tag{8}$$

In section 3.2.2 we relaxed the price flexibility assumption. In empirical terms, we simply added the real interest differential to the other three explanatory variables:

$$e = (m - m^*) - \phi(y - y^*) + \lambda(\Pi - \Pi^*) - (1/\theta)[(i - \Pi) - (i^* - \Pi^*)] \tag{14}$$

In this section we extend the synthesis process by relaxing the perfect substitutability assumption.³¹ We integrate the monetary models, as

represented by equation (14), with the portfolio-balance models, as represented by equation (17):

$$B/EF = \beta(i - i^* - \delta \Delta e). \quad (17)$$

In logarithmic form (17) becomes

$$b - e - f = \alpha + \beta(i - i^* - \delta \Delta e). \quad (23)$$

We repeat the expectation equation (12):

$$\delta(\Delta e) = -\theta(e - \bar{e}) + \Pi - \Pi^*. \quad (12)$$

By adding and subtracting the nominal interest differential, we see that (12) implies that the exchange rate deviates from its long-run value by an amount proportional to the real interest differential and the risk premium:

$$e - \bar{e} = -(1/\theta)[(i - \Pi) - (i^* - \Pi^*)] + (1/\theta)[i - i^* - \delta \Delta e]. \quad (24)$$

We substitute in equation (11) for the equilibrium exchange rate:

$$e = (m - m^*) - \phi(y - y^*) + \lambda(\Pi - \Pi^*) - (1/\theta)[(i - \Pi) - (i^* - \Pi^*)] + (1/\theta)[i - i^* - \delta \Delta e]. \quad (25)$$

In the monetarist model, purchasing power parity (6) ensured that the real interest differential was zero and uncovered interest parity (3) ensured that the risk premium was zero, so that equation (25) reduced to (8). The sticky-price monetary model relaxed the first condition but maintained the second, so that (25) reduced only to (14).

The synthesis of the monetary and portfolio-balance equations is accomplished simply by relaxing the second condition. We replace uncovered interest parity (3) with the imperfect substitutability condition (23). Now the exchange rate deviates from its equilibrium value not only because sticky goods prices create a real interest differential, but also because imperfect bond substitutability creates a risk premium. We substitute (23) into (25), getting bond supplies into the exchange rate equation in place of the unobservable risk premium:

$$e = (m - m^*) - \phi(y - y^*) + \lambda(\Pi - \Pi^*) - (1/\theta)[(i - \Pi) - (i^* - \Pi^*)] + [1/(\theta\beta)][b - e - f - \alpha]. \quad (26)$$

Finally, we solve for e :

Table 3.3
Implied regression coefficients of competing exchange rate equations^a

e against	$(m - m^*)$	$(y - y^*)$	$(i - i^*)$	$(\Pi - \Pi^*)$	$(b - f)$
Traditional flow view		+	-		
Modern asset view					
Monetary approach					
Monetarist equation (8)	+	-	+	+	
Overshooting equation (15)	+	-	-		
Real interest differential equation (14)	+	-	-	+	
Portfolio-balance approach (18)					+
Synthesis asset equation (27)	+	-	-	+	+

a. Definitions: $e \equiv \log$ of exchange rate; $m - m^* \equiv \log$ of relative money supply; $y - y^* \equiv \log$ of relative income; $i - i^* \equiv$ nominal interest differential; $\Pi - \Pi^* \equiv$ expected inflation differential; $b - f \equiv \log$ of relative bond supply.

$$e = \frac{\alpha}{\theta\beta + 1} + \frac{\theta\beta}{\theta\beta + 1}(m - m^*) - \frac{\theta\beta\phi}{\theta\beta + 1}(y - y^*) + \frac{\beta(\theta\lambda + 1)}{\theta\beta + 1}(\Pi - \Pi^*) - \frac{\beta}{\theta\beta + 1}(i - i^*) + \frac{1}{\theta\beta + 1}(b - f). \quad (27)$$

In empirical terms we have simply added the relative bond supply to the monetary equation (14) as a fifth explanatory variable.

Equation (27) is intended to synthesize many varieties of asset-market model, monetary as well as portfolio balance. Since it contains the individual competing models as special cases, it provides a framework for evaluating them empirically. Table 3.3 summarizes the coefficient signs implied by the various models in a regression of equation (27). The implications of the various models are so conflicting that one would think that regression could hardly help but reject some models in favor of others.

Table 3.4 reports the regression of equation (27). The results are similar to those in tables 3.1 and 3.2. The coefficients of the variables from the monetary equation—the relative money supply, relative income, interest differential, and inflation differential—are usually correct in sign. However, when we correct for serial correlation, most of them lose their significance. The coefficient of the relative bond supply, in the uniform-preference and German small-country version, appears significant but of the *reverse* sign from that hypothesized in the portfolio-balance model.

An examination of the data on dollar and mark bond supplies readily reveals the problem with tables 3.2 and 3.4. During a period when the dollar/mark rate rose on average, the dollar bond supply (like the dollar

Table 3.4
 Estimation of synthesis exchange rate Equation (27)—log of dollar/mark rate, January 1974–October 1978*

Technique	c	usmlb - gml usy - gy	usi - gi	usII - gII	usb - gb	usb - usf	gb - gf	R ²	D.W.	$\hat{\rho}$
1. OLS	0.086 (0.131)	-0.751* (0.136)	-1.588* (0.550)	2.657* (0.530)	-0.578* (0.121)			0.86	0.56	
CORC	-0.260 (0.230)	-0.011 (0.358)	-0.396 (0.502)	0.852 (0.766)	-0.398* (0.091)			0.94		0.97
2. OLS	-0.520 (0.090)	-0.388 (0.226)	0.706 (0.595)	5.559* (0.597)		0.419* (0.115)		0.83	0.84	
CORC	-0.674 (0.256)	0.190 (0.416)	0.156 (0.570)	0.773 (0.928)		-0.184 (0.194)		0.92		0.98
3. OLS	-0.772 (0.086)	-0.687 (0.116)	-0.491 (0.420)	4.480* (0.371)			0.284* (0.041)	0.89	0.76	
CORC	-1.103 (0.186)	0.050 (0.314)	-0.358 (0.465)	1.851* (0.691)			0.313* (0.052)	0.95		0.92

a. Definitions: see tables 3.1 and 3.2. (Standard errors are in parentheses.)

b. Significant at the 95 percent level and of the incorrect sign.

c. Significant at the 95 percent level and of the correct sign.

money supply) did *not* increase as fast as its mark counterpart. The problem can be traced to foreign exchange intervention: Foreign central banks rapidly increased their holdings of dollar assets in order to keep their own currencies from appreciating against the dollar. As Hooper and Morton [1982] point out, one cannot use a current account deficit within the portfolio-balance model to explain a currency depreciation if the deficit is more than offset by exchange intervention on the part of foreign central banks.

To the extent that this intervention was sterilized, its failure to maintain the value of the dollar is evidence against the portfolio-balance approach and in favor of the monetary approach.³² As noted in section 3.2.3, the purchases of dollars by foreign central banks *were* allowed to increase their money supplies. However, the relative German monetary base did not increase anywhere nearly as quickly as the relative German net bond supply. While 1978 remains a mystery for both models, the updated results in table 3.1 appear promising enough, at least in comparison to the disaster of table 3.2 and 3.4, tentatively to justify a return of attention to the monetary approach.

Notes

1. This distinction between capital mobility and substitutability is made precise by Dornbusch and Krugman [1976]. Earlier references to it appear in Girton and Henderson [1976], Girton and Roper [1976], and Dornbusch [1977]. The distinction is far from universally accepted (for example, Mundell [1963] implicitly took perfect mobility to require perfect substitutability), but is useful.

2. Empirical tests have shown covered interest parity to hold to a high degree of approximation, at least in the Eurocurrency market. See, for example, Frenkel and Levich [1977]. Covered interest parity holds less well if the interest rates used refer to treasury bills, commercial paper, or other financial securities that differ from the forward contract with respect to tax treatment, default risk, or other factors. However, at the level of aggregation relevant for most macroeconomic models we speak only of "the" interest rate, abstracting from distinctions such as that between the 30-day Eurodollar interest rate and the 30-day treasury bill rate. This paper presumes that level of aggregation and presumes covered interest parity.

3. It is difficult to test uncovered interest parity empirically because expectations are not observable. Uncovered interest parity (and, by implication, perfect substitutability) can be tested *jointly* with market efficiency by examining the ex post excess return on domestic currency. The excess return is defined as the interest differential in excess of ex post depreciation, or alternatively (given covered interest parity) as the forward discount in excess of ex post depreciation. Under the joint null hypothesis, the ex post excess return should be random; the forward rate should be an unbiased predictor of the future spot rate (see figure 3.1).

Most such tests take the perfect substitutability component of the joint hypothesis as given and interpret the results as evidence on efficiency. See for example Cornell [1977], Cornell and Dietrich [1979], Frankel [1980], and Frenkel [1977]; the literature is surveyed by Levich [1979] and Kohlhagen [1978]. But a few such tests take the market efficiency component of the joint hypothesis as given and interpret the results as evidence on substitutability. See Stockman [1978], Cumby and Obstfeld [1979], and Frankel [1982b].

4. Some of the many examples are Allen and Kenen [1980]; Black [1973]; Branson [1976]; Branson, Haltunen, and Masson [1977]; Calvo and Rodriguez [1977]; Dooley and Isard [1979]; Dornbusch [1980a]; Flood [1979]; Girton and Henderson [1977]; Girton and Roper [1976]; Kouri [1976a, 1978]; Kouri and deMacedo [1978]; McKinnon [1976]; Porter [1979]; Tobin and deMacedo [1980]; and Rodriguez [1980]. The antecedents are the portfolio-balance approach under fixed exchange rates, as represented by Branson [1968], and the portfolio-balance model in a closed economy, as represented by Tobin [1969].

5. Examples are Frenkel [1976, 1977, 1980], Mussa [1976], Dornbusch [1976a,b], Girton and Roper [1977], Bilson [1978a,b], Hodrick [1978], and Frankel [1979b].

6. Officer [1976] surveys the literature on purchasing power parity. Some recent empirical studies are Isard [1977], Genberg [1978], and Krugman [1978].

7. This distinction between the monetary approach to exchange rates and the more restrictive monetarist model follows the distinction made by Whitman [1975] in the theory of fixed exchange rates between the monetary approach to the balance of payments and the more restrictive "global monetarist" model. (In the past—Frankel [1979b]—I have used the term "Chicago model" for what I am here calling the monetarist model.)

8. Little, if any, published monetarist work asserts this restrictive special case, the monetarists having long ago relaxed the quantity theory of money to study the effect of expected inflation on money demand.

A recent paper by Caves and Feige [1980] that purports to test "the monetary approach to exchange-rate determination" uses as its criterion the unusual proposition that the exchange rate is entirely explainable by the past history of the money supplies. Even the most extreme monetarist proponent of the monetary approach recognizes the importance of fluctuations in real income.

In a further confusion, Caves and Feige claim that proponents of the monetary approach "have failed to recognize that one of the consequences of an efficient foreign exchange market is to eliminate the possibility of directly observing a systematic relationship [between] exchange rates and past supplies of national monies. If the foreign exchange market is efficient, all monetary effects on exchange rates will be contemporaneous" [1980, p. 121]. But as is well known, market efficiency requires not that changes in the spot rate be independent of past variables such as money supplies, but that changes in the spot rate *in excess of the interest differential* (or forward discount) be independent of past variables. In any monetary model except the restrictive special case described above, the past history of the money supply may contain information on changes in the spot rate without violating efficiency. In the benchmark monetarist model, for example, the interest differential

and the rationally expected change in the spot rate are each equal to the relative rate of expected monetary growth; actual changes in the spot rate will be independent of past money supply *changes*, not *levels*. In the Dornbusch overshooting model, changes in the spot rate are not independent of either past money supply changes or levels.

9. See Mundell [1964], Argy and Porter [1972], Nichans [1975], and Dornbusch [1976a,b].

10. The version that follows is based on Dornbusch [1976b] as generalized in Frankel [1979b] to include the case of secular inflation. (In that paper I used the term "Keynesian model" for what I am here calling the overshooting model. We should also note that overshooting is possible in other models, as shown by Flood [1979].) Investigations of the overshooting properties of the Dornbusch model include Mathieson [1977] and Bhandari [1981].

11. In the appendix to Frankel [1979b], it is proved that the form of exchange rate expectations specified in (12) is rational, assuming an additional equation in which the price level adjusts in the short run in response to excess goods demand (itself a function of relative prices, and possibly income and the real interest rate) and increases in the long run at the secular inflation rate (Π).

12. For example, Bilson [1978a,b], Hodrick [1978], Dornbusch [1978], Kohlhagen [1979], Frankel [1979b], and Driskill [1981].

13. For example, Dornbusch [1980], and an earlier version of the present paper.

14. The unexplained fall in demand for dollars relative to marks may be associated with the observed unexplained downward shift in the US money demand function known as "the mystery of the missing money."

15. Krugman [1980] identifies OPEC's asset-holding and importing preferences between the United States and Europe as the key determinants of the effect of oil price increases on the value of the dollar. Obstfeld [1980b] is typical of a number of papers that emphasize oil's role as an intermediate input and are primarily relevant for small countries.

16. For example, Hooper and Morton [1982], Isard [1980] and Dornbusch [1980b].

17. The expenditure channel is represented by Dornbusch and Fischer [1980]. Wealth enters the money demand function in Dornbusch [1976c] and Frankel [1982a]. Both effects are present in Turnovsky and Kingston [1979]. The strategy of attempting to "put the current account back" into the asset-market models through the portfolio-balance effect is made explicit by Kouri [1976a], Kouri and deMacedo [1978], Hooper and Morton [1982], Porter [1979], Dooley and Isard [1979], and Rodriguez [1980]. Dornbusch [1980b] mentions all three wealth effects (pp. 154–57, 164, and 164–68, respectively), but emphasizes the imperfect substitutability effect as "more persuasive."

18. If portfolio-balance behavior is the outcome of the maximization of expected utility by risk-averse investors, then we are implicitly assuming in (16) that the variances of currency values, and covariances with other forms of real wealth, are stationary over time. Only the expected rate of return is assumed to vary.

19. If the expected future exchange rate is $\overline{\mathcal{E}}_{t+1}$, then the solution for the current exchange rate, in log form, is

$$e = -\frac{\alpha}{1 + \beta} + \frac{1}{1 + \beta}(b - f) + \frac{\beta}{1 + \beta}(\overline{\mathcal{E}}_{t+1} - (i - i^*)).$$

20. Kouri [1976a] considers the alternatives of static and rational (or perfect foresight) expectations.

21. If government-issued assets are not considered net wealth by the private sector because they imply off-setting liabilities in the form of future taxation, the Ricardian principle, then the possibility arises that the net supply of outside assets to the world market is zero. If there are no outside assets (including real assets) then exchange risk is completely diversifiable. Under these very special circumstances, investors will consider domestic and foreign bonds perfect substitutes in market equilibrium because they can always cover any exchange risk on the forward market *without* paying any risk premium; the perfect substitutability assumption holds despite risk aversion. (The argument is made in Frankel [1979a]. For an empirical test of perfect substitutability based on equation (17) see Frankel [1982b].)

22. Of course many small countries do sometimes issue debt denomination in foreign currencies, and even the United States began to do so with its Carter notes. (The Roosa bonds of the 1960s do not count because they were held by foreign governments rather than citizens.) In empirical work, any such debt must be counted according to its currency of denomination. A bigger problem is central bank behavior. Purchases of domestically denominated assets in foreign exchange intervention (by foreign as well as domestic central banks) must be subtracted from treasury debt to arrive at the proper measure of the net supply of domestically denominated assets to the private market.

23. At the opposite extreme, Solnik [1974] derives asset-demand functions as the outcome of maximization by agents who consume only goods produced in their own countries.

24. Branson [1976], Kouri [1976a], Flood [1979], Branson, Halttunen, and Masson [1977], Porter [1979], Dornbusch and Fischer [1980], and Rodriguez [1980], among others, assume that domestic assets are not held by foreigners.

25. Shafer [1979] assumes that the foreign country is the small country, that is, the foreign accumulated current account surplus is the supply of domestically denominated bonds.

26. A small but growing number of models allow the foreign preference for holding domestic assets to be less than the domestic preference and yet greater than zero. In the category of finance models that derive asset-demand functions from expected-utility maximization are Kouri [1976b] and Kouri and deMacedo [1978] and the appendix to Dornbusch [1980a]. The necessary assumption at first appears to be only that the foreign preference for consuming domestic goods is less than the domestic preference and yet greater than zero. However, Krugman [1981] shows in a continuous-time stochastic model that it is also necessary that the coefficient of relative risk-aversion be greater than one.

In the category of macroeconomic models of portfolio balance which take asset-

demand functions as given are Dooley and Isard [1979] and parts IV and V of Allen and Kenen [1980]. Henderson and Rogoff [1981] use such a model to investigate the possibility that negative holdings of foreign assets cause dynamic instability (a possibility that in a small-country context concerns Branson, Halttunen, and Masson [1977] and Obstfeld [1980a] among others).

27. These calculations become especially difficult after October 1978 because of the issuing of Carter notes by the Treasury, the holding of foreign exchange reserves valued at current exchange rates by the Federal Reserve, and the turning over of reserves to the European Monetary System by the Bundesbank. For this reason the data sample used in tables 3.2 and 3.4 ends in October 1978. Data sources were the *Federal Reserve Bulletin* and the *Bundesbank Monthly Report Statistical Supplements*. Data and details of the calculations are available on request.

28. The term "currency substitution" was originated by Girton and Roper [1981] to describe the allocation of market portfolios between domestic and foreign money. Other examples are Barro [1978] and Calvo and Rodriguez [1977]. In many of the theoretical models, only the use of the words "money" or "currency" distinguishes them from the other portfolio-balance models, which use the words "bonds" or "assets." But one might argue, following note 21, that, to the extent that government debt implies future tax liabilities to pay it off, high-powered money is the only true outside asset, and thus the only asset able to create nondiversifiable exchange risk for the private market.

Presumably if only money is included in the asset measures, the interest rates do not belong in the equation. Some currency substitution models, such as Miles [1978], use interest rates as the opportunity cost of money, thus hypothesizing a *positive* coefficient in the exchange rate equation. It is difficult to distinguish such an equation from the reduced form of the monetarist model (7), in which national moneys are held only in their own countries but bonds and goods are perfect substitutes across countries.

Branson, Halttunen, and Masson [1977, 1979] include bonds in their theoretical model, in addition to money, and use them to solve out the endogenous interest rate. However, they restrict the empirical estimation to money supplies under the rationale that the effect of an increase in the supply of domestic bonds on the exchange rate is ambiguous: The resulting increase in the interest rate has the opposite effect from the increase in total domestic assets. Porter [1979] does the same. Dooley and Isard [1979] restrict their asset measures to bonds throughout, which strategy table 3.2 follows.

29. Of course, if the world really consisted of only two countries, one country's current account would be the negative of the other and row 4 would be subject to perfect multicollinearity. However, there are many wealth holders not residing in either Germany or the United States.

30. Branson, Halttunen, and Masson [1977, 1979] regress the exchange rate against all four stock variables although their theoretical discussion is based on the small-country model. Such an equation cannot be rationalized by the assumption that both the United States and Germany are small countries, aside from the unrealism of such an assumption, unless the current account and intervention figures that enter into usf and gf are cumulated in terms of some third currency such as the

SDR. This method of calculation produces results no better than those in table 3.2.

One possible rationale for such an equation is that it is a log-linear approximation to the two-country relation described after equation (22).

31. Hooper and Morton [1982] and Isard [1980] integrate the risk premium into the monetary equation in a very similar fashion. For a more theoretical synthesis of the portfolio-balance model and the sticky-price monetary model, see Henderson [1980].

32. In the monetary approach, foreign exchange intervention affects the exchange rate *only* to the extent that it is nonsterilized, that is, allowed by the central banks to affect the money supplies. Girton and Henderson [1977], p. 169, and Obstfeld [1980a, pp. 142-43], illustrate this point in portfolio-balance models as the special case in which domestic and foreign bonds are perfect substitutes.

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