#101

The Process of Exchange-Rate Determination: A Survey of Popular Views and Recent Models

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Revised: September 1977

Forthcoming as Princeton Study in International Finance No. 42, May 1978

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENT

The views expressed in this study are my own and have not been endorsed by the Board of Governors of the Federal Reserve System. I am particularly grateful to my colleagues Dale W. Henderson and Jeffrey R. Shafer for sharpening my focus on numerous issues. I am also indebted to Polly R. Allen, Betty C. Daniel, Rudiger Dornbusch, Allen B. Frankel, Lance W. Girton, George B. Henry, Peter Hooper, Peter B. Kenen, Steven W. Kohlhagen, Val Koromzay, Ralph W. Smith, Edwin M. Truman and John Williamson for valuable comments on earlier drafts. In addition, my thanks extend to Henry C. Wallich for originally encouraging me to undertake this study. None of the above should be blamed for its shortcomings or assumed to agree entirely with its contents.

1. INTRODUCTION

The purpose of this study is to evaluate the various viewpoints within the economics profession regarding the processes that determine exchange rates between currencies. Although much of the study focusses jointly on spot and forward exchange rates, the term "exchange rate", when unmodified, should be interpreted to refer to spot rates and not necessarily to forward rates.

It is uniformly agreed that exchange rates should be viewed as market-clearing prices that fluctuate (under a flexible-exchange-rate regime) to equilibrate demands and supplies in foreign-exchange markets. It is also agreed that foreign-exchange markets are only one part of a complex world economy of interrelated markets, that exchange rates are determined in a process which simultaneously determines many other variables in the world economy, and that it accordingly is not feasible to model the process of exchange-rate determination without making major simplifications. Different views of the process of exchange-rate determination reflect different simplifying assumptions and should be judged by considering the appropriateness of the underlying simplifications, in terms of both theoretical implications and predictive accuracy. The appropriateness of different simplifications depends on the time horizon over which one is interested in predicting exchange-rate changes, and can change with the evolution of the international economy.

This study is concerned with the appropriateness of alternative theories for explaining short-run movements of exchange rates in today's world. Much of the survey focusses on the recent development of financial-equilibrium models. Before these recent models are discussed, however, Chapter 2 analyzes four popular and older views of exchange-rate determination:

(2.1) purchasing-power-parity theory; (2.2) a popular balance-of-payments view; (2.3) forward-exchange theory; and (2.4) the speculative-run view. Each of the first three of these views is shown to be inadequate by itself, on both theoretical and empirical grounds, as an explanation of exchange-rate behavior in the short-run. This does not deny the usefulness of these views in other contexts. Purchasing-power parity is rejected as a short-run hypothesis, but it may have considerable validity over periods of time sufficiently long for ratios of national price indexes to change radically. The popular balance-of-payments view and forward-exchange theory are inadequate in the different sense of being incomplete theories. When embedded in appropriate larger models, each of these views contributes to understanding the short-run behavior of exchange rates. The speculative-run view derives some support from both empirical tests and anecdotal evidence, but proponents of this view have not yet provided an adequate model for predicting exchange rates from historical data.

Chapter 3 turns to the analytic insights provided by open-economy models with financial markets. Sections 3.1 and 3.2 discuss the historical background and basic structure of these models. Section 3.3 then summarizes the basic insights that a streamlined model provides about the short-run impacts of unanticipated open-market monetary policies and exchange-market interventions. As is shown in the appendix to Chapter 3, the impact of such policies on exchange rates depends on (i) the degree of substitutability between assets denominated in domestic and foreign currencies, (ii) the extent to which changes in observed exchange rates lead to revisions in expectations about future exchange rates, and (iii) the extent to which financial portfolios are diversified between assets denominated in domestic and foreign currencies. Section 3.4 argues that extensions of the streamlined model do not substantially alter

the basic insights about how exchange rates respond to central-bank policies. Section 3.5 discusses the limited analysis that exists on the sensitivity of exchange-rate movements to anticipations of the policy changes or other exogenous events that generate them. Section 3.6 briefly considers the relevance of long-run neutrality results.

Section 3.7 shifts to the analysis of fiscal policies. Many models of financial equilibrium are unsuitable for analyzing the effects of policy-induced shifts in wealth, and analysis of fiscal policy has suffered from this deficiency. A balance-budget fiscal expansion is conventionally viewed to induce a once-and-for-all exchange-rate appreciation, but induced shifts in the current account also have wealth effects that put opposite and continuing pressure on the exchange rate. Thus, there is a presumption that a balanced-budget fiscal expansion will cause the exchange rate to depreciate in the long run. And this presumption is even stronger for a fiscal expansion financed by increasing the supply of debt denominated in home-currency units.

The desire to distinguish formally between the short-run and long-run effects of policy changes has generated several models of exchange-rate dynamics. Section 3.8 discusses a few of these models. Section 3.9 then turns to the analysis of exchange-rate volatility and overshooting. It is argued that much of the volatility of observed (and expected) exchange rates is not explained by the type of overshooting that arises in the dynamic models discussed in Section 3.8, but may rather reflect the influence of discrete (even if small) revisions in expectations about the future time paths of money supplies and other policy variables.

Chapter 4 describes selected empirical applications of open-economy models with financial markets. Section 4.1 discusses examples of the monetary approach,

and section 4.2 considers multiple-equation models. Chapter 5 concludes the study with a discussion of important challenges for research.

2. POPULAR VIEWS OF EXCHANGE-RATE DETERMINATION

2.1. Purchasing-power-parity theory

The term "purchasing-power parity" (PPP) originated with Cassel (1918), who is generally credited for first formulating PPP as an empirically-testable hypothesis. Myhrmann (1976) notes, however, that PPP played a key role in the monetary view of exchange-rate determination, both during the Bullionist Controversy in early 19th-century England and during earlier debates in mid-18th-century Sweden. And Einzig (1970, pp. 145-6) traces PPP theory as far back as Spanish writers in the 16th and 17th centuries. (See Officer, 1976a, for a recent review article on PPP theory.)

PPP theory has many variants, but this study only considers those popular variants that view exchange rates as being held strictly in line with relative price indexes.[1/] The absolute PPP hypothesis states that the exchange rate between the currencies of any pair of countries should equal the ratio of the general price levels in the two countries. This is not a useful operational hypothesis, however, because price information is usually compiled in the form of price indexes rather than absolute price levels. Consequently, this study focusses on the "strict" relative PPP hypothesis, which states that the exchange rate between the currencies of any pair of countries should be a constant multiple of the ratio of general price indexes for the two countries, or equivalently, that percentage changes in the exchange rate should equal per-

1/ In contrast, Officer (1976a) applies the term PPP more broadly to all theories that include a relative-price index among the variables on which the exchange rate is assumed to depend.

centage changes in the ratio of price indexes. This proposition does not necessarily imply that relative-price movements cause exchange-rate fluctuations. Nor does it pretend to be a complete model of exchange-rate determination, since it does not explain the behavior of relative prices.

Several points must be clarified to put PPP into proper perspective. First, PPP is a theory about the equilibrium relationship between an exchange rate and some designated ratio of price indexes. Underlying this theory is the notion that any divergence of the exchange rate from the designated ratio of price indexes will set in motion corrective forces acting to restore equilibrium. Because these corrective forces may take time to restore equilibrium, however, the validity of PPP depends on the time horizon under consideration. Evidence of purchasing-power disparities that persist in the short run does not prove that PPP is invalid in the long run; and support for PPP based on data spanning a long time horizon does not deny the possibility of substantial purchasing-power disparities in the short-run.

Proponents of PPP hold vague and differing views about which particular ratio of price indexes should parallel the exchange rate. These views correspond to vague and differing notions about the forces that act to correct purchasing-power disparities. A monetarist school of thought, to which Cassel adhered, views the exchange rate to be held in line by general price indexes that summarize the prices of both tradable and nontradable goods and services: "People value currencies primarily for what they will buy and, in uncontrolled markets, tend to exchange them at rates that roughly express their relative purchasing powers (Yeager, 1958, p.516)." A second version of PPP views exchange rates to be held in line by cost-of-production indexes, arguing that competition and the international mobility of industry will prevent persistent purchasing-power disparities (see Hansen, 1944). A third version, not

inconsistent with the first two, focusses on commodity arbitrage through international trade as the mechanism that corrects purchasing-power disparities: "The proposition that general price levels in different countries are connected through the prices of internationally traded goods is the foundation of the purchasing-power parity doctrine (Haberler, 1975, p. 24, who is critical of PPP theory)." Implicit in this third version is the additional proposition that relative prices of tradables and nontradables remain fairly constant within countries.

A fourth version of PPP combines the propositions that: (i) the expected rate of change in the exchange rate between any two currencies is approximately equal (assuming approximate risk neutrality) to the difference between the nominal rates of interest on assets denominated in the two currencies; (ii) nominal rates of interest equal real rates of interest plus expected rates of domestic price inflation; and (iii) real rates of interest tend to equality across countries. Jointly, these three propositions argue that the expected rate of change in the exchange rate is approximately equal to the difference between expected rates of domestic price inflation; and this is further argued to suggest that observed rates of exchange-rate change approximate differences between observed rates of domestic price inflation. Equivalently, observed rates of exchange-rate change are viewed to approximate observed rates of change in ratios of domestic price indexes.

Each of these four views can be challenged. The fourth version is disputed by evidence that differences between nominal rates of interest have been highly-inaccurate predictors of actual exchange-rate movements in recent years--evidence that will be presented in section 2.3 below. Yeager's statement of the monetarist view must bow to the fact that transportation and other transactions costs in reality leave room for substantial purchasing-power disparities to occur before residents in any one country would find it economical to exchange an "overvalued" local currency for currencies

to use in purchasing goods and services abroad. Similarly, advocates of the cost-parity view must recognize that high information and relocation costs weaken the equilibrating forces sufficiently to permit substantial purchasing-power disparities.

The third version of PPP, which postulates commodity arbitrage combined with constant relative prices of tradables and nontradables, has been attacked on both counts. Cassel himself recognized that real changes in an economy are likely to alter the relative prices of tradables and nontradables, while Isard (1977) has attacked the practical relevance of commodity arbitrage with empirical evidence that disputes the "law of one price" at the most-disaggregated level of product classification for which available price data can be readily matched across countries. Isard's evidence shows that, at this level of commodity detail, tradable goods manufactured by different countries behave like differentiated products that systematically exhibit large changes in their relative common-currency prices. Moreover, large relative-price disparities at this level of commodity detail can persist for at least several years. Thus, aggregate price indexes constructed from available data on tradable-goods prices are also likely to be such that the ratio of price indexes for any pair of countries diverges substantially from the corresponding exchange rate for periods of at least several years. (See Dornbusch and Krugman, 1976, for additional support of this proposition.)

These criticisms substantially weaken the theoretical bases of PPP. Nevertheless, it is appropriate to examine how well PPP stands up as an empirical proposition. The most-carefully constructed price indexes available for PPP comparisons are those of Kravis et al. (1975) and Gilbert and Kravis (1954). Table 1 compares exchange rates with relative-price indexes (ratios of gross product deflators) available from these sources. Although this sample of data is small, it suggests that ratios of exchange

TABLE 1

PURCHASING-POWER-PARITY COMPARISONS

Country[b/]	Ratio of Exchange Rate to Relative Price Index[c/]	Percentage Change From Previous Period[d/]
France		
1950	.75	
1970	.81	8%
Germany		
1950	.72	
1970	.87	19%
Italy		
1950	.70	
1970	.74	6%
Japan		
1967	.66	
1970	.68	3%
United Kingdom		
1950	.70	
1967	.83	17%
1970	.72	-14%

a/ Sources are: Kravis et al. (1975), Tables 1.5, 1.6, 13.17 and 13.19; and Gilbert and Kravis (1954), Table 4.

b/ Paired with the United States.

c/ Relative-price indexes are ratios of gross domestic product deflators for 1967 and 1970, and ratios of gross national product deflators for 1950. Both exchange rates and relative-price indexes are expressed in U.S. dollars per currency unit of the partner country.

d/ Based on midpoints of the intervals of change.

rates to relative-price indexes do change noticeably over time.[2/]

Table 1 can also be used to illustrate the potential pitfalls of using PPP comparisons to make normative judgements about appropriate levels of exchange rates. Between 1950 and 1970 the dollar equivalent of Germany's price level increased by 19 per cent more than the U.S. price level. Yet who would have argued in 1970 that the mark was overvalued by 19 per cent, or that the mark should have been devalued by 5 per cent rather than revalued by 14 per cent during the 1950-70 period?

2/ Such changes over time seem consistent with cross-section evidence that ratios of gross-product deflators deviate from exchange rates in a manner correlated with the relative per-capita gross products of the countries under comparison. (See Balassa, 1964, or Kravis et al., 1975; but also see the challenge by Officer, 1976b.) The cross-section evidence is generally conjectured to reflect (i) rough equality between exchange rates and ratios of the tradable-goods components of gross-product deflators, combined with (ii) a tendency for prices of nontradables (e.g., services) to be lower, relative to prices of tradables, the less advanced is a country's stage of development, as indexed by per-capita gross product. Consistently, the ratios in Table 1 generally increase toward unity over time as the per-capita gross products of foreign countries rise relative to that of the United States.

It may be objected that the data in Table 1 reflect observations at only a few widely-speced points in time. Table 2 is based on a larger number of observations taken one year apart during the 1969-76 period, for each of six industrial countries paired with the United States. For each of the six countries, using both consumer and either industrial or wholesale price indexes, the table focusses on the foreign-country price index (P_f) converted at the prevailing exchange rate (X, in dollars per unit foreign currency) into a dollar-equivalent price index (P_fX), expressed as a proportion of the U.S. price index (P_{us}).

Tests of the validity of PPP amount to tests of how narrowly the purchasing-power exchange rate (P_fX/P_{us}) fluctuates about some long-run equilibrium level. Accordingly, Table 2 reports how observed values of purchasing-power exchange rates have fluctuated about their sample means. On the assumption that sample means (for the 8 selected time periods) are good estimates of any long-run equilibrium levels of purchasing-power exchange rates, the table entries can be interpreted as percentage deviations of observed exchange rates from estimated purchasing-power parity levels. Independently of this interpretation, however, Table 2 emphasizes that purchasing-power exchange rates have fluctuated widely in recent years, indicating substantial short-run variation in exchange rates relative to corresponding ratios of price indexes.

Such empirical evidence, piled on top of the theoretical weaknesses noted above, discredits PPP as a theory that can be relied upon to provide accurate predictions of exchange-rate behavior in the short run. Predictions confidently held about relative movements in national price levels over short time horizons (up to several years) cannot be translated into predictions confidently held about movements in corresponding exchange rates. This does not imply, however, that PPP has no predictive usefulness. Over periods of time long enough for ratios of national price indexes to change

TABLE 2

PERCENTAGE DEVIATIONS OF PURCHASING-POWER EXCHANGE RATES FROM THEIR MEANS, 1969-1976

		June 1969	June 1970	June 1971	June 1972	June 1973	June 1974	June 1975	June 1976
CANADA	CPI	-5.7	-4.4	-4.5	0.9	0.9	5.3	0.1	7.4
	IPI	-7.9	-7.6	-8.3	-2.1	6.7	11.5	0.9	6.7
FRANCE	CPI	-7.4	-16.1	-15.5	-4.4	14.2	-1.5	23.3	7.4
	IPI	not available		-14.6	-5.9	17.1	6.6	5.2	-8.5
GERMANY	CPI	-27.4	-21.8	-18.1	-7.2	16.2	19.7	25.9	12.7
	IPI	-26.9	-17.5	-13.8	-5.2	15.4	19.1	21.1	7.8
ITALY	CPI	-5.8	-6.9	-6.0	3.2	6.5	1.4	14.8	-7.1
	IPI	-10.1	-7.2	-7.1	-0.7	6.1	11.0	11.2	-3.2
JAPAN	CPI	-18.9	-18.8	-15.9	1.5	23.3	9.1	9.5	10.3
	IPI	-14.0	-14.7	-17.6	-5.8	15.5	22.3	8.4	6.0
UNITED KINGDOM	CPI	-8.8	-8.8	-2.7	6.6	10.3	0.5	10.9	-7.9
	IPI	-4.4	-2.9	2.6	10.1	10.2	-4.2	2.7	-14.1

Purchasing-power exchange rates are constructed as $P_f X / P_{us}$, where P_f and P_{us} respectively denote price indexes for the foreign (tabulated) country and the United States, and where denotes the exchange rate in dollars per unit foreign currency. Table entries represent percentage deviations of purchasing-power exchange rates from their means, which can be interpreted as percentage deviations of observed exchange rates from estimated purchasing-power-parity levels. Calculations are based on both consumer price indexes (CPI) and either industrial or wholesale price indexes (IPI), taken from International Financial Statistics. Exchange rates are taken from the Federal Reserve Bulletin.

radically, PPP may have considerable validity.[3/]

2.2 A popular balance-of-payments view

The notion that exchange rates move to equilibrate supplies of and demands for currencies, and hence to bring balance to international payments, goes back at least as far as the mid-1600s.[4/] As a general statement this view is uniformly accepted by economists today. Few economists, however, subscribe without qualification to the popular notion that increases in a country's trade or current-account deficit are likely to lead to exchange-rate depreciation.

This notion, here labeled the "popular balance-of-payments view", received nurishment during the Bretton Woods regime of adjustable pegs. During that regime, official permission or pressure to adjust exchange rates was predicated on the occurance of "fundamental disequilibrium", which for pratical purposes became associated with the occurance of persistant current-account imbalances. Thus, the Bretton Woods Agreement sanctioned, and thereby induced, a correlation between current-account imbalances and subsequent changes in exchange rates.

The popular balance-of-payments view can also be related to an invalid application of the elasticities approach to modelling the balance of payments. Typically, that approach takes the capital account to be predetermined, while treating both imports and exports as functions of the exchange rate and a list of other predetermined variables. Text-book versions of the elasticities model have generally been used to determine

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3/ During the German hyperinflation, for example, relative-price movements swamped all other influences on German exchange rates. See Frenkel (1976).

4/ Einzig (1970, pp. 142-3) credits the English economist Thomas Mun for persuading his contemporaries that exchange rates are influenced by trade balances.

the effect on the balance of payments of an exogenous change in the exchange rate, but an inverted form of the model can alternatively be used to analyze exchange-rate behavior in a floating-rate world. Such analysis suggests that an exogenous shift in the current account toward deficit, ceteris paribus, will normally[5/] lead to exchange-rate depreciation.

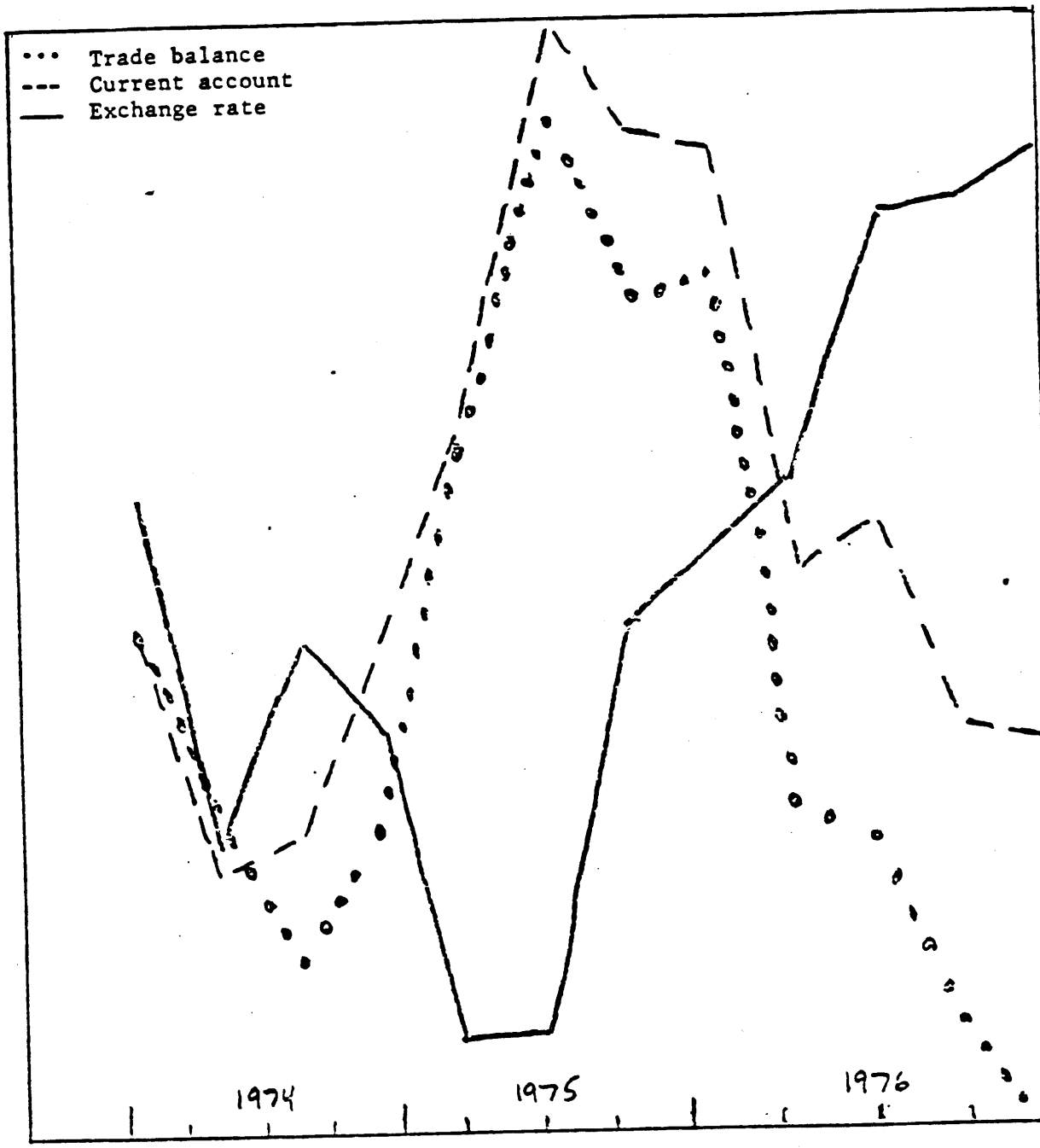
Deletion of the word "exogenous" and the ceteris paribus assumption distorts this conclusion into the popular balance-of-payments view. Figure 1 shows that this distorted view has not been supported by recent data for the United States. During the past several years, swings in the U.S. trade and current accounts have largely reflected cyclical fluctuations in the relative paces of economic activity in the United States and abroad. Other things were not equal as current accounts shifted. The sharp increase in the U. S. current-account balance between second-quarter 1974 and second-quarter 1975 was accompanied predominantly by dollar depreciation, and the decrease in the U.S. current-account balance from second-quarter 1975 through 1976 was accompanied by dollar appreciation.

Such evidence should not be interpreted to suggest that current-account balances have no systematic influence on exchange rates. The correct conclusion, rather, is that the relationship between current-account balances and exchange rates is more complicated than that suggested by the popular balance-of-payments view. In particular, the effect of current-account imbalances on exchange rates depends critically on aggregate supplies and demands in the markets for financial assets denominated in different currency units. This will be elaborated in Chapter 3.

5/ Here "normally" means under the stability conditions attributed to Marshall, Lerner, Bickerdike, Robinson and Metzler. See Haberler (1949) and Dornbusch (1975) for elaboration.

FIGURE 1

U.S TRADE BALANCE, CURRENT ACCOUNT AND EXCHANGE RATE, 1974-1976



Quarterly data, 1974 Q1 through 1976 Q4. Merchandise-trade and current-account balances are official Department-of-Commerce data. Exchange rates are daily averages, for the second month in each quarter, of the Federal Reserve Board's weighted-average value of the dollar in terms of the currencies of the G-10 countries plus Switzerland.

2.3 Forward exchange theory

Although rudiments appear in the 1890s (see Einzig, 1970, pp. 214-5), Keynes (e.g. 1923) is generally credited with the development of forward exchange theory, sometimes referred to as interest-rate-parity theory. Basically, this theory recognizes that asset holders have a choice between holding domestic-currency assets, which yield the own rate of interest r_d, or assets denominated in foreign currency, which yield the own rate of interest r_f. Thus, an investor with one unit of domestic currency at time 0 should compare the option of accumulating $1+r_d$ units with the option of converting spot into s units of foreign currency, investing this in foreign assets, and arranging at time 0 to convert back his principal plus interest at a forward exchange rate f (in foreign currency per unit of domestic currency) into $s(1+r_f)/f$ units of domestic currency for delivery at the end of the interest-payment period. To the extent that investors can accumulate either $(1+r_d)$ or $s(1+r_f)/f$ units of domestic currency with certainty,[6/] arbitragers in pursuit of assured profit will move funds in whatever amounts are required to eliminate any discrepancies between these interest factors. Thus, interest-rate parity is a condition of asset-market equilibrium:

$$(1+r_d) = s(1+r_f)/f$$

which implies

(1) $(f-s)/s = (1+r_f)/(1+r_d) - 1 = (r_f-r_d)/(1+r_d) \approx r_f-r_d$

In words, the percentage forward premium on domestic currency--i.e., the percent by which the forward price of domestic currency exceeds the spot price -- will equilibrate to the excess of the foreign interest rate over the

6/ This abstracts from political or confiscation risk and ignores both transactions costs and capital controls.

domestic interest rate, where interest rates are expressed in percent per period of time (or maturity) to which the forward rate applies.[7/]

Condition (1) was the central focus of much of the theoretical literature on exchange rates during the Bretton Woods era. This literature took the view that exchange-market participants include (i) commercial traders arranging either to obtain foreign currency to pay for imports or to convert foreign-currency receipts for exports into domestic currency, and (ii) pure risk-taking speculators, in addition to (iii) the interest arbitragers whose behavior maintained interest-rate parity. (See Tsiang, 1959 or Grubel, 1966.) Although the functional separation of exchange-market participants was strongly criticized (see Kenen, 1965), there emerged from this literature the notion that speculation in pursuit of profit would prevent large discrepancies between forward exchange rates and the spot rates that speculators expected to prevail on the dates on which forward contracts matured. This notion is based on the argument that speculators who could arrange forward to deliver (or obtain) f units of foreign currency at some future date, in exchange for one unit of domestic currency, would be tempted to do so if the spot rate that they expected to prevail on that future date (s^e, in foreign currency per unit domestic currency) offered them the chance to convert back into foreign currency (or domestic currency) with an expected profit $s^e - f > 0$ (or $1/s^e - 1/f > 0$). Thus

$$(2) \quad s^e \approx f$$

7/ This follows the convention of ignoring the approximation error, which is small for typical values of $1+r_d$ in the vicinity of 1.

was taken to describe a second property of exchange-market equilibrium; and together, conditions (1) and (2) imply

$$(3) \quad (s^e - s)/s \approx r_f - r_d$$

Conditions (1) - (3) can be viewed in several different ways. Condition (1) can be viewed as (i) an explanation of the spot rate, given interest rates and the forward rate, or (ii) an explanation of the forward rate, given interest rates and the spot rate, or (iii) an explanation of the interest differential, given spot and forward rates. Alternatively, as an important practical application of forward exchange theory, conditions (2) and (3) can be used to forecast the future. Condition (2) is the basis for using forward rates as forecasts of future spot rates, on the grounds that forward rates approximate prevailing market expectations about future spot rates. A similar argument, relating to condition (3), justifies the use of interest differentials as forecasts of rates of change in spot rates. It is important to emphasize, however, that such forecasts are based on forward exchange rates or interest rates that normally cannot be treated as exogenous. In other words, such forecasts are based on equilibrium relationships between endogenous variables, rather than a complete model in which each endogenous variable can be related to policy instruments or other exogenous variables.

Before assessing the accuracy of forecasts based on conditions (1)-(3), several points can be made about the validity of the assumptions underlying these conditions. Despite considerable confusion in some of the earlier literature on the interest-rate-parity condition, it is now an accepted tautology that any observed deviations from interest-rate parity either reflect the influence of capital controls, which alter the incentives or opportunities faced by interest arbitragers, or reflect the fact that empirical data on

interest rates do not refer to sufficiently-comparable foreign and domestic assets.[8/] It is also recognized that the expected future spot rate may be perceived differently by different exchange-market participants, and is in any case an unmeasurable concept.

The fact that the expected future spot rate is unmeasurable precludes direct tests of whether the forward rate accurately reflects the expected future spot rate. This does not, however, preclude empirical tests of whether the forward rate has been a good predictor of the subsequently-observed future spot rate. Such empirical tests have focussed on both the bias and the variance of the forward rate as a predictor of the future spot rate.

The issue of bias is associated with the notion of risk aversion. In a risk-neutral world, by definition, condition (2) would hold exactly in theory. And in practice, differences between forward rates and observed future spot rates would presumably average out to zero over time, thus characterizing the forward rate as an unbiased predictor of the future spot rate.

8/ See Aliber (1973) or Dooley (1976). Marston (1976) has found, for example, that forward exchange premia conform closely to Eurocurrency yield differentials; and Herring and Marston (1976, footnote 3) state, on the basis of a series of interviews, that Eurocurrency and forward-exchange traders in fact base their quotations on condition (1): "Foreign-exchange traders said that Eurocurrency rate differentials determined the forward rates that they quoted, while Eurocurrency traders said that forward exchange rates determined differentials between non-dollar Eurocurrency rates and the Eurodollar rate."

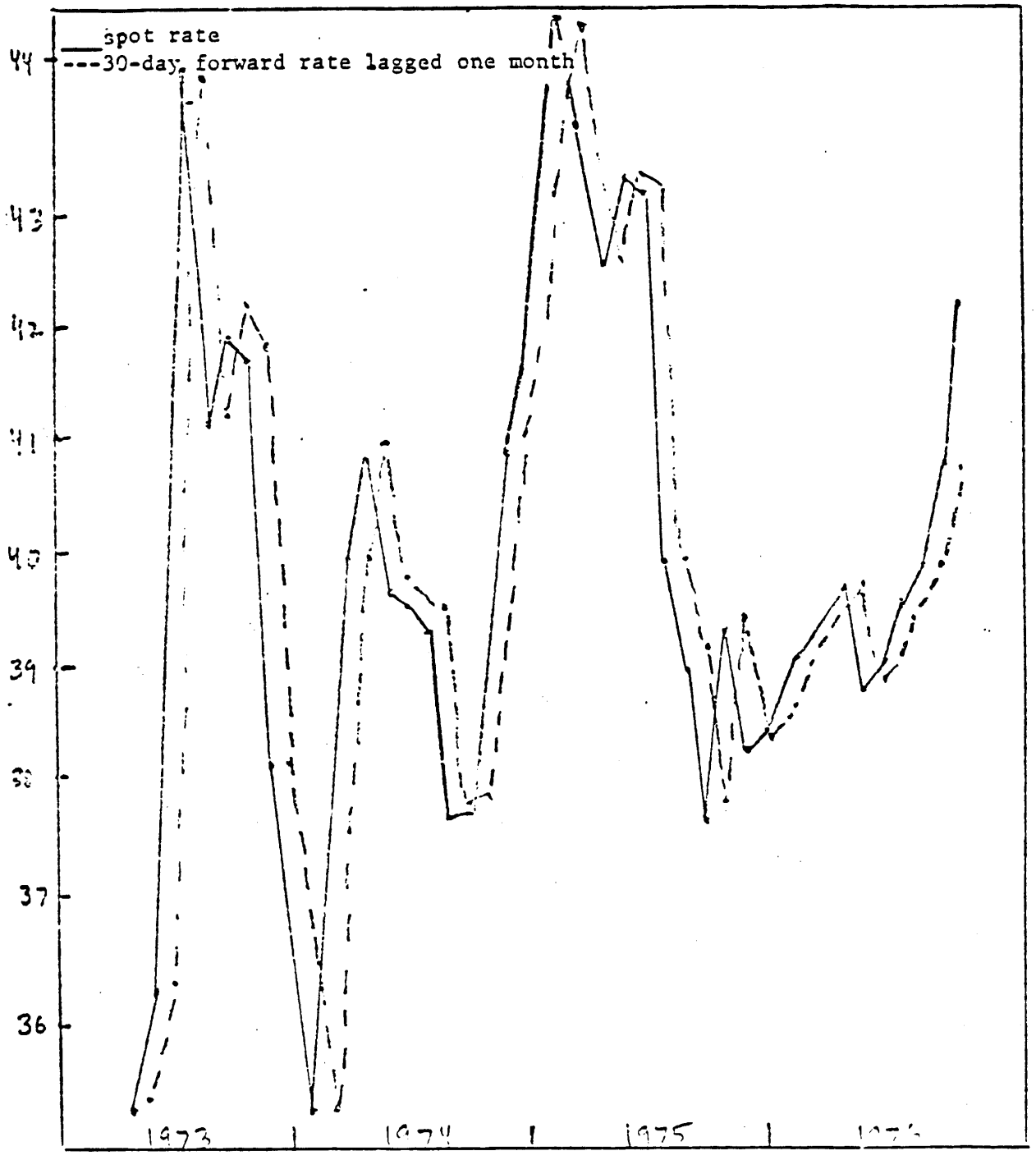
Consider a risk-averse world, on the other hand, consisting of countries (and currencies) A and B. If residents of country A view currency B as a riskier asset to hold than currency A (because exchange-rate variation may offset the purchasing power of currency B over goods in country A) a risk premium may be required to induce residents of country A to agree to accept currency B forward. I.e., residents of country A may be averse to purchasing currency B forward unless the forward price of currency B is lower than the expected future spot price. By a similar argument, however, residents of country B may be averse to selling currency B forward unless the forward price of currency B is higher than the expected future spot price. The apparent parodox -- that the forward rate may be pushed both below and above the expected future spot rate -- can be resolved formally by developing an asset-equilibrium model that focusses on the portfolio preferences of each country's residents. Solnik (1974) has cleared the first road in this direction, showing that the difference between the forward rate and the expected future spot rate can be expressed as a complicated function of exchange-rate covariances. Thus, Solnik has established formally that the forward rate reflects a well-defined risk premium, which may vary over time in both magnitude and direction, but which generally will not equal zero.

The argument that the forward rate does not generally equal the expected future spot rate at any point in time is not inconsistent with the notion that discrepancies between the forward rate and the observed future spot rate will average out over time. The existence of a risk premium is a necessary but insufficient condition for the forward rate to be a biased predictor of the future spot rate. Figure 2 shows end-of-month values of the spot dollar-Deutschemark exchange rate for the period April 1973-September 1976, together with values of forward exchange rates prevailing one month earlier for contracts with 30-day maturities. (A similar figure is presented in Dornbusch, 1977.) Without fail, during months in which the Dmark appreciated

FIGURE 2

SPOT AND FORWARD DOLLAR-DEUTSCHEMARK EXCHANGE RATES,

APRIL 1973 - OCTOBER 1876



End-of-month data, cents per Deutschemark.

(depreciated) relative to the dollar, the end-of-month spot rate exceeded (was below) the level predicted by the end-of-previous-month forward rate. Yet for the same 42 end-of-month observations, a regression of the spot rate (S_t) on the 30-day forward rate that prevailed one month earlier (F_{t-1}) yields a coefficient insignificantly different from unity:[9/]

$$S_t = \underset{(.00581)}{1.00124}\ F_{t-1} + \text{error}_t \qquad \text{D.W.}=1.56$$

Thus, the regression analysis does not support the hypothesis that the forward rate is a biased predictor of the future spot rate. However, the systematic prediction errors revealed by Figure 2 are an unexplained puzzle.[10/]

In addition to examining the issue of bias, empirical studies have assessed the accuracy of forward rates as predictors of future spot rates. Porter (1971) provides an interesting study of the Canadian floating-rate

9/ The standard error of the regression coefficient (shown in parentheses) implies a t-value of .213 for testing whether the true coefficient minus unity differs from zero. Thus, the hypothesis that the true coefficient differs from unity cannot be accepted with 20 percent confidence. A Cochrane-Orcutt correction for serial correlation yields a coefficient of 1.00121 with a standard error of .00738, thus lowering the t-value from .213 to .164. The Durbin-Watson statistic increases to 1.91.

10/ Frenkel's study (1976) of the German hyperinflation, during which the Deutschemark depreciated almost monotonically against the dollar, found that one-month forward rates (between Feb. 1921 and August 1923) provided biased estimates of subsequent spot rates, generally overpredicting the dollar value of the mark. A plot of Frenkel's data resembles the downswing in Figure 2.

period (1953-60) and concludes from quarterly data that Canadian-U.S. yield differentials for two-year maturities were good predictors of actual exchange-rate changes over the subsequent two-year periods, but that yield differentials were poor predictors over 3-month, 1-year and 3-year horizons. Aliber (1976) presents calculations, based on weekly data, of the mean absolute percentage discrepancies between forward exchange rates (for appropriate maturities) and the spot exchange rates that were observed 1 month, 3 months, 6 months and 12 months later. Table 3 reproduces Aliber's calculations for 8 countries paired with the United States, during both a pegged-rate period (Dec. 1, 1967 - July 18, 1969) and a floating-rate period (March 2, 1973 - Nov. 1, 1974). With the exception of 1-month maturities for the French franc (which was devalued during the pegged period) and 1-year maturities for Canada and the United Kingdom, forward rates were less accurate predictors of future spot rates--often substantially less accurate predictors--during the floating-rate period than during the pegged-rate period. Except in the Canadian case, forecasts over short 1-month horizons would have been off target by 2 or 3 per cent on average between early March 1973 and the end of October 1974.[11/]

One conclusion that might be drawn from these data is that forward rates are not satisfactory predictors of future spot rates in a floating-rate

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11/ It is interesting to note that for the floating period the tabulated forecast errors, measured in annual rates, are larger, without exception, the shorter is the forecast horizon.

TABLE 3

MEAN ABSOLUTE PERCENTAGE DISCREPANCIES BETWEEN FORWARD EXCHANGE RATES AND OBSERVED FUTURE SPOT RATES

	1 mo. forecast		3 mo. forecast		6 mo. forecast		12 mo. forecast	
	peg	float	peg	float	peg	float	peg	float
Belgium	.22	3.08	.49	5.97	1.02	7.67	2.30	5.25
Canada	.24	.56	.53	1.20	.91	1.71	1.94	1.83
France	6.64	2.89	1.34	5.48	2.08	9.51	2.93	11.72
Germany	.48	3.44	.86	7.67	1.48	8.05	2.97	10.92
Italy	.19	2.23	.33	3.99	.63	4.90	.99	10.92
Netherlands	.25	3.21	.63	5.55	.88	6.79	1.80	4.23
Switzerland	.30	2.99	.46	5.72	.79	7.12	2.08	3.92
United Kingdom	.41	1.78	.76	4.09	1.45	4.98	4.38	2.69

Computed by Aliber (1976) using weekly observations on exchange rates of national currencies with the U.S. dollar, taken from Harris Trust and Savings Bank, Weekly Review: International Money Markets and Foreign Exchange Rates. Entries for the "peg" period are based on weekly observations between Dec. 1, 1967 and July 18, 1969; entries for the "float" period are based on weekly observations between March 2, 1973 and Nov. 1, 1974.

world, although the volatility of exchange rates has lessened since Aliber's data period, and the accuracy of forward rates as predictors may have consequently increased. It can be argued, however, that no model should be expected to yield more accurate predictions of future spot rates than predictions based on forward rates, on the grounds that the predictions of the market (as summarized in forward rates) are likely to be no less accurate than what a model builder can infer formally from the same information.12/ Thus, we may never be able to predict future spot rates more accurately (on average) than we can with forward rates.

True or false, this conclusion does not imply that predictions of future spot rates, whatever their basis, cannot become substantially more accurate than they have been in the past; in particular, better coordination of national policies might lead to more stable and, perhaps, more-accurately predictable exchange rates. Nor does such a conclusion argue against the development of models that relate exchange rates to the policy instruments and other exogenous parameters which ultimately determine all the endogenous variables that are tied together by interest-rate-parity conditions. By itself, forward exchange theory neither tells us how policy variables affect exchange markets nor provides us with useful insights about the factors responsible for the volatility of exchange rates in recent years. In these important respects forward exchange theory provides an inadequate model of exchange rates.

12/ To the extent that forward rates include a risk premium due to risk aversion on the part of exchange-market participants, a model builder who can quantify the risk premium should be able to do better than forward rates in predicting future spot rates.

3.4 The speculative-run view

The short-run behavior of exchange rates in recent years has been much more volatile than many experts had expected, and considerable attention has consequently been devoted to better understanding the causes of day-to-day fluctuations in exchange rates. Many market operators who follow exchange rates on a daily or hourly basis advance the view that exchange rates move in speculative runs, perhaps touched off by a change in (or a revision of expectations about) fundamental economic conditions, but thereafter reflecting a self-sustaining speculative mentality: "When the train is racing through the station at 90 miles an hour, you don't think very long about where its going to stop; you just try to get on board (anonymous broker)."

This speculative-run view has been challenged by the notion that exchange rates are determined in markets dominated by the transactions of participants who move funds on the basis of (long-run) expectations distilled from information about fundamental economic conditions. Proponents of this latter view argue that speculative runs are precluded (or reduced to insignificance) by the large potential profits that would otherwise be available in the long-run to those who took positions on the basis of expectations related to fundamental economic factors. But after witnessing the large swings in exchange rates that have occurred since the adoption of widespread floating, it is difficult to argue that the market has been dominated by positions taken in pursuit of long-run profits (see McKinnon, 1976). The anecdotal evidence suggests, rather, that many of the largest private participants in exchange markets--namely, international banks--operate within narrow limits on their open positions in different currencies, apparently resisting any temptations to take large positions on the basis of their long-run expectations, which no doubt are very imprecise. Indeed, several of the large banks that participate actively in exchange markets conventionally

refrain from carrying open positions overnight!

A related challenge to the speculative-run view is the (short-run) efficient-markets hypothesis, which in its strong form argues that all relevant new information is fully digested quickly by the market, and that observed exchange rates can never stay long out of line with the market's expectations--based on up-to-date information--of what exchange rates will be a day or a week in the future. As a corollary, the weak efficient-markets hypothesis argues that the past history of exchange rates conveys no information that could help a market participant profit (beyond earning a competive risk premium) by speculating on future exchange-rate changes. Today's exchange rates contain all the information that history provides about what tomorrow's exchange rates are likely to be. Today's new information has its full impact on exchange rates today and provides no profitable information about how exchange rates will change tomorrow. New information sends the the train racing through the station, but the fuel is exhausted before many speculators can climb on board, and tomorrow's ride doesn't promise to be worth the price of a ticket. The speculative run is short-lived.

The weak efficient-markets hypothesis has been tested in several ways by several authors for several data samples. Grubel (1965), Poole (1967) and Upson (1972) have all found evidence of profit-making opportunities for speculators in spot or forward exchange markets during different periods of the 1950s and 1960s, in apparent contradiction of the efficient-markets hypothesis. In contrast, Giddy and Dufey (1975) have found that forecasting future spot rates with linear time-series models (using information drawn from the history of spot rates) is less accurate than forecasting future spot rates to equal prevailing spot rates adjusted for prevailing interest differentials. Giddy and Dufey interpret this evidence to support the weak efficient-markets hypothesis,

although they are careful to note that this hypothesis can never be proven, in the sense that one can never show that every trading rule is unprofitable.

In more recent work, the profitability of simple trading rules--in particular, "buy a currency whenever it has risen x per cent from its most recent trough and sell whenever it has fallen x per cent from its most recent peak"--has been examined by Logue and Sweeney (1975), using daily data on the spot exchange rate between the French franc and the U.S. dollar for the period January 1970 through March 1974, and by Dooley and Shafer (1976), using daily data on spot exchange rates between the U.S. dollar and the currencies of 5 other countries (France, Germany, Japan, the Netherlands, and the United Kingdom) for the period March 1973 through September 1975. These studies present evidence that a wide range of such trading rules would have been profitable, after adjusting for transactions costs and differences in the interest rates that could be earned on different currencies. In particular, Dooley and Shafer show that the choices x=1, 3 or 5 per cent (and presumably all intermediate values) would have been profitable for each of the 5 pairs of currencies if the rules were followed for their entire sample period. Each choice of x, however, would have generated losses in at least one exchange market during at least one subperiod; and choices of x greater than or equal to 10 per cent would have generated losses (or precluded speculative trading altogether) in most cases.

Neither Logue and Sweeney nor Dooley and Shafer have tackled the difficult problem of assessing the expected costs of searching for a profitable trading rule. The fact that Dooley and Shafer found no choice of x that was profitable in all markets during all subperiods raises the question of whether any choice of x would have consistently offered high profits in any market. Dooley and Shafer have split their sample period into thirds and report 15 different cases (involving different currencies and different

choices of x) in which speculative profits would have exceeded an annual rate of 10 per cent during the first or second third of the sample period. In 14 of these 15 cases the profit rate dropped sharply in the immediately-following third of the sample period.

Perhaps it is appropriate to conclude that the weak efficient-markets hypothesis has been weakly but not strongly refuted. The important point for forecasting purposes, however, is that tests of the speculative-run view of exchange markets have not yet provided an attractive model for predicting future exchange rates from historic exchange rates.

3. ANALYTIC INSIGHTS FROM OPEN-ECONOMY MODELS WITH FINANCIAL MARKETS

3.1 Background

Macroeconomic analysis of open economies is heavily indebted to Meade's simultaneous analysis of internal and external balance (1951a, Part III), which drew considerable attention a decade later through the pathbreaking diagrammatic and formal extensions by Mundell (1961, 1962, 1963) and Fleming (1962). Strangely, Meade's mathematical supplement (1951b, eqn. 1.19) did not faithfully translate his verbal theory of the capital account (1951a, p.103), which recognized that a change in international interest-rate differentials causes a once-and-for-all shift of existing portfolio stocks, as well as changing the proportions in which new additions to portfolio stocks are allocated between domestic and foreign assets. Mundell and Fleming, unfortunately chose to follow Meade's mathematical treatment and abstracted from the important stock-adjustment response of the capital account to a change in interest-rate differentials. Objections to the Mundell-Fleming formulation, in which the capital account was treated as a flow related to the level of the interest differential, led McKinnon and Oates (1966) and McKinnon (1969) to take the important step of integrating macroeconomic open-economy analysis with financial portfolio-balance analysis.

The portfolio-balance approach has generated a rebuilding of macroeconomic theory for open economies. The new models that have surfaced during the last decade differ in many respects, but focus in common on the requirement that available stocks of national moneys and other financial assets must equal stock demands for these assets as a necessary condition for equilibrium. Many of these new models, however, have paid too little attention to the central role of wealth variables within the portfolio-balance framework. One of the major shortcomings of the Mundell-Fleming framework, as opposed to a properly-constructed portfolio-

balance model, is the inability of the former to incorporate behavioral responses to changes in private wealth that arise as the counterparts of public budget deficits, and to shifts in the international residence of wealth that are counterpart to current-account imbalances.

In surveying the literature of portfolio-balance models one is struck by their widespread neglect of opportunities to use forward exchange markets in structuring asset portfolios. Before turning to this literature, therefore, it is worth noting that the omission of forward markets will not lead the analysis astray if assets denominated in different currencies are "perfect substitutes except for exchange risk"--i.e., if forward rates are rigidly linked to spot rates by the interest-rate-parity condition.[1/] Under such circumstances, as Kindleberger (1969, p. 102) has noted, "forward markets add nothing essential to the

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1/ It is important to distinguish between the assumption that "covered assets are perfect substitutes" and the stronger assumption that "(uncovered) assets are perfect substitutes." The former, which is the same as the assumption of "perfect substitutes except for exchange risk," is equivalent to assuming that interest-rate differentials and forward premiums are equal. The latter, which can be interpreted as an assumption of risk neutrality, is equivalent to assuming equality between interest-rate differentials and expected rates of change in spot exchange rates. Under rigidly-fixed exchange rates, with zero expected rates of change, the assumption that (uncovered) assets are perfect substitutes implies that interest rates are equal across countries.

capacity for hedging which can also be undertaken by borrowing in one market and lending in the other, earning or paying the interest-rate differential."[2/] Similarly, Dooley (1974) has argued that under interest-rate parity the ability to take forward positions adds only cosmetically to the set of financial portfolios that a market participant can acquire. Moreover, Girton and Henderson (1976) have shown that official intervention in forward markets adds nothing to the ability of policy authorities to achieve desired objectives in an interest-rate-parity world.

Qualifications must be added, as Dooley (1974) notes; but these qualifications arise only insofar as capital controls and discrimination (e.g., between large and small transactors) frustrate the ability of market participants to borrow and lend at those uncontrolled interest rates (e.g., Eurocurrency rates) that are known (recall section 2.3, footnote 8) to conform to the interest-rate-parity condition. For most analytic purposes such qualifications can safely be ignored.

3.2 Basic structures and stock-flow considerations

Portfolio-balance models of open economies typically envision a world of two countries, but often treat macroeconomic variables in one of these countries as predetermined, thereby concentrating on the effects of policy changes in a single country under the assumption that policy instruments in the

2/ Thus, at time 0 a German resident due to receive 1 dollar at time t can arrange to convert forward into f marks, or can alternatively borrow $1/(1+r_d)$ dollars (where r_d is the interest rate on dollars), convert spot into $s/(1+r_d)$ marks, and lend at the interest rate on marks, r_f. At time t, after using his dollar receipt to repay his dollar debt, this alternative strategy will leave him an accumulation of $s(1+r_f)/(1+r_d)$ marks, which equals f under the interest-rate-parity condition. (Recall the derivation of condition (1) in section 2.3.)

other country are manipulated to hold constant the predetermined variables. A variety of assumptions can be made about the number and nature of both financial assets and goods. In most models each country issues its own non-interest-bearing currency (money), which is held only by its own residents; and many models also include interest-bearing securities (bonds) denominated in each currency, both types of which are demanded by asset holders in each country, who may or may not view them as perfect substitutes.

Such models have been analyzed in three essentially-different ways, which have the appearance of corresponding, as Henderson (1977) puts it, to analyses over three different time horizons: (1) a point-in-time or short-run in which the exchange rate and other endogenous variables are determined by conditions in asset markets; (2) a short run in which the exchange rate and (a larger set of) other endogenous variables satisfy the equilibrium conditions of both asset markets and goods markets; and (3) a long-run stationary state. Central to an understanding of why we have been provided with this particular menu of alternatives, and to a better appreciation of the distinctions between these alternatives, is the recognition that analysis is complicated unless portfolio-size or wealth variables are treated as constant (apart from changes in their valuation). Thus, analysis at a point in time (case 1) was developed as a logically-correct way of treating wealth variables as predetermined. Such analysis abstracts from any influence on the economy of conditions in flow markets, particularly markets for goods, on the grounds that savings does not affect the stock of wealth at a point in time. To the extent that empirical application dictates a focus on a sequence of points in time, however, it may be misleading to ignore the flows that occur during the periods between successive points in time. This is one of the motives for adding flows of goods to short-run analysis (case 2). A second motive is that the number of variables that can be treated

as endogenous--i.e., the scope for analysis--increases with the addition of market-clearing conditions for goods flows.

For reasons of analytic tractability, most short-run models with goods markets retain the point-in-time assumption that savings flows do not affect stocks of wealth.[3/] This assumption has been relaxed in computer simulation studies, however, which can be used to test the sensitivity of short-run analysis to the point-in-time constant-wealth assumption.

The long-run stationary-state models (case 3) start out with wealth and capital-stock variables being endogenous, but then assume that these variables converge to long-run equilibium values, instead of growing or fluctuating indefinitely. Most of the interesting analysis of these models is restricted to comparative statics of different stationary states, with the "no growth" assumption facilitating the comparative statics.

This chapter focusses primarily on point-in-time and other short-run models on the grounds that the hypothetical stationary state is too extreme to have much practical applicability. Although point-in-time models are also extreme when strictly interpreted to imply that full adjustment to disequilibrating shocks occurs instantaneouly, it is generally argued that such models are valid over whatever short run is required for asset markets to adjust to changes in policy instruments or other exogenous variables, based on the presumption that asset portfolios adjust to changes before the ongoing flows of income and savings have significant effects on wealth variables.[4/] Many economists agree with Foley (1975, p. 319) that this assumption is quite reasonable:

3/ This is analogous to the assumption that investment flows do not affect stocks of capital in the simple Keynesian model of the closed economy.

4/ This defense of the point-in-time assumption applies equally to (and is required equally by) both (1) short-run models that include only asset markets and (2) short-run models with goods flows that are assumed to have no effects on stocks of wealth.

> Asset markets are in fact among the best organized of markets; information about prices of many (especially financial) assets is disseminated widely and rapidly, and the great bulk of the total wealth in industrialized capitalist economies is held in very large portfolios for which fixed transaction costs will be negligible in relation to portfolio shifts. These observations suggest that the vision of stock equilibrium may be a good approximation to the real situation. Empirical evidence of large transaction costs would, of course, upset this conclusion.

3.3. Analysis of central-bank policies using a streamlined model of financial equilibrium

Foley's argument offers considerable justification for using financial-equilibrium models to analyze the short-run effects of monetary policy and exchange-market intervention -- policies which only impact on wealth through valuation effects that can be endogenized in the model. Fiscal-policy analysis in such models (which requires the introduction of a goods market) is less satisfactory to the extent that it abstracts from the direct wealth effects of any changes in the fiscal budget balance. And analysis of interesting exogenous shocks may also require a more-elaborated model; for example, analysis of major changes in oil prices obviously requires a sharp focus on the effects of the redistribution of wealth between oil-consuming and oil-producing countries.

This section summarizes the qualitative insights that financial-equilibrium models provide about the short-run effects of monetary policy and exchange-market intervention on financial variables such as interest rates and exchange rates. The focus is on an open economy whose residents hold domestic money, bonds denominated in domestic-currency units, and bonds denominated in foreign-currency units. It is assumed that the interest rate on foreign bonds is held constant by foreign monetary authorities, restricting attention to the behavior of two endogenous variables-- the exchange rate and the domestic interest rate. The analysis of this model is developed verbally in Henderson (1977) and formally in the appendix to this chapter. The most important insights that it provides are the following.

First, an open-market purchase of domestic bonds by the monetary authorities drives down the domestic interest rate and also causes a depreciation of domestic currency. The extent of the depreciation will be greater: (i) the greater is the extent to which asset holders switch between domestic assets and foreign assets in response to a change in expected yield differentials (i.e., the more closely substitutable are domestic and foreign assets); (ii) the smaller is the extent to which an initial depreciation of domestic currency increases expectations of subsequent appreciation; and (iii) the smaller are the shares of domestic (foreign) financial portfolios that are initially allocated to foreign-currency (domestic-currency) assets. Point (iii) reflects the fact that smaller shares of foreign-currency (domestic-currency assets in domestic (foreign) portfolios imply smaller changes in the home-currency valuations of portfolios following an unanticipated depreciation of domestic currency, and consequently imply that smaller excess demands for domestic assets are induced by the depreciation. (See the appendix to this chapter for the derivation of these results.)

The effects of exchange-market intervention are likewise sensitive to the degree of asset substitutability, and to the size of the expectations and

asset-valuation effects. In analyzing the effects of intervention, a distinction should be drawn between intervention that changes official net position in domestic money and sterilized intervention that changes official net positions in domestic bonds. If domestic and foreign bonds are (close to) perfect substitutes, for example, sterilized intervention swaps of domestic bonds for foreign bonds will have (almost) no impact on interest rates or exchange rates, while intervention swaps of domestic money for foreign bonds will have (almost) the same effects as an open-market operation by domestic monetary authorities.[5/]

Finally, the model recognizes explicitly that monetary-policy actions and exchange-market intervention affect expectations of future exchange rates, as well as affecting current exchange rates and interest rates. This emphasizes the point (recall section 2.3) that predictions of future exchange rates based solely on interest-rate-parity considerations can be highly inaccurate due to events (e.g., changes in policy instruments) prior to the date of outcome that are unforeseen at the time that predictions are made.

5/ Central-bank intervention to purchase domestic-currency assets with foreign-currency reserves typically involves a purchase of domestic money with foreign bonds. For example, U.S. official intervention in support of the dollar usually amounts, in the first instance, to transferring the ownership of an interest-bearing deposit held abroad from the Federal Reserve System to an agent bank (e.g., Chase Manhattan), for which payment in dollars is typically deducted from the agent bank's deposits at the Fed, thereby reducing the reserves of the U.S. banking system. The aggregate balance sheet of the private sector is insensitive to whether the agent bank marries the central-bank transaction by using the foreign deposit to purchase deposits at the Fed (Federal funds) from another private party. If the Fed, however, does not adjust downward its money-supply target, and effectively acts to restore the level of bank reserves through open-market purchases of domestic bonds, the exchange-market intervention is sterilized and essentially amounts to a purchase of domestic bonds with foreign bonds.

3.4 Extensions of the streamlined analysis of central-bank policies

The basic insights provided by the streamlined model are by-and-large unchallenged by extended models.[6/] Girton and Henderson (1973 , 1976) provide a carefully-developed two-country model of financial-market equilibrium for purposes of analyzing the short-run effects of open-market operations and various types of exchange-market intervention. Henderson (1977) has extended his streamlined model by introducing goods flows (each country produces a single traded good that is an imperfect substitute for the other country's good) and using the conditions for equilibrium in the markets for domestic money, domestic bonds and domestic goods to analyze the impacts of policy changes on the exchange rate, the domestic interest rate and the domestic price level.

An interesting check on the streamlined analysis is provided by Shafer's two-country simultation model (1976), based on hypothetical parameter values chosen to be as realistic as casual empiricism would allow. The countries are equal in size; each produces a single and different tradable good; financial portfolios include domestic and foreign moneys, domestic and foreign bonds, and claims on domestic and foreign physical capital; endogenous wealth variables reflect the ongoing processes of savings, investment and shifts in the international residence of wealth through current-account imbalances, as well as changes in the valuation of assets; and expectations variables are modeled in a sophisiticated manner that allows a distinction between the effects of anticipated and unanticipated policy changes. Shafer's simulations over 30 quarters suggest that

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6/ In attributing credit for basic insights this statement should be turned around, since the extended models predate the streamlined model.

the introduction of endogenous income, savings, wealth and price variables does not lead to any changes in our qualitative insights about how exchange rates respond to monetary and intervention policy changes, although the response of nominal interest rates can be different than the streamlined model suggests if policy changes lead to quick and substantial revisions in expectations about future rates of inflation.

3.5 The importance of anticipations

It is widely appreciated that observed exchange rates can jump quickly in response to any event that leads to a substantial revision in expectations of future exchange rates. The streamlined model (see the appendix to this chapter) emphasizes that the expected rate of exchange-rate appreciation is one of the components of expected yields on financial assets; and the relative demands for domestic and foreign assets can shift substantially (the more so the more substitutable are these assets in private portfolios) in response to changes in expected yield differentials, potentially leading to substantial international capital movements if significant changes in expected yield differentials were sustained. Similarly, revisions in expectations of future exchange rates can potentially alter the timing of shipments of tradable goods and induce substantial leads or lags in payments for imports. Thus, in a floating-exchange-rate world a revision in expectations of future exchange rates can quickly change the balance of supply and demand in foreign-exchange markets, thereby leading quickly to whatever changes in observed exchange rates (and interest rates) are necessary to restore equilibrium.

The theoretical literature on both the analysis of devaluation and the exchange-rate impacts of policy changes pays almost no attention to cases in which policy changes are anticipated in advance. (See Isard and Porter ,1975, for a criticism of this oversight.) Shafer's simulations (1976) illustrate

dramatically that one cannot hope to estimate or predict the impact of a policy change on exchange rates without prior assumptions about (or knowledge of) the nature of advanced expectations of the policy change. For example, Shafer considers a policy shift to a faster rate of monetary expansion and simulates the impact of this shift under alternative assumptions of (i) no foresight and (ii) perfect foresight 4 quarters in advance. The exchange-rate paths in the two cases are quite similar following the quarter during which the policy shift occurs. But in the former case the exchange rate jumps by roughly 5 per cent in this quarter, while in the latter case a similar 5 per cent exchange-rate change is spread over 5 quarters, with half of the 5 per cent change occurring when the policy shift is first expected four quarters in advance, and almost seven-eighths of the 5 per cent change occurring before the policy shift takes place.

Although there is danger in leaning too heavily on the results of a single simulation exercise, most economists probably agree with the proposition that the changes in the exchange rates and interest rates observed immediately after a policy shift will be larger, ceteris paribus, the greater the extent to which the policy shift catches economic participants by surprise. A second conclusion is that not all of the impact effects of a perfectly-foreseen policy shift necessarily occur in advance of the policy shift. In general, the time path of the impact effects depends on the distance (or time horizon) over which foresight is perfect.

3.6 Long-run neutrality results

Recent models of flexible exchange rates have included several contributions in which changes in nominal money supplies have no long-run effects on real variables (such as real incomes, consumption and trade balances) and equi-proportionate long-run effects on exchange rates and

price levels; for example, see Dornbusch (1976a or b).[7/] If long-run neutrality was an accurate description of reality, expectations of the long-run exchange-rate impacts of monetary-policy changes might provide strong bounds on the short-run impacts, depending on the extent to which financial-asset holders were willing to take open positions on the basis of their long-run expectations.

A discussion of the model properties that lead to long-run neutrality can be found in Roper (1975). Sufficient conditions are that (i) all real variables are homogeneous of degree zero as functions of their nominal arguments and (ii) no more than one nominal variable is exogenous. Thus, most models in which the menu of outside (or exogenously-controlled) financial assets extends beyond money will not exhibit long-run neutrality; and obversely, models that do exhibit long-run neutrality tend to be unrealistically over-simplified in their highly-aggregated treatment of financial assets. Isard and Porter (1975) have suggested, however, that the world could move increasingly toward both short-run and long-run neutrality if debt becomes increasingly denominated in real (purchasing-power) units, while wages, other nominal factor payments, and product prices become increasingly tied to a standard index.

3.7 Analysis of fiscal policies

It seems safe to assert that open-economy models have provided better insights on the exchange-rate impacts of central-bank policies than on the exchange-rate impacts of fiscal policies. Part of the reason is that fiscal-

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7/ These models are linked closely to analyses of devaluation in which exchange-rate changes have no long-run effects on real variables and equi-proportionate long-run effects on price levels (and other nominal variables); for example, see Dornbusch (1973) and Laffer (1974). Whitman (1975) provides a critical evaluation.

policy changes can generate different and opposite pressures on exchange rates, and the relative strengths and timing of these pressures can be difficult to judge.

Consider first a balanced-budget fiscal expansion. In Henderson's model (1977) the expansion leads to an increase in nominal income that increases the transactions demand for money and puts upward pressure on the domestic interest rate, hence creating an excess demand for domestic assets and an excess supply of foreign bonds, thus leading to an appreciation of domestic currency. Balanced-budget fiscal expansion also leads to domestic-currency appreciation in Mundell's classic model (1963) with perfect capital mobility. There, the domestic interest rate cannot diverge from the fixed foreign interest rate, and the fixed money stock thus prevents a fiscal expansion from stimulating domestic income. Hence, the increase in government spending requires an equal increase in imports, which can only result from a currency appreciation that changes the terms of trade in favor of imported goods.

Such conventional association of balanced-budget fiscal expansion with currency appreciation is based on an incomplete story. To the extent that fiscal expansion causes the current account to shift to a (greater) deficit, as it does in both the Henderson and Mundell models, the counterpart transfer of financial wealth from domestic residents to foreigners is likely to result in an increase (decrease) in worldwide private demand for assets denominated in foreign (domestic) currency units, which puts downward pressure on the value of domestic currency.

Attempts to judge how the conventional Mundell-Henderson-type effect and the current-account effect will balance out in reality confront two major complications. First, "balanced-budget fiscal policy" refers to a variety of expenditure and tax programs that may differ considerably in their impacts on domestic income and the current account. As an extreme example, a balanced-budget

expansion of military expenditures abroad might have little effect on domestic income, in which case the conventional effect would presumably be out-weighed by the current-account effect, leading to a depreciation of domestic currency, and thereby reversing the Mundell-Henderson result.[8/] A second complication is that the balance of the conventional and current-account effects can be presumed to shift over time. In particular, the former effect provides a one-time upward push on the value of domestic currency, while the latter effect provides a continuing downward push, associated with a continuing flow of financial wealth out of domestic portfolios into foreign portfolios, over whatever time horizon the current account remains in deficit (relative to what would have occurred in the absence of the fiscal expansion).

Debt-financed fiscal expansions generate a third pressure on exchange rates, which has apparently escaped the attention of analytic models. If the new public debt is denominated in domestic-currency units, and if private asset holders desire to diversify any additions to their financial portfolios between domestic and foreign-currency assets, the fiscal expansion will create an excess supply of domestic-currency assets, putting downward pressure on the value of domestic currency. Moreover, the downward pressure due to this diversification effect will continue over time insofar as the new stance of fiscal policy (with its higher rate of public-debt issue) is maintained for purposes of holding nominal income at its new level.

Because the diversification and current-account effects put continuing downward pressures on the value of domestic currency, in contrast to the one-time upward push provided by the conventional Mundell-Henderson-type effects, there is a strong presumption that <u>in the long run</u> a fiscal expansion

8/ The result is also reversed in Branson's (1976a) polar case of zero capital mobility. There a balanced-budget fiscal expansion stimulates domestic income, causing domestic currency to depreciate in order to maintain current-account balance.

financed by debt will depreciate the value of domestic currency, despite the fact that some analytic models produce the opposite result.[9/] It is important to note, however, that the diversification effect would put continuing upward pressure on the value of domestic currency if the fiscal expansion were financed by borrowing abroad via debt-issues denominated in foreign-currency units.[10/]

In this connection it is instructive to note that countries with depreciating currencies are often advised that they can brake the currency depreciation by tightening their fiscal policies, even in cases in which they have been borrowing foreign currencies extensively. The previous analysis of fiscal policy suggests that such advice can only be sound in these latter cases if the current-account effect swamps the combination of the Mundell-Henderson and diversification effects. But there may be a semantical difference here: analytic models distinguish between fiscal and monetary policies in a manner that may seem quite artificial to policy advisers. More specifically, to the extent that

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9/ Shafer's simulations (1976) produce the result that an unanticipated permanent reduction in the rate of real government spending, accompanied by a matching reduction in the rate of issuance of new public domestic-currency-denominated debt, leads to a depreciation of the domestic currency in the quarter in which fiscal spending is first reduced, with only minor subsequent changes in the exchange rate.

10/ In a multicurrency world, however, this upward pressure would only apply to the value of domestic currency in terms of that foreign currency in which debt issues were denominated, whereas denominating debt in domestic currency would tend to depreciate the domestic currency vis-a-vis all foreign currencies.

political pressures--e.g., in opposition to high or continuously-rising interest rates--dictate that fiscal expansions be accompanied by monetary ease, the real-world experiment of a fiscal-expenditure cut should be modeled analytically as a simultaneous tightening of fiscal and monetary policies. And advice to tighten fiscal policy in reality then appears analytically to be a much sounder prescription for curbing an exchange-rate depreciation.

3.8 Models of exchange-rate dynamics

Recognition that the long-run effects of policy changes are different from the short-run effects, or more specifically, that a policy change does not simply shift the time path of the exchange rate by a uniform amount, has led in the last few years to a new theoretical literature on exchange-rate dynamics. This literature embeds models of an economy (almost) continuously in asset equilibrium within larger models of an economy adjusting over time toward a full long-run equilibrium of both asset and goods markets. Among the important contributions to dynamic analysis are Shafer's simulation model (1976) and several smaller models that can be analyzed without a computer: Dornbusch (1976a and b), Kouri (1976) and Branson (1976b). These latter models are charting an important path toward improving our theoretical insights, though each, not surprisingly, has adopted major simplications in order to achieve dynamic tractability.

Dornbusch (1976b) emphasizes the linkage between expected exchange-rate changes and interest-rate differentials, focussing on how a monetary expansion affects the time paths of the exchange rate, the domestic price level and the domestic interest rate. An appendix extends the analysis to describing the perturbations of real output around a fixed long-run equilibrium under the assumption of endogenous output supply. Characteristically, Dornbusch gets a lot of mileage out of a simple and elegant framework--in this case a framework that explicitly considers only one asset, domestic money, the demand for

which is assumed to be independent of wealth. Due to the latter assumption, however, this framework cannot adequately capture the effects of shifts in the international residence of wealth through trade imbalances.

In sharp contrast, Kouri (1976) develops a model that distinguishes between domestic-currency-denominated and foreign-currency-denominated assets, with asset demands depending on both wealth and the expected rate of exchange-rate depreciation (which equals the expected rate of domestic inflation), but with domestic and foreign nominal interest rates both fixed (and for convenience set equal to zero). Kouri's model highlights the process of wealth accumulation through current-account imbalances.

Branson (1966) follows Kouri in spirit, extending Kouri's framework by distinguishing between domestic money and domestic interest-bearing assets, and by endogenizing the interest rate on the latter. Branson's model resembles the streamlined model of section 3.3 and the appendix, with one major difference: international lending occurs only through transactions in foreign-currency-denominated assets, so that domestic residents can only increase their holdings of foreign-currency assets by running a current-account surplus. While this assumption reduces the appropriateness of Branson's model for short-run analysis, it simplifies the dynamic analysis.

Each of these models supports the conclusion that monetary expansion leads to currency depreciation in the short-run, and none of the models adds significantly to our insights about the effects of fiscal policy on exchange rates. The principal direct contributions of these models, in addition to laying important groundwork for further

analysis, are the insights they offer on the time path of the exchange rate--both in isolation and in comparison with relative price levels or purchasing-power parity--following a change in monetary policy. Dornbusch and Kouri conclude that the short-run response of the exchange rate to a monetary change will overshoot the new long-run equilibrium exchange rate (as will be discussed in section 3.9 below); and Dornbusch shows that overshooting can occur even when exchange-rate expectations reflect perfect foresight.

In addition to providing insights on overshooting, the Dornbusch and Branson analyses illustrate that relative prices and exchange rates do not move together during the process of adjustment to a new long run equilibrium following a monetary change that disrupts an initial long-run equilibrium. Dornbusch deals a staggerring blow to purchasing-power-parity theory by providing a model in which purchasing-power parity holds only in long-run equilibrium and never when the goods market is out of equilibrium.[11/] The knock-out punch comes from Branson, however, who shows that a purely monetary disturbance of an initial asset-and-goods-market equilibrium will drive the economy to a new asset-and-goods-market equilibrium in which the exchange rate no longer bears its original proportion to the relative-price level. This insight is derived from Branson's explicit incorporation of the services account into the balance-of-payments

11/ This point is not stressed by Dornbusch (1976b); but it is clear that purchasing-power parity holds only on the 45° line, or at points A and C, of his diagram of the adjustment process (Figure 2 in his paper).

condition. A monetary expansion that depreciates domestic currency and thereby improves the domestic trade balance[12] leads to an accumulation of domestically-owned claims on foreigners and increases the continuing inflow of interest income from abroad. The new long-run equilibrium (in which unchanging asset portfolios imply capital and current-account balance) must therefore be one in which the domestic trade balance has shifted back into deficit, relative to the original trade balance, by an amount that exactly matches the increase in interest income from abroad; and this requires that the new equilibrium terms-of-trade differ from the old. Thus, purchasing-power disparities --though perhaps only small ones--are sustained in the long run, even in a world of purely-monetary disturbances.[13]

3.9 Explanations of exchange-rate volatility and overshooting

During the past several years exchange rates have exhibited wider swings than many economists had expected to occur, and considerable attention has been devoted to better understanding the causes of this short-run volatility. Models of exchange-rate dynamics have also provided insights on the conditions under which the short-run responses of exchange rates to policy changes or other exogenous events "overshoot" the changes that are required to restore equilibrium in the long run.

The preceding sections offer several different perspectives on exchange-rate volatility. (See Schadler, 1977, for additional perspectives.) Section 2.4

12/Branson assumes that the Marshall-Lerner conditions preclude any deterioration of the trade balance in response to currency depreciations.

13/ Despite this conslusion, Branson (1976b, p. 23) defends purchasing-power parity as a useful long-run approximation.

notes that many inside observers of exchange markets believe in volatile speculative runs, a view that draws support from the fact that it is difficult to find evidence that major private participants in exchange markets (notably, international banks) have taken large open positions on the basis of long-run exchange-rate expectations. The "institutional explanation" of this nonemergence of long-run positions is that banks are conservative and have placed tight limits on the open positions that their foreign-exchange managers may take. A fundamental explanation of this institutional phenomenon, however, is that banks and multinationals undoubtedly have very imprecise long-run expectations about exchange rates, and consequently perceive that a high degree of risk is associated with long-run open positions. There has not been much formal analysis of this risk, but Mussa (1976) has begun to zero in on the link between the imprecision of long-run expectations and the variability or unpredictability of policy variables, as will be discussed below.

A second perspective on volatility is offered by the streamlined model of financial equilibrium (section 3.3 and the appendix), which suggests that the magnitude of the response of the exchange rate to a policy change will be greater: (i) the more substitutable are domestic and foreign assets in private portfolios; (ii) the smaller is the extent to which an observed depreciation (appreciation) of the exchange rate raises expectations of future appreciation (depreciation); and (iii) the smaller are the shares of their financial portfolios that residents of any one country desire to hold in assets denominated in the currencies of other countries.

A third perspective on volatility is provided by Shafer's simulation model (1976), which suggests (recall section 3.4) that exchange-rate movements will be more gradual, or more spread out over time, the further in advance

exchange-market participants correctly and confidently foresee the policy changes (or other exogenous shocks) that generate them.[14/]

The dynamic models discussed in section 3.8 also address the issue of volatility. Dornbusch (1976a and b) focusses on the impacts of a monetary expansion, which causes the domestic interest rate to fall to the point at which the private sector willingly absorbs the new money issue. If the foreign interest rate is pegged by foreign monetary authorities (or to the extent that the foreign interest rate falls less than the domestic interest rate), the forward premium (discount) on domestic currency must consequently increase (fall), relative to what it was prior to the monetary expansion, in order to make domestic and foreign bonds equally attractive at the margin (i.e., in order to maintain interest-rate parity). Thus, the monetary expansion must cause the domestic currency to initially depreciate spot by more than any depreciation forward in order to increase (reduce) the forward premium (discount) on domestic currency. To the extent that the spot rate is expected to move toward the forward rate over time, the spot rate can be said to overshoot the level toward which it is expected to move in the long run.

It is interesting to note that this argument is quite general and does not depend on the simplifying assumptions that Dornbusch adopts in his illustrative models. It is also important to note that overshooting does not necessarily imply substantial volatility. The appropriate lesson to draw from Dornbusch's story is that spot exchange rates should be observed to fluctuate more widely than forward exchange rates by amounts that can be large or small, depending on the extent to which policy authorities allow interest rates to diverge internationally. Most of the volatility in spot exchange rates during recent years, however,

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14/ Brock (1975) suggests a similar point in a different context.

has also been observed in 3-month forward rates, and even appears to be evident (on casual inspection) in the forward rates implied by interest differentials for maturities of up to 5 years.

Kouri (1976) provides a different explanation for the fact that exchange rates may overshoot in response to a monetary disturbance. In his model a monetary expansion initially causes the domestic currency to depreciate, which reduces the real wealth of domestic residents. Subsequently, the current account moves into surplus (given an initial equilibrium with current-account balance), which by shifting wealth from foreigners to domestic residents creates an excess demand for domestic assets and appreciates the domestic currency. Branson (1976b) illustrates, however, that Kouri's type of overshooting does not necessarily occur in more general models. In Branson's model, it is the ratio of the exchange rate to the domestic price level that overshoots. After initially depreciating in response to a monetary expansion, the exchange rate may continue to depreciate as long as the domestic price level rises more rapidly.

It seems fair to conclude that the types of overshooting highlighted by dynamic models do not provide a convincing explanation of the exchange-rate volatility we have observed in the past several years. This brings us back to the impression that expectations about future exchange rates are imprecise--hence the observed wide fluctuations in forward rates and the lack of evidence of large open positions taken on the basis of long-run expectations.

Our insights into why expectations are imprecise (and hence into why observed exchange rates have been so volatile) have recently been expanded by an appendix to Mussa (1976). Mussa starts from the proposition that the way in which exchange-rate expectations are assumed to be formed should be consistent with assumptions about the underlying economic structure--i.e., should be "rational". He then develops a simple model that focusses on the potentially-large variability of such expectations.

To illustrate, let m^s denote the logrithm of the money supply, let m^d denote the logrithm of money demand, let s denote the logrithm of the exchange rate, let E be the expectations operator, and consider the condition for money-market equilibrium at time t:

(1) $m^s(t) = m^d(t) = as(t) - bE_t[s(t+1)-s(t)] + g(t)$ for $a,b > 0$.

where the demand for money has been conveniently oversimplified as a log-linear combination of (i) the exchange rate, (ii) the expected rate of change in the exchange rate, and (iii) all other influences, $g(t)$.[15/] Since $s(t)$ is known at time t, $E_t[s(t)] = s(t)$. Hence

(2) $s(t) = b(a+b)^{-1}E_t[s(t+1)] + (a+b)^{-1}E_t[m^s(t)-g(t)]$

Furthermore, under the assumption of rational expectations

(3) $E_t[s(t+1)] = b(a+b)^{-1}E_t[s(t+2)] + (a+b)^{-1}E_t[m^s(t+1)-g(t+1)]$

(4) $E_t[s(t+2)] = b(a+b)^{-1}E_t[s(t+3)] + (a+b)^{-1}E_t[m^s(t+2)-g(t+2)]$

and so forth. Therefore, by substituting (4) into the right-hand side of (3) and continuing through an infinite sequence of similar substitutions, we arrive at

(5) $E_t[s(t+1)] = (a+b)^{-1}\sum_{i=1}^{\infty}[b/(a+b)]^{i-1}E_t[m^s(t+i)-g(t+i)]$

15/ The assumptions of continuous purchasing-power parity (PPP) and risk neutrality are required to derive Mussa's money-demand function from the conventional specification in which the log of nominal money demand is a linear function of the log of the domestic-price level, the domestic nominal interest rate, and the log of real income. Under PPP the log of the domestic-price level equals the sum of the logs of the exchange rate and the foreign-price level; and under risk neutrality the domestic interest rate is replaced by the foreign interest rate plus the expected rate of change in the exchange rate.

Thus, today's expectations of tomorrow's exchange rate depends on today's expectations of the entire future time paths of both the money supply and all variables (other than exchange rates) that influence money demand. Obversely, to the extent that expectations of these latter time paths are imprecise and subject to sudden shifts--for example, when newly available economic data differ from earlier predictions and lead to revised expectations about the money-supply path that the central bank will pursue--both exchange-rate expectations and observed exchange rates will also be subject to sudden shifts. Moreover, shifts in expected and observed exchange rates can be volatile even if shifts in expectations of money supplies and other relevant variables are gradual, depending both on the parameters "a" and "b" and also on the number of future time periods for which the latter expectations are revised. Volatility of exchange rates may well be linked to volatility of other economic variables, but it is also consistent with gradual changes in other economic variables.

Needless to say, these results are based on a simplified model that heavily obscures the underlying economic structure. We must await subsequent analysis of more-elaborated models to better appreciate the sensitivity of observed and expected exchange rates to shifts in <u>expected</u> money-supply paths. Moreover, in embellishing the importance of changes in the expected time path of the domestic money supply, conditions (2) and (5) provide no insights into the relative importance of changes in the expected time paths of foreign money supplies and other domestic and foreign policy variables. Nevertheless, this avenue of analysis suggests that changes in <u>expectations</u> about policy variables may be an important cause of exchange-rate volatility. The tentative conclusion is that exchange-rate volatility could be reduced

(perhaps substantially) by the dissemination of information that would allow market participants to better predict the time paths of policy variables, or possibly by pursuing smoother time paths of policy variables. Perhaps better still, for purposes of smoothing exchange rates, would be a smoothing of policy variables relative to other influences on exchange-rate expectations (e.g., in the example above, a smoothing of m^s relative to g). Whether or not the costs of such measures would be outweighed by the benefits of reduced exchange-rate volatility is another matter.

APPENDIX: A Streamlined Model of Financial Equilibrium

To formalize the argument of section 3.3, consider an open economy whose residents hold domestic money, bonds denominated in domestic-currency units, and bonds denominated in foreign-currency units. Assume that private demand for any asset is a positive function of the yeild on that asset, a negative function of yields on other assets, and a positive function of wealth, where wealth is valued in the same currency unit as the asset being demanded.

(1) $M^d = m(\overset{+}{r_m}, \overset{-}{r_b}, \overset{-}{r_f}, \overset{+}{W}$, other predetermined variables)

(2) $B^d = b(\overset{-}{r_m}, \overset{+}{r_b}, \overset{-}{r_f}, \overset{+}{W}$, other predetermined variables)

(3) $B^{*d} = b^*(\overset{-}{r^*_{m^*}}, \overset{+}{r^*_b}, \overset{-}{r^*_f}, \overset{+}{W^*}$, other predetermined variables)

where

M^d = domestic demand for domestic money

$\bar{M}$ = supply of domestic money

B^d, B^{*d} = domestic and foreign demands for domestic bonds

$\bar{B}$ = supply of domestic bonds

r_m, r_b, r_f = expected yields in domestic-currency units on domestic money, domestic bonds, and foreign bonds

$r^*_{m^*}$, r^*_b, r^*_f = expected yields in foreign-currency units on foreign money, domestic bonds, and foreign bonds

W, W^* = domestic and foreign wealths valued in domestic-currency units[16/]

s = spot exchange rate in foreign currency per unit domestic currency

s^e = spot rate currently expected to prevail one period in the future

16/Denomination of W^* in domestic-currency units implies that assumption (3) is consistent with assumptions (1) and (2) if and only if asset-demand functions are homogeneous of degree one in wealth.

Although savings flows are ignored, wealth variables are not completely predetermined since the valuation of asset portfolios depends on the exchange rate. Specifically

$$(4) \quad W = W(s) \quad \text{with} \quad \partial W/\partial s < 0$$

$$(5) \quad W^* = W^*(s) \quad \text{with} \quad \partial W^*/\partial s < 0$$

where the partial derivatives reflect the fact that an increase in s lowers the domestic-currency value of the foreign-bond holdings of both domestic and foreign residents, as well as the domestic-currency value of the foreign-money holdings of foreign residents.[17/]

Now consider the expected-yield variables. It is assumed either that inflation rates are exogenous or that asset demands are insensitive to those changes in expected yields that do not change any differential expected yields. Under this assumption the analysis is insensitive to whether yields are specified in real or nominal units, and it is valid to focus on nominal units, in terms of which the yields on moneys are zero:

$$(6) \quad r_m = r^*_{m^*} = 0$$

The own-currency yield on domestic bonds (r_b) is one of the endogenous variables, and the own-currency yield on foreign bonds (r^*_f) is assumed to be held constant by foreign monetary authorities. The expected domestic-currency yield on foreign bonds is the foreign-currency yield minus the expected rate of appreciation of domestic currency.

$$(7) \quad r_f = r^*_f - (s^e - s)/s$$

and the expected foreign-currency yield on domestic bonds is the domestic-currency yield plus the expected rate of appreciation of domestic currency

$$(8) \quad r^*_b = r_b + (s^e - s)/s$$

17/ It is assumed that private domestic net holdings of foreign bonds and private foreign holdings of foreign assets are each positive.

It is assumed that exchange-rate expectations are regressive or stabilizing in the sense that an appreciation of the exchange rate reduces the rate at which the exchange rate is expected to appreciate in the future. That is

(9) $\partial S/\partial s < 0 \quad$ for $S(s)=(s^e-s)/s$

The model is in equilibrium when both the money and domestic bond markets are clear, or when[18]

(10) $M_d = \bar{M}$

(11) $B^d + B^{*d} = \bar{B}$

Under assumptions (1) - (9), the equilibrium conditions can be written as functions of the two endogenous variables r_b and s:

(10a) $m(\overset{-}{r_b}, \overset{-}{r^*_f} S(s), \overset{+}{W}(s)) = \bar{M}$

(11a) $b(\overset{+}{r_b}, \overset{-}{r^*_f} S(s), \overset{+}{W}(s)) + b^*(\overset{+}{r_b} S(s), \overset{-}{r^*_f}, \overset{+}{W^*}(s)) = \bar{B}$

Since $\partial m/\partial r_b < 0$ and

$\partial m/\partial s = \overset{-}{-}[\overset{-}{\partial m/\partial}(r^*_f - S)][\overset{-}{\partial S/\partial s}] + [\overset{+}{\partial m/\partial W}][\overset{-}{\partial W/\partial s}] < 0$

the locus of (r_b, s) pairs for which the money market is in equilibrium is a negatively-sloped curve $m=\bar{M}$. And since

$\partial b/\partial r_b + \partial b^*/\partial r_b > 0$ while

$$\partial b/\partial s + \partial b^*/\partial s = \overset{-}{-}[\overset{-}{\partial b/\partial}(r^*_f - S)][\overset{-}{\partial S/\partial s}] + [\overset{+}{\partial b/\partial W}][\overset{-}{\partial W/\partial s}] + [\overset{+}{\partial b/\partial}(r_b+S)][\overset{-}{\partial S/\partial s}]$$
$$+[\overset{+}{\partial b^*/\partial W^*}][\overset{-}{\partial W^*/\partial s}] < 0$$

the locus of (r_b, s) pairs for which the domestic bond market is in equilibrium is a positively-sloped curve, $b+b^*=\bar{B}$. These curves are illustrated in Figure 3.

In order to analyze policy changes diagrammatically, it is necessary to know how the curves shift following changes in $\bar{M}$ and $\bar{B}$. Since $\partial m/\partial r_b < 0$, for any s the value of r_b that lies on the $m=\bar{M}$ curve shifts leftward when $\bar{M}$

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[18] It is assumed that domestic and foreign bonds are imperfect substitutes. In the case of perfect substitutes, condition (11) would be incomplete and irrelevant.

FIGURE 3

The $\bar{M}$ and $\bar{B}$ Curves

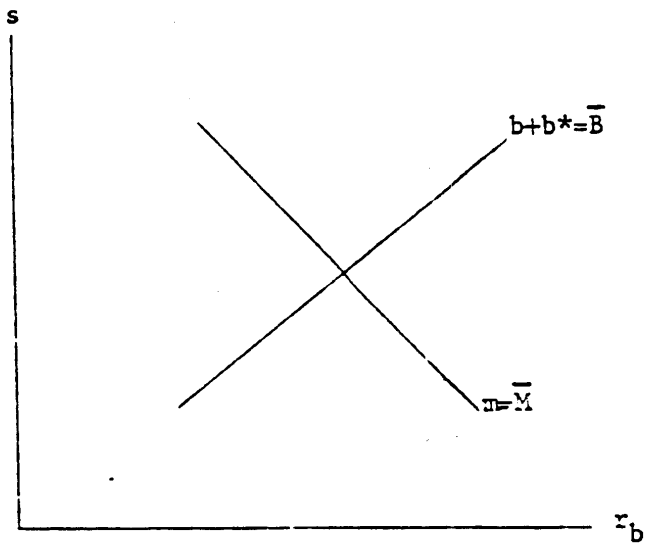
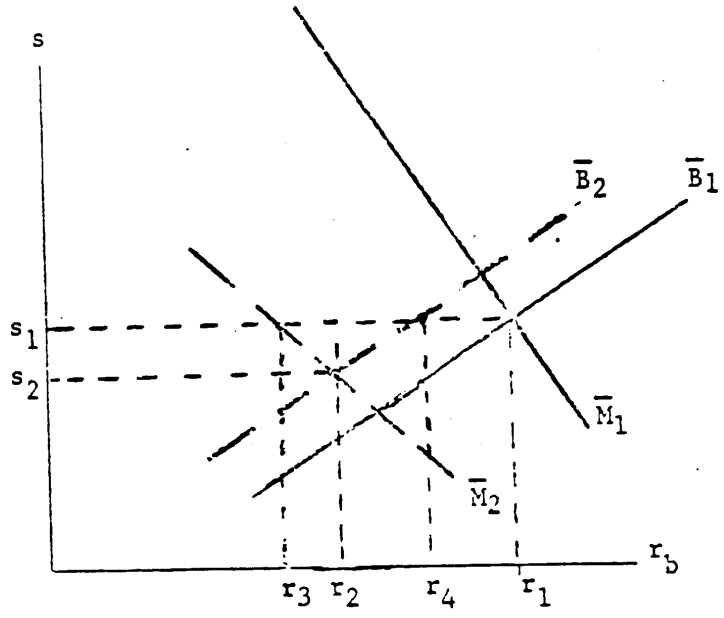


FIGURE 4

The Effects of Central-Bank Policies



increases; and since $\partial(b+b^*)/\partial r_b > 0$, the $b+b^*=\bar{B}$ curve shifts rightward when $\bar{B}$ increases. In addition, an increase in r_b, ceteris paribus, increases domestic demand for domestic bonds and reduces domestic demand for both money and foreign bonds, with the former increase equal to the sum of the latter reductions. Thus, $\partial(b+b^*)/\partial r_b > \partial b/\partial r_b > |\partial m/\partial r_b|$, which implies that an increase in $\bar{M}$ accompanied by an equal reduction in $\bar{B}$ shifts the $m=\bar{M}$ curve further to the left (at any particular value of s) than the $b+b^*=\bar{B}$ curve.[19/]

These results allow the following analysis of an open-market purchase of domestic bonds by the domestic monetary authorities. As illustrated in Figure 4, the $\bar{M}$ curve shifts leftward from $\bar{M}$ to $\bar{M}_2$ while the $\bar{B}$ curve also shifts leftward from $\bar{B}_1$ to $\bar{B}_2$. The increase in the money supply puts downward pressure on the domestic interest rate. At the initial exchange rate s_1, the increase in the demand for money arising from a fall in the interest rate would be less than the reduction in the demand for domestic bonds, since asset holders would shift not only from domestic bonds to money but also from domestic bonds to foreign bonds. This latter shift would put downward pressure on the exchange rate--i.e., the point (r_3, s_1) is not an equilibrium position. So in fact a depreciation is required to restore equilibrium (at r_2, s_1) by dampening the reduction in the demand for domestic bonds.

It can be noted that the extent of the required exchange-rate depreciation, and the resulting interest-rate change, depend on the extent to which asset holders attempt to switch between domestic assets and foreign bonds when the domestic interest rate falls relative to the foreign interest rate. For the extreme case of strict and effective capital controls, in which domestic residents were not permitted to hold foreign bonds and

19/ That is, at any particular value of s the reduction in r_b required to equate $\Delta(b+b^*)=\Delta\bar{B}=-\Delta\bar{M}$ = is less than the reduction in r_b required to equate $\Delta m=\Delta\bar{M}$, for $\Delta\bar{M} > 0$.

foreign residents were not permitted to hold domestic bonds, an open-market purchase would shift the $\bar{B}$ curve as far to the left as the $\bar{M}$ curve, and equilibrium would be restored at a lower interest rate with no change in the exchange rate. More generally, the extent of depreciation will be greater, and the interest-rate decline smaller, the more substitutable are domestic assets for foreign bonds. If domestic and foreign bonds were perfect substitutes, the decline in the domestic interest rate, given a fixed foreign interest rate, would equal the amount by which the exchange-rate depreciation reduced the expected future rate of exchange-rate depreciation.

It can also be noted that the exchange-rate depreciation which follows an open-market monetary expansion will be smaller, ceteris paribus: (a) the greater the extent to which a depreciation lowers expectations of future depreciation (i.e., the more negative is $\partial S/\partial s$); (b) the greater the extent to which domestic-asset portfolios are initially allocated to foreign bonds (i.e., the more negative is $\partial W/\partial s$); and symmetrically, (c) the greater the extent to which foreign-asset portfolios are initially allocated to domestic bonds.[20/]

20/ Parts (a) and (b) of this result can be demonstrated by totally differentiating conditions (10a) and (11a), and then solving for ds and dr_b as functions of $d\bar{M}=-d\bar{F}$. It can also be noted that ds is inversely related to $\partial W^* \partial s$. But interpretation of this relationship is complicated by the fact that b^* and W^* are not measured in the home-currency unit of foreign portfolio holders, and intuition suggests that the appropriate result must be the symmetric analog of conclusion (b), which is the basis for conclusion (c).

As a final point it is worth distinguishing exchange-market intervention that exchanges foreign assets for domestic money from sterilized intervention that essentially exchanges foreign assets for domestic bonds. Because of their different effects on the composition of (outside) asset supplies available to private portfolio holders, the two types of intervention have different effects on market interest rates and exchange rates. Returning to Figure 4, suppose the intervention authorities want to keep the exchange rate fixed at s_1 subsequent to the open-market operation that in the absence of intervention would push the economy to (r_2,s_2). Intervention sales of foreign assets for domestic money could push the economy to the point (r_4,s_1), whereas intervention sales of foreign assets for domestic bonds could push the economy to (r_3,s_1). Or, to draw the distinction in a different way, the interest-rate decline attendant upon an open-market monetary expansion of any particular size is greater under fixed exchange rates than under flexible rates if exchange intervention (under fixed rates) is sterilized to essentially swap foreign assets for domestic bonds, but is smaller under fixed rates than under flexible rates if exchange intervention is conducted by swapping foreign assets for domestic money with no sterilization.

4. EMPIRICAL APPLICATIONS OF FINANCIAL-EQUILIBRIUM MODELS: SELECTED EXAMPLES

The recent period of widespread floating has stimulated several attempts to explain exchange-rate movements empirically. Analytic models of open economies with financial markets have provided the underlying framework for two different empirical approaches: (1) attempts to estimate "complete" or multiple-equation models of open economies, and to explain exchange rates as one of several simultaneously-determined endogenous variables; and (2) the short-cut approach of estimating a single-equation reduced-form model of the exchange rate, generally derived by singling out and manipulating one of the several equilbirum conditions that would constitute a complete open-economy model.

4.1 The monetary approach

Most examples of the latter short-cut approach derive exchange-rate equations by manipulating money-market equilibrium conditions, thereby acquiring the labor of "the monetary approach" to exchange-rate determination. This approach has produced several interesting variations, as exemplified by Bilson (1976), Frenkel (1976) and Girton and Roper (1977). Other references can be found in Magee's (1976) survey article.

Frenkel develops a model of the mark-dollar exchange rate during the German hyperinflation, which is tested with monthly data for the period February 1920-November 1923. The demand for German money, measured in real units (M^d/P), is represented simply as a function of the expected rate of German inflation (ρ^*), on the asumption that the effects of these expectations swamped the effects of changes in either real income or the real rate of

interest during the time period under consideration:

$$M^d = Pg(\rho^*) \quad \text{with } \partial g/\partial \rho^* < 0$$

The U.S. price level is assumed to be fixed and normalized to equal 1, and the assumption of purchasing-power parity is invoked to equate the exchange rate (S, in marks per dollar) with the German price level (P). Equating nominal money demand to nominal money supply (M) then yields the exchange-rate equation

$$S = M/g(\rho^*)$$

By assumption, the expected rate of inflation equals the expected rate of currency depreciation, which in turn is assumed to be reflected by the forward discount on the mark ($\rho - 1$). A log-linear version of the exchange-rate equation is then estimated as:

$$\log S = \underset{(0.731)}{-5.135} + \underset{(0.050)}{0.975}\log M + \underset{(0.073)}{0.591}\log \rho$$

$$\bar{R}^2 = 0.994, \quad D.W. = 1.91$$

with standard errors shown in parentheses. The model is supported by the goodness of fit, the signs and significance of the coefficients, and the fact that the coefficient on logM does not differ significantly from unity.

Frenkel's model is based on the assumption of purchasing-power parity, which has credence during times of hyperinflation, but which has been discredited as a short-run hypothesis in more general circumstances (recall section 2.1). An interesting monetary approach which avoids the purchasing-power-parity assumption is that of Girton and Roper (1977), who generalize their model to explain "exchange-market pressures" under either fixed, floating or intermediate exchange-rate regimes. The reduced-form equation of this model, with reference to the exchange rate between the Canadian and U.S. dollars, has the form:

$$e_c + r_c = a_o + a_1 d_c + a_2 h_u + a_3 y_c + a_4 y_u + v$$

where

e_c = the rate of appreciation of the Canadian dollar

r_c = the increase in Canada's international reserves, valued in Canadian dollars, as a fraction of the Canadian base-money stock

d_c = Canadian domestic-credit expansion as a fraction of the Canadian base-money stock

h_u = the rate of growth of the U.S. base-money stock

y_c, y_u = the rates of growth of real income in Canada and the United States, respectively

v = random error term

The dependent variable is viewed as a measure of exchange-market pressure. The model is applied to annual data and explains roughly 95 per cent of the variation in $e_c + r_c$ during the 1952-1974 period, with the estimated slope coefficients all having expected signs and significant at the 95 per cent confidence level. In order to test the sensitivity of the results to the composition of exchange-market pressure -- i.e., to whether the exchange rate is predominantly fixed or predominantly allowed to float -- Girton and Roper reestimate the model with $Q = e_c/r_c$ included as an additional right-hand-side variable. The coefficients are left essentially unchanged by the inclusion of Q. This result is interpreted as empirical confirmation that the model is insensitive to the composition of exchange-market pressure.

Bilson (1976) presents a third type of monetary approach, combining the assumption of purchasing-power parity with the hypothesis that the money-market equilibrium condition may be written as:

$$\log M_j = a_j + \log P_j - bi_j + c\log Y_j$$

where

M_j = the money supply in country j

P_j = the price level in country j

i_j = the nominal interest rate in country j

Y_j = real income in country j

and where the interest-rate and income parameters of the money-demand function (b and c) are assumed to be the same for all countries. The assumption of purchasing-power parity allows Bilson to write

$$\log e_j + \log M_o - \log M_j = (a_j - a_o) - b(i_j - i_o) + c(\log Y_j - \log Y_o)$$

where the subscript o denotes the United States and e_j is the exchange rate for country j (in units of currency j per U.S. dollar). The model is estimated from annual data for the 1954-1974 period pooled over 33 countries, with exchange rates and money supplies combined into a single endogenous variable, as in the above specification. The estimates are then used to construct in-sample predictions of exchange rates. The mean absolute percentage error in the predicted logrithms of exchange rates is 16 per cent when country-specific information is taken into account.

4.2 Multiple-equation models

The analytic models of chapter 3 have stressed that the exchange rate is one of several simultaneously-determined endogenous variables. In this context, single-equation (reduced-form) empirical models can have serious shortcomings.

At the other end of the empirical spectrum, large-scale econometric models, at least those for the U.S. economy, are felt to inadequately

represent the foreign sector, particularly in their treatment of capital transactions, and thus to provide inadequate (if any) descriptions of exchange-rate determination. Such sentiment has stimulated a model-building effort currently underway at the Federal Reserve Board, in which: (i) the world is divided into 5 countries (the United States, Canada, Germany, Japan and the United Kingdom) and a Rest-of-the-World bloc; each of these 6 blocs is viewed to consist of markets for 5 composites--goods, labor, money, short-term securities and long-term securities; and (iii) there are a total of 29 independent market-clearing conditions, or 29 independent endogenous variables, including 5 independent bilateral exchange rates. (See Berner et al., 1976, for a description of this model-building effort.)

An interesting model of Germany's monetary sector and the dollar-Deutschemark exchange rate has been estimated by Artus (1976). Artus spells out both demands for and supplies of the most important items on the Bundesbank's balance sheet, specifying behavioral assumptions about both the Bundesbank's demands or supplies and the counterpart supplies or demands of the private sector. The introduction of policy-reaction functions, or endogenous central-bank behavior, is innovative (although the particular specifications of policy-reaction functions can be criticized), and the two-stage simultaneous estimation of a 5-equation reduced-form model is commendable. It is noteworthy that the model provides empirical support (based on monthly data for the period between March 1973 and July 1975) for the view that exchange rates move in speculative runs: a 1 per cent appreciation of the mark in any given month is estimated to generate an additional .3 per cent appreciation in the next month, ceteris paribus. A major criticism of the Artus model is

that it does not adequately take account of the major transfers of wealth from oil-importing countries to the oil-exporting (OPEC) countries, which probably had major impacts on exchange rates during the sample period. A second criticism is that Artus does not treat expectations of exchange-rate changes as "rational" in the sense of being consistent with the specification form that is assumed to describe observed exchange-rate changes.

Armington and Armington (1976) have been simulating, and hope to estimate, a multilateral portfolio-balance model of exchange-rate movements. One noteworthy feature of their model is the assumption that private asset holders throughout the world can be aggregated into a single collectivity, without regard to country of residence, having a single stable set of portfolio preferences. Private demands for assets denominated in difference currency units are thus represented as functions of expected yields and net global private wealth. This aggregation of wealth seems quite restrictive. Among other things it denies conventional notions about the transations demand for money.

A number of other multiple-equation models with exchange rates have been estimated, including several of the Canadian economy during the 1950s. Not to be overlooked is Black's important study (1973) of international financial markets and the dollar-pound exchange rate during the 1936-39 period. Black provides a stock-equilibrium model of the simultaneous determination of spot and forward exchange rates and interest rates, in which expectations of future spot rates are "rational" in the sense of reflecting perfect foresight.[1/]

1/ McCallum (1977) uses a similar representation of rational expectations in his study of the forward rate between the Canadian and U.S. dollars during the 1953-60 period. McCallum bases his estimates on a model of the net flows of foreign exchange demanded by interest arbitragers, speculators and traders -- as distinct from a model of asset-stock equilibrium.

Unfortunately, Black's framework requires data on forward-exchange positions. Such data are no longer available, and this precludes the direct applicability of his model to recent periods.

5. IMPORTANT CHALLENGES FOR RESEARCH

The preceding chapters have pointed to several major shortcomings of the models that are presently available for analyzing the process of exchange-rate determination. One shortcoming is the inadequate representation of the foreign sector in large-scale econometric models. The multicountry-model-building efforts of Berner et al. (1976) and Armington and Armington (1976) are attempts to remedy this deficiency.

Considerable scope also exists for additional analysis of the dynamics of smaller-scale portfolio-balance models, such as the streamlined model presented in the appendix to chapter 3. Important new ground has been broken by the dynamic models discussed in section 3.8, but better descriptions are needed of the complete time path of the exchange-rate response to a monetary or fiscal-policy change that shifts the time paths of current-account balances and asset supplies, and which thereby sets in motion a continuing shift in the size, residence and currency-composition of private wealth.

Addition of the dynamics of wealth accumulation may well complicate the analysis of portfolio-balance models to a degree that precludes any new and unambiguous theoretical insights. As an alternative, the challenge of better modelling the dynamics of wealth accumulation might be tackled empirically, through the estimation of portfolio-balance models in a dynamic multi-period framework. Unfortunately, the empirical counterpart of even the streamlined model of portfolio equilibrium requires data that at present are incompletely collected, partially confidential, and difficult to assemble. In particular, empirical portfolio-balance models require data on global stocks of outside assets (public debt) not held by official agencies, broken down by currency of denomination, rather than by debt-issuing country. In addition, unless it is assumed that the private sectors of different countries

have similar asset preferences (in the sense that the interest-bearing portions of private-sector portfolios are allocated to assets denominated in different currency units in proportions that are invariant to the private sector's country of residence), it seems necessary to know the currency composition of each private sector's portfolio, inclusive of positions in forward exchange.

Judgement of how well empirical portfolio-balance models can make do with existing data is beyond the scope of this paper. Only very-limited data are available on the currency composition of the portfolios of the oil-exporting countries (OPEC); and our inability to isolate OPEC behavior is particularly bothersome in view of inferences that the composition of OPEC portfolios during the past several years has both fluctuated widely and differed substantially from the composition of private and official portfolios for other countries. The inference that OPEC portfolio preferences have differed from the portfolio preferences of other countries is supported by the striking fact that Germany's public debt (measured in marks) increased by more than 100 per cent between the end of March 1973 and the end of March 1976, almost twice the percentage increases over the same period in the public debts (measured in home-currency units) of France and the United Kingdom, and three times the percentage increases for Belgium, Canada and the Netherlands.[1/] Yet Germany had the strongest currency of all these countries during this period. An appealing explanation (loosely speaking) is that Germany was able to issue public debt in marks to pay for her

1/ Based on government debt figures from the International Monetary Funds's International Financial Statistics, and for the United Kingdom, from the Financial Statistics of the Central Statistical Office.

higher oil bills, while other countries were not as able to issue public debt in their own currencies and instead resorted to foreign borrowing in U.S. dollars. The obverse of this explanation, however, would be that the OPEC countries were more willing to accumulate mark-denominated assets than to denominate their new wealth in the currencies of the other countries.

The strength of the German mark during a period of relatively-rapid expansion of German public debt may well be due to a combination of factors, however. Explanations can be suggested that do not rely on the conjecture that OPEC has relatively-strong portfolio preferences for assets denominated in marks. Dornbusch and Krugman (1976) have recently stressed that both inflation rates and exchange rates are quite sensitive to the mix of fiscal and monetary policies that are used to provide a given aggregate stimulus to real output. Monetary expansion alone will depreciate the exchange rate, which in turn will lead both directly and indirectly to higher domestic prices, and perhaps to a further spiral of exchange-rate depreciation and domestic inflation. If expansion is pursued through fiscal policy, however, combined with whatever mix of monetary policy is appropriate to hold the exchange rate steady (which Dornbusch and Krugman take to be the monetary policy that holds the domestic interest rate steady relative to foreign interest rates) the same expansion of real output can be achieved without stimulating currency depreciation and domestic inflation.[2/]

Dornbusch and Krugman have revived the old but important issue of appropriate policy mixes. The development of models that directly relate exchange-rate movements to the mix of monetary and fiscal policies

2/ This result is based on a conventional model in which fiscal expansion leads to currency appreciation, at least in the short-run.

can provide a better understanding of both the German experience and the factors that underlie the large doses of currency depreciation and internal inflation experienced by some other countries.

In addition to requiring better models of the process of wealth accumulation and the role of policy mixes, an improved understanding of exchange-rate behavior requires better models of exchange-rate expectations. Mussa (1976) has argued for assuming that expectations of future spot rates are rational in the sense of reflecting the same model that is assumed to describe the formation of observed exchange rates. (Recall section 3.9.) To the extent that prevailing spot rates depend on expected future spot rates as well as "other determining variables," and to the extent that expectations are rational, prevailing spot rates depend--through expected future spot rates--on current expectations of the future time paths of the "other determining variables." Mussa emphasizes that some of the joint volatility of observed spot rates and expected future spot rates (as indicated by observed forward rates) may be attributable to changes in <u>expectations</u> about policy variables. Further analysis within the framework suggested by Mussa may illuminate the underlying causes of volatility, pointing at the same time to potential cures.

Simultaneous modelling of current and expected future spot rates can also proceed without relying on Mussa's assumption of rational expectations. The general recognition that current and expected future spot rates are jointly-determined variables -- i.e., that events which have impacts on currently-observed spot rates also change expectations of future spot rates--denies the simple notion that an x percentage-point widening of the difference between domestic and foreign interest rates should be

associated with an x per cent change in the observed spot rate. Instead, it emphasizes that a change in the interest differential will affect expectations of future spot rates--and hence will affect prevailing forward rates-- as well as, and often in the same direction as, the prevailing spot rate. Thus, the spot rate will often have to change by more than x per cent, ceteris paribus, in order for the change in the forward premium (for a given maturity) to exactly match an x percentage-point change in the interest differential (on assets having the same maturity as the forward premium).

Simultaneous modelling of current and expected future spot rates, or of current spot and forward rates, is probably the key to improving the accuracy with which future spot rates can be predicted. Sophisticated models may never significantly exceed the accuracy of using observed forward rates as predictors of future spot rates. But sophisticated models may point out why spot and forward rates have been volatile in recent years, and how policy makers could reduce this volatility and thereby make forward rates more accurate predictors of future spot rates, if it were judged that the benefits of doing so would outweigh the costs.

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