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U.S. INTERNATIONAL CAPITAL FLOWS: PERSPECTIVES FROM RATIONAL MAXIMIZING MODELS

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I. INTRODUCTION

In the first half of the 1980s the United States experienced a large appreciation of the value of the U.S. dollar relative to foreign currencies in nominal and real terms. The current account of the U.S. balance of payments also moved from a surplus of $6.339 billion, which was 0.2% of GNP in 1981, into a series of large current account deficits, as the country evolved from a net exporter of capital to the rest of the world to a net importer of capital from the rest of the world.[1] The current account is graphed in Figure 1.

Even as the dollar began to depreciate in nominal and real terms, after peaking in February 1985, current account deficits continued to grow larger, reaching an annual rate of $164 billion in the second quarter of 1987, which was 3.7% of GNP. The counterpart of such deficits is a flow increase in U.S. net foreign liabilities. Even though there is some debate about the exact magnitude of the U.S. net external liability positic , with

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[1]Calculations are from the 1987 Economic Report of the President, Tables B-1 and B-99. The sources of all data used in the paper are described in a data appendix that is available directly from the author.

some economists, such as Milton Friedman (1987), arguing that the U.S. has not yet become the world's largest debtor nation since we continue to receive substantial asset income, the magnitude of the recent current account deficits and the rate of change of the current account over recent years appear perplexing and potentially dismaying.

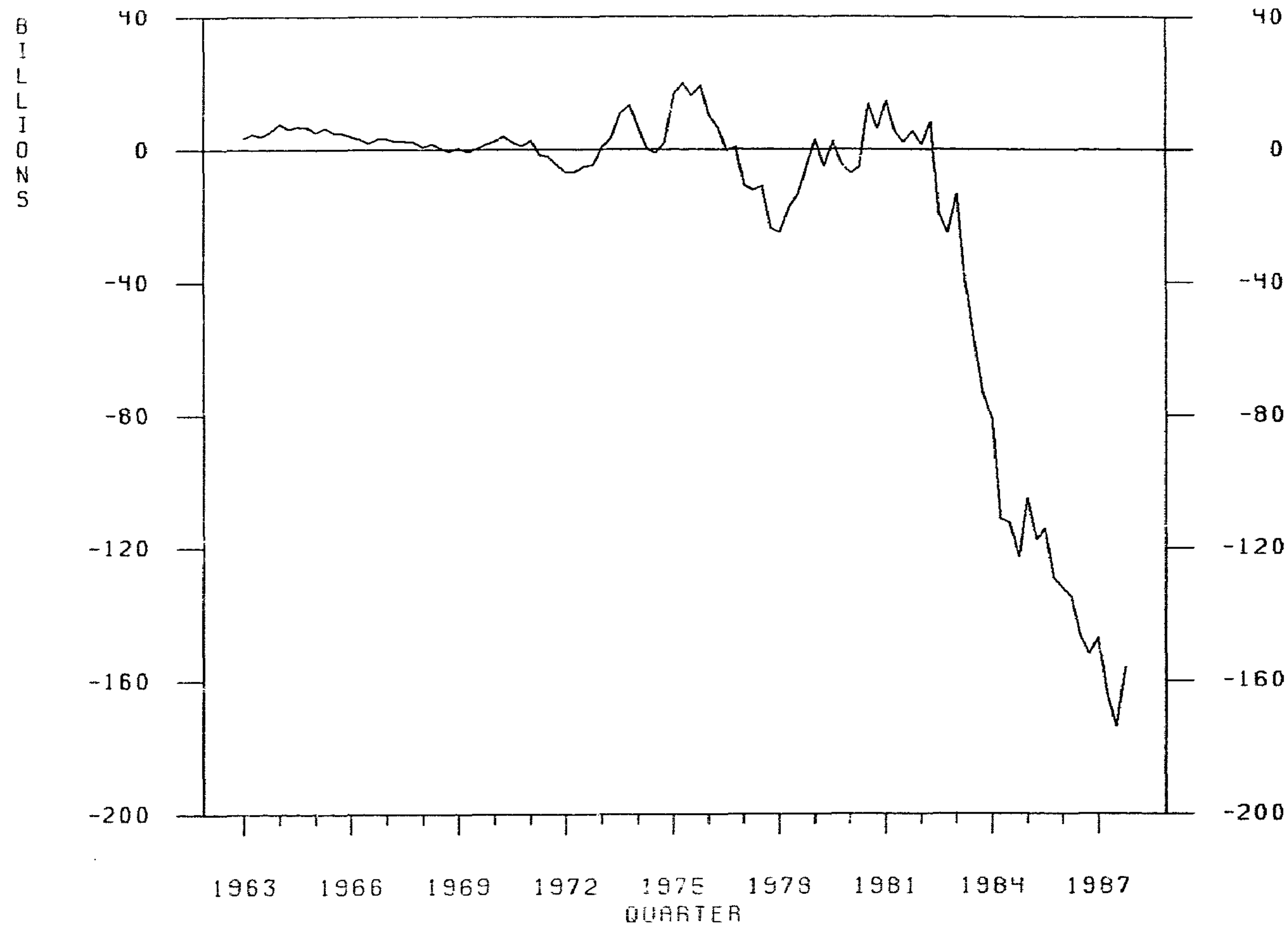
The purpose of this paper is to provide a perspective on these phenomena and to assist in the development of a theoretical and empirical foundation for discussion of the policy issues that are inherent in the analysis. Is the current account deficit a major policy problem that must receive high political priority? Has the United States become unable to compete abroad, or is the current account merely reflecting normal fluctuations associated with cyclical fluctuations and differential growth rates across countries? Are we impoverishing future generations by acquiring a massive amount of net foreign liabilities? Should we adopt protectionist policies that will cut the inflow of imports? Must we have either further depreciation of the dollar or protection of our industries, as Rudiger Dornbusch (1987) argues, if we are to achieve external balance without inducing a recession?

These are important and difficult questions, and I will return to them briefly in the conclusion of the paper. My primary purpose, though, is to ask how we should attempt to model these ideas and to examine two approaches that place other research in perspective.

I first examine the data graphically to summarize the issues. I next discuss some conventional wisdom that is often cited in policy discussions and the popular press as explanations of U.S. capital flows. This analysis focuses on differential growth rates of real income and demand in the United States and abroad, on the real value of the dollar in foreign exchange markets, and on the federal budget deficit of the Reagan administration which is seen as one of the driving forces in the appreciation of the dollar. This, in turn, is thought to be a major cause of the deterioration in the balance of trade. I then discuss two types of dynamic economic theoretical models that could provide explanations of the phenomena.

The first theoretical model is a version of the Lucas (1982) model that has become a workhorse of international financial asset pricing. I extend the analysis of Stockman and Svensson (1987) who first explored capital flows in this two-country framework. Government budget deficits are not the cause of capital flows in this model since it has the property

FIGURE 1 US CURRENT ACCOUNT



of Ricardian equivalence.[2] The second model is a stochastic two-country overlapping generations economy in which the Ricardian equivalence property does not hold. The stark contrast between the implications of the two models sets up a discussion of some empirical work that extends the evidence of Paul Evans (1986).

Additional empirical evidence on alternative models of expected returns in international financial markets is then presented. This evidence is addressed to the question of whether it is appropriate to use an assumption of risk neutrality in discussing the evolution of exchange rates and capital flows.

II. POPULAR STORIES AND CONVENTIONAL WISDOM

This section discusses the results of several economic analyses of the U.S. current account that have been advanced in recent years.

The Official Explanation

Chapter 3 of the 1987 Economic Report of the President outlines one of the popular descriptions of the causes of the deterioration of the current account balance of the United States. The focus is directly on the trade balance rather than on the determinants of aggregate savings and investment. Imports are thought to be determined by the income of a country and the relative prices or terms of trade that the country faces, with exports determined symmetrically by foreign incomes and relative prices. The explanation is the following.

In the years following the 1981-82 recession, U.S. imports grew rapidly while U.S. exports were stagnant for essentially three reasons. First, demand in the United States, from increased real income, grew faster than in our developed country trading partners who continued to experience high unemployment rates and comparatively sluggish growth of their real economies. Second, the problems of developing country debts, especially in Latin America, reduced demand for U.S. exports to those countries, which were forced by the debt crisis to expand their exports and contract their imports in order to avoid acquiring additional debt and to begin to service

[2]Ricardian equivalence is a property of the equilibrium of an economy in which the mix of financing of the government sector between bond issues and taxation does not matter.

their outstanding debts. Third, the United States became increasingly uncompetitive in world markets as a result of the large real appreciation of the dollar.

Before continuing to discuss alternative explanations of the current account, it is useful to examine Figure 2 which places the nominal data of Figure 1 in perspective by dividing by the nominal U.S. gross national product. I have also included in Figure 2 the ratios of exports of the U.S. to GNP (measured positively) and imports of the U.S. to GNP (measured negatively). Both imports and exports have increased as a percentage of GNP since the 1960s. The large current account deficit of Figure 1 does not appear quite so daunting when it is placed in perspective by dividing by GNP.

The initial deterioration of the trade balance is also not particularly surprising given the large appreciation of the dollar that began in 1979. Figure 3 graphs the real exchange rate of the U.S. dollar as measured by the International Monetary Funds relative unit labor cost. A large real appreciation of the dollar lowers the prices of foreign goods in the United States and raises the prices of U.S. goods abroad. The large real depreciation that began in 1985 should similarly raise the prices of foreign goods in the United States and decrease the prices of U.S. goods abroad.[3]

Explanations Of Large Econometric Models

The deterioration of the current account has been the focus of a number of recent studies employing large econometric models, and these studies support the hypothesis that less has changed than one might have thought from a casual glance at Figure 1. The results of several forecasting experiments are reported in Bryant, Holtham, and Hooper (1988). Bryant and Holtham (1988) report the results of forecasting experiments from eight large models, and Helkie and Hooper (1988) report the results of a partial equilibrium analysis that is essentially based on the U.S. current account sector of the Federal Reserve Board Multicountry Model.

Given the Lucas (1976) critique of the practice of building econo-

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[3]Feldstein and Bacchetta (1987) examine whether the U.S. dollar has actually fallen significantly relative to U.S. trading partners. They find, using the latest multilateral trade weights from 1984, that the dollar appreciated in real terms by 40% from January 1980 until February 1985, and that by May 1987 it had reversed three-fourths of the appreciation.

FIGURE 2 US CUR ACCT DATA/GNP

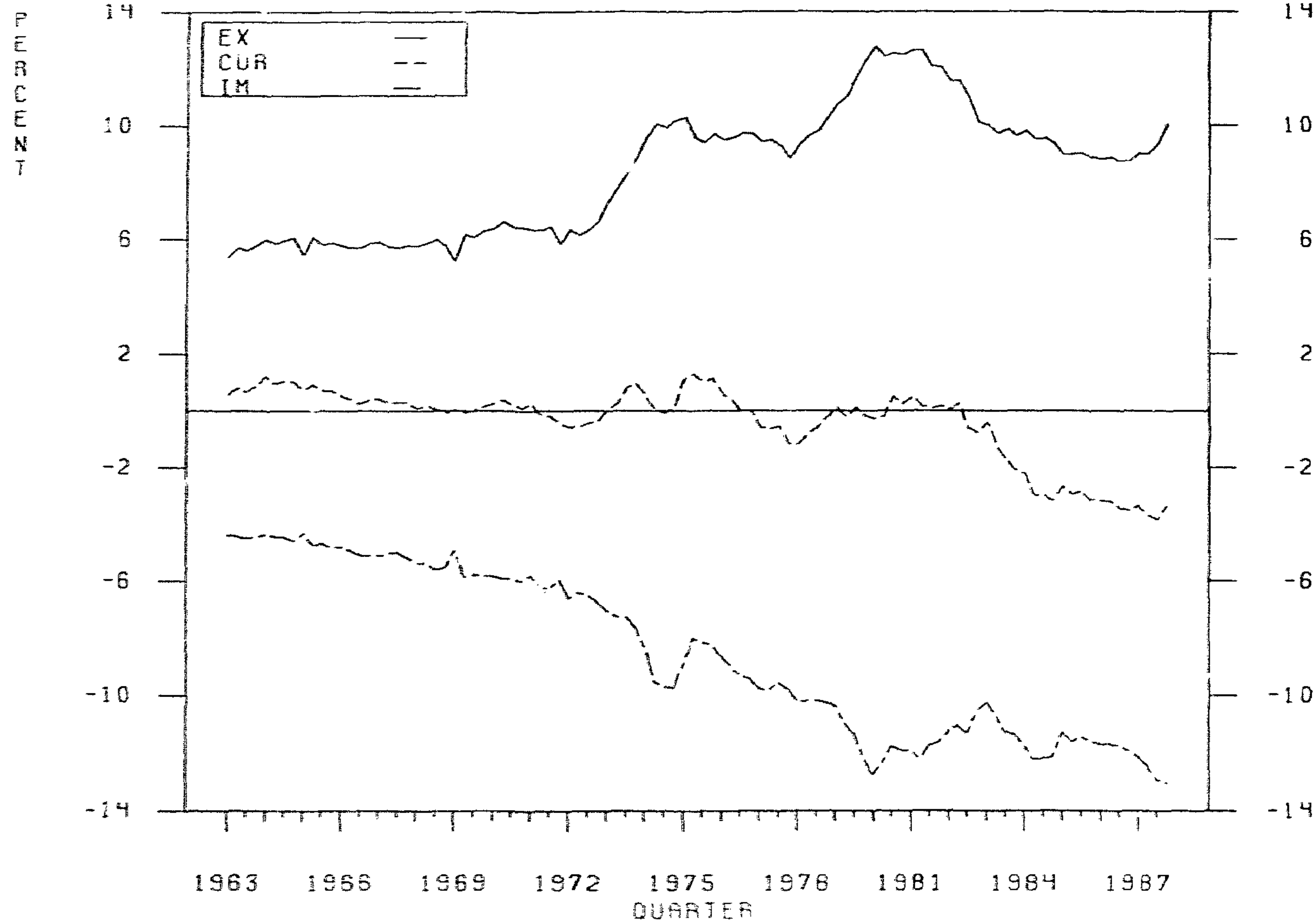
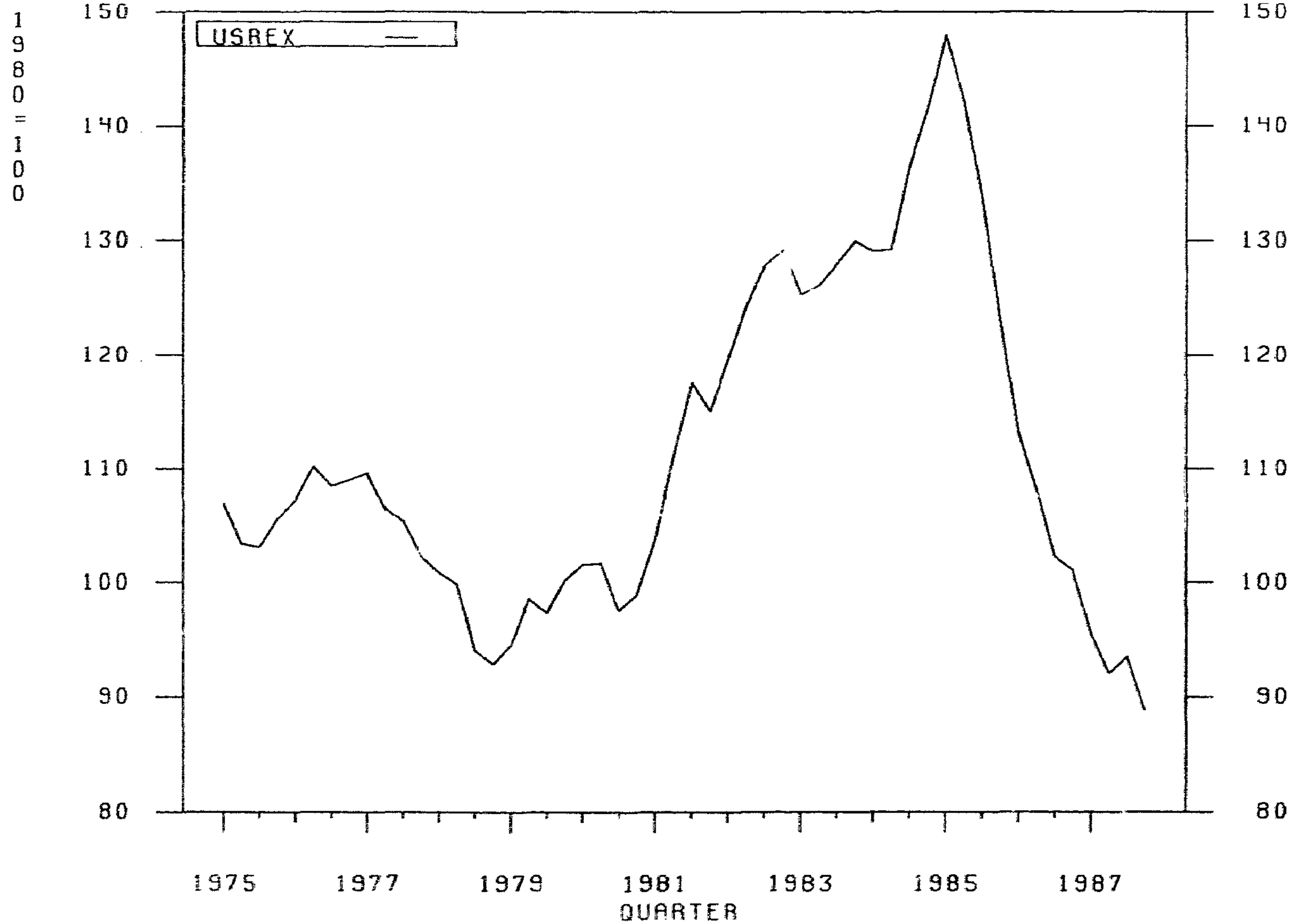


FIGURE 3. US REAL EXCHANGE RATE



metric models without explicit consideration of the maximizing problems of economic agents, it seems unlikely to me that the large econometric models are capturing the true economic structure in the economy. Nevertheless, the models incorporate income and substitution effects of current and lagged variables, and it is interesting to ask how well the models predicted the current account deficit of the 1980s given their historical parameter values estimated until 1980 and the out-of-sample values of real GNP in the United States and abroad, the respective rates of capacity utilization, and the course of real exchange rates. This is the experiment reported in Bryant and Holtham (1988) who conclude (p. 59), "past macroeconomic relationships can successfully predict the deterioration of the U.S. external imbalance...(since) the predictions were often within a few billion dollars of the actual deficit in 1986, more than five years after the start of the dynamic simulations."

One major reason why large econometric models are not considered structural is that the distributed lags in their decision rules often can be shown to be a confounding of the equilibrium dynamic distributed lag responses of agents due to various costs of adjustment with the distributed lags necessary to forecast relevant state variables. If the large econometric models continue to track the current account in dynamic simulations, one reason may be that the forecasting problem has not changed. In this sense the structure of the economy is not different.

Similarly successful out-of-sample forecasting results are reported by Helkie and Hooper (1988). Their model breaks the current account into a nineteen-equation system with the major component, merchandise trade, being comprised of an eight-equation system. Four equations are for the volumes of imports and exports of agricultural and nonagricultural commodities. A fifth models U.S. oil consumption, and three equations are for the relative prices of exports of agricultural and nonagricultural commodities and of nonoil imports. The specification has been subject to considerable search, as evidenced by the differences across the lag lengths of relative price variables in the various equations. The authors also admit that some of the variables are ad hoc adjustments included because of deficiencies in the data. Nevertheless, Helkie and Hooper (1988) find that the post-sample (1985-86) performance of their model has smaller root mean squared prediction errors than the average in-sample errors.

Given that large econometric models with ex post values of real incomes and relative price variables can track the current account, is it fair to conclude that the structure of the world has not changed? It seems that the answer is yes, and the interesting issue becomes what the sources of the fluctuations are in these variables.

The 1987 Economic Report of the President states (p. 97), "Underlying these developments are several macroeconomic imbalances, including the deterioration of the U.S. saving-investment balance that has resulted from the failure of the Federal Government to bring its expenditures in line with revenues."

It is clear that the Report takes as exogenous the government budget deficit and assumes that the imbalance between government purchases and revenues is not sufficiently offset by private sector savings such that the current account must be in deficit. There is a superficial plausibility to this argument, especially if one looks only at data from the 1980s, because the size of the federal government budget deficits is roughly of the same magnitude as the current account deficit.

Before turning to the development of more formal economic models, I discuss the merits of some analysis of the current account deficit that has been done by Dornbusch (1987).

An Informal Regression Approach

Policy discussions of the U.S. current account often incorporate simple regressions of the type reported by Dornbusch (1987). He regresses the U.S. NIPA net exports relative to GNP on a constant, a time trend, a distributed lag of the logarithm of the real exchange rate, and a distributed lag of the logarithm of U.S. demand relative to foreign demand measured by a weighted average of demand in the OECD countries.[4] The regression incorporates a correction for serial correlation. The reported results for a sample of quarterly data from 1975 to 1986 with t-statistics in parenthesis are the following:

$$\underset{}{NET} = \underset{(7.86)}{90.0} - \underset{(-3.78)}{5.961\log(P/ep^*)} - \underset{(-3.68)}{12.23\log(D/D^*)} - \underset{(-6.18)}{0.04Time} + \varepsilon \qquad (1)$$

$$\bar{R}^2 = 0.96; \quad \text{rho} = 0.43; \quad \text{standard errors} = 0.28$$

[4]Dornbusch (1987) reports that the real exchange rate is the International Monetary Fund's value-added deflator in manufacturing from the IMF's International Financial Statistics. The index of relative levels of real gross domestic spending is constructed from a weighted average of interpolated OECD annual data with weights given by GNP shares.

Dornbusch (1987, p. 257) states, "The regression shows that real exchange rates and relative spending levels are significant determinants of net exports. A 16-percent real depreciation increases net exports by 1 percent of GNP, as does an 8-percent rise in the level of foreign real spending. There is an adverse time trend in net exports that leads over a six-year period to a deterioration in net exports by one percent."

Dornbusch used the estimated coefficients to argue that the real value of the U.S. dollar must fall or we must adopt protectionist policies, since the necessary correction of the current account could not be produced in sufficient time by an expansion of demand in Europe and Japan. Contracting demand in the United States by raising taxes is ruled out on the grounds that it would produce unemployment. It is argued that what is needed is an appropriate combination of expenditure-switching policies to keep demand for our products and employment in U.S. production high, with expenditure-reducing policies to cure the trade balance deficit.

While I do not have space to document the theory underlying this analysis, Dornbusch's neo-Keynesian policy advice is based on an essentially static theory supplemented with ad hoc dynamics. The key element in the analysis is the regression. It is the implausibility of faster foreign growth combined with the size of the coefficient on relative demand that leads to the call for a change in government policy or an explicit drive to depreciate the dollar in real terms.

There are several potential problems with the regression. One is simultaneous equation bias. Typical rational expectations models, like the one presented in the next section, call for simultaneous determination of the current account and the real exchange rate. Another aspect of the regression that is suspect is the serial correlation correction. What is the source of the exogenous serially correlated variable that is left out of the regression? Alternative models of dynamics might call for a lagged dependent variable. A third problem is the significant time trend. It is implausible that net exports as a percent of GNP will deteriorate forever at a rate of one percent every six years. Foreign investors are unlikely to finance a deficit forever.

Consider the following regression that is similar to the one above. I regress the U.S. current account relative to GNP on a constant, trend, one lag of the dependent variable, and one lag of the logarithm of the real exchange rate and the logarithm of U.S. real GNP relative to a weighted average of the real GNP or GDP of France, Germany, Japan, and the United Kingdom. The data are quarterly, and the sample is 1975:2 to 1986:2. The results with t-statistics in parenthesis are the following:

$$\begin{aligned} CUR/GNP = \ & \underset{(1.91)}{17.13} + \underset{(7.77)}{0.78}\,(CUR/GNP)(-1) - \underset{(-2.49)}{2.11}\,\log(P/eP^*)(-1) + \\ & -\underset{(-1.24)}{5.50}\,\log(Y/Y^*)(-1) - \underset{(-1.17)}{.02}\,Time + \varepsilon \end{aligned} \qquad (2)$$

$$\bar{R}^2 = .94; \quad \text{standard error} = .34; \quad Q(18) = 9.10.$$

The dynamics of equation (2) are very different from the dynamics of equation (1). The presence of the lagged dependent variable with a coefficient of 0.78 implies larger ultimate effects of changes in real relative GNP and the real exchange rate. A permanent 8-percent increase in foreign GNP relative to U.S. GNP now implies an improvement of the current account by 2 percent of GNP, and a 16-percent real depreciation improves the current account by 1.5 percent of GNP. There is also no significant negative time trend in (2). These are merely the point estimates, and 95-percent confidence intervals around these forecasts would be quite large.

Is equation (2) superior to equation (1) for policy purposes? My direct answer is no, but neither is the latter superior to the former. What is needed is a better understanding of the stochastic nature of the economy and the way in which economic agents react in that stochastic environment. It is the role of economic theory to provide this understanding, and I now turn to the development of alternative frameworks that can be used to address the questions of the determinants of the U.S. current account.

III. AN EARLY RATIONAL FRAMEWORK FOR CAPITAL FLOWS AND EXCHANGE RATES

I now discuss a model that is a useful foundation for the economics behind the informal discussions of the previous sections. The model is taken from Mussa (1984). Mussa's framework considers a country that is large in the market for its own good but small in the market for world assets and the foreign good. While this is probably a poor description of the United States, the issues here are sufficiently complicated relative to some recent arguments regarding the nature of U.S. current account deficits that a review appears warranted. The model is also sufficiently general that these ideas ought to be present in any correct formulation of the economics of the current account and real exchange rate determination.

The trade balance is derived from an equilibrium condition in the market for home goods. Foreign demand for the home good is

$$d_t^* = - \beta^* q_t + x_t^*. \tag{3}$$

It depends negatively on the natural logarithm of the relative price of the home good in terms of foreign goods, q_t, which is the home country's terms of trade, and on an exogenous shift variable, x^*. An improvement in the terms of trade is an increase in q_t, and this will be identified with a real appreciation of the domestic currency. The home country's excess demands for foreign goods, f, and for home goods, d, are specified as follows:

$$f_t = (1 - \sigma)\bar{y}_t + \beta q_t - x_t \tag{4}$$

$$d_t = \sigma \bar{y}_t - \beta q_t + x_t. \tag{5}$$

These excess demands depend on the terms of trade, on an exogenous shift variable, x, that affects the relative demands for domestic and foreign goods, and on the excess of expenditure over the value of domestic product, $\bar{y}$. From a market-clearing condition in the domestic goods market, $d_t + d_t^* = 0$, and from the accounting identity that the trade balance surplus is the negative of the excess of a country's expenditures over the value of its production, the trade balance is found to be

$$TA_t = - \bar{y}_t = \nu(z_t = q_t), \tag{6}$$

where $\nu \equiv (\beta + \beta^*)/\sigma$ and $z_t \equiv (x_t + x_t^*)/(\beta + \beta^*)$.

At any point in time the economy has a stock of foreign asset denoted A_t that have a return r^*. The change in net foreign assets is the value of the current account, the trade balance plus the income on net foreign assets:

$$A_{t+1} - A_t = \nu(z_t - q_t) + r^* A_t. \tag{7}$$

The change in net foreign assets is therefore simultaneously determined with the real exchange rate, and equation (7) incorporates a crucial assumption of a constant real interest rate on net foreign assets.

Clearly, Mussa's equation for the current account is simple, since at the same values of the exogenous shift variable, z_t, and of the predetermined variable, A_t, the same q_t should produce current account balance. This type of reasoning leads some economists to argue that the dollar currently must depreciate, since relative to 1980 when the current account was last in balance, we are now in debt, and the real value of the dollar is approximately where it was in 1980 but the current account is still in deficit. Yet, what is z_t, and do expectations of the future matter, since equation (7) is part of a simultaneous system that determines current and expected future time paths of q_{t+i} and A_{t+i} given the current level of A_t?

Given the simultaneous nature of equation (7), a second dynamic equation is necessary to solve the model, and it is a specification of the desired flow of expenditure relative to income, i.e., desired saving of foreign assets. In equilibrium this must be equal to the change in net foreign assets, and it is postulated to depend positively on the excess of the level of target net foreign assets, $\hat{A}_t$, relative to current net foreign assets, and to depend negatively on the domestic real interest rate, r_t. The domestic real interest rate is defined to be the rate of return on foreign assets minus the consumption share of the domestic good times the expected rate of change of the relative price of the domestic good. In Mussa's framework the desired or target level of net foreign assets is specified as an exogenous variable, hence the second dynamic equation is

$$r^*A_t - \bar{y}_t = \alpha(r_t - r^*) + \mu(\hat{A}_t - A_t), \tag{8}$$

where $r_t = r^* - \sigma E_t(q_{t+1} - q_t)$. The left-hand side of equation (8) is the excess of income over expenditure. The right-hand side indicates that, when the domestic interest rate is equal to r^*, the net foreign assets of the domestic country converge to their target level at the rate μ, but desired savings is also assumed to be positively responsive to increases in the domestic real interest rate. When people expect the relative price of the domestic good to fall, the real interest rate is high and people delay their purchases of home goods, which increases domestic saving.

The solution of the two equation system is a real exchange rate and a level of net foreign assets that is predetermined. The equilibrium is such that the real exchange rate is below its "long-run equilibrium level" when the net foreign assets of the economy are below their "long-run equilibrium level" as in

$$q_t = \bar{q}_t + \gamma[A_t - \bar{A}_t] \tag{9}$$

where the long-run levels are not constant. The long-run level of net foreign assets depends upon the discounted present value of target foreign assets, and the long-run level of the real exchange rate depends both upon the long-run level of net foreign assets and upon the discounted present value of the exogenous excess demand shifts that are both domestic and foreign in origin as in

$$\bar{A}_t = (1 - \theta) \sum_{j=0}^{\infty} \theta^j E_t[\hat{A}_{t+j}] \tag{10}$$

and

$$\bar{q}_t = (r^*/v)\bar{A}_t + (1 - \theta) \sum_{j=0}^{\infty} \theta^j E_t[z_{t+j}] \; . \tag{11}$$

Although the relationship between the current account and the real exchange rate is simple, if one knows z_t, there need not be a well-defined relationship between the level of the real exchange rate that clears the balance of payments at a particular point in time and the magnitude of the current account when that real exchange rate is at that same level at some other point in time.

The inadequacy of the model of this section is highlighted by its inability to address interesting policy issues. Although it is a rational expectations model, it does not have firm microeconomic foundations for its expenditure and excess-demand functions. We also need information on expected future values of exogenous variables that shift excess-demand functions toward and away from U.S. goods.

Adequate economic models of the current account and capital flows should be based on maximizing behavior, should be explicitly stochastic so that they may be addressed to data, and should account for growth of real income and for the role of the government sector in the economy. Given the importance of expectations of the future in equation (11), current modeling strategies dictate that the model should also have rational expectations. I therefore turn to the discussion of such models.

IV. A RICARDIAN MODEL

The purpose of this section is to lay out an explicitly maximizing rational expectations model that has been used to address issues of exchange rate determination, international financial asset pricing, and capital flows. The section builds heavily on Stockman and Svensson (1987). My basic purpose here is to add government sectors to their framework.[5]

Countries and Production Possibilities

There are two countries, denoted country one and country two, that each produce a distinct good denoted Y_{1t} and Y_{2t}, respectively. The goods are produced with the following production functions:

$$Y_{it} = Y_i(K_{it}, \varepsilon_{it}), \quad i = 1, 2, \tag{12}$$

where K_{it} is the capital stock employed in country i, i = 1, 2, at time t, and ε_{it} is a stochastic productivity shock. The capital stocks are predetermined at time t. The productivity shocks are in the time t information set and are assumed to be independently and identically distributed.

The arrangement of markets for goods and assets follows the original timing of the Svensson (1985) model with the goods market open in the beginning of a period after the realization of the state. Agents are constrained to purchase goods with monies carried into the period from the time t-1 asset market. After the closing of the goods market, the asset markets open. The key assumption is not the beginning or end of period timing of markets, but whether new information is available between the time that agents make portfolio decisions and when they purchase goods. With this timing, the agents may not spend all of their monies, which means that velocity of circulation can be variable.

Government Sectors

The government of each country buys some of that country's goods in the competitive market. The exogenous amount purchased each period is denoted G_{it}, for i = 1, 2. It is assumed that real government spending is a

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[5] Svensson (1987) considers an alternative but similar model with exogenous output and nominal prices that are preset one period in advance.

stochastic fraction of available output, $\theta_{it} \equiv G_{it}/Y_{it}$, and each θ_{it} is assumed to be independently and identically distributed.

Each government is subject to a budget constraint that requires balance between purchases of goods and taxes collected net of securities issued and redeemed. I consider only nominal head taxes, which are denoted τ_{it}, for i = 1, 2. Taxes are paid to the government at the asset market in the currency issued by that government. The governments also issue state-contingent claims to nominal money, where $B_i(x_t)$ denotes the amount of currency i that the government of country i promises at time t-1 to pay at time t contingent on the state of the world being x_t. The assumption that governments only issue state-contingent claims on their own money stocks is not substantive. The money stocks are also exogenous and are given by M_{it}, i = 1, 2, for the outstanding quantities of monies at the end of period t-1. The money of country one is called the "dollar," and the money of country two is called the "pound." The gross rates of money growth are denoted $\omega_{it} \equiv M_{it+1}/M_{it}$, and each is assumed to be independently and identically distributed.

The two flow budget constraints of the governments are therefore

$$P_{it}G_{it} = \tau_{it} + \int n_i(x_{t+1}, x_t)B_i(x_{t+1})dx_{t+1} - B_i(x_t) + (M_{it+1} - M_{it}). \quad (13)$$

The function $n_i(x_{t+1}, x_t)$ is the endogenous market determined nominal pricing function associated with money i. It provides present values in terms of money i at time t in state x_t of promises to state-contingent amounts of money i at time t+1, given that state x_{t+1} occurs. The dollar price of good one is denoted P_{1t}, and the pound price of good two is denoted P_{2t}.

The governments are assumed to purchase on credit in the goods markets. Therefore, the sequence of flow budget constraints fully characterizes the constraints on government behavior if the intertemporal budget constraints are satisfied. The intertemporal budget constraints are obtained by forward integration of the flow budget constraints. The intertemporal constraints are

$$\sum_{j=0}^{\infty}\int[\tau_{it+j}][\Pi_{k=1}^{j}[n_i(x_{t+k}, x_{t+k-1})dx_{t+k}] = B_i(x_t) +$$
$$\sum_{j=0}^{\infty}\int[P_{it+j}G_{it+j} - (M_{it+j+1} - M_{it+j})][\Pi_{k=1}^{j}[n_i(x_{t+k}, x_{t+k-1})dx_{t+k}], \quad (14)$$

for i=1, 2. The product operator is defined by $\Pi_{k=1}^{j} X_{t+k} \equiv X_{t+1} X_{t+2} \ldots X_{t+j}$, and it is assumed to be one if j < k. Also, the integrals in equation (14) are implicitly multiple integrals over the future states, $dx_{t+1} dx_{t+2} \ldots dx_{t+j}$. Since the nominal bond payments, $B_i(x_t)$, are predetermined in period t, and because the time series of government spending and money creation are assumed to be exogenous, the intertemporal government budget constraint restricts the feasible paths of debt and taxes.

Lucas (1984) and Backus and Kehoe (1987) demonstrate that, in equilibrium, the pattern of taxation and government budget deficits is not important in this type of model, as long as the stochastic paths of government spending and money creation are unchanged. Here, I demonstrate that the equilibrium values of assets and prices and the equilibrium decisions of agents are not altered by changes in the timing of debt and taxes. Hence, budget deficits cannot affect capital flows in this model.

Preferences And Budget Constraints

The preferences of agents in each country are assumed to be homothetic and identical. Agents trade in a number of different assets including the monies and government bonds of the two countries, the titles to the outputs of the firms in the two countries, and tax-related assets that facilitate the discussion of an equilibrium.

The objective function of the representative consumer of either country is to maximize expected lifetime utility as in

$$E_0\{\sum_{t=0}^{\infty} \beta^t U(C_{1t}, C_{2t})\}, \quad 0 < \beta < 1, \tag{15}$$

by choice of consumption of the good of country one, C_{1t}, and consumption of the good of country two, C_{2t}. In equation (15), $E_0(\cdot)$ is the expectation operator conditional on initial information in period zero, and β is the subjective discount factor. The period utility function, $U(\cdot,\cdot)$, is sufficiently concave that the Inada conditions are satisfied and an internal equilibrium is guaranteed. Agents are assumed to receive either no utility from government purchases of goods or utility that is separable from the utility of other goods.

I follow Stockman and Svensson (1987) and assume that the purchase of an equity share carries with it the commitment to purchase a pro rata share of the investment of the representative firm in capital next period. If Z_{it} is the ownership of share i, i = 1, 2, the commitment is to purchase $Z_{it}K_{it+1}$ units of output of good i for the firm at the time t goods market.

Information relevant to the decisions for the period is obtained at the beginning of the period. At that time the representative consumer faces two cash-in-advance constraints that dictate the quantities of each good that can be consumed. In the period t-1 asset market the representative agents acquire M_{it}^p of currency i. The cash-in-advance constraints are

$$P_{1t}C_{1t} + P_{1t}Z_{1t}K_{1t} \le M_{1t}^p, \tag{16}$$

$$P_{2t}C_{2t} + P_{2t}Z_{2t}K_{2t} \le M_{2t}^p. \tag{17}$$

The agent's budget constraint during the asset market requires that the value of the purchases of assets be less than or equal to wealth at that time. Sources of wealth are the values of the existing shares in the firms, any unspent monies from the goods markets, any state-contingent payoffs on government bonds, and the payoffs on the tax-related assets.

Let $B_i^p(x_t)$ denote the amount of money i that the consumer of country 1 purchased at the time t-1 asset market for delivery at the time t asset market, conditional on the state being x_t. Let Z_{3t}^i and Z_{4t}^i be the holdings of the consumer of country i of the tax-related assets of country one and country two, respectively. The uses of wealth include tax liabilities and purchases of new assets.

The budget constraint in period t of the agent of country one is therefore

$$\begin{aligned}
&M_{1t+1}^p + S_t M_{2t+1}^p + \int n_1(x_{t+1}, x_t) B_1^p(x_{t+1}) dx_{t+1} + \\
&S_t \int n_2(x_{t+1}, x_t) B_2^p(x_{t+1}) dx_{t+1} + Q_{1t}Z_{1t+1} + S_t Q_{2t} Z_{2t+1} + Q_{3t} Z_{3t+1}^1 + \\
&+ S_t Q_{4t} Z_{4t+1}^1 \le [M_{1t}^p - P_{1t}(C_{1t} + K_{1t+1}Z_{1t})] + S_t[M_{2t}^p - P_{2t}(c_{2t} + \\
&+ K_{2t+1}Z_{2t})] + (Q_{1t} + D_{1t})Z_{1t} + S_t(Q_{2t} + D_{2t})Z_{2t} + (Q_{3t} + D_{3t})Z_{3t}^1 + \\
&+ S_t(Q_{4t} + D_{4t})Z_{4t}^1 + B_1^p(x_t) + S_t B_2^p(x_t) - \tau_{1t}.
\end{aligned} \tag{18}$$

The dollar price of a share of country 1 output is Q_{1t}, and the dollar dividend per share is D_{1t}. The pound price of a share of country 2 output is Q_{2t}, and the pound dividend per share is D_{2t}. Similarly, the dollar price of the tax-related asset of country one is Q_{3t}, and the pound price of the tax-related asset of country two is Q_{4t}. The dollar payoff on the tax-related asset of country one is $D_{3t} = (1/2)\tau_{1t}$, and the pound payoff on the tax-related asset of country two is $D_{4t} = (1/2)\tau_{2t}$.

Solution Of The Agent's Problem

In order to study an equilibrium of this economy, consider the value function of the agent's problem. Let Z_t be the vector of asset holdings other than monies. The consumer has current asset stocks and stocks of money, and he is facing uncertainty about the future that can be characterized by the probability distribution of future states of the world. Hence, the value function of the agent's problem is

$$V(Z_t, M_{1t}^D, M_{2t}^D, x_t) = \max\{U(C_{1t}, C_{2t}) + \beta\int V(Z_{t+1}, M_{1t+1}^D, M_{2t+1}^D, x_{t+1})F(x_{t+1}|x_t)dx_{t+1}\}, \tag{19}$$

where the maximization is over current choices of consumption goods and new holdings of monies and other assets and is subject to the constraints in equations (16), (17) and (18). The assumption of rational expectations is employed in equation (19) because the conditional expectation of the agent is taken with respect to the true transition probability of the future state.

The solution of the agent's problem provides demands for assets and goods. An equilibrium path is characterized by equality of the marginal utility of consumption and the marginal utility of a real dollar, which incorporates its value in the goods and asset markets. A similar condition relates the marginal utility of good two to the marginal real value of the pound, which is its marginal value in the goods and asset markets. An important aspect of these two conditions is that the current marginal utility of consumption is not equated to the marginal utility of wealth unless the cash-in-advance constraint associated with that good is not binding.

The decision to hold an additional unit of nominal money involves a tradeoff of the product of the current marginal utility of wealth against the discounted expected marginal utility of the money in the next period, which is the marginal value of wealth next period plus the marginal value of the money in the consumption good market at that time. The Euler equations associated with the purchases of shares in the two production processes require that investment at time t in a title to future output, which involves a utility sacrifice given by the product of the current nominal price of the asset measured in dollars and the current marginal value of dollar wealth, is equal to the expected marginal utility gain to purchasing an asset, which is the expectation of the product of the nominal dollar resources available from holding the asset with the marginal value of dollar wealth at time t + 1. In addition, the holder of stock agrees to a purchasing contract requiring the purchase of capital for the firm in the goods market. The nominal dollar value of this commitment times the marginal value of a dollar in the goods market must be subtracted from the payoff on the assets.

The purchase of state-contingent government bonds or the purchase and delivery of state-contingent monies in the next asset market is also possible. If a unit of money i for delivery in a particular state x_{t+1} is purchased today, the nominal price is $n_i(x_{t+1}, x_t)$, and the price expressed in dollars times the marginal value of dollar wealth is the marginal utility cost to the investor. The value received in return is the marginal value of the unit of money conditional on the realization of the particular state times the marginal utility of wealth in that state times the probability of that state being realized. These equations must hold for all possible future states.

Investment Decisions Of Firms

The values of the firms depend on the capital stocks and the optimal investment decisions, K_{it+j}, for i = 1, 2 and j = 1, 2, ..., that are functions of the state at time t+j-1. The firms are assumed to pay out all of their revenue as dividends; hence $D_{1t} = P_{1t}Y_{1t}$ and $D_{2t} = P_{2t}Y_{2t}$. Maximization of the values of the firms requires them to have contingency plans for the capital stocks such that K_{1t+1} equates the marginal utility that must be sacrificed if an additional unit of investment is made in the capital stock to the discounted expected marginal utility gains from having an additional unit of the capital stock.

Definition Of An Equilibrium

Given the setup of the model at this point, it is now possible to define an equilibrium. The only equilibrium I consider is the perfectly pooled stationary equilibrium of Lucas (1982) who noted that if agents have the same preferences and if preferences are homothetic, the ratios of consumptions of the goods will be identical across countries. The perfectly pooled equilibrium arises when agents have identical wealth as well, and therefore their consumption is the same. If the agents in each country are endowed initially with the ownership of the production process of their country and are liable for the taxes of their country, the perfectly pooled equilibrium requires that at initial prices, the wealths of the two countries be the same. Different levels of wealth will result in different equilibrium consumption levels, but with the homothetic preferences, asset prices will be identical.

In the pooled equilibrium, agents share equally the available outputs of the two goods net of government consumption of the two countries and of the endogenous investment decisions of the firms, and they hold half of the outstanding stocks of the firms and the monies with the outstanding number of shares in the firms normalized to be one. The tax-related assets are in zero net supply in the world. Since each citizen is liable for the taxes of his country, the agent of country one holds an asset that is the liability of the agent of country two, and the asset provides contingent deliveries of dollars equal to half of the country-one contingent tax liability. The agent of country two also holds a similar asset that is the liability of the agent of country one.

Net Foreign Assets And Capital Flows

The total dollar value of world assets in positive supply consists of the dollar value of the two production processes, the dollar value of the money stocks, and the dollar value of outstanding government bonds. In the pooled equilibrium, the representative agent of each country owns half of each of these assets. In addition, the agent of country one owns the tax-related asset that is the liability of the agent of country two; similarily, the agent of country two owns the tax-related asset that is the liability of the agent of country one.

Net foreign assets of country one in the asset market at time t are denoted A_{1t+1}. They are defined to be the value of country-two assets owned by country one minus the value of country-one assets owned by country two:

$$A_{1t+1} = (1/2)[S_tQ_{2t} + S_tM_{2t+1} + \int n_1(x_{t+1}, x_t)S_{t+1}B_2(x_{t+1})dx_{t+1} + \tag{20}$$
$$+ Q_{3t} - Q_{1t} - M_{1t+1} - \int n_1(x_{t+1}, x_t)B_1(x_{t+1})dx_{t+1} - S_tQ_{4t}]$$

From the definitions of the current account and the capital account, the current-account surplus of country one is its capital-account deficit, which is the change in net foreign assets of country one,

$$CA_{1t} = A_{1t+1} - A_{1t}. \tag{21}$$

Although it appears from the definition of A_{1t+1} in equation (20) that the current account ought to depend on government bonds and taxes, one major point about the equilibrium of this model is that the values of net foreign assets do not depend directly on the financing of the government sector.

To see why, consider the dollar value of the tax-related asset whose payoff is perfectly correlated with the taxes of country one. The equilibrium price of the asset is found from discounting the value of its payoffs, which is

$$Q_{3t} = \sum_{j=1}^{\infty} \int [(1/2)\tau_{1t+j}]\Pi_{k=1}^{j}[n_1(x_{t+k}, x_{t+k-1})dx_{t+k}], \tag{22}$$

and from equation (14)

$$Q_{3t} - \int n_1(x_{t+1}, x_t)B_1(x_{t+1})dx_{t+1} =$$

$$\sum_{j=1}^{\infty} \int [P_{it+j}G_{it+j} - (M_{it+j+1} - M_{it+j})]\Pi_{k=1}^{j}[n_i(x_{t+k}, x_{t+k-1})dx_{t+k}], \tag{23}$$

where the left-hand side of equation (23) is what appears in the definition of A_{1t+1} in equation (20), and the right-hand side of equation (23) is the present value of nominal government spending beginning in period t+1 in excess of what is financed by money creation. The time pattern of taxation and bond financing of country one does not enter the value of net foreign assets and cannot be a determinant of capital flows. A similar argument would apply to the government-financing policies of country two. The next section examines a model in which the financing of government debt does affect the equilibrium of the world economy.

The model of this section is a logical extension of the real business cycle models that are the focus of much macroeconomic research.[6] Capital flows in this economy are simply the response to equilibrium risk sharing. Things that increase the value of country one's technology will lead to a measured capital outflow because they increase the wealth of the foreigner. Stockman and Svensson (1987) demonstrate how additional covariances of capital flows and other endogenous variables can be calculated from the model. I do not undertake any of these exercises because of the simplicity of the driving processes. Solving the model with more realistic driving processes appears to require numerical methods.

V. A TWO-COUNTRY OVERLAPPING GENERATIONS MODEL

This section develops a model of maximizing rational agents in a stochastic environment. Because agents have finite lives and do not form intergenerational families, the time pattern of government debt does matter fundamentally in this equilibrium.

Preferences And Technologies

Consider a two-country model of a one-good economy. The world is populated with overlapping generations of agents who live for two periods, working only in the first. Labor and capital are used to produce a good that may be consumed or invested to become capital that is employed the following period. Each country's government buys some of the consumption good, taxes the young and issues government bonds.

The preferences of agents born at time t are identical across countries and ar

$$\log(C_{iyt}) + \beta E_t[\log(C_{iot+1})], \quad i = 1, 2. \tag{24}$$

where C_{iyt} is consumption of the young agent of country i at time t, C_{iot+1} is consumption of the old agent of country i at time t+1. The population of

[6] See Volume 21, No. 2/3 of the Journal of Monetary Economics for an introduction to this growing body of literature, most of which is conducted in a closed economy framework.

the generation born at time t in country i is denoted N_{it}, i = 1, 2. Population growth is assumed to be an exogenous stochastic process.

Assume that an agent supplies a unit of labor inelastically when young and consumes his savings when old. The first-period budget constraint is

$$C_{iyt} = W_{it} - \tau_{it} - S_{it}, \quad i = 1, 2, \tag{25}$$

where W_{it} is the real wage rate in country i, τ_{it} is the head tax of government i paid only by the young, and S_{it} is the savings of the young.

I assume that there is a world rental market for capital. If the state of the world is known before capital has to be allocated, the rate of return to capital, denoted r_t, will be identical across countries. Since there are stochastic elements in the production process, r_t will be stochastic when viewed from periods before the allocation of capital.

I also assume a world bond market for government debt. The government bonds of countries will only be held if they offer a common competitive rate of return, r_{bt}, that will be determined in equilibrium at time t-1 when the bonds are issued. I assume that the government bonds are default free and riskless in terms of consumption goods.

Let θ_{t+1} be the share of savings in either country at time t that is allocated to risky capital. Since preferences are the same, the portfolio shares of the two agents are the same. The budget constraints of the old are

$$C_{iot+1} = [(1 + r_{bt+1}) + \theta_{t+1}(r_{t+1} - r_{bt+1})]S_{it}, \quad i = 1, 2. \tag{26}$$

The technology is assumed to be constant returns to scale with stochastic productivity. The parameters of the production function are the same across countries, but the productivity shocks are not common. I follow King, Plosser, and Rebelo (1988) and specify the technology as

$$Y_{it} = \Psi_{it}K_{it}^{\alpha}(N_{it}\Gamma_{it})^{1-\alpha}, \quad i = 1, 2, \tag{27}$$

where Γ_{it} is labor augmenting technological change, which is assumed to be a nonstationary stochastic process, Ψ_{it} is a stationary stochastic process representing an overall productivity shock, K_{it} is the amount of capital allocated to the ith country, and full employment is assumed.

Competition for capital across the countries produces a return to capital that is its marginal product of capital. The two wage rates will be different, though, since labor is not mobile across countries and technology is not identical at a point in time. The wage rates will be the marginal products of labor.

Government Budget Constraints

Government purchases of goods are financed through taxation of the working young and issuance of government bonds. Let G_{it} be the purchases of goods and B_{it} be the bonds issued by government i at time t. Then, the government budget constraint in period t is

$$G_{it} + r_{bt}B_{it} = N_{it}\tau_{it} + B_{it+1} - B_{it}, \quad i = 1, 2. \tag{28}$$

If government expenditures are an exogenous stochastic process, taxation must be endogenous to keep government debt bounded. One process that does this and that is consistent with the stylized fact that government debt tends to decline over time after large expenditures is

$$N_{it}\tau_{it} = T_{it} + \rho B_{it}, \quad i = 1, 2. \tag{29}$$

In equation (29) T_{it} is an exogenous part of the aggregate tax system, but ρB_{it} makes aggregate taxes endogenous. Since there is population growth and technological change, government bonds can grow over time, but the value of ρ can be chosen to be sufficiently large that appropriately deflated debt declines over time if the required rate of return on debt and the deflated levels of exogenous spending and taxes are at their unconditional expected values with debt above its unconditional mean.

Equilibrium Conditions

Three markets must clear each period. In asset markets, the capital created in the previous period must be fully employed and the new stocks of government debt must be demanded by the savings of the young. Equilibrium in the goods market requires that the supply of goods from production in the two countries and from previous capital stocks be purchased for consumption of the young and the old, for the government sectors, and for investments in capital goods. When any two of these markets clear, the third is in equilibrium when agents satisfy their budget constraints.

The balance of payments also can be derived from these conditions. The trade-account surplus of country one, TA_{1t}, is the excess of production in the country over the total expenditure by the country for consumption goods, government goods, and net investment. Therefore,

$$TA_{1t} = Y_{1t} - N_{1t}C_{1yt} - N_{1t-1}C_{1ot} - G_{1t} - (\theta_{t+1}N_{1t}S_{1t} - \theta_t N_{1t-1}S_{1t-1}). \quad (30)$$

The current-account surplus of country one, CA_{1t}, is obtained by adding the service-account surplus to the trade balance. The service-account surplus, SA_{1t}, is income on net foreign assets. This is the sum of the interest income on the ownership of government bonds by country one residents net of total interest paid by their government and the return on capital owned by country one net of the total payments to capital employed in the country. Therefore, the service-account surplus of country one is

$$SA_{1t} = r_{bt}[(1 - \theta_t)N_{1t-1}S_{1t-1} - B_{1t}] + r_t[\theta_t N_{1t-1}S_{1t-1} - K_{1t}], \quad (31)$$

and the current-account surplus is $CA_{1t} = TA_{1t} + SA_{1t}$.

By substitution of the budget constraints of the individuals and the governments, the current account here is the change in the net ownership of government bonds, as in

$$CA_{1t} = [(1 - \theta_{t+1})N_{1t}S_{1t} - B_{1t+1}] - [(1 - \theta_t)N_{1t-1}S_{1t-1} - B_{1t}]. \quad (32)$$

Since physical capital is mobile across countries, ex ante net foreign assets are not well-defined, but ex post net foreign assets are

$$A_{1t+1} = [\theta_{t+1}N_{1t}S_{1t} - K_{1t+1}] + [(1 - \theta_{t+1})N_{1t}S_{1t} - B_{1t+1}]. \quad (33)$$

The Allocation Of Capital

Let the aggregate amount of capital in period t be denoted K_t. The four production efficiency conditions relating the marginal products of the factors of production to the wage rates and the common rental rate on capital can be combined with the capital market equilibrium condition to determine the allocation of capital across countries and the returns to the factors of production as functions of K_t and the productivity shocks. The stock of capital employed in country one is

$$K_{1t} = [\sigma_{1t}/(1 + \sigma_{1t})]K_t, \quad (34)$$

with the remainder employed in country two, where the allocation of capital is determined by $\sigma_{1t} \equiv (\psi_{1t}/\psi_{2t})^{1/(1-\alpha)}(N_{1t}r_{1t}/N_{2t}r_{2t})$.

The technology and population shocks affect the allocation of a given amount of capital by shifting capital to the country that is relatively more productive, either because there are more workers for a given unit of capital or because labor is more productive.

Consumption, Savings, and Portfolio Decisions

Given the wage rates in the two countries, consumption, s... portfolio allocations are found as the first-order conditions o... agents' maximization problems. With logarithmic preferences consumptio... a constant fraction of after-tax wealth, and savings is

$$S_{it} = [\beta/(1+\beta)](W_{it} - \tau_{it}), \quad i = 1, 2. \tag{35}$$

The portfolio choice of the agent solves

$$E_t \left\{ \frac{(r_{t+1} - r_{bt+1})}{[1 + r_{bt+1} + \theta_{1t+1}(r_{t+1} - r_{bt+1})]} \right\} = 0. \tag{36}$$

The choice of θ_{t+1} sets the conditional expectation of the product of the marginal utility of second-period consumption and the difference between the two returns equal to zero.

Discussion of the equilibrium dynamics of the capital stocks requires linearizations; the linearized version of equation (36) is simply $r_{bt+1} = E_t(r_{t+1})$. The required return on the government bond must adjust to be equal to the expected return on the capital stock in period t+1, which will depend on the amount of investment and on the expected productivity of capital.

Equilibrium Dynamics

The evolution of the stocks of capital and bonds provides the dynamics of the model. The capital stock depends on the share of savings in the risky asset and on the total amount of savings. The share of savings in bonds is dictated by the requirement that the government bonds be willingly held as part of saving, with the result that

$$K_{t+1} = (N_{1t}S_{1t} + N_{2t}S_{2t}) - (B_{1t+1} + B_{2t+1}). \tag{37}$$

From equations (28) and (29) the total stock of government debt depends upon the aggregation of the two countries' government budget constraints:

$$B_{t+1} = (1 + r_{bt} - \rho)B_t + (G_{1t} + G_{2t}) - (T_{1t} + T_{2t}), \tag{38}$$

where $B_t \equiv B_{1t} + B_{2t}$. This equation is one of a two-equation system. The other is found by substitution from the savings conditions equation (35) to derive

$$K_{t+1} = [\beta/(1+\beta)][N_{1t}W_{1t}(K_t) + N_{2t}W_{2t}(K_t) - T_{1t} - T_{2t} - \rho B_t] +$$

$$- \{[1 + r_{bt}(K_t) - \rho]B_t + G_{1t} - T_{1t} + G_{2t} - T_{2t}\} \tag{39}$$

which is the second nonlinear difference equation in the aggregate system. The stocks of capital and bonds, K_{t+1} and B_{t+1}, evolve as functions of K_t and B_t, with the exogenous government spending and taxation policies and the stochastic population and productivity shocks as driving processes. In equations (38) and (39) there is explicit dependence of the wage rates and the interest rate on government bonds on the outstanding stock of capital, while their dependence on the population and productivity shocks is left implicit.

Linearization And Stochastic Trends

When populations grow and technological change is nonstationary, there is no unconditional mean value or stochastic steady state to the system of equations (38) and (39). If common trends are removed, as in King, Plosser and Rebelo (1988), by deflating the variables by an appropriate permanent component, a stochastic steady state in the deflated variables exists.

Population is assumed to be driven by a common stochastic trend, N_t, such that $n_{it} \equiv (N_{it}/N_t)$, $i = 1, 2$, is stationary. If one country is not to dominate the other country eventually, the permanent component in labor augmenting technological change, Γ_t, also must be the same. The variables $\gamma_{it} \equiv (\Gamma_{it}/\Gamma_t)$, $i = 1, 2$, are therefore stationary. If there is to be a stochastic steady state, the exogenous government spending and taxation policies must also share the permanent components of population growth and technological change such that $g_{it} \equiv (G_{it}/N_t\Gamma_t)$ and $t_{it} \equiv (T_{it}/N_t\Gamma_t)$, $i = 1, 2$, are stationary.

In the presence of population growth and technological change, the endogenous variables K_t and B_t must also be allowed to grow. The permanent efficiency units of labor, $N_t r_t$, are the source of all growth. The gross rate of change in this variable is $\delta_{t+1} \equiv (N_{t+1} r_{t+1})/(N_t r_t)$. To discuss a stationary representation, let $x_t = (X_t/N_t r_t)$, for $X_t = K_t$, B_t, or for the individual country capital stocks or bonds. Let x denote the unconditional mean or stochastic steady state of x_t. If $\hat{x}_t$ is defined to be the percentage deviation of x_t from its unconditional value, $\ln(X_t) = \ln(r_t) + \ln(N_t) + \ln(x) + \hat{x}_t$. The series $\hat{x}_t$ is a stationary stochastic process with unconditional mean equal to zero. The transformed dynamic system is obtained by dividing equations (38) and (39) by $N_t r_t$:

$$k_{t+1}\delta_{t+1} = [\beta/(1+\beta)][n_{1t}w_{1t}(k_t) + n_{2t}w_{2t}(k_t) - t_{1t} - t_{2t} - \rho b_t]$$
$$- [[1 + r_{bt}(k_t) - \rho]b_t + g_{1t} - t_{1t} + g_{2t} - t_{2t}] \tag{40}$$

$$b_{t+1}\delta_{t+1} = [[1 + r_{bt}(k_t) - \rho]b_t + g_{1t} - t_{1t} + g_{2t} - t_{2t}], \tag{41}$$

where the rate of return on bonds need not be deflated and the wage rates are $w_{it} \equiv W_{it}/r_t$.[7]

Consider the dependence of r_{bt} on the exogenous variables. The government bonds promise an uncontingent rate of interest, $r_{bt} = E_{t-1}(r_t)$. The expected value of the rate of return on capital depends upon the expected rates of population growth and of technological change in period t as well as on the capital stock at time t, which is in the time t-1 information set. The percentage deviation of r_{bt} from its steady state is

$$\hat{r}_{bt} = (1/2)E_{t-1}[\hat{\psi}_{1t} + \hat{\psi}_{2t} + (1 - \alpha)[\hat{n}_{1t} + \hat{\gamma}_{1t} + \hat{n}_{2t} + \hat{\gamma}_{2t}]] - \hat{k}_t. \tag{42}$$

A larger capital stock lowers the marginal product of capital and lowers the interest rate on competing assets. Expectations of higher-than-average productivity of either type in either country or of higher-than-average population in either country increase the expected rate of return to capital and increase the real interest rate on government bonds.

The state of the system is defined to be the values of capital stock and government bonds as well as the values of government spending and taxation policies. In addition, the anticipated and unanticipated values

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[7]An unpublished appendix available directly from the author investigates the uniqueness of the steady state of the system and of the dynamic path to the stochastic steady state.

of the two types of productivity shocks and the population growth rates of the two countries, relative to the time t-1 information set, enter the state. Therefore, the deviation of the capital stock from its steady-state value can be written as a linear function, F_k, of these variables:

$$\hat{k}_{t+1} = F_k[\hat{\delta}_{t+1}, \hat{k}_t, \hat{b}_t, \hat{g}_{it}, \hat{t}_{it}, u\hat{\psi}_{it}, u\hat{\gamma}_{it}, u\hat{n}_{it}, E_{t-1}(\hat{\psi}_{it}), \\ E_{t-1}(\hat{\gamma}_{it}), E_{t-1}(\hat{n}_{it}), \quad i = 1, 2], \tag{43}$$

where ux_t denotes the innovation in x_t relative to time t-1. The responses of the aggregate capital stock as a function of these state variables is presented in Table 1.

The deviation of the aggregate stock of bonds from its steady state can be written as a linear function, F_b:

$$\hat{b}_{t+1} = F_b[\hat{\delta}_{t+1}, \hat{k}_t, \hat{b}_t, \hat{g}_{it}, \hat{t}_{it}, E_{t-1}(\hat{\psi}_{it}), E_{t-1}(\hat{\gamma}_{it}), E_{t-1}(\hat{n}_{it})], \tag{44}$$

and the values of the coefficients are given in Table 2. The aggregate government bond stock does not depend on the unanticipated productivity shocks or population growth rates because the tax system is not dependent on current income.

Once the aggregate capital stock is determined, the country-specific capital stocks are found to be

$$\hat{k}_{it} = \hat{\sigma}_i \hat{\sigma}_{1t} + \hat{k}_t, \quad i = 1, 2, \tag{45}$$

where $\hat{\sigma}_1 \equiv 1/(1 + \sigma_1)$ and $\hat{\sigma}_2 \equiv - \sigma_1/(1 + \sigma_1)$, and the deviation from the steady state of the parameter determining the share of capital allocated across countries is

$$\hat{\sigma}_{1t} = [1/(1 - \alpha)](\hat{\psi}_{1t} - \hat{\psi}_{2t}) + (\hat{n}_{1t} - \hat{n}_{2t}) + (\hat{\gamma}_{1t} - \hat{\gamma}_{2t}). \tag{46}$$

Linearization of the individual government budget constraints provides the evolution of the bonds, given the behavior of the real interest rate on the bonds:

Table 1

Coefficients in $\hat{k}_{t+1}$ Equation

State Variable	Effect on $\hat{k}_{t+1}$
$\hat{\delta}_{t+1}$	$\pi_{k0} = -1$
$\hat{k}_t$	$\pi_{k1} = (\beta/1+\beta)(\alpha/k_Y)[w_1n_1+w_2n_2] + (rb/k_Y)(1-\alpha)$
$\hat{b}_t$	$\pi_{k2} = -(\beta/1+\beta)(\rho b/k_Y) - (b/k_Y)(1+r-\rho)$
$\hat{g}_{1t}$	$\pi_{k3} = -(g_1/k_Y)$
$\hat{g}_{2t}$	$\pi_{k4} = -(g_2/k_Y)$
$\hat{t}_{1t}$	$\pi_{k5} = [1/(1+\beta)](t_1/k_Y)$
$\hat{t}_{2t}$	$\pi_{k6} = [1/(1+\beta)](t_2/k_Y)$
$u\hat{\psi}_{1t}$	$\pi_{k7} = [\beta/(1+\beta)](w_1n_1/k_Y)$
$u\hat{\psi}_{2t}$	$\pi_{k8} = [\beta/(1+\beta)](w_2n_2/k_Y)$
$u\hat{\gamma}_{1t}$	$\pi_{k9} = \pi_{k7}(1-\alpha)$
$u\hat{\gamma}_{2t}$	$\pi_{k10} = \pi_{k8}(1-\alpha)$
$u\hat{n}_{1t}$	$\pi_{k11} = \pi_{k7}(2-\alpha)$
$u\hat{n}_{2t}$	$\pi_{k12} = \pi_{k8}(2-\alpha)$
$E_{t-1}(\hat{\psi}_{1t})$	$\pi_{k13} = \pi_{k7} - (1/2)(rb/k_Y)$
$E_{t-1}(\hat{\psi}_{2t})$	$\pi_{k14} = \pi_{k8} - (1/2)(rb/k_Y)$
$E_{t-1}(\hat{\gamma}_{1t})$	$\pi_{k15} = \pi_{k9} - (1/2)(1-\alpha)(rb/k_Y)$
$E_{t-1}(\hat{\gamma}_{2t})$	$\pi_{k16} = \pi_{k10} - (1/2)(1-\alpha)(rb/k_Y)$
$E_{t-1}(\hat{n}_{1t})$	$\pi_{k17} = \pi_{k11} - (1/2)(1-\alpha)(rb/k_Y)$
$E_{t-1}(\hat{n}_{2t})$	$\pi_{k18} = \pi_{k12} - (1/2)(1-\alpha)(rb/k_Y)$

Table 2

Coefficients in $\hat{b}_{t+1}$ Equation

State Variable	Effect on $\hat{b}_{t+1}$
$\hat{\delta}_{t+1}$	$\pi_{b0} = -1$
$\hat{k}_t$	$\pi_{b1} = -(r/\gamma)$
$\hat{b}_t$	$\pi_{b2} = (1+r-\rho)/\gamma$
$\hat{g}_{1t}$	$\pi_{b3} = (g_1/b\gamma)$
$\hat{g}_{2t}$	$\pi_{b4} = (g_2/b\gamma)$
$\hat{t}_{1t}$	$\pi_{b5} = -(t_1/b\gamma)$
$\hat{t}_{2t}$	$\pi_{b6} = -(t_2/b\gamma)$
$E_{t-1}(\hat{\psi}_{1t})$	$\pi_{b7} = (1/2)(r/\gamma)$
$E_{t-1}(\hat{\psi}_{2t})$	$\pi_{b8} = \pi_{b7}$
$E_{t-1}(\hat{\gamma}_{1t})$	$\pi_{b9} = (1-\alpha)\pi_{b7}$
$E_{t-1}(\hat{\gamma}_{2t})$	$\pi_{b10} = \pi_{b9}$
$E_{t-1}(\hat{n}_{1t})$	$\pi_{b11} = \pi_{b9}$
$E_{t-1}(\hat{n}_{2t})$	$\pi_{b12} = \pi_{b9}$

$$\hat{b}_{it+1} = -\hat{\delta}_{t+1} + [(1 + r_b - \rho)/\delta]\hat{b}_{it} + (g_i/\delta b_i)\hat{g}_{it} + \\ - (t_i/\delta b_i)\hat{t}_{it} + (r_b/\delta)\hat{r}_{bt}, \quad i = 1, 2. \tag{47}$$

Given these solutions, international capital flows can be determined.

EQUILIBRIUM INTERNATIONAL CAPITAL FLOWS

The absolute level of the current account of country one is given in equation (31). It depends implicitly on savings in the two countries and on the evolution of government bonds. Individual savings behavior is given in equation (34). Consequently, deflating equation (31) by $N_t r_t$ and rearranging terms gives the deflated current account as

$$ca_{1t} = [\phi_t b_{2t+1} - (1 - \phi_t)b_{1t+1}]\delta_{t+1} - [\phi_{t-1}b_{2t} - (1 - \phi_{t-1})b_{1t}] \tag{48}$$

where $\phi_t \equiv [n_{1t}s_{1t}/(n_{1t}s_{1t} + n_{2t}s_{2t})]$, which is the share of country-one saving in world saving. If in the stochastic steady state, this share times the government bond stock of country two is larger than the share of savings in country two times the country-one bond stock, $[\phi b_2 - (1-\phi)b_1] > 0$, either because the size of the country-one bond stock is smaller, or because its government sector is smaller, the current account of country one is in surplus. As long as this difference is not zero, it makes sense to discuss a log-linearization of the current account.

Expressing the deflated current account in percentage deviations from the steady state gives a quasi-reduced form expression

$$\hat{ca}_{1t} = \pi_{c0}\hat{\delta}_{t+1} + \pi_{c1}[\delta\hat{\phi}_t - \hat{\phi}_{t-1}] + \pi_{c2}[\delta\hat{b}_{2t+1} - \hat{b}_{2t}] + \pi_{c3}[\delta\hat{b}_{1t+1} - \hat{b}_{1t}] \tag{49}$$

where $\pi_{c0} \equiv \delta[\phi b_2 - (1-\phi)b_1]/ca_1 > 0$, $\pi_{c1} \equiv (\phi b/ca_1) > 0$, $\pi_{c2} \equiv \phi b_2/ca_1 > 0$, $\pi_{c3} \equiv -[1 - \phi)b_1]/ca_1 < 0$, and the signs of the π_c coefficients are premised on $ca_1 > 0$. If country one is in surplus in the steady state, it experiences a transitory current-account surplus whenever there is a transitorily high growth rate of either stochastic trend. Also, things that increase the share of country-one savings in world savings increase the current-account surplus of country one. Finally, increases in the resort of country-two's government to financing deficits with bonds lead to current-account surpluses for country one; and, symmetrically, increases in the resort of country-one's government to financing deficits with government bonds lead to current-account deficits of country one.

Expressing the current account as a true reduced form requires an expression for the percentage deviation from the steady state of the share of savings of country one in world saving. Since the expression is long, the coefficients are presented in Table 3. Transitory increases in working-age population or the productivity of country one improve the current account, while the converse is true of changes in these variables for country two. Tax increases in country one cause a decrease in the savings rate of the private sector, but they decrease the resort of the government sector to bond finance, which improves the current account.

VI. COMPLEMENTARY EMPIRICAL INVESTIGATIONS

The previous two sections develop alternative rational expectations models that are explicitly stochastic. As such, they are potentially directly testable. Unfortunately, they are not sufficiently well-formulated that I think they deserve to be examined empirically. Rather than formally test and reject the models, I examine some of their implications empirically in this section. I view the theory and empirical sections of this paper as complementary avenues of investigation that are leading toward a well-designed theory that will eventually not be rejected by the data.

An Update Of Evans (1986)

One of the most striking differences across the two models is the implication that government budget deficits do not affect real allocations and relative prices such as the real exchange rate in the Ricardian model, whereas they do affect the consumption and savings decisions in the overlapping generations model. Budget deficits also figure prominently in the explanation of the movement in real exchange rates in the popular press, in neo-Keynesian frameworks, and in the writings of Feldstein (1986). Budget deficits are thought to appreciate the dollar in nominal and real terms leading to an overvalued currency and a current-account deficit.

One way to investigate the influence of budget deficits on the economy is to adopt the reduced-form methodology of Plosser (1982). The idea is to assume that one knows the return generating process for an asset or an exchange rate from a rational expectations model. This supplies an observable unexpected component to the return or the change in the exchange rate. The unexpected change in the exchange rate is then regressed on

Table 3

Coefficients in $\hat{\phi}_t$ Equation

State Variable	Effect on $\hat{\phi}_t$
$\hat{\psi}_{1t}$	$\pi_{\phi 1} = \Delta\{(w_1/s_1)[1+(\alpha/(1-\alpha))(1/(1+\sigma_1))] + (w_2/s_2)[\sigma_1/(1+\sigma_1)][\alpha/(1-\alpha)]\} > 0$
$\hat{n}_{1t}$	$\pi_{\phi 2} = \Delta\{(w_1/s_1)[1-\alpha+(\alpha/(1+\sigma_1))] + (w_2/s_2)[\alpha\sigma_1/(1+\sigma_1)]\} > 0$
$\hat{\gamma}_{1t}$	$\pi_{\phi 3} = \pi_{\phi 2} > 0$
$\hat{t}_{1t}$	$\pi_{\phi 4} = -\Delta(t_1/n_1 s_1) < 0$
$\hat{b}_{1t}$	$\pi_{\phi 5} = -\Delta(\rho b_1/n_1 s_1) < 0$
$\hat{\psi}_{2t}$	$\pi_{\phi 6} = -\Delta\{(w_1/s_1)[\alpha/(1-\alpha)][1/(1+\sigma_1)] + (w_2/s_2)[1+\sigma_1/(1+\sigma_1)][\alpha/(1-\alpha)]\} < 0$
$\hat{n}_{2t}$	$\pi_{\phi 7} = -\Delta\{(w_1/s_1)[\alpha/(1-\alpha)] + (w_2/s_2)[1-\alpha+(\alpha\sigma_1/(1+\sigma))]\} < 0$
$\hat{\gamma}_{2t}$	$\pi_{\phi 8} = \pi_{\phi 7} < 0$
$\hat{t}_{2t}$	$\pi_{\phi 9} = \Delta(t_2/n_2 s_2) > 0$
$\hat{b}_{2t}$	$\pi_{\phi 10} = \Delta(\rho b_2/n_2 s_2)[\beta/(1+\beta)](1-\phi) > 0$
$\hat{k}_t$	$\pi_{\phi 11} = \Delta\alpha[(w_1/s_1) - (w_2/s_2)] < 0$
	$\Delta = [\beta/(1+\beta)](1-\phi) > 0$

innovations in government policy variables and other exogenous variables that are presumed to be exogenous and that are generated from a vector autoregression (VAR). One must assume that the VAR is sufficiently well-specified that the true structure of the economy is captured by the regressions. If it is, the results of Pagan (1984) indicate that the two-step procedure produces consistent and asymptotically efficient estimators of the influence of the policy variables on the returns. If the VAR is misspecified, as it will be if the agents of the economy have more information than is attributed to them by the econometrician, the approach is suspect and may be bankrupt in the sense that the parameter estimates will be inconsistent.

Evans (1986) used this approach in an investigation of exchange rates using quarterly data for the period 1973:II to 1984:III. Stockman (1986), in his comment on Feldstein (1986), cites Evans (1986) as providing evidence in opposition to the conclusions of Feldstein (1986) that budget deficits of the United States appreciate the dollar. Stockman (1986, p. 404) states:

> When changes in real government spending and the deficit are simultaneously included in an equation for the exchange rate, his (Evans's) estimates show a sizable and statistically significant effect of higher government spending, leading to real appreciation (of the dollar), and a coefficient on the budget deficit that is opposite in sign from Feldstein's estimates and sometimes statistically significant. Evans's results show a larger U.S. deficit, given real government spending, leading to a dollar depreciation. When Evans included foreign variables in his equations, he found that greater foreign government spending leads to dollar depreciation and greater foreign deficits lead to dollar appreciation, with the estimated effects of U.S. government spending and deficits remaining essentially unchanged.

Stockman (1986) recognized that additional data might be very useful in the debate about the effects of deficits on the dollar, since the dollar depreciated by a substantial amount from its peak in February 1985. Because Evans's evidence has figured prominently in the debate on the determinants of the dollar with its attendant influence on the balance of payments, I updated his analysis with available data.

The results are presented in Table 4. The dependent variable is $\log(S^i_{t+1}/F^i_t)$ with exchange rates measured as the value of currency i in

TABLE 4

Ordinary Least Squares Update Of Equation (50)

Currency	β_{i0} (Std Err) MLS	β_{i1} (Std Err) MLS	β_{i2} (Std Err) MLS	β_{i3} (Std Err) MLS	β_{i4} (Std Err) MLS	R^2 DW
Deutsche	-0.002	0.047	0.123	1.133	-0.200	-0.036
mark	(0.009)	(0.343)	(1.286)	(0.947)	(3.197)	1.646
	.824	.892	.924	.232	.950	
British	-0.004	0.148	-1.108	0.446	1.480	-0.039
pound	(0.007)	(0.294)	(1.102)	(0.811)	(2.739)	1.344
	.614	.615	.314	.582	.589	
Canadian	-0.003	0.016	0.148	0.157	-0.411	-0.056
dollar	(0.003)	(0.122)	(0.456)	(0.336)	(1.132)	1.910
	.316	.898	.745	.638	.717	
Belgian	0.003	0.164	0.341	1.269	-0.125	-0.019
franc	(0.009)	(0.352)	(1.320)	(0.972)	(3.281)	1.570
	.739	.640	.796	.192	.970	
French	-0.003	0.196	0.689	0.635	2.071	-0.046
franc	(0.008)	(0.333)	(1.247)	(0.919)	(3.100)	1.417
	.717	.557	.581	.489	.504	
Dutch	-0.00001	0.099	0.256	1.072	0.733	-0.042
guilder	(0.009)	(0.349)	(1.309)	(0.964)	(3.253)	1.540
	.999	.778	.845	.266	.822	
Swiss	0.0004	0.071	-0.030	0.966	1.389	-0.059
franc	(0.010)	(0.408)	(1.530)	(1.127)	(3.802)	1.690
	.966	.863	.985	.391	.715	

Note: The standard errors of the estimated coefficients are in parenthesis below the coefficients. The marginal level of significance of the test of the hypothesis that the coefficient is zero is reported below the standard errors.

terms of the U.S. dollar. The exchange rate data were obtained from the OECD Main Economic Indicators and are end-of-quarter rates for the spot and the three-month forward exchange rates. The currencies are the Belgian franc, the British pound, the Canadian dollar, the Deutsche mark, the Dutch guilder, the French franc, and the Swiss franc. Since several of these currencies are members of the European Monetary System, it is unlikely that the results provide independent information across all currencies.

The motivation for the dependent variable is the unbiasedness hypothesis that links forward rates to expected future spot exchange rates under a presumption of risk neutrality. Evidence on the validity of this specification is presented below. Here I merely note that previous research, surveyed in Hodrick (1987), suggests that the specification is questionable. Since unanticipated changes in exchange rates are so large, though, it may be reasonable to conclude that nothing particularly critical in the interpretation of these results hinges on the failure of the unbiasedness hypothesis. This is certainly not true as a general rule.

The regressors in Table 4 include a constant and the residuals from a VAR that are the unanticipated changes in the logarithm of real federal government purchases, UG; in the real federal government deficit relative to trend, UD, measured by deflating nominal deficits by the product of trend real GNP and the GNP deflator; in the logarithm of real balances, UM, measured as the M1 money supply for the last month of the quarter divided by the GNP deflator; and in the logarithm of the GNP deflator, UP.[8] I followed Evans (1986) and estimated a fourth-order VAR on seven variables that included a constant, the four variables described above, the discount rate of the Federal Reserve, and the logarithms of real GNP and the monetary base. The VAR was estimated from 1962:II to 1987:IV, and the results of Table 4 are for 1973:III to 1987:IV due to availability of exchange rate data.

Before I discuss my extension of Evans (1986), I present a typical equation from his Table 1 with the coefficients and standard errors in parenthesis. The currency is the Deutsche mark, and the constant is suppressed:

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[8]Evans (1986), footnote 10, indicates that he uses a monthly GNP deflator that was constructed by the Federal Reserve Bank of Minneapolis. The deflator series used here is the quarterly data reported by the U.S. Department of Commerce. Evan's results are less dramatic when the quarterly deflator is employed than the deflator for the last month of the quarter, although the inference is not changed dramatically.

$$\log[S^i/F^i(-1)] = \underset{(0.32)}{-1.005UG} + \underset{(1.55)}{5.96UD} + \underset{(1.18)}{2.60UM} + \underset{(2.59)}{7.99UP} + \varepsilon \quad (5)$$

$$R^2 = 0.323; \quad S.E. = 0.0543; \quad D.W. = 1.87$$

Since the exchange rates are U.S. dollars per Deutsche mark, a depreciation (appreciation) of the dollar is a positive (negative) movement in the dependent variable. Hence, Evans found that an increase in federal government spending causes a statistically significant appreciation of the dollar relative to the mark, while increases in federal budget deficits, which are measured positively, cause a statistically significant depreciation of the dollar, as do unanticipated increases in U.S. real balances and in the U.S. price level. One possible explanation of the coefficients on budget deficits is that they are substantially endogenous and are merely reflecting bad news about the performance of the U.S. real economy, which depreciates the dollar. Another explanation is that budget deficits are eventually financed by printing of money, and an increase in the budget deficit creates expected inflation which depreciates the dollar. Evans (1986) examined cyclically adjusted budget deficits and found similar effects which tend to support the latter interpretation.

The results in Table 4 indicate that extension of the sample period to 1987:IV completely eliminates the statistical significance of the variables. The magnitudes of the coefficients are reduced and are often opposite of Evan's estimates. The standard errors of the coefficients have increased dramatically, which eliminates the statistical significance of the variables. In particular, the effects of the government purchases and deficit variables are now no longer significantly different from zero. The reduction in the explanatory power of the variables in the larger sample is now reflected in negative adjusted R^2's.

I have not attempted to determine why the results deteriorate in the longer sample, but I have attempted to replicate Evans's results over his sample period with my versions of the variables. My results are not as strong as Evans's even over his sample period. Apparently, Evans's measurement of the GNP deflator as the last month of the quarter is one source of difference between the two estimations. The results also appear to be somewhat sensitive to the starting date.

A complete explanation for the differences across periods would require more space than can be used here, but one thing stands out. If the VAR methodology were correct, in the sense of capturing the exogenous forces of the economy, and there were no changes in regimes, the results would not be so dependent on the sample. Hence, the dependence I find must indicate that the VAR methodology is very suspect and cannot be used to interpret causal influences on exchange rates and capital flows.

In the next section I discuss additional evidence that suggests the importance of risk aversion in developing international financial models to guide our interactions with the data.

INTERNATIONAL CAPITAL MARKET EQUILIBRIUM

Correct analysis of current accounts and international capital flows requires an appropriate description of equilibrium expected returns in international capital markets. Frankel (1985) and Krugman (1986, 1988) have used an argument, premised on the appropriateness of risk neutrality, to address the issue of the sustainability of exchange rates. Unsustainable rates are thought to be part of a "bubble" or possibly an irrationality in the foreign exchange market.[9]

A basic building block of the sustainability explorations is the assumption that the expected rate of change in the real exchange rate is the real interest differential across countries. The level of the real exchange rate is deemed to be wrong or unsustainable if this calculated rate of change implies too much accumulation of external debt over the future. The rate at which the United States accumulates external debt is modeled in a simplistic fashion similar to equation (1), but with constant domestic and foreign growth rates. I find this approach wrong for at least two reasons.

First, it is inappropriate to hold other things constant. Growth rates of countries ought to be allowed to differ over time, and there are determinants of the current account other than the current real exchange rate. Secondly, the assumption of risk neutrality is not well supported by the available evidence.[10] In Hodrick (1987a) I discuss a considerable body of evidence that indicates the inappropriateness of an assumption of risk

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[9] Flood, Hodrick and Kaplan (1987) examine the evidence for the stock market that has been interpreted as findings of bubbles. A critical examination indicates that changes in required expected rates of return are more consistent with the data. Whether the changes in expected returns are sufficient to justify the volatility of stock prices is an open question. A similar argument can be applied to the exchange-rate literature that has purported to find bubbles, e.g., Evans (1986) and Meese (1986).

[10] See Mussa's (1986) discussion of Krugman (1986) for other criticisms of this approach.

neutrality. In this section I present some new results that are representative of the previous findings of myself and others.

Implications Of Risk Neutrality

Let S_t denote the spot exchange rate of dollars per foreign currency, and let F_t be the forward price at which one can contract at time t for purchase of foreign currency in one period. The nominal dollar profit from a long position in the forward foreign currency market is $(S_{t+1} - F_t)$. If π_t is the purchasing power of a dollar, the real value of the profit is $(S_{t+1} - F_t)\pi_{t+1}$. Since there is no opportunity cost to making the forward contract, risk-neutral preferences imply that the expected value of the real profit on the forward contract is zero,

$$E_t[(S_{t+1} - F_t)\pi_{t+1}] = 0. \tag{51}$$

The standard way that an hypothesis such as (51) is tested is to regress realizations of the real profit at time t+1 on information in the time t information set.[11] Since the stationarity of the regressors is a factor in the derivation of the asymptotic distribution theory of the estimators, I first divided the real profit at time t+1 by the product of the exchange rate and the purchasing power of the dollar at time t. The specification of the regression allows a small number of different instruments across currencies:

$$\frac{[S^i_{t+1} - F^i_t]\pi_{t+1}}{S^i_t\pi_t} = \beta_{i0} + \beta_{i1}\frac{[F^i_t - S^i_t]}{S^i_t} + \beta_{i2}\frac{[S^i_t - F^i_{t-1}]\pi_t}{S^i_{t-1}\pi_{t-1}} + \varepsilon^i_{t+1} \tag{52}$$

where ε^i_{t+1} is the rational expectations error term, and the null hypothesis of risk neutrality is $\beta_{ij} = 0$, $j = 0, 1, 2$, for each currency i.

An alternative derivation of the deflation in equation (52) recognizes that its left-hand side, when multiplied by one plus the foreign nominal interest rate, is the difference in two real rates of return. Investing a dollar at time t is a sacrifice of π_t goods. The one dollar purchases $(1/S_t)$ units of foreign currency. Each unit of foreign currency can be

[11]Engel (1984) first tested the risk neutral specification in this way.

invested to give one plus the foreign interest rate in foreign currency at time t+1. If the investment is uncovered, the agent sells the accumulated foreign currency for dollars in the future spot market at S_{t+1}, while if the investment is covered to remove the uncertainty of repatriation at a random exchange rate, the agent contracts to sell the interest plus principal on the foreign currency at F_t. In either case the dollar proceeds of the investment are valued at π_{t+1} in terms of real goods. If agents are risk neutral, the expected real rate of return on all investments should be equal, and the left-hand side of equation (52) should have expected value of zero.

The motivation for the instruments on the right-hand side of equation (52) is the following. As Fama (1984) noted, the forward premium, $(F_t-S_t)/S_t$, can be defined to be the market's assessment of the expected rate of depreciation of the home currency plus an adjusted risk premium. Therefore, it should be a useful instrument if risk is actually present. If expected real returns are not the same across assets, the lagged dependent variable should capture serial correlation in the difference of the two returns if it is present.

Tests of equation (52) were conducted using the same OECD data on exchange rates described above. I examined the hypothesis from two perspectives: a U.S. investor using U.S. dollar per foreign currency exchange rates and a U.K. investor using British pound per foreign currency exchange rates. The purchasing powers of monies were measured as the reciprocals of the U.S. National Income and Product Accounts deflator of consumer nondurables plus services and the U.K. deflator for nondurables.

I examined two types of estimation of the system of equations. In the first I constrained the three parameters of each equation to be the same across the seven equations and estimated the system with Hansen's (1982) Generalized Method of Moments (GMM) without imposing the auxiliary assumption of conditional homoscedasticity. I employed three orthogonality conditions for each currency requiring that the expectation error be orthogonal to the three right-hand side variables.

For the U.S. dollar system, the constrained value of β_0 is -1.722 with a standard deviation of 0.793; the constrained value of β_1 is -0.458 with a standard deviation of 0.122, and the constrained value of β_2 is 0.140 with a standard deviation of 0.061. The value of the chi-square statistic with three degrees of freedom that tests the hypothesis that the three coefficients are zero is 16.483, which corresponds to a marginal level of significance of .0009. This is strong evidence that the expected real returns to speculation by a U.S. investor in the forward foreign exchange market are not constant. The value of the chi-square statistic with eighteen degrees of freedom that tests the hypothesis that the constraints on the coefficients across equations are inappropriate is 15.322, which corresponds to a marginal level of significance of .640.

For the U.K. pound system the constrained value of β_0 is 1.799 with a standard deviation of 1.632; the constrained value of β_1 is -0.325 with a standard deviation of 0.107, and the constrained value of β_2 is 0.157 with a standard deviation of 0.056. The value of the chi-square statistic with three degrees of freedom that tests the hypothesis that the three coefficients are zero is 15.517, which corresponds to a marginal level of significance smaller than .001. The chi-square statistic with eighteen degrees of freedom that tests the hypothesis that the constraints on the coefficients are inappropriate has a value of 19.319, which corresponds to a marginal level of significance of .372.

The other system estimation that I performed was seemingly unrelated regression under the auxiliary assumption of homoscedasticity. The results of this estimation for the U.S. dollar system are presented in Table 5 and for the U.K. pound system in Table 6. The test of the hypothesis that the expected real returns are zero in this case is a chi-square statistic with twenty-one degrees of freedom. For the U.S. dollar system, the value of 52.267 corresponds to a marginal level of significance of .0002, which is quite strong evidence against the null hypothesis. For the U.K. pound system, the value of 77.816 corresponds to a marginal level of significance of .0000001, which is also exceedingly strong evidence against the null hypothesis.

I also constrained the systems to three coefficients as above. For the U.S. dollar system, the constrained value of β_0 is -1.329 with standard deviation of 1.145; the constrained value of β_1 is -0.536 with a standard deviation of 0.117, and the constrained value of β_2 is 0.075 with a standard deviation of 0.049. The value of the chi-square statistic with three degrees of freedom that tests the hypothesis that the three coefficients are zero is 28.411, which corresponds to a marginal level of significance smaller than .000001. The chi-square statistic with eighteen degrees of freedom that tests the hypothesis that the constraints on the coefficients are inappropriate has a value of 19.649, which corresponds to a marginal level of significance of .353. For the U.K. pound system, the constrained value of β_0 is 2.739 with a standard deviation of 2.034; the constrained value of β_1 is -0.641 with a standard deviation of 0.129, and

TABLE 5

System Estimation of Equation (52) for U.S. Exchange Rates

Currency	β_{i0} (Std Err) MLS	β_{i1} (Std Err) MLS	β_{i2} (Std Err) MLS	R^2	$\chi^2(2)$ MLS	$\chi^2(3)$ MLS
Deutsche	4.015	-1.065	0.008	.029	9.795	9.805
mark	(3.449)	(0.350)	(0.066)		0.007	0.020
	0.244	0.002	0.905			
British	-0.435	-0.565	0.196	0.054	4.790	4.802
pound	(2.712)	(0.475)	(0.111)		0.091	0.187
	0.873	0.234	0.077			
Canadian	-2.091	-1.469	-0.063	0.061	3.436	4.207
dollar	(1.281)	(0.794)	(0.133)		0.179	0.240
	0.103	0.064	0.635			
Belgian	1.659	-0.878	0.032	0.020	8.987	9.624
franc	(3.317)	(0.312)	(0.071)		0.011	0.022
	0.617	0.005	0.653			
French	-0.541	-0.796	0.122	0.077	5.221	5.221
franc	(3.040)	(0.615)	(0.076)		0.073	0.156
	0.859	0.195	0.111			
Dutch	3.606	-1.137	0.050	0.038	15.114	15.183
guilder	(3.239)	(0.349)	(0.069)		0.001	0.002
	0.265	0.001	0.473			
Swiss	14.171	-2.309	-0.153	0.062	10.461	10.681
franc	(5.423)	(0.724)	(0.086)		0.005	0.014
	0.009	0.001	0.074			

Note: The system of equations was estimated by seemingly unrelated regression. See also Table 4.

TABLE 6

System Estimation of Equation (52) for U.K. Exchange Rates

Currency	β_{i0} (Std Err) MLS	β_{i1} (Std Err) MLS	β_{i2} (Std Err) MLS	R^2	$\chi^2(2)$ MLS	$\chi^2(3)$ MLS
Deutsche	6.630	-1.273	-0.060	0.098	34.319	34.432
mark	(2.827)	(0.218)	(0.062)		0.000	0.000
	0.019	0.000	0.335			
U.S.	2.081	-0.319	0.210	0.091	5.945	6.807
dollar	(2.568)	(0.448)	(0.090)		0.051	0.078
	0.418	0.477	0.026			
Canadian	1.078	-0.753	0.243	0.145	11.810	12.026
dollar	(2.614)	(0.466)	(0.092)		0.003	0.007
	0.680	0.106	0.008			
Belgian	3.159	-0.779	-0.015	0.075	13.453	14.854
franc	(2.733)	(0.216)	(0.068)		0.001	0.002
	0.248	0.000	0.827			
French	0.774	-1.297	-0.055	0.127	15.757	15.815
franc	(2.526)	(0.327)	(0.076)		0.000	0.001
	0.760	0.000	0.472			
Dutch	5.248	-1.142	0.003	0.110	27.641	27.933
guilder	(2.641)	(0.224)	(0.062)		0.000	0.000
	0.047	0.000	0.967			
Swiss	14.021	-1.819	-0.142	0.112	15.366	15.838
franc	(4.354)	(0.470)	(0.088)		0.000	0.001
	0.001	0.000	0.106			

Note: The system of equations was estimated by seemingly unrelated regression. The data are U.K. pounds per foreign currency. See also Table 4.

the constrained value of β_2 is 0.065 with a standard deviation of 0.049. The value of the chi-square statistic with three degrees of freedom that tests the hypothesis that the three coefficients are zero is 31.937, which corresponds to a marginal level of significance smaller than .000001. The chi-square statistic with eighteen degrees of freedom that tests the hypothesis that the constraints on the coefficients are inappropriate has a value of 35.211, which corresponds to a marginal level of significance of .009.

Should the above analysis be taken as evidence against risk-neutral asset pricing for U.S.- and U.K.-based investors, or is there reason to think that the time series properties of the data are not consistent with the ergodicity assumption implicit in the derivation of the test statistics? These are questions that have been answered differently by different researchers, and I refer the interested reader to Hodrick (1987a) for a survey of the opinions.

Risk-Averse Models

If risk neutrality is not a correct measure of international capital market equilibrium, what is? One natural direction to proceed is to examine models of risk-averse behavior that are capable of reconciling the pattern of time variation in expected returns. Although there has been considerable investigation of intertemporal asset-pricing equations derived from representative agent Euler equations since the publication of Hansen and Singleton (1982), there is not as yet a consensus on the appropriate intertemporal asset-pricing model. Here I merely inquire how well two simple versions work. The first model is in the spirit of the original analysis of Hansen and Singleton (1982). The second is related to the Ricardian model derived above.

If agents are averse to risk, expected returns depend on the nature of the risk aversion and the opportunities that they have for trading assets. In simple intertemporal asset-pricing models, such as Hansen and Singleton (1982), the portfolio decisions require equality between the marginal utility foregone when the asset is purchased and the expected discounted marginal utility of the payoff on the asset. The early empirical tests of the intertemporal asset pricing used the cost of the asset in real terms times the marginal utility of consumption goods as the opportunity cost of the investment, and the tests used the real payoff on the asset times the marginal utility of consumption in the future as the realization of the marginal gain on the investment.

With this timing the difference between the uncovered and covered foreign money market investments is given by

$$E_t\left[\frac{[S^i_{t+1} - F^i_t]\pi_{t+1}U'(C_{t+1})}{S^i_t\pi_t U'(C_t)} \right] = 0 \tag{53}$$

where $U'(C_t)$ is the marginal utility of consumption at time t. If marginal utility is parameterized by $C_t^{-\alpha}$, and consumption is taken to be the consumption of nondurables plus services per household for the U.S. investor and the consumption of nondurables for the U.K. investor, the Euler equations (53) can be estimated for the seven currencies. This specification was tested with monthly data for the U.S. dollar over the sample 1973:3 to 1983:7 by Mark (1985).

I estimated the two seven-equation systems for the U.S. data and the U.K. data separately. Each system contains one free parameter, α, and I used the same set of three instruments per equation as above. For the U.S. data the estimated α is 60.918 with a standard error of 22.208. Although this estimate seems wildly high, in the sense that it implies extremely risk-averse behavior, and consequently probably ought to be taken as evidence against the specification of the model, the chi-square statistic that tests the twenty overidentifying restrictions has a value of 22.656, which corresponds to a marginal level of significance of .329. Hence, while the instrumental variables were powerful enough to provide a strong rejection of the risk-neutrality hypothesis, the orthogonality conditions implied by the risk-averse model are not rejected by the data. Similar results with monthly data are reported by Mark (1985). He found very high estimates of α, and the overidentifying restrictions of the model did not indicate rejection of the specification.

For the U.K. data, the estimated α is 2.1513 with a standard error of 3.0488. The chi-square statistic that tests the twenty overidentifying restrictions has a value of 24.593, which corresponds to a marginal level of significance of .217. The U.K. data do not produce a coefficient of relative risk aversion that is significantly different from zero, but the very strong evidence against the risk-neutral model also is not present when consumption is allowed to vary.

One reason the above specifications of the intertemporal asset-pricing model might be incorrect is that the timing of the marginal utility of consumption is incorrect. In cash-in-advance models such as the one above, the dollar proceeds from an investment can only be used in the next available goods market, and the value of the return in terms of goods is not certain. If this alternative timing is followed, the specification of the Euler equation becomes

$$E_t \left[\frac{[S^i_{t+1} - F^i_t]\pi_{t+2}U'(C_{t+2})}{S^i_t\pi_t U'(C_t)} \right] = 0. \tag{54}$$

I estimated equation (54) for the same seven currencies and with the same set of instruments as employed in equation (53).[12] The results for both currencies are similar in that the estimated α for the U.S. system is 53.652 with a standard error of 16.880, and the chi-square statistic with 20 degrees of freedom is 21.656, which corresponds to a marginal level of significance of .359. For the U.K. system the results are an estimate of α of 3.037 with a standard error of 2.876, and a chi-square statistic of 24.463, which corresponds to a marginal level of significance of .222.

Alternative Interpretations

One puzzling aspect of the above regression analysis is the persistent statistically significant negative coefficient on the forward premiums. This suggests that high values of the forward premium (high forward prices of foreign currencies in term of dollars relative to spot prices) are associated with less depreciation of the dollar relative to the foreign currency than is predicted by the forward premium. Probably, the smaller depreciation is actually an appreciation of the dollar relative to foreign currencies.

A potential explanation of this phenomenon is that the data are simply not reflecting all of the possible events that concern agents when they are setting asset prices. Fama (1984) credits Mussa for advancing the following hypothesis explaining why the sample statistics might not be consistent with the true underlying probability distributions that agents assess rationally.

Since the forward premium is directly related to the nominal interest

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[12] In the formation of the optimal weighting matrix of the orthogonality conditions, I allowed for the first-order moving average process induced by forecasting out two periods. I employed the Newey and West (1987) algorithm to keep the weighting matrix positive definite.

differential across countries from covered interest rate parity, a large positive value of the forward premium indicates that the U.S. nominal interest rate is high relative to the foreign nominal interest rate. Mussa suggested that periods of high expected inflation in either country may also be periods of highly skewed distributions of possible inflation rates. One reason would be because the private sector is worried that the public sector may lose control of the economy. This skewed distribution of possible inflation rates raises the expected rate of inflation, which would raise that country's nominal interest rate and increase the absolute value of the forward premium. If the sample size is insufficiently large, the realizations of high inflation and large depreciations of currencies that concern the private sector may be occurring with less frequency in the actual data than is necessary to reconcile the use of asymptotic statistics. Hence, high nominal interest rates appear in a small sample to be associated with high ex post real interest rates, and large values of the forward premium are associated with appreciations of the dollar while large discounts on forward foreign currencies are associated ex post with depreciations of the dollar.

Bates (1987) examines the evidence from option prices on Deutsche mark futures, which provide additional information about the subjective distributions of future exchange rates implicit in market prices. He finds a lack of symmetry in the ex ante distribution of the dollar-DM rate. Perhaps use of additional data such as option prices will allow a better understanding of the phenomenon in future work.

Additional data in the form of surveys of expected future spot rates have also been employed by Frankel and Froot (1987). Their findings with relatively short sample periods indicate that rationality of the survey data can be rejected.

One possible explanation of the above empirical work is that the market is assessing more possible events than have occurred during the sample period. If this is the case, econometric analysis of the determination of international capital flows and real exchange rates is probably also suspect.

VII. CONCLUSIONS

In this paper I discuss alternative reasons for the current large U.S. capital flows and attempt to provide some perspectives that can guide future modeling of these issues. One major finding is that movements of U.S. real income growth relative to that of the rest of the world and movements in the U.S. real exchange rate do a reasonable job of "explaining" the U.S. current account, when allowance is made for lags in responses. Given this, it seemed reasonable to develop models of the current account as a rational equilibrium response of competitive agents to the stochastic forcing processes of their economies.

I examined two aggregative dynamic models that have strong micro-economic foundations. Both models explicitly develop the savings and investment decisions of the private sector, and both consider rudimentary government sectors. Neither model is, at this point, sufficiently well-posed to be consistent with the data. Solution of the Ricardian model required a number of strong assumptions such as serially uncorrelated driving processes, and separability of the utility function. Solution of the overlapping generations model required that there be one good in the world economy, that the capital stock be allocated costlessly across countries after the realization of productivity, that the government bonds of the two countries be perfect substitutes, and that there be no money. Explicit solution for the flow of capital across countries also required a linearization which imposed an assumption of risk neutrality. Both models allowed for perfect capital mobility across countries with the Ricardian model imposing a perfectly pooled equilibrium. Little work has been done on alternatives to this idea in which the reasons why countries do not accumulate large claims on each other are endogenous.[13]

One different prediction of the two models involves the role of government budget deficits. Both models predict that movements in productivity across countries and in the sizes of the government sectors affect the real equilibrium, but the Ricardian model predicts that the financing of the government sector does not matter as long as taxation is nondistortionary.

This difference in predictions was then examined empirically. The highly significant empirical analysis in Evans (1986) that was interpreted as evidence that U.S. budget deficits do not appreciate the dollar is not supported with an additional two and a half years of data. The specifi-

[13]Feinman, Garber, and Garfinkel (1987) discuss financial warfare and the periodic disruptions of international financial markets that characterize the history of relations across countries.

cation deteriorates very badly. While it is certainly possible that inference from the VAR approach is worthwhile, one suspects that agents have additional sources of information about future deficits not captured by the regressions. Developing a model of the alternative way that agents forecast is necessary before scientific inquiry can proceed.

I next explored two simple models of international capital market equilibrium. The results of these risk premium studies have several alternative interpretations. One may be that international capital markets function poorly and allow exchange rates to be excessively volatile. Another is that risk aversion is an important attribute of our economic environment that interacts with changes in the environment to produce substantial changes in required expected returns and asset prices.[14] A third is that the reported statistics are not appropriate because agents are assigning probabilities to events that have not occurred with sufficient frequency. The sample statistics are poor measures of the subjective probability distributions implicit in the calculations that lead to the decisions of agents. If this is the case, such problems will infect any analysis of exchange rates, and any regressions purporting to explain capital flows will no doubt be misspecified.

Understanding capital flows across countries requires an understanding of the savings and investment decisions of economic agents and of the sources of business cycles and of economic growth. Equilibrium models of these dynamic aspects of the economy are still being developed. Understanding capital flows also requires an understanding of the determination of exchange rates and other asset prices, which requires knowledge of expectations formation of the private sector and of the influence of the government sector on the economy. The models in this paper may prove useful in the development of future economic models of these phenomena.

In the introduction I outlined several important questions that have been posed because of recent U.S. current account deficits. I now provide a simple answer to the questions based more on the style of model that I have developed than on the validity of the actual models. The basic answer to all of the questions is that the recent experience of the current account can be thought of as a normal response of the economies of the

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[14]Hodrick (1987b) explores the ability of changes in the conditional variances of money and output to explain changes in exchange rates. The theory works better than the empirical analysis to date.

world to variations in the shares of government spending in the world economy, to cyclical fluctuations, and to diversities in rates of growth across countries. People who want government protection often think that foreign exchange and other asset markets are not working correctly. I do not share this opinion. I think that stability of government policies and coordination of policies across countries would help ease the forecasting problems that agents face.

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