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1 The Theory of Exchange Rate Determination

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1.1 Introduction

This essay develops an integrated model of exchange rate behavior that synthesizes many recent and older contributions to the theory of exchange rate determination. Since the task of exchange rate theory is to explain behavior observed in the real world, the essay begins (in sec. 1.2) with a summary of empirical regularities that have been characteristic of the behavior of exchange rates and other related variables during periods of floating exchange rates. This discussion continues (in sec. 1.3) with the presentation of a schematic model of the exchange rate as an "asset price" that depends on a discounted sum of economic factors that are expected to affect the foreign exchange market in present and future periods. This schematic asset price model implies a convenient decomposition of exchange rate changes into their expected and unexpected components; and it suggests a general explanation for the dominance of the random, unexpected component of exchange rate change in actual exchange rate movements.

Specific content for the schematic asset price model of the exchange rate is provided (in sec. 1.4) by considering a reduced-form expression for the condition of money market equilibrium in which both the level and the expected rate of change of the exchange rate affect the demand to hold domestic money. Under the assumption of rational expectations, this reduced-form equilibrium condition implies that (the logarithm of) the nominal exchange rate is an exponentially weighted average of expected future differences between (the logarithms of) the nominal money supply and the exogenous component of money demand. This result, which allows a key role for expectations concerning future money supply and money demand behavior in determining the current exchange rate, is contrasted with simple monetary models that focus on current money supplies and current money demands as the determinants of exchange rates.

An alternative asset price model of the exchange rate emerges (in sec. 1.5) from a reduced-form expression of the condition of balance of payments equilibrium that is derived from an extended version of the standard two-country model of international trade. This model, which focuses on the real exchange rate and other real variables, embodies the essential ideas of the elasticities and absorption approaches to the balance of payments and the traditional partial equilibrium model of the foreign exchange market. Under the assumption of rational expectations, the model yields an expression for the current real exchange rate as a discounted sum of the expected future values of the exogenous real factors that affect excess demands for foreign and domestic goods and the desired relationship between spending and income. From this result conclusions may be derived concerning the relationships among the real exchange rate, the current account balance, and the net stock of foreign assets.

Combination of the reduced-form models of monetary and balance of payments equilibrium yields (in sec. 1.6) an equilibrium model of the determination of the exchange rate. This model illustrates the coordinate importance of monetary factors affecting the supply and demand for money and real factors affecting excess demands for specific goods and of the desired relationship between spending and income in influencing the behavior of the exchange rate. Modification of this equilibrium model by the introduction of an appropriately specified adjustment rule for the domestic money price of domestic goods (in sec. 1.7) results in a disequilibrium model of the exchange rate in which monetary disturbances have real effects on levels of output, relative prices, and the real exchange rate. The model illustrates the phenomenon of exchange rate "overshooting" in response to monetary disturbances and the role of such disturbances in inducing temporary divergences from purchasing power parity. The essay concludes with a brief summary and a discussion of possible extensions.

1.2 Empirical Regularities and Their Theoretical Implications

A central objective of theoretical models of exchange rate determination ought to be a clearer understanding of the economic mechanisms governing the actual behavior of exchange rates in the real world and of the relationships between exchange rates and other important economic variables. In surveying theoretical models of exchange rate determination, therefore, it is appropriate to examine the empirical regularities that have been characteristic of the behavior of exchange rates and other related variables under floating exchange rate regimes. It is also relevant to discuss the minimum requirements for any theoretical model of exchange rate determination to be consistent with these empirical regularities.[1]

1. Empirical regularities in the behavior of exchange rates and their implications for exchange rate theory are discussed in Mussa (1979); see also Dooley and Isard (1978), Frenkel and Mussa (1980), Isard (1980), and Frenkel (1981).

1.2.1 The Stochastic Behavior of Exchange Rates and Related Variables

Experience with floating exchange rates between the United States dollar and other major currencies (the British pound, the German mark, the French franc, the Swiss franc, and the Japanese yen) during the 1970s has revealed five general characteristics of the behavior of exchange rates and related variables under a flexible exchange rate regime in which the authorities do not intervene too actively in the foreign exchange markets. These characteristics also apply, in general, to the experience with floating exchange rates between major currencies during 1920s and 1930s and, with some modifications, to the experience of floating exchange rates between the United States and Canadian dollars during the 1970s. They do not always apply, however, to situations in which exchange rates have been very actively managed, such as the exchange rate between the Mexican peso and the United States dollar or the exchange rates between currencies within the European Monetary System.

First, statistical examination of the behavior of (logarithms of) spot exchange rates reveals that they follow approximately random walks with little or no drift. The standard deviation of monthly changes in exchange rates between major currencies and the United States dollar (except the Canadian dollar) has been about 3% per month, with changes of more than 5% occurring with moderate frequency. (In comparison, changes in national price levels, measured by consumer price indices, have had a standard deviation of about 1% per month, and monthly changes have virtually never exceeded 5% in major industrial countries during the 1970s.) Moreover, there has been virtually no predictable pattern in monthly exchange rate changes, and, at most, only a small fraction of such changes has been anticipated by the market, as measured by the forward discount or premium. These facts may be summarized in a general characteristic: Monthly changes in exchange rates are frequently quite large and are almost entirely random and unpredictable.

Second, analysis of the correlation between contemporaneous movements in spot and forward exchange rates (for maturities extending out to 1 year) indicates that spot and forward rates tend to move in the same direction and by approximately the same amount, especially when changes are fairly large. Some evidence suggests that forward rates are marginally affected by risk premia and hence do not correspond exactly to the market's expectation of the spot exchange rate at the maturity date of the forward contract.[2] This evidence, however, is not sufficiently strong to overturn the assumption that forward rates are reasonable though approximate estimates of the market's expectation of corresponding future spot exchange rates. This assumption, together with the observed contemporaneous correlation of movements in spot and forward rates, implies a second general characteristic of exchange rate behavior: Changes in spot exchange rates which are largely unantici-

2. See, in particular, Hansen and Hodrick (1980).

pated correspond fairly closely to changes in the market's expectation of future spot exchange rates.

Third, contrary to the doctrine of purchasing power parity (PPP), there has not been a close correspondence between movements in exchange rates and movements in the ratio of national price levels, especially during the 1970s.[3] Monthly (or quarterly) changes in exchange rates have averaged about three times as great as monthly (or quarterly) changes in the ratio of consumer price indices, and the correlation between exchange rate changes and changes in the ratio of national price levels has been close to zero. Moreover, while there has usually been positive serial correlation of monthly changes in the ratio of consumer price indices, there has been no corresponding serial correlation of monthly exchange rate changes. Over longer time periods, such as a year, cumulative divergences from relative purchasing power parity between the major industrial countries have frequently been as large as 10%. Using the concept of the "real exchange rate" (defined as the price of a unit of foreign money in terms of domestic money, divided by the ratio of the home consumer price index to the foreign consumer price index), these facts may be summarized in the following characteristic: Monthly changes in nominal exchange rates are closely correlated with monthly changes in real exchange rates, and cumulative changes in real exchange rates over a period of a year have been quite large.

Fourth, during the recent period of floating exchange rates, there may have been a weak general tendency for countries that experienced sharp deteriorations in their current accounts subsequently to experience depreciation in the nominal and real foreign exchange value of their currencies. There also may have been a weak general tendency for countries that experienced sharp appreciations in nominal and real foreign exchange values of their currencies subsequently to experience deterioration in their current accounts. It has not been the case, however, that exchange rates have adjusted rapidly to eliminate current account imbalances, nor has there been strong correlation between exchange rate changes and either levels of changes in current account balances that has held up consistently over time and across countries.[4] These facts may be summarized in the following characteristic: There is no strong and systematic relationship between movements in nominal or real exchange rates and current account balances that allows for an explanation of a substantial fraction of actual exchange rate movements.

Fifth, countries that experience very rapid expansion of their domestic

3. See, for example, Kravis and Lipsey (1978) and Frenkel (1981a).

4. Some evidence has been presented that movements in current account balances are among the factors influencing movements in exchange rates; see Branson (1976), Branson, Haltunen, and Masson (1977), Dooley and Isard (1978), Dornbusch (1978, 1980a), Isard (1980), Artus (1981), and Driskill (1981). It has not been the case, however, that exchange rates have adjusted rapidly to eliminate current account imbalances or that a large fraction of monthly or quarterly movements in exchange rates is easily explained by movements in current account balances.

money supplies also experience rapid depreciation of the foreign exchange value of their money, relative to the monies of countries with much less rapid monetary expansion.[5] For countries with only modest differences in their rates of monetary expansion (such as has been true for the major industrial countries during the 1970s), however, there is only a tenuous, long-run relationship between high relative rates of monetary expansion and depreciation in the foreign exchange value of domestic money. In particular, there is little or no statistical correlation between monthly changes in exchange rates and monthly differences in rates of monetary expansion for the major industrial countries during the 1970s.[6] These facts may be summarized in the following characteristic: Movements in nominal and real exchange rates are not closely related to differential rates of monetary expansion, except possibly for some very highly inflationary economies.

1.2.2 Implications for Theories of Exchange Rate Behavior

One of the implications of these general facts is that no simple model of exchange rate determination provides an adequate explanation of most of the observed movement in nominal and real exchange rates under a floating exchange rate regime. The bulk of observed movements in exchange rates cannot be explained by a naive "payments flows" model, which suggests that exchange rates adjust either immediately or gradually to maintain balance of payments equilibrium. A naive monetary model that relates exchange rate movements to differential rates of monetary expansion (with or without some form of lagged adjustment) does not perform appreciably better in explaining the bulk of exchange rate movements, except possibly for highly inflationary economies. A naive PPP explanation (not really a theory) of exchange rate movements also performs rather poorly.

A second important implication of the observed characteristics of the behavior of exchange rates and related variables concerns the general conception of exchange rates as "asset prices." Exchange rates share many of the general behavioral characteristics of the prices of assets that are traded on organized exchanges, such as common stocks, long-term bonds, and various metals and agricultural commodities. Monthly changes in the prices of these assets, like monthly changes in exchange rates (but unlike monthly changes in consumer price indices) are largely random and unpredictable. For assets with quoted spot and future prices, there tends to be a strong correlation between changes in spot prices and contemporaneous changes in futures prices, indicating that changes in spot prices are largely unanticipated and correspond fairly closely to changes in the market's expectation of future spot prices. Monthly changes in the prices of assets traded in organized

5. See, in particular, Frenkel (1976).

6. For an assessment of the failures of simple monetary models to explain exchange rate movements in the 1970s, see Dornbusch (1978, 1980a), Frankel (1979, 1982), Meese and Singleton (1980), and Meese and Rogoff (1982).

markets are not closely correlated with monthly changes in the general price level, as measured by the consumer price index, implying that most nominal price changes are also real price changes.

These common characteristics in the behavior of prices of assets traded in organized markets suggest that there should be important common elements in the theory of the behavior of such prices. In particular, for any asset that may be held in inventory at a relatively small storage cost and bought and sold with a relatively small transaction cost, we ought to expect that the price today would be reasonably closely linked to the price that is expected at some day in the near future, such as a month hence. The reason for this linkage is that if there were a substantial expected rise in the price of the asset over the course of a month, individuals would have a strong incentive to acquire and hold the asset, putting upward pressure on its current price and downward pressure on its expected future price, until the difference between these two prices was brought within the limits implied by storage and transactions costs.

This same argument implies that there should be a reasonably close linkage between the price of an easily storable and tradable asset that is expected 1 month from now and the price of that same asset that is expected 2 months from now, between the price of the asset expected 2 months from now and the price expected 3 months from now, and so on into the more distant future. Through this mechanism, the current price of an easily storable and tradable asset is linked to the economic conditions that are expected to affect the ultimate demand and supply of that asset in all future periods. Expected changes in the prices of such assets should reflect expected changes in the economic conditions that affect the ultimate demand and supply of the asset. In contrast, unexpected changes in the prices of such assets should reflect new information that changes expectations concerning the economic conditions that affect the ultimate demand for and supply of the asset. The observation that changes in many asset prices are largely random and unpredictable reflects the empirical preponderance of unexpected price changes due to new information over expected price changes in determining the actual behavior of most asset prices.[7]

1.3 The Asset Market View of Exchange Rate Determination

The gross similarities between the behavior of exchange rates and the behavior of the prices of other assets traded in highly organized markets suggests a common general approach to analyzing the behavior of such asset prices. The essential elements of this general approach, as applied to exchange rates, may be represented in a simple theoretical model that relates

7. It is not theoretically necessary that the unexpected component of price change should dominate actual movements in asset prices. Nevertheless, this appears to be true in all organized asset markets.

the current exchange rate to present and future conditions that are expected to affect the foreign exchange market.[8] This simple model assumes that the logarithm of the exchange rate at time t, $e(t)$; is determined by

$$e(t) = X(t) + a \cdot E\{[e(t + 1) - e(t)]; t\}, \tag{1}$$

where $E\{[e(t + 1) - e(t)]; t\}$ denotes the expected percentage rate of change of the exchange rate between t and $t + 1$, conditional on information available at t, and where $X(t)$ represents the basic conditions of supply and demand that affect the foreign exchange market at time t. The essential idea of equation (1) is that the exchange rate that yields equilibrium in the foreign exchange market at time t is affected not only by the basic factors of supply and demand summarized by $X(t)$, but also by the expected rate of change of the exchange rate which motivates domestic and foreign residents to move assets either into or out of foreign exchange depending on whether the price of foreign exchange is expected to rise or fall.

To close the model, it is necessary to specify how expectations of future exchange rates are determined. It is assumed that these expectations are "rational" in the sense that they are consistent with the validity of equation (1) in all future periods. By forward iteration of (1) and application of the appropriate boundary condition, we arrive at the conclusion that the exchange rate expected at any $t + j$, for $j \geq 0$, depends on a weighted average of expected future X's, starting at $t + j$ and extending farther into the future;[9] specifically,

$$\begin{aligned} E(e(t + j); t) = (1/(1 + a)) \cdot \sum_{i=0}^{\infty} (a/(1 + a))^i \\ \cdot E(X(t + j + i); t). \end{aligned} \tag{2}$$

Setting $j = 0$, we obtain the expression for the current exchange rate as a weighted average of present and expected future X's.

Using equation (2), we may obtain a convenient decomposition of the actual change in the exchange rate, $D[e(t)] = e(t + 1) - e(t)$, into its expected change component, $D^e[e(t)] = E\{D[e(t)]; t\} = E[e(t + 1); t] - e(t)$, and its unexpected change component, $D^u[e(t)] = e(t + 1) - E[e(t + 1); t]$. Specifically, applying the expected change operator $D^e(\ )$ to (2) with $j = 0$, we may conclude that

$$\begin{aligned} D^e[e(t)] = [1/(1 + a)] \cdot \sum_{i=0}^{\infty} [a/(1 + a)]^i \\ \cdot E\{D[X(t + j); t]\}. \end{aligned} \tag{3}$$

8. It is widely recognized that expectations are critically important in determining the behavior of exchange rates; see, for example, Dornbusch (1976, 1980b), Frenkel (1976), Kouri (1976a), Mussa (1976, 1982a), Ethier (1979), Rogoff (1979), and Wilson (1979). The present exposition of the asset price model is based on that given in Frenkel and Mussa (1980).

9. A boundary condition is imposed on the forward-looking solution of (1) to ensure an economically sensible, nonexplosive solution.

Thus, the expected change in the exchange rate is a weighted average of all expected future changes in the X's. This result may also be written in the alternative form,

$$D^e[e(t)] = [1/(1 + a)] \cdot \{E[e(t + 1); t] - X(t)\}, \tag{4}$$

which expresses the expected change in the exchange rate as proportional to the difference between the weighted average of all expected future X's that determines $E[e(t + 1); t]$ and the current $X(t)$, with a factor of proportionality of $[1/(1 + a)]$. The unexpected change in the exchange rate is determined by applying the unexpected change operator $D^u(\ )$ to (2) with $j = 0$;

$$\begin{aligned} D^u[e(t)] = {} & [1/(1 + a)] \cdot \sum_{i=0}^{\infty} [a/(1 + a)]^i \\ & \cdot \{E[X(t + j + 1); t + 1] \\ & - E[X(t + j + 1); t]\}. \end{aligned} \tag{5}$$

Thus, the unexpected component of the change in the exchange rate is a weighted average of the change in expectations about future X's, based on new information that is received between t and $t + 1$.

From these results, it is possible to argue that expected changes in exchange rates are unlikely to be very large. Specifically, consider the monthly expected change in the exchange rate between two countries with similar and modest inflation rates and nominal interest rates. It is reasonable to suppose that the parameter, a, that measures the sensitivity of the current exchange rate to the expected rate of change of the exchange rate is on the order of ten or twenty.[10] It follows that the factor $1/(1 + a)$ that appears on the right-hand side of (4) will be on the order of one-tenth or one-twentieth. This implies that it takes a difference of 10% or 20% between the current expected value of $X(t)$ and the weighted average of future expected X's summarized by $E[e(t + 1); t]$ to justify a 1% expected change in the exchange rate between t and $t + 1$.

No similar argument can be advanced for why the unexpected component of the change in the exchange rate should usually be small. This component of the change in the exchange rate is necessarily random and unpredictable because it depends on the effect of new information received between t and $t + 1$ on expectations of all future X's. A small unexpected change in X, for instance, might convey information that leads to a substantial revision of expectations of all future X's and hence to a substantial unexpected change in the exchange rate.

These results also explain why spot and forward exchange rates tend to move together, especially for when changes are fairly large. If expected exchange rate changes are usually small, then any large change in an ex-

10. A justification for this assumption is given in connection with the discussion of the monetary model of exchange rate determination in the next section; see specifically n. 18 below.

change rate is likely to be primarily attributable to a large unexpected component of the change in the exchange rate. Since the unexpected component of the change in the exchange rate depends on a weighted average of changes in expectations about all future X's, large unexpected changes in an exchange rate should generally be associated with substantial changes, in the same direction, in expectations about each of these future X's. From (2), it is apparent that substantial changes in the same direction in expectations about each future X should induce substantial movements in the same direction of both the current spot exchange rate and expectations of future spot exchange rates.

From this discussion, it should be apparent that the simple asset market model represented by equations (1) and (2) is capable at least of rationalizing some of the important empirical regularities that characterize the behavior of floating exchange rates. The critical result that allows for this rationalization is the pricing formula (2) which expresses the exchange rate as a discounted sum of the basic factors that are expected to affect the foreign exchange market in the present and in future periods. This formula is obviously similar to the standard formula for expected present discounted value that is relevant in determining the current value of an income-yielding asset. Any model of exchange rate determination that ultimately yields a pricing rule similar to (2), with a discount rate that is not too large, will possess the essential properties illustrated by the present simple model. Differences among such models reflect differences in the specification of the "basic factors affecting the foreign exchange market" or in the determinants of the sensitivity of the current exchange rate to the expected rate of change of the exchange rate. In this general conception of the exchange rate as an asset price, however, nothing has been said about the fundamental importance of asset market equilibrium conditions, as opposed to flow market equilibrium conditions, in determining the exchange rate. As subsequent analysis will show, it is perfectly possible to arrive at an asset price model of the exchange rate by focusing on the condition for equilibrium in balance of payments flows as the fundamental equilibrium condition that determines the exchange rate.[11]

1.4 Monetary Models of Exchange Rate Determination

Since an exchange rate is the relative price of one nation's money in terms of the money of another nation, it is natural to think of an exchange rate as

11. Many of the earlier papers that described the asset market approach to exchange rates, including some of my own papers, wrongly placed their emphasis on the conditions of asset market equilibrium as the critical determinants of exchange rates. It is clear to me that one can arrive at an asset price expression for the exchange rate from a model that focuses on flow market equilibrium conditions. More generally, one must recognize that in any sensible model of exchange rates both asset market and flow market equilibrium conditions are important, and it is a matter of expository convenience which of them one chooses to emphasize.

determined, at least proximately, by the outstanding stocks of these monies and by the demands to hold these stocks. This simple proposition is the starting-off point for two related but distinct classes of monetary models of exchange rate determination. The first class of monetary models, which have been widely applied in empirical studies of exchange rate behavior, expresses the current exchange rate as a function of the current stocks of domestic and foreign money and the current determinants of the demands for these monies, including domestic and foreign income and interest rates. The second class of monetary models, which has been more widely used in theoretical work, focuses on the influence on the current exchange rate of the expected future path of money supplies and of factors affecting money demands. The distinguishing features of these two classes of models requires that they should be given separate attention.

The essential content of the first class of monetary models may be summarized in an equation of the form

$$e = m - m^* - (l[y, i, k] - l^*[y^*, i^*, k^*]), \tag{6}$$

where e is the logarithm of the price of foreign money in terms of domestic money, m is the logarithm of the domestic money supply, l is the logarithm of demand for domestic money (a function of domestic income, y, the domestic interest rate, i, and other factors k), and an asterisk (*) indicates variables for the foreign country.[12] In some presentations, equation (6) is derived from the following assumptions: (1) The logarithm of the domestic price level, P, is determined by domestic money market equilibrium to be $P = m - l(y, i, k)$. (2) The logarithm of the foreign price level, P^*, is determined by the foreign money market equilibrium condition to be $P^* = m^* - l^*(y^*, i^*, k^*)$. (3) The equilibrium exchange rate is determined by the requirement of purchasing power parity to be $e = P - P^* = m - m^* - (l[y, i, k] - l^*[y^*, i^*, k^*])$.

Monetary models of exchange rate determination have been criticized because of the inadequacy of the assumptions used to derive equation (6). In particular, the assumption of purchasing power parity has been criticized as not consistent with the facts, especially the facts of the 1970s.[13] The collapse of purchasing power parity in the 1970s, however, is not (in my judgment) adequate reason for rejecting equation (6) as a model (albeit an incomplete model) of exchange rate determination.[14] This equation can be derived without explicit reference to purchasing power parity; indeed, it can

12. Models of this type are examined in Bilson (1978, 1979), Hodrick (1978), Frenkel (1980), and Frenkel and Clements (1982).

13. For example, this is one of Dornbusch's (1980*a*) main criticisms of the monetary model of exchange rate determination.

14. In my own work on exchange rates, I have almost never assumed that purchasing power parity always holds, and have not regarded this assumption as essential to analyzing the role of monetary variables in influencing exchange rates; see Mussa (1976, 1977, 1979, 1981a, 1982*a*) and Frenkel and Mussa (1980).

be derived from a model that allows explicity for divergences from purchasing power parity. Moreover, some empirical studies employing equation (6) have noted that there are divergences from purchasing power parity and have argued that the conditions of money market equilibrium are more immediately relevant for determining the exchange rate (which is a freely adjusting asset price) than they are for determining national price levels.[15] This, of course, leaves open the important question of what determines the behavior of national price levels, which in turn is an important element in explaining the behavior of real exchange rates. Nevertheless, if equation (6) worked well in explaining the behavior of nominal exchange rates, this form of monetary model of exchange rate determination would clearly make a substantial contribution to our understanding of the economic forces influencing the behavior of exchange rates.

The principal empirical difficulty with this form of monetary model is that equation (6) does not work well in explaining actual movements in nominal exchange rates, unless we take into account shifts in the demands to hold different national monies that are difficult to explain in terms of traditional arguments appearing in money demand functions.[16] An example illustrates this difficulty as well as a set of regressions. Between October 1976 and October 1980, the British pound appreciated by 50% in terms of the United States dollar, from $1.60 to $2.40. During this same period, monetary aggregates in Britain grew more rapidly than corresponding monetary aggregates in the United States, while real income (a key variable affecting the demand for money) grew less rapidly in Britain than in the United States. Of course, the increase in dollar value of sterling might be explained by an increase in the demand to hold sterling combined with a decrease in the demand to hold dollars, resulting from increased confidence in the future value of sterling (due to North Sea oil and the policies of Prime Minister Thatcher) and from increased concern about the inflationary consequences of the policies of the Carter administration. However, it is difficult to take these effects into account in a rigorous and disciplined fashion in an empirical version of equation (6).

Another important deficiency of equation (6) as a model of exchange rate determination is that it does not explicitly reveal the critical role of expectations of future economic conditions in determining the current exchange rate. From equation (6), there is no immediately apparent reason why changes in exchange rates should be largely random and unpredictable, or why new information that alters expectations about future economic conditions (including supplies and demands for national monies) should induce such random and unpredictable changes in exchange rates.

15. Bilson (1979) advances this argument in his paper concerning the dollar-mark exchange rate.

16. The relatively poor empirical performance of monetary models in explaining exchange rate movements in the 1970s is documented in Meese and Rogoff (1982).

The second general class of monetary models of exchange rate determination does not suffer from this deficiency. These models usually treat a small or moderate size economy that takes conditions in the rest of the world as given.[17] The critical condition determining the exchange rate for this country is the requirement of money market equilibrium;

$$m = k + \zeta \cdot e - \eta \cdot D^e(e), \quad \zeta, \eta > 0, \tag{7}$$

where m is the logarithm of the domestic money supply, e is the logarithm of the price of foreign money in terms of domestic money, k summarizes all exogenous factors affecting the logarithm of the demand for domestic money, and $D^e(e) = E(e(t + 1); t) - e(t)$ is the expected rate of change of the exchange rate. As will be made clear by the analysis in section 1.6, equation (7) should be thought of as a reduced-form equilibrium condition derived from a more basic model of goods and asset market equilibrium. In this reduced form, the parameter ζ captures all of the mechanisms through which an increase in the price of foreign money increases the demand for domestic money, and the parameter η captures all of the mechanisms through which an increase in the expected rate of change of the price of foreign money affects the demand for domestic money.

Since the reduced-form demand for domestic money depends on the expected rate of change of the exchange rate, it follows that the current equilibrium exchange rate depends not only on the current values of m and k, but also on the expectation of next period's exchange rate;

$$\begin{aligned} e(t) = {} & [1/(\zeta + \eta)] \cdot [m(t) - k(t)] + [\eta/(\zeta + \eta)] \\ & \cdot E(e(t + 1); t). \end{aligned} \tag{8}$$

Forward iteration of (8), justified by the assumption of rational expectations, leads to the conclusion that the exchange rate expected at any future date is an exponentially weighted sum of expected future differences between m and k;

$$\begin{aligned} E(e(s); t) = {} & [\zeta/(\zeta + \eta)] \cdot \sum_{j=0}^{\infty} [\eta/(\zeta + \eta)]^j \\ & \cdot E(w(s + j); t), \end{aligned} \tag{9}$$

where $w(u) = (1/\zeta) \cdot [m(u) - k(u)]$. The current exchange rate, $e(t) = E(e(t); t)$, is found by setting $s = t$ in (9). This result reveals the fundamental principle that the current exchange rate depends on the entire future expected path of differences between (the logarithms of) the money supply and the exogenous component of money demand.

Using the general procedure outlined in section 2.3, (9) may be used to decompose the change in the exchange rate into its expected and unexpected

17. Monetary models of the type examined here are considered in Mussa (1976, 1982c) and Barro (1978).

components. The expected change in the exchange rate is given by

$$D^e[e(t)] = (\zeta/(\zeta + \eta)) \cdot [E(e(t + 1); t) - E(w(t); t)]. \tag{10}$$

If, as is plausible to suppose, $\zeta/(\zeta + \eta)$ is on the order of one-tenth or one-twentieth, then large monthly expected changes in the exchange rate should be unlikely.[18] In contrast, the unexpected change in the exchange rate is given by

$$\begin{aligned} D^u[e(t)] = (\zeta/(\zeta + \eta)) \cdot \sum_{j=0}^{\infty} (\eta/(\zeta + \eta))^j \\ \cdot [E(w(t + j + 1); t + 1) \\ - E(w(t + j + 1); t)]. \end{aligned} \tag{11}$$

If the new information received between t and $t + 1$ leads to a substantial revision of expectations concerning all future w's (in the same direction), this random and unpredictable component of the change in the exchange rate could be quite large.

To proceed with the analysis of changes in the exchange rate, it is necessary to specify how expectations about m and k are formed and revised. One convenient *theoretical* assumption is that k is a known constant, $\bar{k}$, that the money supply is observed each period before the exchange rate is determined, and that the stochastic process generating the money supply is known to economic agents and used by them (together with data on the present and past money supplies) to project the future course of the money supply. To be specific, suppose that m is generated by a random walk plus noise but that economic agents observe only m and not its permanent (random walk) and transitory (noise) components. In this case, economic agents will form an estimate $\hat{m}(t)$, of the current level of the permanent component of m by taking a weighted average of present and past m's, and they will attribute the difference, $m(t) - \hat{m}(t)$, to the present transitory component of m. The expected level of m in any future period will equal $\hat{m}(t)$. The current exchange rate, $e(t) = (1/\zeta) \cdot [\hat{m}(t) - \bar{k}] + [1/(\zeta + \eta)] \cdot [m(t) - \hat{m}(t)]$, fully reflects the component of the money supply that is thought to be permanent, but is less strongly affected by the component of the money supply that is thought to be transitory. The expected change in the exchange rate, $D^e[e(t)] = -[1/(\zeta + \eta)] \cdot [m(t) - \hat{m}(t)]$, reflects the expected disappearance of the transitory component of m. The information received by economic agents between t and $t + 1$ is measured by difference between the actual level of $m(t + 1)$ and the level that was expected at time t, $E(m(t + 1); t) = \hat{m}(t)$. A fraction, α, of this difference is attributed to an increase in

18. In order to have an interest elasticity of money demand (given by $i \cdot \eta$) equal to 0.1, when the nominal interest rate is 1% per month, we must have $\eta = 10$. If $\zeta = 1$, as it would under strict purchasing power parity and no currency substitution, then $\zeta/(\zeta + \eta)$ would equal 1/11. If the interest elasticity of money demand were as large as 0.2 and ζ were as small as 0.5, then $\zeta/(\zeta + \eta)$ would be as small as 1/41.

the permanent component of m, and the remaining fraction, $1 - \alpha$, is attributed to the transitory component in $m(t + 1)$, where the fraction α is an increasing function of the ratio of the variance of disturbances to the permanent component of m to the variance of transitory disturbances to m.[19] The unexpected change in the exchange rate, $D^u[e(t)] = \{(\alpha/\zeta) + [(1 - \alpha)/(\zeta + \eta)]\} \cdot [m(t + 1) - \hat{m}(t)]$, reflects, as it should, the information received by economic agents between t and $t + 1$. Consistent with common sense, this unexpected change in the exchange rate is greater the greater is the deviation of the money supply from its expected level and the greater is the fraction of this deviation that is attributed to a change in the permanent component of the money supply.

This example illustrates the key point that the nature of the stochastic process governing the behavior of the exchange rate depends on the process generating the behavior of the money supply and on the information about this process that is available to economic agents. In particular, this example illustrates that the response of the exchange rate to a change in the money supply depends on the extent to which this change was unanticipated and on the extent to which any unanticipated change is thought to indicate a permanent change in the money supply.[20]

Aside from its theoretical usefulness, however, the assumption that economic agents use their knowledge of the (fixed) stochastic process generating the money supply as the primary ingredient in forming the expectations necessary for determining the exchange rate is not likely to provide a fully adequate empirical explanation of actual exchange rate movements. One likely reason for this inadequacy is that economic agents use many sources of information, other than the observed money supply series and other easily measured variables, in forming and revising their expectations concerning future money supply behavior. For example, the depreciation of the French franc on the day following the election of President Mitterand clearly was not due to any observed policy change (registered in the behavior of the money supply or other variables) since President Mitterand did not assume office until 3 weeks later. It must have been due to a change in expectations about future policy resulting from the fact of his election.

Another important barrier to monetary explanations of actual exchange rate movements arises from the lack of adequate measures of the exogenous factors affecting the demand for money and of expectations concerning the future behavior of these factors. Almost certainly, there have been shifts in the demands to hold national monies that are not accounted for either by changes in the traditional arguments appearing in money demand functions

19. See Muth (1960) for a description and derivation of this result.

20. For stochastic processes that allow for changes in the long-run growth rate of the money supply, as well as its long-run level, it is possible for unanticipated changes in the money supply to generate even stronger responses of the exchange rate. This possibility is examined in Mussa (1976).

(such as levels of national income) or by changes in expectations about future exchange rate movements induced by changes in expectations about money supply behavior. In theory, such demand shifts should play a role of coordinate importance with changes in money supplies (and changes in expectations about future money) supplies in determining movements in exchange rates. The inadequacy of measures of money demand shifts means, therefore, that a substantial fraction of actual exchange rate movements will not be adequately explained by monetary models.

One possible way around this difficulty is to adopt the view that changes in exchange rates which cannot be explained by changes in the actual or expected behavior of money supplies must be due to changes in the actual or expected behavior of money demands. The tautological view of the monetary model of exchange rate determination can be justified on the grounds that the money market equilibrium condition represented by equation (7) is a reduced form that incorporates all of the conditions of goods and asset market equilibrium. However, this tautological view of the monetary model still does not provide an explanation of many exchange rate movements, other than ascribing them to "shifts in money demands" arising from unknown sources. Moreover, while it is possible to view all economic forces affecting the exchange rate as operating through money demand or money supply, this may lead to a rather convoluted and unnatural view of the mechanisms through which some economic forces affect the exchange rate. In such circumstances, it is not sensible to insist on an exclusively monetary interpretation of the determination of exchange rates.

1.5 Balance of Payments Equilibrium and the Exchange Rate

The traditional approach to analyzing exchange rate behavior focuses on the condition of balance of payments equilibrium as the proximate determinant of the equilibrium exchange rate. A common feature of models that adopt this approach is the assumption that an increase in the price of foreign exchange implies an increase in the relative price of a country's imports in terms of its exports and (provided certain elasticity conditions are satisfied) an increase in the net inflow of foreign exchange arising from current account transactions.[21] The (momentary) equilibrium exchange rate in such a model is the exchange rate at which the net inflow of foreign exchange arising from current account transactions is balanced by the net outflow resulting from capital account transactions. In this section I consider a formulation of this traditional approach to the theory of exchange rate deter-

21. This assumption is made in the standard flow model of the foreign exchange market that is described in virtually every textbook on international economics. The elasticity condition that is required to ensure stability of the foreign exchange market is sometimes the Marshall-Lerner condition and sometimes the more complicated Robinson-Metzler-Bickerdike condition.

mination that results in an "asset price" model of the exchange rate which shares the general features of the schematic model examined in section 1.3.

1.5.1 Goods Market Equilibrium and the Trade Balance

To avoid the complexities of dealing with nominal prices and nominal exchange rates, it is convenient to phrase the present model of balance of payments equilibrium in terms of real variables. The model considers a moderate-size home country that trades two goods (domestic goods and foreign goods) and a single real asset (denominated in foreign goods) with the rest of the world (referred to as the foreign country). Real assets pay a fixed rate of return, r^*, in terms of foreign goods; and the net stock of such assets held by domestic residents, A, may be positive or negative.[22] Foreign residents are willing to exchange large flow amounts of foreign goods in exchange for foreign (real) assets at the prevailing rate of return r^*, but they are not willing to purchase large amounts of domestic goods (of the home country) in exchange for foreign goods at a fixed relative price of these two goods. Instead, the value of foreign demand for domestic goods (measured in units of foreign goods) is given by

$$d^* = -\beta^* \cdot q + x^*, \tag{12}$$

where q is the logarithm of the relative price of domestic goods in terms of foreign goods, x^* is a shift parameter that takes account of all exogenous factors (including government commercial and expenditure policies) that affect foreign demand for domestic goods, and $\beta^* > 0$ reflects the relative price elasticity, equal to $-[1 + (\beta^*/d^*)]$, of foreign demand for domestic goods.

The desired trading position of the home country with respect to goods is described by that country's excess demand for foreign goods, f, and by the value (in terms of foreign goods) of its excess demand for domestic goods, d:

$$f = (1 - \sigma) \cdot \psi + \beta \cdot q - x, \tag{13}$$

$$d = \sigma \cdot \psi - \beta \cdot q + x, \tag{14}$$

where ψ is the excess of domestic spending over the value of domestic product (measured in terms of foreign goods), σ and $1 - \sigma$ are the (marginal) shares of domestic and foreign goods in domestic spending, x is a shift parameter that accounts for exogenous factors (including tariffs and government spending policies) that affect the distribution of home excess demand between foreign and domestic goods, and $\beta > 0$ reflects the relative

22. A nontradable domestic asset may be added to the model without altering its basic character or its analytical complexity. The equilibrium condition that the demand for this asset must equal the available supply can be used to determine the equilibrium rate of return on this asset and eliminate this variable from the model.

price elasticity, equal to $-(\beta/f)$, of home demand for imports of foreign goods.[23]

The system of excess demand functions (12), (13), and (14) can be interpreted as a modified and extended version of the standard two-country, two-commodity model of the real theory of international trade.[24] In this interpretation, equation (12) represents the offer curve of the foreign country and equations (13) and (14) represent the offer curve of the home country. The home offer curve is displaced from the origin of commodity trade by the excess of the domestic spending over the value of domestic product. There is no corresponding displacement of the foreign offer curve because, by assumption, the large foreign country absorbs the home country's excess spending through a flow of securities, without any effect on foreign demand for domestic goods of the home country. This interpretation of equations (12), (13), and (14) can also be applied in the special case of the standard two-country, two-commodity model that is widely used in discussions of macroeconomic issues in which it is assumed that each country produces a distinct output. To arrive at this form of model, all that is necessary is to assume, without any formal change in the equations, that the home country produces no foreign goods. Along a somewhat different line, equations (12), (13), and (14) can be interpreted as representing the standard model of a "dependent economy" which produces and consumes its own domestic nontraded good and also produces, consumes, and either exports or imports a traded good that is identical to traded goods sold on the world market. To arrive at this interpretation, all that is necessary is to regard the foreign good as the traded good (recognizing that domestic excess demand for this good could be positive or negative), to view d as domestic excess demand for the nontraded good (which must be zero in equilibrium), and to specify that foreign excess demand for this nontraded good, d^*, must be zero.

Consistent with all of these interpretations of the excess demand functions (12), (13), and (14), it is appropriate to express the requirement for equilibrium in the market for domestic goods (of the home country) by the requirement

$$d + d^* = 0. \tag{15}$$

There is no similar condition for equilibrium in the market for foreign goods because, by assumption, the foreign country absorbs the home country's excess for these goods in exchange for a flow of securities. Thus, equation (15) represents the condition for goods market equilibrium.

23. It is noteworthy that the total value of home excess demand for foreign and domestic goods, $f + d$, is equal, as it should be, to the excess of domestic spending over the value of domestic product. Thus, given the value of ψ, there is really only one independent excess demand function specified by (13) and (14).

24. This is the model that is described, for instance, in Mundell (1960) and in most advanced texts in international economics.

From this goods market equilibrium condition and from the specification of the determinants of d and d^* given in (12) and (14), we may derive a critical relationship between the excess of domestic spending over the value of domestic product, ψ, the (logarithm of the) relative price of domestic goods in terms of foreign goods, q, and the shift parameters affecting domestic and foreign demand for domestic goods, x and x^*;

$$(16) \qquad -\psi = \nu \cdot (z - q),$$

where

$$(17a) \qquad \nu = (\beta + \beta^*)/\sigma$$

and

$$(17b) \qquad z = (x + x^*)/(\beta + \beta^*).$$

The significance of this relationship becomes apparent when we recognize that the trade balance of the home country (measured in units of foreign goods), T, must equal the excess of the value of foreign purchases of domestic goods, d^*, over domestic purchases of foreign goods, f; that is, $T = d^* - f$. Using this fact together with (12), (13), and (16), we arrive at the conclusion that

$$(18) \qquad T = -\psi = \nu \cdot (z - q).$$

This result expresses the fundamental equivalence between the "absorption" and the "elasticities" approaches to analyzing the behavior of the trade balance.[25] The absorption approach views that trade balance as the excess of the value of domestic output over domestic spending; that is, as $-\psi$. The elasticities approach views the trade balance as a function, $\nu \cdot (z - q)$, of the relative price of domestic goods in terms of imported goods and of the other (exogenous) factors affecting demands for imports in the two countries. From the perspective of the elasticities approach, it is noteworthy that the assumption that the parameters β and β^* are positive is sufficient to insure that the Marshall-Lerner condition is satisfied and hence that an increase in the relative price of domestic goods worsens the trade balance.

1.5.2 The Meaning and Implications of Balance of Payments Equilibrium

Ignoring unilateral transfers, and assuming that services such as transport, insurance, and tourism have been incorporated into the trade balance, the current account balance of the home country must equal its trade balance plus the interest income that home residents receive (or pay) on their net foreign asset holdings; that is,

$$(19) \qquad b = T + r^* \cdot A = \nu \cdot (z - q) + r^* \cdot A.$$

25. On the subjects of the elasticities and absorption approaches to the balance of payments, see Alexander (1959) and Johnson (1958).

In the absence of official intervention, the current account balance must correspond to the rate of accumulation of net foreign assets by home residents,

$$D(A) = b = \nu \cdot (z - q) + r^* \cdot A, \tag{20}$$

where D is the forward difference operator.

As a matter of economic behavior, the rate of accumulation of net foreign assets must also correspond to the desired excess of domestic income (including net interest income) over domestic spending. The behavioral determinants of the desired excess of income over spending are indicated by the relationship

$$r^* \cdot A - \psi = \alpha \cdot (R - \rho) + \mu \cdot (\hat{A} - A), \quad \alpha, \mu > 0, \tag{21}$$

where $r^* \cdot A - \psi$ represents the accounting value of the excess of income over spending, R is the domestic real interest rate, ρ is the natural level of the real interest rate at which domestic residents would want to spend exactly their income (provided that net foreign assets were at their target level), and $\hat{A}$ is the target level of net foreign assets that home residents would like to hold if R were equal to ρ. Since only the sum, $\alpha \cdot \rho + \mu \cdot \hat{A}$, matters in (21), and not either ρ or $\hat{A}$ independently, it can be assumed, without loss of generality, that $\rho = r^*$, and all exogenous changes in the desired excess of income over spending can be treated as arising from changes in the target level of net foreign assets.

The domestic real interest rate that influences the desired relationship between income and spending, R, depends on the foreign real interest rate, r^*, and the expected rate of change of the relative price of domestic goods, $D^e(q)$:

$$R = r^* - \sigma \cdot D^e(q). \tag{22}$$

The idea underlying (22) is that spending behavior of home residents is affected by the rate of return they expect to earn on their assets measured in terms of a consumption basket that includes domestic and foreign goods with weights of σ and $1 - \sigma$. If the relative price of domestic goods in terms of foreign goods is expected to rise at a rate $D^e(q)$, the expected real rate of return on assets that have a fixed price in terms of foreign goods and pay a fixed rate of return of r^* in terms of such goods is less than r^* by an amount $\sigma \cdot D^e(q)$.

The desired rate of asset accumulation implied by the desired excess of domestic income over domestic spending, as determined by (21) and (22), must in equilibrium, be consistent with the net inflow of foreign assets resulting from the current account balance, as determined by (19) or (20). This consistency requirement is expressed by the condition

$$\nu \cdot (z - q) + r^* \cdot A = -\alpha\sigma \cdot D^e(q) + \mu \cdot (\hat{A} - A). \tag{23}$$

This condition may be interpreted as the requirement for balance of payments equilibrium. It says that current account surplus, which is the sum of the trade balance surplus, $\nu \cdot (z - q)$, and the service account surplus, $r^* \cdot A$, must be equal to the capital account deficit, $-\alpha\sigma \cdot D^e(q) + \mu \cdot (\hat{A} - A)$, which is determined by desired asset accumulation by home residents.

A superior, but not necessarily conflicting, interpretation of (23) is that it represents two distinct sets of economic conditions that must simultaneously be satisfied in order for the economic system to be in (momentary) equilibrium. The left-hand side of (23) summarizes the implications of the excess demand functions (12), (13), and (14) and the requirement of goods market equilibrium (15). The left-hand side of (23) has real interpretation as a net flow of goods and services, and it has a financial interpetation as a corresponding flow of financial claims. The right-hand side of (23) summarizes the content of the behavioral equations and equilibrium conditions that underlie the determination of the desired excess of domestic income over domestic spending. It too has a real interpretation, as an excess of real income over real spending; and it has a financial interpretation, as a corresponding rate of accumulation of financial claims. Equation (23) simply requires that the real flows of goods and services and the corresponding flows of financial claims determined by the relationships that underlie the two sides of this equation be mutually consistent.

The determination of the momentary equilibrium "real exchange rate," which is identified with q, by the balance of payments equilibrium condition (23) is illustrated in figure 1.1. The negatively sloped line labeled $\nu \cdot (z - q) + r^* \cdot A$ shows the net flow demand for foreign exchange arising from current account transactions. The positively sloped line labeled $\alpha\sigma[q - E(q(t + 1); t)] + \mu(\hat{A} - A)$ shows the net flow supply of foreign exchange arising from desired asset accumulation by domestic residents.[26] The intersection of these two lines determines the current q that is consistent with balance of payments equilibrium, given the values of z, A, $\hat{A}$, and $E(q(t + 1); t)$. In many discussions, the positively sloped line in figure 1 (or its equivalent) is interpreted as representing the behavior of "foreign exchange speculators" who are distinguished from ordinary transactors in the foreign exchange market (whose behavior is represented by the negatively sloped line in fig. 1.1 or its equivalent). As the preceding analysis makes clear, however, this distinction between "speculators" and "ordinary transactors" is artificial and unnecessary. The two sides of equation (23) and the corresponding lines in figure 1.1 represent different behavioral equations and equilibrium conditions, but for the same set of economic agents.

26. The model of exchange rate determination that is represented in figure 2.1 is consistent with the rather naive descriptions of the foreign exchange market that appear in many textbooks and with more sophisticated "flow market" models of the exchange rate developed by Tsiang (1959), Stein (1965), Stein and Tower (1967), Black (1973), and Niehans (1977).

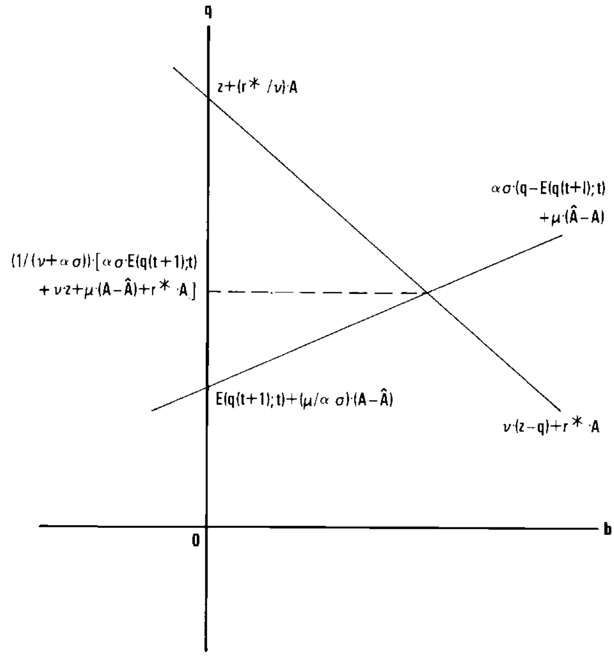

Fig. 1.1 Balance of payments equilibrium and the equilibrium real exchange rate.

Under the assumption of rational expectations, the difference equations (20) and (23) may be treated as a simultaneous, forward-looking system that jointly determines the expected future paths of A and q, conditional on the inherited level of net foreign assets, $A(t)$, and the expected future paths of the exogenous forcing variables z and $\hat{A}$. The solution of this system for the current value of q may be written in the form[27]

(24) $$q(t) = \bar{q}(t) + \gamma \cdot [A(t) - \bar{A}(t)],$$

where

(25) $$\bar{q}(t) = (r^*/\nu) \cdot \bar{A}(t) + (1 - \theta) \cdot \sum_{j=0}^{\infty} \theta^j \cdot E(z(t + j); t),$$

(26) $$\bar{A}(t) = (1 - \theta) \cdot \sum_{j=0}^{\infty} \theta^j \cdot E(\hat{A}(t + j); t),$$

(27) $$\theta = [1/(1 + \lambda)], \quad \gamma = (\lambda/\nu) - (1/\alpha\sigma),$$

27. As in the case of the monetary model of the previous section, a boundary condition is imposed that ensures an economically sensible, nonexplosive solution for the difference equation system (20) and (23).

$$(28) \qquad \lambda = (1/2) \cdot \{[r^* + (\nu/\alpha\sigma)] + \sqrt{[r^* + (\nu/\alpha\sigma)]^2 + 4 \cdot (\mu\nu/\alpha\sigma)}\}.$$

These results may be interpreted in the following manner: $\bar{q}$(t) represents the "long-run equilibrium exchange rate" that is expected to be consistent with the current account balance ($b = 0$) on average in the present and in future periods, with an appropriate rate of discount, λ, for future current account imbalances, and assuming that net foreign assets are currently at their long-run desired level. The long-run desired level of net foreign assets, $\bar{A}$(t), is a discounted sum of the expected target levels of net foreign assets in the present and in future periods. The discount rate that is applied to expected future $\hat{A}$'s in determining $\bar{A}$(t) and to expected future z's in determining $\bar{q}(t)$ depends, in an economically appropriate manner, on the sensitivity of the trade balance of changes in q and on the sensitivity of capital flows to changes in the domestic real interest rate and to changes in the net stock of foreign assets held by domestic residents. Finally, the current real exchange rate, $q(t)$, reflects both the current estimate of the long-run equilibrium exchange rate, $\bar{q}(t)$, and the current divergence of $A(t)$ from its long-run desired level, $\bar{A}(t)$.

1.5.3 The Real Exchange Rate as an Asset Price

The balance of payments equilibrium condition (23) that is the essential ingredient in deriving the results (24)–(28) is, on its face, a flow market equilibrium condition rather than an asset market equilibrium condition. Nevertheless, this equilibrium condition implies a solution for $q(t)$—which is identified with (the logarithm of) the real exchange rate—that may be thought of in two distinct ways as the expression for an asset price.

First, given $\bar{q}(t)$ and $\bar{A}(t)$, it is apparent from (24) that the current real exchange rate, $q(t)$, is related to the stock of net foreign assets, $A(t)$, in the manner that is suggested by a number of recent "asset market models" of the role of the current account in exchange rate dynamics.[28] The essential idea of these models is that the momentary equilibrium real exchange rate is determined by the price at which domestic residents are willing to hold their existing net position in foreign assets. The greater is the net stock of foreign assets, A, the lower is the price at which domestic residents will hold this stock; that is, the higher is the momentary equilibrium value of q (which is defined as the logarithm of the relative price of domestic goods in terms of foreign goods). Given the exogenous factors affecting trade balance, the higher is q the smaller is the trade balance surplus (or the greater is the trade balance deficit) and hence the slower is the rate of accumulation of foreign assets by domestic residents. These relationships imply a dynamic

28. Models of this type include those developed by Branson (1976), Kouri (1976a), Calvo and Rodriguez (1977), Dornbusch and Fischer (1978), and Rodriguez (1980).

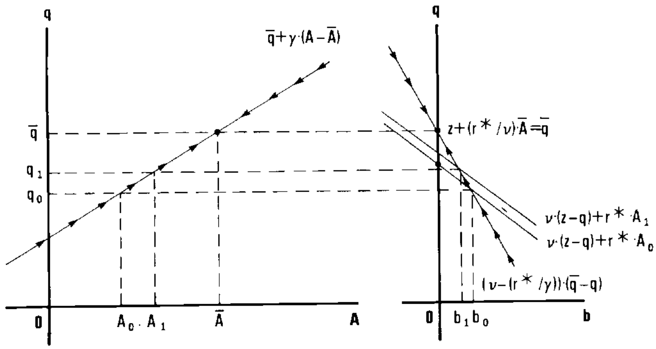

Fig. 1.2 Dynamic interaction among the exchange rate, asset stocks, and the current account.

process, which is illustrated in figure 1.2, in which an initial divergence of net foreign assets from their long-run equilibrium level, $\bar{A}$, implies a divergence of the momentary equilibrium level of q from the level that would yield a zero current account balance, and a subsequent sequence of current account imbalances and corresponding changes in net foreign assets that ultimately drive net foreign assets to their long-run equilibrium and q to the level that yields a zero current account balance. This is exactly the dynamic process that is implied by the results (24)–(28) when the exogenous forcing variables z and $\hat{A}$ are constant.

Second, the value of $q(t)$ determined by (24)–(28) is an "asset price" in the sense discussed in Section 1.3 because the long-run equilibrium exchange rate, $\bar{q}(t)$, and the long-run desired level of net foreign assets, $\bar{A}(t)$, which influence $q(t)$ are, respectively, forward-looking weighted averages of the present and expected future exogenous factors affecting the trade balance (the z's) and the present and expected future target levels of net foreign assets (the $\hat{A}$'s). The critical assumption that confers this "asset price" property on q(t) is the assumption that the expected rate of change of q, $D^e(q)$, affects the desired excess of income over spending and hence the condition for balance of payments equilibrium. As previously explained, one justification for this assumption is in terms of the effect of $D^e(q)$ on the real interest rate that is relevant for domestic spending and saving decisions. Another, essentially equivalent justification is in terms of the effect of anticipated capital gains on net foreign asset holdings on the level of desired spending. When the relative price of domestic goods is expected to decline, domestic residents anticipate capital gains on their holdings of assets denominated in terms of imported goods. The expectation of such capital gains encourages domestic residents to save more than if such gains were not expected. Yet a third way of justifying an influence of $D^e(q)$ on the current q that is consistent with balance of payments equilibrium is in terms of the effect of an anticipated change in q on the temporal pattern of desired trading. If $D^e(q)$ is positive, then domestic residents have an incentive to expand purchases of domestic goods in the current period and to delay purchases of imported goods until they are relatively cheaper. Foreign residents have a similar incentive to expand current purchases of goods exported by the home country and delay purchases of their own goods. Together, these forces tend to improve the balance of payments of the home country and hence to raise the $q(t)$ that is consistent with balance of payments equilibrium.

The extent to which $q(t)$ exhibits the properties of an "asset price" that depends on expected future economic conditions, rather than only on current conditions, is determined by the discount rate λ that is given by (28). It is apparent that for λ to be small, ν and μ must be small relative to $\alpha\sigma$. This makes sense. Expected future economic conditions should have considerable weight, relative to current economic conditions, in determining $q(t)$ if divergences between $q(t)$ and $z(t)$ and between $A(t)$ and $\hat{A}(t)$ have relatively small effects on the balance of payments, in comparison with the effect of $D^e(q)$.

1.54 Dynamics of the Real Exchange Rate

Analysis of the causes of changes in the real exchange rate may be carried out by applying the general procedures of section 1.3 to the results (24)–(28). Specifically, the expected change in the real exchange rate is given by

$$D^e[q(t)] = D^e[\bar{q}(t)] + \gamma \cdot D^e[A(t) - \bar{A}(t)]. \tag{29}$$

In the special case where the long-run equilibrium exchange rate and the long-run desired level of net foreign assets are not expected to change, this result simplifies to

$$D^e[q(t)] = \gamma \cdot D^e[A(t)] = \gamma \cdot E(b(t); t) \tag{30}$$

where $E(b(t); t)$ is the expected current account balance. In this special case, there is a positive relationship between $D^e[q(t)]$ and $E(b(t); t)$. More generally, however, there is no guarantee of such a relationship. The expectation of rising values of z implies a positive expected change in $\bar{q}$, but a negative contribution to the expected current account balance. The intuitive explanation of this relationship is as follows: The expectation of rising values of z means that the expected demand for domestic goods is less strong, and the expected demand for foreign goods is more strong, in the current period than it will be, on average, in future periods. The response to this situation is to allow the trade balance to go into deficit to absorb part of the strong demand for foreign goods and to reduce the relative price of domestic goods (increase the relative price of foreign goods) in order to reduce the excess demand for foreign goods in the current period relative to future periods. The result is a temporary expected deterioration in the current account combined with the expectation of a rise in the relative price of domestic goods. If this effect is sufficiently strong, it clearly could induce a negative, rather than a positive, relationship between the expected change in q and the expected current account balance.

The unexpected change in the real exchange rate, $D^u[q(t)]$, depends on the unexpected change in the long-run equilibrium real exchange rate, $D^u[\bar{q}(t)]$, and the unexpected change in the difference between A and $\bar{A}$;

$$D^u[q(t)] = D^u[\bar{q}(t)] + \gamma \cdot D^u[A(t) - \bar{A}(t)]. \tag{31}$$

If there are no unexpected changes in $\bar{q}$ or $\bar{A}$, then the unexpected change in q will depend exclusively on the unexpected change in net foreign assets which, in turn, must equal the "innovation" in the current account balance;

$$D^u[q(t)] = \gamma \cdot D^u[A(t)] = \gamma \cdot [b(t) - E(b(t); t)]. \tag{32}$$

More generally, however, the unexpected change in q will reflect changes in expectations about future z's and future $\hat{A}$'s which induce unexpected changes in $\bar{q}$ and $\bar{A}$. To the extent that unexpected movements in the trade balance are one of the sources of information that lead to revisions of expectations concerning future z's and A's, there is an additional channel for such innovations to affect the real exchange rate.[29]

1.6 Real and Monetary Factors in Exchange Rate Determination

Models of exchange rate behavior that focus on the condition of balance of payments equilibrium as the final determinant of the exchange rate are most directly relevant to understanding the real economic forces affecting the behavior of *real* exchange rates. In contrast, monetary models of exchange rate behavior are useful primarily in analyzing the influence of actual and anticipated movements in money supplies and money demands on *nominal* exchange rates. To arrive at a theoretical model that comprehends all of the factors that influence the actual behavior of exchange rates, it is necessary to combine the essential features of these two classes of models.

1.6 Monetization of the Real Model

To analyze the influence of the real sector of the economy on its monetary sector and arrive at a combined model of the determination of real and nominal exchange rates, it is convenient simply to expand the real model of the preceding section by introducing nominal prices and an appropriately specified money demand function. The logarithm of the domestic money price of domestic goods is denoted by p; the logarithm of the foreign money price of imported (or traded) goods is denoted by p^*; and the logarithm of the nominal exchange rate (defined as the domestic money price of a unit of foreign money) is denoted by e. These assumptions imply that the logarithm

29. The dynamic relationships between the current account and the exchange rate are explored more fully in Mussa (1981a).

of the relative price of domestic goods in terms of imported goods (previously identified with the real exchange rate) is given by

$$q = p - (e + p^*). \tag{33}$$

The logarithm of the general price level in the home country, denoted by P, is a weighted average of the domestic money prices of domestic and imported goods.

$$P = \sigma \cdot p + (1 - \sigma) \cdot (e + p^*) = e + p^* + \sigma \cdot q, \tag{34}$$

where σ is the same as the σ of the preceding section and measures the weight of domestic goods in the expenditure of residents of the home country.

The logarithm of the demand for domestic money is given by

$$m^d = K + L \cdot P - N \cdot i - U \cdot D^e(e) + W \cdot A + V \cdot q. \tag{35}$$

The parameter K represents all exogenous factors (such as real income) that affect money demand. The general price level affects money demand with a positive elasticity, L, which could equal unity. The exchange rate affects money demand (because of wealth valuation or currency substitution effects) with an elasticity J that is nonnegative. The domestic nominal interest rate, i, affects the demand for money with a negative semielasticity, $-N$. The expected rate of change of the nominal exchange rate, $D^e(e)$, affects the demand for domestic money through a "currency substitution effect" which is represented by a negative semielasticity, $-U$. Net holdings of foreign assets are assumed to affect the demand for domestic money with a positive semielasticity, W. Finally, the relative price of domestic goods in terms of imported goods affects the demand for domestic money with an elasticity, V, which may be either positive or negative.[30]

The money demand function specified in (35) may be converted into a reduced-form money demand function that is similar to that used in the simple monetary model of exchange rate behavior (see equation [7]). The general level of domestic prices can be eliminated as an explicit argument in the money demand function by substituting $e + p^* + \sigma q$ for P. The domestic nominal interest rate can be eliminated from the money demand function by utilizing the Fisher equation.

$$i = R - D^e(P), \tag{36}$$

where $D^e(P)$ is the expected rate of change of the domestic price level and

30. The relative price of domestic goods could affect money demand because of effects on the value of domestic product in terms of imported goods, on the distribution of income within the home country, on the value of domestic nontraded assets in terms of imported goods, or on the rate of return on such assets. In the next section, it will be assumed that whatever the signs of all of these effects, their cumulative impact is not very great.

R is the domestic real interest rate. Repeating equation (22), the domestic real interest rate is given by

$$R = r^* - \sigma \cdot D^e(q), \tag{37}$$

where $D^e(q)$ is the expected rate of change of q and r^* is the exogenous foreign real interest rate. Further, assuming that expectations about domestic inflation take account of (34), it follows that

$$D^e(P) = D^e(e) + \pi^* + \sigma D^e(q), \tag{38}$$

where $\pi^* = D^e(p^*)$ is the expected rate of change of the foreign money price of imported goods (i.e., the expected foreign inflation rate). Substituting the right-hand side of (38) for $D^e(P)$ in (36), and making all of the relevant substitutions in the money demand function (35), it follows that this money demand function can be rewritten in the form

$$m^d = k + \zeta \cdot e \cdot \eta \cdot D^e(e), \tag{39}$$

where $\zeta = L + J > 0$ and $\eta = N + U > 0$, and

$$k = \kappa + W \cdot A + (V + \sigma L) \cdot q \tag{40}$$

$$\kappa = K + L \cdot p^* - N^*(r^* + \pi^*). \tag{41}$$

The distinction between k and κ is that k summarizes the influence on money demand of all factors that are exogenous to the monetary sector of the economy (including the endogenous real variables q and A), while κ summarizes the influence on money demand of all of the fully exogenous variables. It is noteworthy that the reduced-form money demand function (39) is consistent with the interest parity condition

$$i = i^* + D^e(e) + \chi, \tag{42}$$

where $i^* = r^* + \pi^*$ is the foreign nominal interest rate and χ is a risk premium that may be specified as any linear function of e, $D^e(e)$, A, q, and $D^e(q)$.[31] The derivation of the reduced-form money demand function (39) establishes the point that the reduced-form money market equilibrium condition specified in equation (7) of section 1.3 is consistent with a very general specification of the structural factors influencing money demand.

1.6.2 Solution of the Combined Real and Monetary Model

The reduced-form money market equilibrium condition (7), together with equations (20) and (23) from the analysis of balance of payments equilib-

31. The implications of such a risk premium in the foreign exchange market are explored in papers by Kouri (1976b), Stockman (1978), and Fama and Farber (1980). Some evidence of such a premium is provided by Hansen and Hodrick (1982). The incorporation of such a risk premium in the present model alters only the structural interpretation of the parameters of the reduced-form money demand function.

rium, constitute a simultaneous system of difference equations that, under the assumption of rational expectations, determines the expected future paths of the real exchange rate, q, the net stock of foreign assets, A, and the nominal exchange rate, e, conditional on expectations concerning the future paths of the exogenous variables z, A, and $m - \kappa$. This system can be expressed in matrix form as

$$\begin{bmatrix} -\nu & r^* - D^e & 0 \\ \nu - \alpha\sigma \cdot D^e & \mu - r^* & 0 \\ V + \sigma L + \sigma N \cdot D^e & w & \zeta - \eta \cdot D^e \end{bmatrix} \cdot \begin{bmatrix} q \\ A \\ e \end{bmatrix} = \begin{bmatrix} -\nu \cdot z \\ \nu \cdot z - \theta \cdot A \\ m - \kappa \end{bmatrix}. \tag{43}$$

A key property of this dynamic system is determined by the two zeros that appear in the last column of the matrix on the left-hand side of (43). This property implies that dynamic system determining the expected future paths of the two real variables, q and A, is independent of the nominal exchange rate and of the exogenous monetary forcing variables, $m - \kappa$.[32] Indeed, the dynamic system determining the expected paths of q and A is identical to the dynamic system examined in section 1.5. This implies that the behavior of these variables is exactly as described by the analysis in that section. Moreover, given the behavior of q and A that is implied by the real subsystem of (43), we may treat the money demand parameter k (which is defined by [40] as a variable that is exogenous to the monetary sector of the economy); and we solve for the expected future path of the nominal exchange rate by using the reduced-form equilibrium condition given in (7). Thus, all that has been said in the preceding two sections concerning the behavior of the nominal and real exchange rates remains valid in the combined real and monetary model.

The fact that we determine the behavior of the nominal exchange rate by using a reduced-form model of monetary equilibrium, however, should not be allowed to obscure the important role that real variables play in determining the behavior of the nominal exchange rate. In the reduced-form monetary model, the influence of real variables on the nominal exchange rate is all subsumed into the influence of such variables on the money demand variable k. The influence of these real variables is brought into sharper focus by writing the solution for the expected path of the nominal exchange rate implied by the system (43) in the form

32. If desired expenditure were affected by the level of real money balances, then the real sector of the economy would not be independent of monetary influences. For some theoretical purposes, it is useful to assume that there is such a real balance effect. In the present context, however, the costs in terms of losing a convenient solution for the combined real and monetary model by introducing this effect outweigh its benefits.

(44) $$E(e(s); t) = E(F(s); t) - E(p^*(s); t) - \sigma \cdot E(q(s); t)$$

where

(45) $$F(s) = [1/(\zeta + \eta)] \cdot \sum_{j=0}^{\infty} [\eta/(\zeta + \eta)]^j [m(s + j) - x(s + j)]$$

with

(46) $$x = K - N \cdot r^* + U \cdot [D^e(p^*) + \sigma \cdot D^e(q)] + W \cdot A + V \cdot q.$$

$F(s)$ is a weighted sum of differences between (the logarithm of) the nominal money supply, m, and the money demand shift variable, x, defined by (46). The economic significance of $F(s)$ is that its expected value is the common element influencing all nominal prices, as reflected in (44) and in the results

(47) $$E(p(s); t) = E(F(s); t) + (1 - \sigma) \cdot E(q(s); t)$$

(48) $$E((e(s) + p^*(s)); t) = E(F(s); t) - \sigma \cdot E(q(s); t)$$

(49) $$E(P(s); t) = E(F(s); t).$$

Comparing the results (44), (47), (48), and (49), it is apparent that movements in $E(F(s); t)$ are accommodated by equal movements in (the logarithms) of all nominal prices (measured in terms of domestic money). Movements in $E(p^*(s); t)$ are accommodated by offsetting movements in the nominal exchange rate which leave all domestic money prices unaltered. Movements in $E(q(s); t)$ are accommodated partly by movements in the nominal exchange rate (and corresponding movements in the domestic money price of imported goods) and partly by movements in the domestic money price of domestic goods, thereby allowing the general level of domestic prices, $E(P(s); t)$, to remain unaltered.

1.6.3 Exchange Rate Dynamics

Assuming that all current prices are observable, we obtain from (44) the following expression for the current nominal exchange rate:

(50) $$e(t) = E(F(t); t) - p^*(t) - \sigma \cdot q(t).$$

Applying the general procedures of section 1.3 to (50), it follows that the expected change in the exchange rate is given by

(51) $$D^e[e(t)] = D^e[F(t)] - D^e[p^*(t)] - \sigma D^e[q(t)],$$

where $D^e[p^*(t)] = \pi^*(t)$ is whatever people expect to be the rate of inflation in the foreign country, $D^e[q(t)]$ is determined by (29), and

(52) $$D^e[F(t)] = [\zeta/(\zeta+\eta)]. \{E(F(t+1); t) - (1/\zeta) \cdot [m(t) - x(t)]\}.$$

The unexpected change in the exchange rate is given by

$$(53)\qquad D^u[e(t)] = D^u[F(t)] - D^u[p^*(t)] - \sigma \cdot D^u[q(t)],$$

where $D^u[p^*(t)]$ is the unexpected component of the foreign inflation rate, $D^u[q(t)]$ is determined by (31), and

$$(54)\qquad D^u[F(t)] = [1/(\zeta + \eta)] \cdot \sum_{j=0}^{\infty} [\eta/(\zeta + \eta)]^j \cdot [E((m(t + j + 1) - x(t + j + 1)); t + 1) - E((m(t + j + 1) - x(t + j + 1)); t)].$$

The general principle that is embodied in all of these results is that the change in the nominal exchange rate reflects expected and unexpected changes in the entire future time paths of the exogenous forcing variables that ultimately drive the behavior of the economy. One of these forcing variables is (the logarithm of) the nominal money supply, m. Its influence on (the logarithm of) the nominal exchange rate, $e(t)$, comes through the term $E(F(t); t)$ that involves an exponentially weighted sum of current and expected future m's. Since $E(F(t); t)$ is common to all nominal prices, it follows that expected and unexpected changes in $F(t)$ which are induced by expected and unexpected changes in m imply expected and unexpected changes in the exchange rate which are equal (proportionately) to the corresponding expected and unexpected changes in all domestic money prices and hence are consistent with purchasing power parity.

Another exogenous variable that affects the nominal exchange rate is the foreign money price of imported goods, p^*. It is apparent from (51) and (53) that expected and unexpected changes in p^* induce offsetting expected and unexpected changes in e which insulate domestic nominal prices from purely nominal disturbances in the foreign money price of imported goods. In addition, expected changes in p^* may influence e through a currency substitution effect on domestic money demand, as captured by the term $U \cdot D^e(p^*)$ appearing in the money demand parameter x defined in (46).

Real forcing variables affect the dynamic behavior of the exchange rate through two distinct channels. First, the real forcing variables z and $\hat{A}$ which enter into the determination of q (in the manner described in the preceding section) affect the expected and unexpected change in the exchange rate through the terms $-\sigma \cdot D^e[q(t)]$ and $-\sigma \cdot D^u[q(t)]$ that appear in (51) and (53). It is apparent that these contributions to the change in the nominal exchange rate, which are associated with changes in the relative price of domestic goods, give rise to deviations from purchasing power parity. Second, real forcing variables affect the change in the nominal exchange rate through their influence on expected and unexpected changes in the real demand for domestic money. In particular, the forcing variable K directly affects the demand for money, and the forcing variables z and $\hat{A}$ indirectly affect the demand for money through effects on the terms $W \cdot A$, and $(V + \sigma L) \cdot q$ that appear in the composite forcing variable x defined in (46). Since these effects come through the terms $D^e[F(t)]$ and $D^u[F(t)]$ that are common to changes in all nominal prices, it is apparent that they induce exchange rate changes that are consistent with purchasing power parity.

1.7 Sticky Prices and Disequilibrium Dynamics

The combined real and monetary model of the preceding section assumes complete neutrality of money and allows no latitude for monetary disturbances to have real effects on output levels or relative prices. One way of modifying this result is by assuming that some nominal price is sticky and does not adjust immediately to its equilibrium value.[33] Usually, the nominal wage rate would be chosen as this sticky price; but, because the wage rate does not appear in our model, the domestic money price of domestic goods is selected to play this role. An adjustment rule that governs the behavior of this sticky price which may be derived from a microeconomic theory of price adjustment and shown to have desirable mathematical properties is given by

$$D(p) = D^e(\tilde{p}) + \delta \cdot (\tilde{p} - p), \qquad \delta > 0, \tag{55}$$

where $\tilde{p}$ is (the logarithm of) the "conditional equilibrium price" of domestic goods.[34] The "conditional equilibrium price" of domestic goods is defined as the price that would yield equilibrium in the market for domestic goods (and in all other markets) conditional on the actual expected path of net foreign assets.[35] The first term in the price adjustment rule, $D^e(\tilde{p})$, causes the actual price of domestic goods to move in line with expected changes in its conditional equilibrium value. The second term in the price

33. This approach corresponds to "contracting approach" to introducing monetary nonneutralities into macroeconomic models that has been developed by Fisher (1977), Phelps and Taylor (1977), and Taylor (1980). An alternative approach is that developed by Lucas (1972, 1973, 1975), Sargent and Wallace (1975), and Barro (1976) which emphasizes incomplete information as the source of nonneutral effects of monetary disturbances. Differences between these approaches with respect to their implications for the usefulness of stabilization policy should carry over from closed to open economy models. For applications of these approaches to open economy macroeconomic models, see Flood (1979), Saidi (1980) and 1982), Stockman (1980), and Buiter and Miller (1981, 1982).

34. The economic justification for the assumption of this form of price adjustment rule is discussed in Mussa (1981*b*, 1982*B*).

35. The full equilibrium price of domestic goods is calculated on the assumption that domestic holdings of net foreign assets will follow their equilibrium path. When there is disequilibrium, the actual path of net foreign assets will not correspond to this full equilibrium path. For reasons of analytical convenience it is useful to specify that the conditional equilibrium price of domestic goods plays the role of the equilibrium price in the price adjustment rule. Designation of the full equilibrium price to play this role would not alter the basic conclusions of the analysis of this section, but it would make the analysis more complicated.

adjustment rule, $\delta \cdot (\bar{p} - p)$, causes any gap between the actual and the conditional equilibrium price of domestic goods to be eliminated at an exponential rate δ.

1.7.1 The Disequilibrium Situation

When the inherited value of $p(t)$ differs from $\bar{p}(t)$, there is disequilibrium in the market for domestic goods. Consistent with the assumption that producers of these goods are holding their prices temporarily fixed, it is assumed that this disequilibrium is absorbed by variations in the output of domestic goods. Formally, this assumption is represented by specifying that

$$(56) \qquad y = d + d^*,$$

where y denotes the *deviation* of the value of output of domestic goods from its equilibrium level, d^* is the value of foreign excess demand for domestic goods, and d is the excess of the value of domestic demand for domestic goods over the equilibrium level of output of such goods.

The value of foreign excess demand for domestic goods, d^*, is still determined by (12), namely,

$$(57) \qquad d^* = \beta^* \cdot q - x^*.$$

There must be some modification, however, in the specification of d and f to take account of the disequilibrium situation; specifically, (13) and (14) are replaced by

$$(58) \qquad f = (1-\sigma) \cdot \psi + \beta \cdot q - x + (1-\sigma) \cdot (1-\xi) \cdot y$$

$$(59) \qquad d = \sigma \cdot \psi - \beta \cdot q + x + \sigma \cdot (1-\xi) \cdot y,$$

where ψ is the excess of the equilibrium level of domestic spending over the equilibrium value of domestic output, and ζ is the marginal propensity to save out of a disequilibrium increase in the value of domestic output.

Since, by assumption, disequilibrium does not affect domestic output of foreign goods (if such goods are produced domestically), the excess of domestic demand for such goods over the equilibrium level of domestic output of such goods, which is measured by f, corresponds to the actual domestic excess demand for such goods even in the disequilibrium situation. It follows that the trade balance of the home country, T, is given by

$$(60) \qquad T = d^* - f = \sigma \cdot \nu \cdot (z - q) - (1 - \sigma) \cdot \psi - (1 - \sigma) \cdot (1 - \xi) \cdot y$$

where, as before, $\nu = (\beta + \beta^*)/\sigma$ and $z = (x + x^*)/(\beta + \beta^*)$. Substituting (57) and (59) into the disequilibrium market-clearing condition (56), it is easily shown that

$$(61) \qquad \psi = \nu \cdot (q - z) + [(1 - \sigma + \xi\sigma)/\sigma] \cdot y.$$

Substitution of (61) into (60) yields the result that

$$T = -(\psi - \xi \cdot y) = \nu \cdot (z - q) - [(1 - \sigma)/\sigma] \cdot y. \tag{62}$$

This result (which is the analogue of [18]) expresses the equivalence between the absorption and elasticities approaches to the trade balance when the economy is in disequilbrium.[36]

The budget constraints and accounting identities which must apply in disequilibrium as well as equilibrium situations imply that the rate of accumulation of net foreign assets by home residents must equal the current account balance of the home country; hence

$$D(A) = b = \nu \cdot (z - q) + r^* \cdot A - ((1 - \sigma)/\sigma) \cdot y. \tag{63}$$

Further, adding disequilibrium savings, $\xi \cdot y$, to the equilibrium desired excess of domestic income over domestic spending, $r^*A - \psi = -\alpha\sigma D^e(q) + \mu(\hat{A} - A)$, it follows that the modified version of the balance of payments equilibrium condition that is relevant in disequilibrium is given by

$$\begin{aligned} \nu \cdot (z - q) + r^* \cdot A - [(1 - \sigma)/\sigma] \cdot y = \\ -\alpha\sigma \cdot D^e(q) + \mu \cdot (\hat{A} - A) + \xi \cdot y. \end{aligned} \tag{64}$$

The money market equilibrium condition must also be modified to take account of disequilibrium variations in the value of domestic output (and domestic income) on the demand for domestic money. Specifically, adding an amount $\omega \cdot y$ to the money demand function (35), it follows that the modified condition of money market equilibrium can be written as

$$\begin{aligned} \zeta \cdot e - \eta \cdot D^e(e) + W \cdot A + (V + \sigma L) \cdot q \\ + \omega \cdot y = m - \kappa, \end{aligned} \tag{65}$$

where κ is the exogenous money demand parameter defined in (41).

1.7.2 Expected Convergence toward Conditional Equilibrium

Under the assumption of rational expectations, the difference equations (63), (64), and (65) are three of the four equations that are required for the system that determines the expected paths of the four endogenous variables, q, A, e, and y, conditional on the expected future paths of the exogenous forcing variables. To complete this system, we tentatively assume that

36. From the perspective of the absorption approach, the trade balance is given by $T = -(\psi - \xi \cdot y)$, and it appears that a disequilibrium increase in income improves the trade balance (since some of this income is saved). From the prospective of the elasticities approach, the trade balance is given by $T = \nu \cdot (z - q) - [(1 - \sigma)/\sigma] \cdot y$, and it appears that a disequilibrium increase in income worsens the trade balance (since it increases domestic demand for foreign goods). The two results are consistent, however, because for the absorption approach we are implicitly holding ψ constant, while for the elasticities approach we are implictly holding q constant.

(66) $$y = \Lambda \cdot (\bar{p} - p),$$

where Λ is a constant whose value is yet to be determined. If (66) is valid, then it follows from the price adjustment rule (61) that

(67) $$D^e(y) = \Lambda \cdot D^e[(\bar{p} - p)] = -\delta \cdot \Lambda \cdot (\bar{p} - p) = -\delta \cdot y.$$

This difference equation completes the system required to determine the expected paths of q, A, e, and y.

The assumption of (66) is justified by showing that under this assumption all variables converge to their respective conditional equilibrium values (on an expected basis) in a consistent and correct manner. In the process of this demonstration, the appropriate value of the coefficient Λ is derived. The definition of the concept of conditional equilibrium implies that the current conditional equilibrium values of all endogenous variables (which are denoted by a tilde) must satisfy the equations of the combined real and monetary model developed in sections 1.4–1.6.[37] In particular, since q and e must be consistent with the balance of payments equilibrium condition and the money market equilibrium condition, it follows that the deviations $q - \tilde{q}$ and $e - \tilde{e}$ must satisfy the conditions[38]

(68) $$\nu \cdot (q - \tilde{q}) - [(1 - \sigma)/\sigma] \cdot y = -\alpha\sigma \cdot D^e(q - \tilde{q}) + \xi \cdot y,$$

(69) $$\zeta \cdot (e - \tilde{e}) - \eta \cdot D^e(e - \tilde{e}) + (V + \sigma L) \cdot (q - \tilde{q}) + \omega \cdot y = 0.$$

Further, consistent with (66) and (67), it may be assumed that q and e are expected to converge to their respective conditional equilibrium values, $\tilde{q}$ and $\tilde{e}$, at the same exponential rate δ that characterizes the expected speed of convergence of p to $\bar{p}$. This implies that the terms $D^e(q - \tilde{q})$ and $D^e(e - \tilde{e})$ appearing in (68) and (69) can be replaced by $-\delta \cdot (q - \tilde{q})$ and $-\delta \cdot (e - \tilde{e})$, respectively. In addition, the deviation $e - \tilde{e}$ can be replaced by $(p - \bar{p}) - (q - \tilde{q})$. The modified versions of (68) and (69) that result from these substitutions constitute a linear system in the three variables y, $q - \tilde{q}$, and $p - \bar{p}$, which may be solved to obtain the results

(70) $$q - \tilde{q} = \Omega \cdot (p - \bar{p})$$

(71) $$y = -[\sigma/(1 - \sigma + \xi\sigma)] \cdot (\nu + \alpha\sigma\delta) \cdot \Omega \cdot (p - \bar{p}),$$

37. The only difference between the conditional equilibrium and full equilibrium is that in conditional equilibrium we allow for the disequilibrium behavior of net foreign assets. This difference does not affect the applicability of the equilibrium conditions described in previous sections to the conditional equilibrium values of economic variables.

38. To derive these results, note (64) and (65) are satisfied when $q = \tilde{q}$, $e = \tilde{e}$, and $y = 0$.

where

$$(72) \qquad \Omega = \frac{1}{1 - \left[\dfrac{V + \sigma L}{\zeta + \eta\delta}\right] + \left[\dfrac{\omega\sigma}{1 - \sigma + \xi\sigma}\right]\left[\dfrac{\nu + \alpha\sigma\delta}{\zeta + \eta\delta}\right]}.$$

It is apparent that (71) is equivalent to (66) under the stipulation that

$$(73) \qquad \Lambda = [\sigma/(1 - \sigma + \xi\sigma)] \cdot (\nu + \alpha\sigma\delta) \cdot \Omega.$$

Further, using the fact that $(e - \tilde{e}) = (p - \tilde{p}) - (q - \tilde{q})$, it follows that

$$(74) \qquad e - \tilde{e} = \Phi \cdot (p - \tilde{p}), \quad \Phi = (1 - \Omega).$$

The results (70)–(74) justify the initial assumption of (66) and the future assumption that deviations of p, q, and e from their respective conditional equilibrium values are expected to be eliminated that the exponential rate δ. The results (72) and (73) give the appropriate value of the coefficient Λ.

These results permit a reasonably simple description of the state of disequilibrium of the economy at any moment and of how this state of disequilibrium is expected to evolve over time as the economy converges toward its equilibrium path. The state of disequilibrium is determined completely by the divergence between the inherited value of $p(t)$ and the conditional equilibrium value of this price, $\tilde{p}(t)$. This divergence determines the deviation of the value of output of domestic goods from its equilibrium level, $y(t) = -\Lambda \cdot [p(t) - \tilde{p}(t)]$, and also the deviations of the relative price of domestic goods and the exchange rate from their respective conditional equilibrium values, $q(t) - \tilde{q}(t) = \Omega \cdot [p(t) - \tilde{p}(t)]$ and $e(t) - \tilde{e}(t) = \Phi \cdot [p(t) - \tilde{p}(t)]$. Over time, it is expected that the price of domestic goods will converge toward its conditional equilibrium value at an exponential rate δ. Correspondingly, the deviation of the value of the value of domestic output from its equilibrium level, y, and the deviations of q and e from their respective conditional equilibrium values are also expected to disappear at the exponential rate δ.[39]

From all of these results, it is apparent that the coefficients Λ, Ω, and Φ are of critical importance in determining the magnitude of the effects disequilibrium created by divergences between p and $\tilde{p}$ on other economic variables. Consider first the coefficient Ω which determines the response of $q - \tilde{q}$ to $p - \tilde{p}$. There is a strong presumption that $\Omega > 0$ and weaker

39. This same basic description of the state and expected evolution of disequilibrium applies to other endogenous variables of the economic system. In particular, if we assume that there is no risk premium in the foreign exchange market, then using the interest parity condition (42) we may show that the deviation of the domestic nominal interest rate from its conditional equilibrium value is given by $(i - \tilde{i}) = -\delta\Phi \cdot (p - \tilde{p})$. As disequilibrium is eliminated, the domestic nominal interest rate is expected to converge toward its conditional equilibrium value at the exponential rate δ.

presumption that $\Omega > 1$. The only thing that could make Ω negative is if $V + \sigma L$ were significantly greater than $\zeta + \eta\delta$. But, going back to (39), we find that $\zeta = L + J$ which is definitely greater than σL. Thus, the only thing that could make $\Omega < 0$ is if V were strongly positive, that is, if an increase in the relative price of domestic goods had a strong effect of increasing the nominal demand for domestic money. There is no reason to suppose that this relative price should have such a strong effect on nominal money demand. The weak presumption that $\Omega > 1$ comes from the notion that transitory changes in income associated with disequilibrium should have relatively weak effects on the demand for money. If this notion is correct, then the parameter ω which indicates the response of money demand to the deviation of the value of output from its equilibrium level should be small. If ω is small, then the third term in the denominator of Ω in (72) should be smaller (in absolute value) than the second term in this denominator, implying that $\Omega > 1$.

The conclusion that $\Omega > 1$ is of critical importance for the sign of the coefficient Φ and hence for the phenomenon of "exchange rate overshooting." If $\Omega > 1$, then $\Phi = 1 - \Omega < 0$, and from (74) it follows that $e - \tilde{e}$ is inversely related to $p - \tilde{p}$. In this case, we have Dornbusch's phenomenon of "exchange rate overshooting," in the sense that an increase in the conditional equilibrium price of domestic goods relative to the actual price of such goods (induced by an unexpected increase in the money supply) causes the actual exchange rate to increase by even more than the conditional equilibrium exchange rate. In the present model, however, overshooting of the exchange rate in response to monetary disturbances is not assured. If money demand responds strongly to deviations of the value of output from its equilibrium level (ω is large), or if increases in the relative price of domestic goods have a strong negative effect on money demand (V is large and negative), then Ω may be less than one and $\Phi = 1 - \Omega$ may be positive. In this case, the actual exchange rate will rise by less than the conditional equilibrium exchange rate in response to an unanticipated increase in the money supply that increases $\tilde{p}$ relative to p.[40]

The coefficient Λ determines the response of the value of domestic output to divergences between p and $\tilde{p}$. From (73) it follows that the strong presumption that Ω is positive translates into a strong presumption that Λ is positive. Since $y = -\Lambda \cdot (p - \tilde{p})$, a positive Λ means that y is negatively related to $p - \tilde{p}$. As one should expect, a high value of p implies a low demand for domestic goods, and the producers of these goods (who temporarily hold their price fixed) respond to this low demand by reducing the value of output of such goods below its equilibrium level.

40. In Dornbusch's (1976) original analysis of exchange rate overshooting, it is recognized that a strong response of income to an increase in the money supply may counteract the normal overshooting effect of a monetary disturbance.

1.7.3 Disequilibrium Dynamics

The preceding analysis indicates how current state of disequilibrium in the economy, at time t, is determined by the divergence between $p(t)$ and its conditional equilibrium value $\tilde{p}(t)$, and how this disequilibrium is expected to disappear, at the exponential rate δ, as the economy converges toward its conditional equilibrium path. To obtain the complete picture of the dynamic behavior of the economy it is also necessary to describe how the conditional equilibrium price of domestic goods and the conditional equilibrium values of other endogenous variables are expected to change over time, how these expectations are altered by the receipt of new information, and how new disequilibrium is generated within the economic system.

To obtain the correct expressions for the expected conditional equilibrium paths of the endogenous variables of the economic system, it is only necessary to modify slightly the results which describe the expected equilibrium paths of these variables in the combined real and monetary model of section 1.6. Specifically, the solutions for the expected value of an endogenous variable as a weighted sum of expected future values of the exogenous forcing variables z, $\hat{A}$, and $w = (1/\zeta) \cdot (m - k)$ give the correct expressions for the expected conditional equilibrium value of that variable provided that

$$
\begin{aligned}
&z(t+j) \text{ is replaced by } z(t+j) - [(1-\sigma)/\nu\sigma] \\
&\quad \cdot (1-\delta)^j \cdot y(t) \\
&\hat{A}(t+j) \text{ is replaced by } \hat{A}(t+j) + (\xi/\mu) \cdot (1-\delta)^j \cdot y(t) \\
&w(t+j) \text{ is replaced by } w(t+j) + \omega \cdot (1-\delta)^j \cdot y(t),
\end{aligned}
\tag{75}
$$

where $y(t)$ is determined by the divergence between $p(t)$ and $\tilde{p}(t)$ in accord with $y(t) = \Lambda \cdot [\tilde{p}(t) - p(t)]$.

From (75) it is apparent that if there is no disequilibrium at time t, then all of the forcing variables have the same values as in the equilibrium analysis, and hence the expected conditional equilibrium paths of all endogenous variables correspond exactly to the expected full equilibrium paths of these variables. Further, since the terms involving $y(t)$ in (75) (which are responsible for all differences between the expected full equilibrium and the expected conditional equilibrium values of endogenous variables) all decay with a factor $(1 - \delta)^j$, it follows that conditional equilibrium value of any endogenous variable is expected to converge toward its full equilibrium value at the exponential rate δ. For example, from (75) it follows that the difference between the current conditional equilibrium exchange rate and the current full equilibrium exchange rate—denoted by $\bar{\bar{e}}(t)$—can be written as

$$
\tilde{e}(t) - \bar{\bar{e}}(t) = \theta \cdot y(t) = \theta\Lambda \cdot [\tilde{p}(t) - p(t)],
\tag{76}
$$

where θ is a coefficient that is made up of weighted sums of the factors multiplying $y(t)$ in (75). Applying the expected forward difference operator to (76) and taking account of the price adjustment rule (55), we determine the expected rate of convergence of the conditional equilibrium exchange rate toward its full equilibrium value,

$$\text{(77)} \qquad \begin{aligned} D^e[\tilde{e}(t) - \bar{\bar{e}}(t)] &= -\delta\Lambda \cdot [\tilde{p}(t) - p(t)] \\ &= -\delta \cdot [\tilde{e}(t) - \bar{\bar{e}}(t)]. \end{aligned}$$

Similar results can be derived for the expected rate of convergence of the conditional equilibrium values of other variables, such as the real exchange rate, toward their full equilibrium values.

Expected changes in the actual values of endogenous variables can, in general, be decomposed into three parts: (i) the expected change in the full equilibrium value of the variable; as determined by the combined real and monetary model of section 1.6; (ii) the expected convergence of the actual value of a variable toward its conditional equilibrium value, which is equal to $-\delta$ times the existing divergence between the actual and the conditional equilibrium value of the variable; and (iii) the expected convergence of the conditional equilibrium value of the variable toward its full equilibrium value, which is equal to $-\delta$ times the existing divergence between the conditional and full equilibrium values of the variables. In particular, for the nominal exchange rate we have

$$\text{(78)} \qquad \begin{aligned} D^e[e(t)] &= D^e[\bar{\bar{e}}(t)] - \delta \cdot [e(t) - \tilde{e}(t)] \\ &\qquad -\delta \cdot [\tilde{e}(t) - \bar{\bar{e}}(t)] \\ &= D^e[\bar{\bar{e}}(t)] - \delta \cdot (\theta\Lambda - \Phi) \cdot [\tilde{p}(t) - p(t)], \end{aligned}$$

where $D^e[\bar{\bar{e}}(t)]$ is given by the result (51). Similar results apply for the expected changes in the actual values of other endogenous variables.

The state of disequilibrium which influences expected changes in all endogenous variables is itself the consequence of past unexpected changes in the conditional equilibrium price of domestic goods. Specifically, since the price adjustment rule (55) specifies that the expected change in $\tilde{p}$ is incorporated into the actual change in p, it follows that the innovation in disequilibrium between t and $t+1$ corresponds to the unexpected change in the conditional equilibrium price of domestic goods,

$$\text{(79)} \qquad D^u[\tilde{p}(t) - p(t)] = D^u[\tilde{p}(t)].$$

The total change in disequilibrium is the sum of this innovation and the expected change $D^e[\tilde{p}(t) - p(t)] = -\delta \cdot [\tilde{p}(t) - p(t)]$, that is,

$$\text{(80)} \qquad D[\tilde{p}(t) - p(t)] = D^u[\tilde{p}(t)] - \delta \cdot [\tilde{p}(t) - p(t)].$$

Taking the backward-looking solution of this difference equation, we find that the existing state of disequilibrium is a weighted average of past unexpected changes in the conditional equilibrium price of domestic goods;

(81) $$\tilde{p}(t) - p(t) = \delta \cdot \sum_{j=0}^{\infty} (1 - \delta)^j \cdot D^u[\tilde{p}(t - j - 1)].$$

Unexpected changes in the conditional equilibrium price of domestic goods that are the fundamental source of disequilibrium must themselves be the result of changes in expectations about the exogenous forcing variables, z, $\hat{A}$, and w, that ultimately determine $\tilde{p}$. In particular, exploiting (47), it follows that

(82) $$\tilde{p}(t) = E(F(t); t) + (1 - \sigma) \cdot E(\bar{\bar{q}}(t); t) + \Gamma \cdot y(t),$$

where $F(t)$ is the weighted sum of differences between money supply and money demand defined in (45), $\bar{\bar{q}}(t)$ represents the full equilibrium relative price of domestic goods as determined by the present stock of net foreign assets and the present and future values of the forcing variables z and $\hat{A}$, and Γ is the coefficient that indicates effect of $y(t)$ on $\tilde{p}(t)$ implied by the modifications of the forcing variables listed in (75). Applying the unexpected difference operator to (83) and making use of (66) and (80), it follows that

(83) $$D^u[\tilde{p}(t)] = [1/(1 + \lambda\Gamma)] \cdot \{D^u(E(F(t); t)) + (1 - \sigma) \cdot D^u[\bar{\bar{q}}(t)]\},$$

where the presumption is that $1 + \lambda\Gamma > 0$.

The price adjustment rule (55) prescribes that $D^u[p(t)]$ has no effect on the actual price of domestic goods in period $t + 1$, but is instead absorbed by the state of disequilibrium at $t + 1$. Because of its effect on the state of disequilibrium, however, $D^u[\tilde{p}(t)]$ does influence the magnitudes of the unexpected changes in the values of all other endogenous variables between t and $t + 1$ by affecting both the divergence between the actual value of a variable and its conditional equilibrium value and the divergence between the conditional equilibrium value of the variable and its full equilibrium value. For example, from (74) and (76) it follows that the unexpected change in the nominal exchange rate is given by

(84) $$D^u[e(t)] = D^u[\bar{\bar{e}}(t)] + (\theta\lambda - \Phi) \cdot D^u[\tilde{p}(t)].$$

The first factor affecting $D^u[e(t)]$ is the unexpected change in the full equilibrium exchange rate, $D^u[\bar{\bar{e}}(t)]$, as determined by (53). The second factor is the combined effect of the innovation in disequilibrium, $D^u[\tilde{p}(t)]$, on the divergences between $\tilde{e}$ and $\bar{\bar{e}}$ and between e and $\tilde{e}$.

1.7.4 Disequilibrium Effects of Real and Monetary Disturbances

The principal advantage of disequilibrium model of the present section over the equilibrium model of the previous section is its capacity to deal with the disequilibrium effects of real and monetary disturbances, especially their effects on real output and on the real exchange rate. Since unexpected changes in the conditional equilibrium price of domestic goods are the fundamental source of disequilibrium, it follows from (83) that "real disturbances" may conveniently be identified with unexpected changes in the full equilibrium relative price of domestic goods, $D^u[\bar{\bar{q}}(t)]$, and "monetary disturbances" may be identified with unexpected changes in the common element in the full equilibrium values of all nominal prices, $D^u(E(F(t);\ t))$. These disturbances would be "transitory" if the change in expectations due to new information received between t and $t+1$ affected only expectations about the exogenous real and monetary factors (the z's, $\hat{A}$'s, and w's) in the near future and left expectations concerning their longer-run values unchanged. These disturbances would be "permanent" if the new information altered expectations concerning the exogenous real and monetary factors by approximately the same amount for all future periods.

With respect to their effects on the disequilibrium component of domestic output (and income), real and monetary disturbances have essentially the same effects in the sense that positive values of $D^u[\bar{\bar{q}}(t)]$ and $D^u(E(F(t);\ t))$ both induce positive innovations in y; formally,

$$\text{(85)} \qquad \begin{aligned} D^u[y(t)] = \lambda \cdot D^u[\tilde{p}(t)] &= [\lambda/(1+\lambda\Gamma)] \\ &\cdot \{D^u(E(F(t);\ t)) \\ &+ (1-\sigma) \cdot D^u[\bar{\bar{q}}(t)]\}. \end{aligned}$$

Moreover, for a given size disturbance, either real or monetary, it makes no difference for its effect on y whether the disturbance is transitory or permanent. As indicated by (66) and (81), however, the effect of any particular disturbance on y decays with the passage of time and the actual price of domestic goods gradually adjusts toward its conditional equilibrium value. Thus, a continuing sequence of real and monetary disturbances is necessary to sustain deviations of output from its equilibrium level.

With respect to their effects on the real exchange rate, there are important differences between real and monetary disturbances and between permanent and transitory disturbances. Formally, using the fact that $q - \tilde{q} = p - \tilde{p} - (e - \tilde{e})$ and $\tilde{q} - \bar{\bar{q}} = \tilde{p} - \bar{\bar{p}} - (\tilde{e} - \bar{\bar{e}})$, together with the results (74), (76), and (82), we may reach the conclusion that

$$\text{(86)} \qquad q(t) = \bar{\bar{q}}(t) = -\Delta \cdot [\tilde{p}(t) - p(t)],$$

with $\Delta = 1 - \Phi + \theta\lambda - \Gamma\lambda$, where the presumption is that $\Delta > 0$.[41] The right-hand side of (86) measures the effect of disequilibrium on the real exchange rate (which is identified with the relative price of domestic goods).

41. Using (73) and (74) it may be shown that $\Delta = 1 + \Omega \cdot \{1 + (\theta - \Gamma) \cdot [\sigma/(1 - \sigma + \xi\sigma)] \cdot (\nu + \alpha\sigma\delta)\}$. As previously discussed, there is a strong presumption that $\Omega > 0$. The term multiplying Ω in the expression for Δ is also likely to be positive, except in the unlikely event that $(\theta - \Gamma)$ is both large and negative. Even if the term multiplying Ω is negative, it is still likely that Δ is positive.

Applying the expected and unexpected change operators to (86) yields the results

(87) $$D^e[q(t)] = D^e[\bar{\bar{q}}(t)] - \delta[q(t) - \bar{\bar{q}}(t)]$$

(88) $$D^u[q(t)] = D^u[\bar{\bar{q}}(t)] - \Delta D^u[\tilde{p}(t)].$$

Thus, the expected change in the real exchange rate reflects both the expected change in the full equilibrium real exchange rate and the expected convergence of the actual real exchange rate toward its full equilibrium value. The unexpected change in the real exchange rate reflects both the full equilibrium effect of the real disturbances measured by $D^u[\bar{\bar{q}}(t)]$ and the disequilibrium effect of the real and monetary disturbances summarized by $D^u[\tilde{p}(t)]$. It is noteworthy that full equilibrium effect of real disturbances on the real exchange rate will be permanent if the disturbances themselves are permanent, but that disequilibrium effect or real and monetary disturbances on the real exchange rate must be transitory, even if the disturbances are permanent, because the effect of any individual disturbance on the state of disequilibrium decays with the passage of time.

Further insight into the effects of real and monetary disturbances on the real exchange rate comes from substituting (83) into (88):

(89) $$\begin{aligned} D^u[q(t)] = {} & [1 - (1 - \sigma) \cdot \mathrm{T}] \\ & \cdot D^u[\bar{\bar{q}}(t)] - \mathrm{T} \cdot D^u(E(F(t); t)), \end{aligned}$$

where $\mathrm{T} = \Delta/(1 - \Gamma\lambda)$. The second term on the right-hand side of (89) measures the effect of monetary disturbances. This effect is exclusively a disequilibrium effect which does not arise in the full equilibrium model of the preceding section. If the nominal exchange rate "overshoots" in response to monetary disturbances—in the sense that $D^u(E(F(t); t)$ has a more than one-for-one effect on $D^u[e(t)]$—then the coefficient T must be positive, and the real exchange rate must decline in response to a positive monetary disturbance. The first term on the right-hand side of (89) measures the combined equilibrium and disequilibrium effects of real disturbances on the real exchange rate. It is apparent that if the nominal exchange rate overshoots in response to monetary disturbances (for which the necessary and sufficient condition is $\mathrm{T} > 0$), then the real exchange rate must undershoot in response to real disturbances or, in the extreme case where $(1 - \sigma) \cdot \mathrm{T} > 1$, the real exchange rate may move in the opposite direction to the change in its full equilibrium value in response to real disturbances.

These results are directly relevant to the explanation of deviations from purchasing power parity, which are identified, one for one, with movements in the real exchange rate. In an economy where the prices of domestic goods are not immediately adjusted to unexpected changes in their equilibrium values, monetary disturbances will induce temporary divergences from purchasing power parity. Temporary real disturbances will also induce temporary deviations from purchasing power parity through both their equilibrium and disequilibrium effects. It is not necessary, however, that all deviations from purchasing power parity be temporary. Permanent real disturbances will require permanent adjustments in the relative price of domestic goods and hence permanent changes in the real exchange rate.

1.8 Summary and Extensions

It is desirable that theoretical models of exchange rate determination be consistent with the empirical regularities that have generally characterized the actual behavior of floating exchange rates. This requires that the exchange rate be treated as an asset price that is affected not only by current economic conditions but also, to an important extent, by expectations of future economic conditions. In such an asset price model, there is a general explanation of how new information that alters expectations concerning future economic conditions induces unexpected changes in exchange rates and of why such unexpected changes may dominate actual exchange rate movements. There is also an explanation of the empirically observed phenomenon that spot and forward exchange rates tend to move together, especially when there are fairly large changes. In such an asset price model of the exchange rate, it is desirable that the behavior of national money supplies and the demands to hold these monies play an important role in influencing the behavior of exchange rates, but, consistent with the observed facts, the model should not insist on too rigid a link between movements in money supplies and movements in exchange rates. It is also desirable that the model of exchange rate determination allow for variations in real exchange rates (and hence deviations from purchasing power parity) and that it permit real economic conditions relevant for determining relative prices to play a role in influencing the behavior of exchange rates. Consistent with the observed facts, however, the model should not insist that nominal or real exchange rates adjust rapidly to eliminate current account imbalances.

The theoretical model of exchange rate determination developed in this paper possesses these desirable properties. This model is a compendium of monetary and real models of exchange rate behavior, with equilibrium and disequilibrium features, that have been integrated into a unified theoretical framework in which the exchange rate is treated as an asset price. The model incorporates a simple, reduced-form condition of money market equilibrium that is consistent with a very general specification of the structural factors influencing money demand, including wealth and income effects, currency substitution effects, and the possibility of a risk premium in the foreign exchange market that affects the demand for money by influencing nominal interest rates. Under the assumption of rational expectations, the condition of money market equilibrium implies an asset price expression for (the logarithm of) the nominal exchange rate as a discounted sum of expected future differences between (the logarithms of) the domestic money supply and the exogenous (to the monetary sector of the economy) component of the demand for domestic money.

The model of exchange rate determination developed in this paper also incorporates a theory of the determination of the real exchange rate by means of a general equilibrium specification of the condition of balance of payments equilibrium. This specification is consistent with the standard two-country, two-commodity model of the real theory of international trade, with the dependent economy model in which the home country produces and consumes its own nontraded good as well as a traded good that is a perfect substitute for goods produced and consumed in the rest of the world, and with the usual "Keynesian" model in which the home country produces an output that is distinct from the output of the rest of the world. An important feature of this model of balance of payments equilibrium is that both the level and the expected rate of change of the real exchange rate affect the desired difference between domestic spending and domestic income and the current account balance. Under the assumption of rational expectations, it follows that (the logarithm of) the real exchange rate that is consistent with balance of payments equilibrium (but not necessarily with a zero current account balance) depends on the long-run equilibrium real exchange rate and on the divergence between the actual level of net foreign assets held by domestic residents and the long-run desired level of such asset holdings. The dependence of the real exchange rate on the level of net foreign assets is consistent with the relationship described in a number of recent models of the dynamic interaction between the current account and the exchange rate. The asset price property of the exchange rate is reflected in formulas expressing the long-run equilibrium real exchange rate and the long-run desired level of net foreign assets as discounted sums of expected future values of the exogenous factors affecting excess demands for domestic and foreign goods (and hence the trade balance) and the desired level of domestic spending.

In the equilibrium version of the model of exchange rate determination developed in this paper, money is strongly neutral and the real sector of the economic system functions independently of the monetary sector. For this reason, real economic conditions affecting the real exchange rate and the demand for real money balances can be taken as exogenous with respect to the monetary sector of the economic system, and the reduced-form condition for money market equilibrium may be treated as the proximate determinant of the nominal exchange rate, as is done in most simple monetary models of exchange rate behavior. An alternative (but analytically equivalent) solution for the equilibrium nominal exchange rate brings the influence of real economic conditions on the exchange rate into sharper focus. Real economic conditions influence the equilibrium nominal exchange rate because they affect the real demand for domestic money and thereby affect the common monetary element that influences the behavior of all domestic nominal prices. Real economic conditions also influence the equilibrium nominal exchange rate by affecting the equilibrium real exchange rate. Specifically, with the general level of domestic prices determined by the requirements of monetary equilibrium, an increase in the equilibrium relative price of domestic goods must be accomplished by an alteration of the nominal exchange rate which allows the domestic price of foreign goods to fall and the domestic price of domestic goods to rise. In the equilibrium model of exchange rate determination, such movements of the nominal exchange rate in response to movements in the equilibrium real exchange rate provide the only explanation for deviations from purchasing power parity.

In the disequilibrium version of the model of exchange rate determination developed in this paper, money is not neutral and monetary disturbances have temporary disequilibrium effects on real output, relative prices, the balance of payments, and real and nominal exchange rates. The source of monetary nonneutrality is the assumption that the domestic money price of domestic goods does not adjust immediately to its equilibrium value, but instead is governed by an adjustment rule that allows for expected changes in the equilibrium price of domestic goods and for gradual elimination of the existing divergence between the actual and equilibrium prices of these goods. The extent of this divergence determines the extent of disequilibrium in the economy, and the divergences of all endogenous variables from their respective equilibrium values are proportional to this measure of the extent of disequilibrium. Expected elimination of disequilibrium through expected convergence of the price of domestic goods toward its equilibrium value contributes an additional term to the expressions from the equilibrium model for expected changes in endogenous variables, including the nominal and real exchange rates. Unexpected changes in the equilibrium price of domestic goods constitute the innovations to disequilibrium in the economy, and the spillover effects of these innovations contribute an additional term to the expressions for unexpected changes in endogenous variables, including the nominal and real exchange rate. In particular, provided that the response of money demand to innovations in disequilibrium is not too strong, it is likely that a monetary disturbance that causes an unexpected increase in the equilibrium values of all domestic money prices will induce a more than proportionate response of the actual nominal exchange rate due to the spillover effect of the innovation to disequilibrium; that is, the nominal exchange rate will "overshoot" in response to monetary disturbances. Correspondingly, the real exchange rate will respond to the disequilibrium effect of a monetary disturbance, even though such a disturbance has no effect on the equilibrium real exchange rate. This effect of a monetary disturbance on the real exchange rate, however, will be temporary because the price of domestic goods will gradually adjust toward its equilibrium value and the disequilibrium created by the monetary disturbance will gradually be eliminated. In contrast, a real disturbance that permanently alters equilibrium relative prices will permanently affect the real exchange rate, and this long-run effect may be greater than the short-run effect of the real disturbance because the disequilibrium spillover effect of such disturbances is likely to work in the opposite direction of their long-run effect.

The results of this paper can be extended in a number of directions. One direction for such extensions is simply to apply the analytical results of the present paper to the examination of specific issues concerning the behavior of exchange rates and their relationships with other economic variables. For instance, we could investigate the effects of economic growth, of changes in desired spending patterns, of changes in government fiscal or commercial policy, and of a host of other economic changes on the behavior of real and nominal exchange rates and on the relationships among exchange rates, prices, interest rates, and the balance of payments, in both an equilibrium and a disequilibrium setting. The general procedure for conducting such investigations is to specify the nature of the initiating economic disturbance in terms of its effects on the paths of the exogenous forcing variables of the model, and then to examine the effects of these changes in the paths of the forcing variables on the paths of the endogenous variables of the model, including real and nominal exchange rates, prices, interest rates, and the balance of payments. Care must be taken in conducting these investigations because, in general, an initiating economic disturbance will affect the paths of all of the exogenous forcing variables. For example, economic growth in domestic goods sector of the home country will affect the demand shift parameter that is important for determining the relative price of domestic goods (the z's). It will also affect the exogenous monetary factor (the w's) by affecting the real demand for domestic money; and as domestic income grows there is also likely to be an effect of the target level of domestic net holdings of foreign assets (represented by an increasing level of $\hat{A}$).

Another direction for possible extensions of the analysis of this paper is by modifying some of the assumptions of the model without altering its basic character. One such modification would be to allow explicitly for a domestic, nontradable asset (other than domestic money) that is not regarded as a perfect substitute for either domestic money or foreign assets.[42] If the demand for this asset were a function only of variables that already appear in the model, its introduction would not require any alteration of the formal results of the present analysis. All that would happen is that the rate of return on this asset would be determined by the requirement that the demand to hold it should equal the supply available to be held. Explicit introduction of such a domestic asset, however, would allow explicit analysis of the effects of economic disturbances on its rate of return and of changes in the

42. Models that employ this type of specification of the structure of the asset markets have been investigated by Dornbusch (1975) and Branson (1976).

supply of this asset (resulting perhaps from open market operations) on the exchange rate and other variables. A more ambitious modification of the assumptions of the present model would be to allow for tradable domestic assets that are not regarded as perfect substitutes for foreign assets by either home or foreign residents. This modification would require alteration of some of the formal results of the present paper. It would permit explicit treatment of issues that arise in portfolio balance models of the exchange rate that assume a multiplicity of tradable securities. Yet another modification of the present model that is worthy of consideration is its extension to a two-country world in which events in the home country have a measurable effect events in the foreign country. This modification would also require alteration of some of the formal results of the present paper. It would permit analysis of issues relating to the dynamic interaction between large economies.[43]

A final direction for possible extension of the present paper is to examine the microeconomic foundations of the economic relationships that are employed in the present model. This direction has been taken in several recent papers that have explored the implications for exchange rate theory of different specification of the microeconomic foundations of the demand for money and of the demands for interest-bearing securities.[44] For these efforts to bear fruit, however, they must yield behavior functions whose implications for the behavior of exchange rates and other variables are at least broadly consistent with the observed empirical regularities.

Comment Jacob A. Frenkel

Recent years have witnessed significant advances in theoretical and empirical research on exchange rate determination. One of the important characteristics of the modern approach is that the exchange rate is being viewed as a financial variable that is determined in general equilibrium within the macroeconomic setting and, like many other financial variables, its current value is strongly influenced by expectations concerning future policies and events. Characteristically, Mussa's paper on the theory of exchange rate determination is comprehensive and perceptive. He starts with a brief outline of empirical regularities which have characterized the regime of flexible rates and presents an outline of the asset market view of exchange rate determination which is consistent with the empirical regularities. He then presents and evaluates various monetary models of exchange rate determination

43. A limited amount of work has been done on genuine multicountry models of exchange rates determination in recent years; see, for instance, Bhandari (1982) and Saidi (1982).

44. See, for example, Krugman (1980), Helpman (1981), Kareken and Wallace (1981), Leviatan (1981), Obstfeld (1981), and Helpman and Razin (1982).

and proceeds to develop the relationship between balance of payments equilibrium and the exchange rate as well as the interaction between real and monetary factors in effecting the equilibrium exchange rate. The paper concludes with an analysis of sticky prices and disequilibrium dynamics.

My remarks will touch on several points in the paper and then will raise some unresolved issues. But in order to appreciate the extent of development in the theory of exchange rates, I should like to note questions that are not central to the paper and which probably would have been key questions in the early 1970s. For example, we do not expect any more flexible exchange rates to eliminate current account imbalances and we do not wonder why changes in exchange rates have not done so. Likewise, we no longer expect a unique relationship between exchange rates (nominal or real) and the current account since it is now obvious (as it should have been since the development of the absorption approach) that the effect of changes in relative prices on the current account depends on the effects of these changes on income as well as on spending, and that without additional assumptions and information on the source of the change in relative prices, on the composition of spending, on the perceived permanence of the change in prices, and the like, there can be no general presumption concerning the overall effect on the excess of income over spending.

The Monetary Models

Mussa discusses two classes of monetary models. The first, which was used in the early developments of the monetary approach to the exchange rate and has been applied to many empirical studies, expresses the exchange rate in terms of the supplies of domestic and foreign nominal balances and the demands for domestic and foreign real balances. Mussa notes correctly that the validity of the monetary approach does not depend on the assumption of purchasing power parity since the model can allow for divergences from parity. However, in empirical research allowances for divergences from parities and for a slow adjustment in the money market need to be introduced with great care. For example, one may not introduce these considerations into the final exchange rate equation by adding a lagged dependent variable. They need to be incorporated directly into the equations that summarize the more fundamental relationships (like the money markets, etc.). This procedure implies that the properties of the error term in the exchange rate equation may not be specified arbitrarily without reference to the properties of the error terms in the underlying relationships.

Mussa believes that the two major difficulties with the simple monetary models are (1) they have not performed well in explaining movements in nominal exchange rates and (2) they do not reveal explicitly the critical role of expectations. While I agree with both of these points, I believe they should be placed in the proper perspective. First, the poor performance in explaining short-term exchange rate movements is not specific to the monetary model of exchange rate determination. Rather, it has been a characteristic of virtually all simple structural models including the various varieties of the monetary models, the portfolio balance models, the current account models, and others. The key reason for the poor performance of the various models is the intrinsic characteristics of exchange rates as asset prices. As Mussa emphasizes, exchange rates are very sensitive to expectations concerning future events and policies. Periods that are dominated by rumors, announcements, and "news" which alter expectations are likely to induce a relatively large degree of exchange rate volatility. Since by definition "news" cannot be predicted on the basis of past information, it follows that by and large the resulting fluctuations of exchange rates are unpredictable. In a way, this asset market perspective suggests that we should not expect to be able to forecast exchange rate changes accurately with the aid of the simple structural models. The role of the simple structural models is to account for the systematic component of the evolution of exchange rates. Second, while there is no doubt that expectations should be central in modeling exchange rate behavior, it is relevant to note that the monetary models (as well as many other models) have incorporated forward-looking variables, like the rates of interest and/or the forward exchange rate, among the determinants of the spot exchange rate. As such, these models do provide for channels through which expectations about the future influence current values. Mussa is justified, however, in noting that the specific link between expectations concerning the future and the current value of the exchange rate should be consistent with the general principles which govern the pricing formulas for durable assets that are traded in organized markets.

Mussa concludes his insightful discussion of the monetary models by pointing out two conceptual difficulties in exchange rate modeling. First, the assumption that in forming expectations about the future money supply individuals use primarily their knowledge of the stochastic process generating the money supply may be inadequate. Rather, Mussa indicates that in forming expectations about the future money supply, it is likely that individuals use diverse sources of information other than the easily measured variables and, specifically, other than the observed money supply series. The second difficulty is the lack of adequate measures of the exogenous factors affecting the demand and the supply, and of expectations concerning the future behavior of these factors. It should be emphasized, however, that these difficulties do not pertain only to the monetary models of exchange rates. Rather, they are sufficiently general to be applicable to practically all available models of exchange rate determination.

The Balance of Payments

Mussa's analysis of the relation between the balance of payments and the exchange rates contains a novel exposition of the fundamental equivalence between the "absorption" and "elasticity" approaches to the analysis of the trade balance. Mussa demonstrates how the current account of the balance of payments may have a "real" interpretation as a net flow of real goods and services and a "financial" interpretation as a net flow of financial assets. But, most important, he shows that even though the model may be rather complex, its reduced-form exchange rate equation looks formally the same as the reduced-form equation of much simpler models. Analytically, the key difference between the various reduced-form equations lies in the determinants of D^e—the variable measuring expectations.

One of the significant implications of Mussa's analysis is that one may not validly criticize or praise a model just on the basis of its formal reduced-form equation. This implication follows from the fact that the various models can be solved so as to yield almost indistinguishable reduced-form equations. It is pertinent to note, however, that even though the exact expression of the reduced-form equation may be based on analytical and expository convenience, the interpretation of empirical reduced-form estimates must reflect the details of the underlying structural model.

Modeling Disequilibrium

Mussa concludes his paper with an analysis of sticky prices and disequilibrium dynamics. Disequilibrium arises whenever the predetermined value of the price of domestic goods differs from its conditional equilibrium value. However, for Mussa "disequilibrium" *is not* a situation in which anything can happen, the basic laws of economics cease to apply, and handwaving replaces economic theory as the tools of analysis. Mussa's concept of disequilibrium is much more attractive. It imposes structure and discipline on the art of modeling. Thus, when there is disequilibrium in the market for domestic goods, it "is necessary to specify how this disequilibrium is accommodated by the agents that participate in the market for domestic goods and also to examine how the disequilibrium in this market affects conditions in other markets." This modeling strategy is commendable in that it forces into the open the key microeconomic reasons which underlie the macroeconomic manifestation of apparent disequilibria. Further, in the context of exchange rate analysis the disequilibrium modeling provides for the mechanism which eliminates gradually divergences from purchasing power parities.

Additional Issues in Exchange Rate Modeling

To the fundamental issues discussed in Mussa's paper, I would like to add three more issues that are critical for empirical research in the area of exchange rate determination and which raise some difficulties that have not yet been resolved. The first issue may be referred to as the "peso problem." This phrase originally characterized the situation with the Mexican peso, which was devalued during the third quarter of 1976. Since this devaluation had been expected for several years, the peso was traded at a forward discount in the market for foreign exchange. Obviously, as long as the devaluation did not occur, the forward exchange rate proved (ex post) to have been a biased forecast of the realized future spot exchange rate. But once the devaluation took place, it exceeded the prediction that was implied by the forward discount on the peso.

Generally, the peso problem may be viewed as a situation in which there are many observations but only few events. In Mexico's case, there were many days (observations) during which the forward discount prevailed and yet only one event—the devaluation itself. These circumstances raise conceptual and practical difficulties for studies which attempt to examine the efficiency of foreign exchange markets and the bias of forecasts of future spot rates based on lagged forward rates. Likewise in such circumstances it is not clear whether a rise in the number of observations in any sample which is being brought about by a larger frequency of measurements should be treated as a corresponding increase in the number of effective degrees of freedom. In a way the peso problem could be cast in terms of a small-samples problem which has much wider application. However, because the foreign exchange market is strongly influenced by expectations of future events and of future policies, and because current expectations of future change in policies (like a devaluation or a specific change in intervention policies) are based on probabilistic evaluations, it seems that the peso problem is especially relevant in the foreign exchange market.

The second issue relates to the role of innovations. The anticipatory role of exchange rates suggests that empirical research of exchange rate determination should relate changes in exchange rates to the *innovations* in the relevant regressors. Because the innovations are intrinsically unobservable, any empirical analysis involves the *joint* examination of the model as well as the measurement of the innovation (i.e., the measurement of the expected values which are used in the construction of the innovations). Since there is no practical way to avoid the joint-hypotheses problem completely, it seems that inference from empirical estimates should be made with great care.

A third difficulty also relates to the anticipatory nature of exchange rates and the prompt response of asset prices to new information. It concerns the implications of different frequencies of data collection for various time series. For example, data on exchange and interest rates are available in a much greater frequency than data on national income or on the current account. These different frequencies of data availability are reflected in different patterns of revisions of expectations and may have a systematic effect on the time series characteristics of the innovations of the various data.

These issues and others—like the treatment and identification of risk premia, the proper definition of money, the specification of the demand for money in an open economy, the relative degree of substitution among various assets, and the role of portfolio balance in affecting exchange rates—remain at this point unresolved problems in exchange rate analysis.

Comment Rudiger Dornbusch

Mussa's paper offers a definitive, comprehensive view of the asset market model of exchange rate determination. It is a restatement of the developments in exchange rate economics of the 1970s to which Mussa himself has been an important contributor. The task of his paper is to be integrative, not a border raid into the unknown or a broad questioning of received wisdom. As Mussa states the objective of his enquiry, "it assists in explaining why expected changes in exchange rates should generally be small and why actual exchange rate changes should be dominated by the random, unexpected component of exchange rate changes."

Mussa's paper gives us an excellent statement of established principles but unfortunately is not much help in explaining the large persistent real exchange rate movements that are at the center of policy debate. Nor does it offer any advice on exchange rate policy.

Real Interest Rates and the Real Exchange Rate

While the basic model that Mussa develops is familiar there are also new ideas well worth stressing. One of these is the definition of the real interest rate appropriate to an open economy macroeconomic model. Mussa notes that the relevant real interest rate, from consumers' point of view, is the nominal rate adjusted by the rate of inflation of the consumer price index. With $\dot{p}$ and $(\dot{e} + \dot{p}^*)$ the rates of inflation in home currency of domestic and imported goods, the real rate of interest then becomes

$$(1) \qquad \begin{aligned} r &\equiv i - a\dot{p} - (1 - a)(\dot{e} + \dot{p}^*) \\ &\equiv i - \dot{p} + (1 - a)(\dot{p} - \dot{e} - \dot{p}^*), \end{aligned}$$

where a is the consumption share of domestic goods. But the equation can also be written in terms of the rate of producer price inflation, $\dot{p}$, and the rate of change of the terms of trade.

Thus there is a link between real interest rates and the rate of change of the real exchange rate. Mussa rightly notes that terms of trade effects on real interest rates are an important part of the trade balance adjustment process. This point emerges particularly when structural change over time affects both incomes and relative prices. Permanent income or life-cycle consumption patterns would lead us to predict that changes in full employment output would lead to increased *current* consumption, whatever the timing of the income growth. But the timing is important for the structure of relative prices over time and thus for real interest rates and consumption. A transitory increase in output today would tend to deteriorate today's terms of trade and thus increase real interest rates, other things equal. The same output change occurring tomorrow would imply a fall in the real interest rate. In bringing these real interest rate effects into an exchange rate and macroeconomic setting, Mussa raises an important issue for further modeling of intertemporal exchange rate models. There is a parallel effort underway in barter models of trade that already offers interesting results.[1]

The Real Exchange Rate Problem

The accompanying figure 1.C.1 shows the real exchange rate for the United States dollar as measured by the value-added deflator in manufacturing. The extraordinary fact, of course, is that the fluctuations of the dollar in real terms have been so large. From 1979 to 1982 there has been a real appreciation in excess of 25% and in 1982 the real dollar was more than 10% above its average for the 1971–81 period. Now the striking fact is that these real exchange rate changes are presumably the by-product of asset market disturbances—tight money and expectations about the course of money and fiscal policy—not changes in full employment equilibrium real exchange rates. The magnitude of rate movements suggests that there may be a real exchange rate "problem" that calls for policy intervention. The trouble is that we would need models that identify the source of the real exchange rate change before we could confidently predict the cure. Asserting that exchange rates are too flexible—along with asset prices, and unlike goods prices and wages—is merely a guess, though probably a correct one.

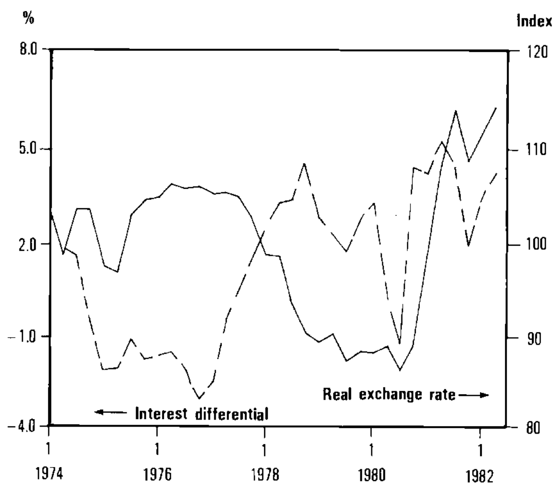

Fig. 1.C.1

1. See Svensson and Razin (1983) and Dornbusch (1983).

The discomfort goes further. As the figure shows, there has been over the last year an interest differential favoring the United States. Theory would predict that a tightening of money in the United States would raise United States interest rates (in the short run), lead to an appreciation of the spot exchange rate, with overshooting, but would then be followed by a rate of depreciation matching the interest differential. But the dollar has not been depreciating. On the contrary, there has been surprising stability in the face of what is broadly considered overvaluation. Mussa's paper is not at all inconsistent with such observations. After all it is spelled out in sufficient generality so that the right expectations can generate any path of nominal and real exchange rates. But the challenge of the evidence is to develop a more specific hypothesis about how markets are working and how overvaluation can be sustained.

Traps and Trips

One direction that I find particularly fruitful is suggested by Blanchard (1979) in his discussion of asset market bubbles. Blanchard notes that risk-averse speculators are willing to hold an asset known to be overvalued provided the expected losses associated with a collapse to fundamentals are offset by sufficient anticipated appreciation. Let e_t and $\bar{e}_t$ be the actual rate and the fundamental rate and x the probability of the fundamental rate prevailing in the next period. Then the arbitrage relation is

$$e_{t+1} - e_t = \frac{i - i^*}{i - x} - \frac{x}{1 - x}(\bar{e}_{t+1} - \bar{e}_t) + \frac{x}{1 - x}(e_t - \bar{e}_t). \tag{2}$$

Suppose the fundamentals rate is constant and equal to $\bar{e}$. Then (2) shows that the home currency could be *appreciating* despite the fact that it is overvalued. In fact it is precisely because it is overvalued that it must, with a sufficient probability, be expected to appreciate further so that asset holders would be willing to carry the hot potato. This type of equilibrium is a very uncomfortable one because it implies that for some period real asset prices can be carried far away from the equilibrium levels appropriate in the goods markets. Speculation in asset markets prevails over fundamentals until some random event carries prices back to fundamentals. Note that (2) implies the possibility of a speculative trap. With an interest differential in favor of the home currency there is overvaluation that is larger the larger the interest differential and the smaller the risk of a collapse to fundamentals.

Models of exchange rate dynamics in the 1970s have stressed rational expectations and the perfect working of markets, mitigated by differential periods of adjustment of asset and goods prices. A new strand of ideas from finance theory now suggests that claims for asset market efficiency may be overrated. Shiller (1981), for example, argues that asset prices are more volatile than is warranted by the underlying fundamentals variability. In the same vein, it is shown that for particular structures of expectational errors it is in practice impossible to tell whether errors are persistent or white noise. Suppose, for example, a simple monetary model,

(3) $$m_t - e_t = -a(\tilde{e}_{t+1} - e_t),$$

and a money supply process,

(4) $$m_{t+1} = \rho m_t + u_t,$$

where $\tilde{e}_{t+1}$ is the current expectation of the exchange rate next period and u_t is a white noise process. Under rational expectations the solution for the exchange rate is given by

(5) $$e_t = xm_t;\ x \equiv 1/[1 + a(1 - \rho)].$$

But suppose instead that the public entertained the wrong exchange rate model, specifically,

(6) $$\tilde{e}_{t+1} = xm_{t+1} + ve_t;\ v \geq 0.$$

Thus an irrelevant variable, e_t, is introduced into the forecasts. If (6) is the expectations model, the equilibrium exchange rate is

(5′) $$e_t = \frac{(1 + a)x}{1 + a(1 - v)}m_t.$$

It is readily verified that forecast errors $e_{t+1} \equiv e_{t+1} - \tilde{e}_{t+1}$ now are serially correlated:

(7) $$e_{t+1} = \rho e_t + \frac{(1 + a)x}{1 + a(1 - v)}u_t.$$

But note the capital point. If there is very little autocorrelation in money, so that ρ is close to zero, then autocorrelation in forecast errors will not be easy to detect. In fact with conventional samples the hypothesis of white noise cannot be rejected and thus economic agents will not uncover that they use the wrong model and make systematic errors. But these errors are of consequence. One of the implications, for instance, is excess variance in the actual exchange rate. The example here is simplistic, of course, but it suggests that modeling exchange rate models including plausible, irrelevant variables may well be an avenue toward explaining two facts: one, the large movements of exchange rates seemingly unrelated to fundamentals, and, two, the failure of any particular structural model to account for the experience of the 1970s.

Comment Pentti J. K. Kouri

With hindsight I have come to feel that there was an unnecessary overshooting in exchange rate theory in the past ten years. This is particularly true of the extreme form of the monetary approach. As a partial equilibrium theory, the "old textbook model" of exchange rate determination, as formulated by Tsiang in particular, gave a basically correct description of the way the foreign exchange market works. It also identified most of the key variables that explain exchange rate fluctuations. Although the exchange rate is a relative price of the monies by definition, it is vacuous to say that "the exchange rate is determined by the relative supplies of and demands for the two monies."

Demand for foreign currency in the foreign exchange market is demand to *spend* foreign money on foreign goods and services, not to hold it over any extended period of time. As an empirical fact individuals and firms do not hold significant transactions balances in foreign currencies. Only commercial banks need to hold small working balances in their capacity as market makers. In advanced countries virtually no domestic transactions are paid for in foreign currency. What we have is a world of *national monies*. As McKinnon has emphasized, the key function of foreign exchange markets is to make each national money international money as well. If foreign exchange markets are efficiently organized, a system of convertible national monies can achieve many of the benefits of a truly global monetary system based on one world money, while still retaining national sovereignty over the creation of money. One may question whether an international rather than a global monetary system is desirable or even viable in the long run, but it certainly is a correct description of the past as well as of the present. For the future, one key factor in determining the viability of any system is bank regulation. If financial institutions were allowed to create a global means of payments, modern information and communications technology would certainly make it possible. We could have a world of global monies cutting across national boundaries.

But we do not have such a system yet. As we trade between different countries we have to go through the foreign exchange market, and therefore all payment flows between countries that belong to different currency areas are registered as supplies and demands in the foreign exchange market. Accordingly, it is both natural and correct to think of equilibrium in the foreign exchange market as a balance between such payment flows.

Now, if there are no capital movements because of government regulation, for example, and if we abstract from small changes in working balances, equilibrium in the foreign exchange market obtains when the trade balance is zero. This gives us the Bicherdicke-Robinson-Machlup supply-demand model. There is nothing wrong with it as far as it goes. However, the simple textbook model fails to explain the foreign exchange market because it does not incorporate speculation and capital movements. Once these features are brought in, the foreign exchange market begins to look like all speculative markets, responding immediately to all new information about the fundamentals. In his classic article, Milton Friedman argued that speculators would stabilize the exchange rate against reversible changes in supply and demand. This argument was simple and persuasive: speculators can make money and therefore survive only if they on average buy foreign exchange when the price is low and sell it when the price is high. Therefore, speculative activity must be stabilizing.

Friedman's paper prompted several authors, among them Baumol and Kemp, to come forward with counterexamples of destabilizing *and* profitable speculation. Baumol provided an example in which speculators sold after the exchange rate peaked and bought after it bottomed out. He was able to show, in the context of a simple dynamic model, that speculators who followed such a trading rule could still make money and, for certain parameter values, increase the amplitude of exchange rate fluctuations or even make the fluctuations explosive. Kemp provided another example in which there were multiple equilibria and demonstrated that speculators could push the market from one equilibrium to another and yet make money. The problem with these counterexamples is that they rely on ad hoc specifications of trading rules and do not allow for forward-looking behavior on the part of speculators. It was only later that Stanley Black (1973) introduced Muth's notion of rational expectations in the foreign exchange market and brought the analysis of speculation on a firmer analytical ground.

If the critics of Friedman were too eager to construct ad hoc counterexamples, the advocates of flexible exchange rates were too ready to conclude that the exchange rate would be quite stable under flexible exchange rates. The following quote from Machlup is typical of the views held by early advocates of flexible exchange rates: "Under a system of greater flexibility such serious disalignments of exchange rates would never, or hardly ever, arise, ... Profits from small changes can be only small, inviting only moderate speculation, which can be easily discouraged, if this is wanted, by relatively minor differentials in interest rates." Against these prior expectations, the volatility of exchange rates in recent years appeared to be a surprise. It has suggested to some that speculation may indeed be destabilizing. There is, however, an important point that was missed in the early discussion: the distinction between ex ante changes and ex post changes. Speculation can stabilize the exchange rate only in the ex ante sense that it eliminates all predictable future changes in the exchange rate in excess of differences in domestic and foreign interest rates. But it does not stabilize the exchange rate ex post when the market is subject to a steady flow of new information or surprises.

A parallel development in the literature of the 1950s and 1960s was the work on the theory of spot and forward markets. In a remarkable paper, S. C. Tsiang (1959) developed a "systematic reformulation of the theory of forward exchange." As Tsiang notes, previous work (e.g., by Keynes) on the forward market had been mostly concerned with covered interest arbitrage and the interest rate parity equation. Although the role of speculation and trade hedging had been recognized, no systematic theory existed which would explain "precisely how the interplay of all these different types of operation jointly determine the forward exchange rate and how the forward exchange market is linked to the spot exchange market." This is exactly what Tsiang's paper does exhaustively, leaving few relevant issues untouched. Stanley Black's important contribution in 1973 provided the finishing touches to a fully worked out model of the foreign exchange market, quite adequate to explain the behavior of exchange rates since then in terms of fundamentals and the intrinsic dynamics of the market. The partial equilibrium model did not imply PPP, nor did it rule out the possibility of exchange rate instability in an unstable environment. The literature of the past ten years largely neglected this earlier work on the foreign exchange market, in part because it followed the wave of the monetary approach in balance of payments theory.

The Chicago monetarist approach, represented by Jacob Frenkel and Michael Mussa, went furthest in throwing away the balance of payments framework. With the assumption of PPP, perfect capital mobility and instantaneous price flexibility import and export schedules or preferences between domestic and foreign assets no longer played a role in explaining exchange rate fluctuations. In effect, the monetarist model is not really a model of exchange rate determination. Rather it was a Cagan-Sargent-Wallace model of price level determination, in which exchange rates were determined simply as ratios of price levels. The monetarist model has failed so clearly as an empirically relevant theory that I need not discuss it further.

My own work on exchange rate theory in 1974 grew out of my work on capital movements with Michael Porter and Victor Argy at the International Monetary Fund. It occurred to me that the Kouri-Porter model would become a model of exchange rate determination if the stock of net foreign assets were exogenous and the exchange rate became endogenous with the domestic interest rate instead. Indeed the model could represent any exchange rate system—for example, Williamson's crawling peg—with appropriate specification of central bank behavior in the foreign exchange and domestic bond markets. Converting the KP model into a model of short-run exchange rate determination was straightforward, but it was not enough. It was necessary to explain the evolution of the exchange rate and asset stocks over time and also the dynamics of expectations formation.

To address these issues I started with an extremely simple model, far too simple if it is not confined to its narrow purpose. I assumed a small open economy producing only traded goods, so that the trade account could be explained simply as a difference between domestic output and absorption. Domestic price level would be determined by world prices and the exchange rate; domestic wage rate could be fixed or flexible. On the asset side, I stripped the KP model to its bare essentials, assuming that there are only two assets: domestic money and foreign money. The allocation of wealth between these two assets would depend on the expected rate of change of the exchange rate. This is the channel through which speculation entered exchange rate determination. I assumed that foreigners do not hold domestic money. With these elements, the short-run model was complete: given the stock of foreign assets and domestic money, the exchange rate would adjust in such a way that existing stocks would be willingly held. If domestic residents wanted to get out of domestic money into foreign money, they could not collectively do so—they would only drive up the price of foreign money. The only way for the stock of foreign assets to change in my model was through current account surpluses or deficits. Depreciation of the domestic currency would reduce domestic absorption and produce a current account surplus: this is the mechanism through which the desired capital transfer is effected over time.

This simple model suggested looking at exchange rate determination and balance of payments adjustment from the viewpoint of Tobin's q theory. The stock of foreign assets is like a stock of houses: it can change only slowly through investment (current account surplus) or disinvestment (deficit). But its valuation—exchange rate—can change immediately. In the same way that an increase in q stimulates capital formation, currency depreciation stimulates accumulation of foreign capital. Domestic currency is undervalued relative to its long-run equilibrium level when the stock of foreign asset is below its long-run equilibrium level and overvalued when the stock of foreign assets is above its equilibrium level.

In Kouri (1976), I developed this idea in a model that was too simple; other chapters of my dissertation introduce variations in the real exchange rate as well as in the real interest rate. The latter model is published in the Bigman-Taya volume (Kouri, 1980). I continue to think that the capital transfer perspective is a fruitful way to look at exchange rate behavior and balance of payments adjustment. It is rich enough to incorporate all relevant factors in a single unified framework. From the point of view of this model, the recent appreciation and continued strength of the dollar can be explained in terms of foreigners' desire to increase their holdings of United States assets, in part because of high real rates of return and in part for other reasons such as shifts in long-term confidence in the United States vis-à-vis Europe. Marketable world wealth can be counted in trillions of dollars; even a small shift in asset preferences can lead to a capital transfer that is very large relative to what can be effected through the current account. In the

1970s, for example, the United States current account deficit never exceeded \$15 billion. Even the *flow* of savings in the world, at close to \$2,000 billion for the OECD countries in 1982, is enormous relative to the feasible range of current account surpluses or deficits.

The capital transfer problem has been one of the themes in my work with Jorge de Macedo. In our joint paper (1978) we analyze the implications of differences in asset and consumption preferences. We also try to find microeconomic foundations for differences in asset preferences, linking them with differences in consumption preferences. Jorge has continued this work in his own subsequent research.

The second concern that I had in my early work was the modeling of expectations. In Kouri (1976) I considered alternative mechanisms of expectations formations, including perfect foresight or rational expectations. Introduction of perfect foresight in the portfolio balance model brought it closer and closer to the familiar capital models and their well-known problems of instability and indeterminacy. So much has been said and written about rational expectations that I need say no more.

In my early work I assumed price flexibility, not because I believed in it but in order to focus on the role of the exchange rate in balance of payments adjustment. I could just as well have assumed that the central bank pegs the domestic price level, leaving the exchange rate to be determined by supply and demand in the foreign exchange market (cf. Kouri 1983). In that paper I develop a dynamic partial equilibrium model of the foreign exchange market that does not restrict the macroeconomic framework. That paper focuses entirely on the process through which the foreign exchange market adjusts to new stationary equilibrium following disturbances in the trade account or in the capital account, assuming exogenously given interest rates, activity levels, and prices. In more recent work I have gone further in modeling the workings of the foreign exchange market with careful specifications of the behavior of various actors in the market, following the lead of Tsiang, 1959 (see my paper "Intertemporal Balance of Payments Equilibrium and Exchange Rate Determination," unpublished manuscript). I believe there is a great deal more to be done along these lines toward a more detailed understanding of the workings of the foreign exchange market.

This brings me to another point. In a world of instantaneous market clearing, there is very little difference between alternative exchange rate regimes—putting aside well-known monetary nonneutralities and asymmetries that may arise because of capital market imperfections. Behavior of relative prices, for example, would be identical in different exchange rate systems, as we know from the work of Lucas and Stockman. But clearly the system of flexible exchange rates is an entirely different system of collecting and disseminating information and coordinating economic activity. As an example, suppose that we have two economies producing differentiated consumer goods with monopolistically competitive market structures.

With a fixed exchange rate, the structure of relative prices would exhibit inertia, and prices would be preset on the basis of wage costs and conjectural demand schedules. If, in contrast, we had a flexible exchange rate between the two currencies, the exchange rate would be determined in a speculative auction market, while domestic currency prices would continue to be set in Hicksian "fix price" markets. Accordingly, relative prices would exhibit more variability under flexible than under fixed exchange rates, and the properties of the two systems in terms of resource allocation, information utilization, and risk sharing would be quite different.

Dornbusch's 1976 paper illuminates with a standard IS-LM model how differences in the mechanisms of market clearing can explain the overshooting of the exchange rate to monetary disturbances. Clearly, there is a great deal more to be done in this area. The optimum currency area literature is basically concerned with the same question from a normative point of view. I suspect that we have to abandon simple rational expectations concepts as we address these questions and recognize diversity of views, and imperfect information which does not permit knowledge of the model or of the expectations of others. We must analyze how alternative market arrangements utilize information, transmit it between individuals, and in the process help them to form a more coherent view of their environment. In saying this I am obviously indebted to my colleague Roman Frydman. Finally, I would also add that we have more or less exhausted the implications of the portfolio balance model. We need to move on from postulated asset demand and supply functions to a more careful consideration of the structure of financial assets, and of other arrangements that facilitate exchange and mediate between borrowers and lenders. My contribution to the Hawkins-Levich-Wihlborg volume is a first step in this direction. The work of Lucas, Helpman, Razin, Svensson, Stockman, and others should also be mentioned in this context. Toward this end, much more empirical work needs to be done on the nature of financial intermediation between different countries.

In summary, work on exchange rates is not finished. We need much less advocacy of simple-minded notions and much more painstaking, time-consuming work. I expect that such work will ultimately turn us against the current system of flexible exchange rates in favor of a more orderly monetary system.

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