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A Theory of Exchange Rate Determination

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This paper develops an equilibrium model of the determination of exchange rates and prices of goods. Changes in relative prices of goods, due to supply or demand shifts, induce changes in exchange rates and deviations from purchasing power parity. These changes may create a correlation between the exchange rate and the terms of trade, but this correlation cannot be exploited by the government to affect the terms of trade by foreign exchange market operations.

I. Introduction

Exchange rates have recently exhibited considerable volatility and together with prices have failed to conform to the predictions of the purchasing power parity theory. Frequently, exchange rate changes have failed to resemble contemporaneous changes in relative price levels in either magnitude or direction. Exchange rates and their rates of change have been more volatile than relative price levels and rates of inflation. These features of exchange rate behavior have often been regarded as inconsistent with equilibrium, and several disequilibrium interpretations of this anomalous behavior have been suggested.[1]

This paper proposes an alternative equilibrium explanation of exchange rate behavior. The explanation is based on a model of the simultaneous determination of exchange rates and relative prices of

This paper draws on my Ph.D. dissertation at the University of Chicago. I wish to thank Jacob A. Frenkel, Robert E. Lucas, Jr., Michael Mussa, and Maurice Obstfeld for many helpful comments.

[1] See especially the papers by Dornbusch (1976*a*, 1976*b*) and Mussa (1976, sec. 4). Wilson (1979) combines some features of these papers.

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different goods in international trade in an intertemporal framework with uncertainty and rational expectations. The model emphasizes the role of relative price changes, caused by real disturbances, in determining the behavior of exchange rates and integrates the important issues discussed by the traditional "elasticity theorists" into a general equilibrium framework.[2]

In the model developed in this paper, exchange rates may be volatile and can exhibit autocorrelated deviations from purchasing power parity, even though prices freely adjust to clear markets. Exchange rate changes may appear to cause relative price changes and generate additional uncertainty even when all markets are in equilibrium. Nevertheless, the relationship between the exchange rate and the terms of trade cannot be exploited by government exchange rate policies.[3]

The model shows how a change in the terms of trade caused by relative supply or demand shifts is divided between nominal price changes in each country and an exchange rate change, creating a correlation between the exchange rate and the terms of trade. The greater the changes in the terms of the trade and the larger the role of changes in the exchange rate in effecting these terms of trade changes, the greater the variability of exchange rates. The more persistent the shifts in the supplies or demands for goods, the more persistent the deviations from purchasing power parity.

Besides rationalizing exchange rate volatility and autocorrelated deviations from purchasing power parity, the model has several other implications. The correlation of the exchange rate with the terms of trade will be greater for countries with more homogeneous monetary policies. Exchange rate changes caused by monetary factors will not affect the terms of trade.[4] The model implies that deviations from purchasing power parity and changes in the terms of trade have roughly the same characteristics and bear approximately the same relationship to each other under both fixed and flexible exchange rate systems.

[2] These relative price changes were emphasized in the traditional literature on exchange rates but have been neglected in the recent exchange rate literature associated with the monetary approach.

[3] Government commercial policies such as tariffs or quotas can, however, affect the exchange rate by changing the terms of trade. Cassel (1922) discussed the role of commercial policies in causing deviations from purchasing power parity. Mussa (1974) examined the effects of commercial policies on the balance of payments, and his argument could be applied to a flexible exchange rate case; the effect he emphasizes is the change in real income and hence the domestic demand for domestic money due to a tariff.

[4] This paper abstracts from real effects of monetary shocks due to incomplete information. Saidi (1977) discusses this issue in an international context.

II. Purchasing Power Parity and the Terms of Trade

Large changes in exchange rates are generally associated with different rates of inflation in the countries concerned. A full model of the foreign exchange market is not required for the inference that a change in the stock of money will, other things the same, be associated with a corresponding increase in all nominal prices including the nominal price of foreign exchange. This result is guaranteed by the zero-degree homogeneity of demands and supplies with respect to all nominal prices. The purchasing power parity hypothesis, which states that there is a proportional relationship between the exchange rate and a ratio of foreign and domestic prices or price indexes, can be thought of as stating that other things *are* approximately the same. The accuracy of this hypothesis is independent of the accuracy of any particular theory of exchange rate determination.

A rough idea of the accuracy of purchasing power parity can be obtained from the percentage deviations from purchasing power parity with the U.S. dollar, from 1900–1904 to 1963–67, calculated by Gailliot (1970). These are, for Canada .04, France −.01, Germany .04, Italy −.11, Japan .26, Switzerland .14, and the United Kingdom .11 or .02.[5] Figure 1 shows the ratio of monthly consumer price indexes of France and the United States and the corresponding exchange rate for some recent years. It is apparent that deviations from purchasing power parity persist over time and that exchange rates vary more than ratios of price indexes. Neither phenomenon is unique to France during this time period.[6]

Monetary models of the exchange rate (Frenkel 1976, 1978; Frenkel and Johnson 1978) supplement the purchasing power parity relation with money demand functions and equilibrium conditions in the money markets. The equation for the exchange rate resulting from the basic monetary model is $d \ln e = d \ln (M^s/M^{*s}) - d \ln (m^d/m^{*d})$, where the exchange rate e is the domestic price of foreign money, M^s and M^{*s} are domestic and foreign nominal money supplies, and m^d and m^{*d} are the demands for real balances of domestic and foreign moneys, typically taken to be functions of real income and nominal interest rates. The success of the monetary models in explaining actual exchange rate behavior has been, perhaps not surprisingly,

[5] These are the percentage changes in exchange-rate-adjusted ratios of wholesale price indexes from the 1900–1904 average to the 1963–67 average.

[6] For example, Friedman and Schwartz (1963, p. 64) note that during the greenback period of 1861–79, the U.S.-U.K. exchange rate varied by about 2 to 1, while the ratio of price levels varied by only about 1.3 to 1. The French experience shown in fig. 1 can be regarded as representative.

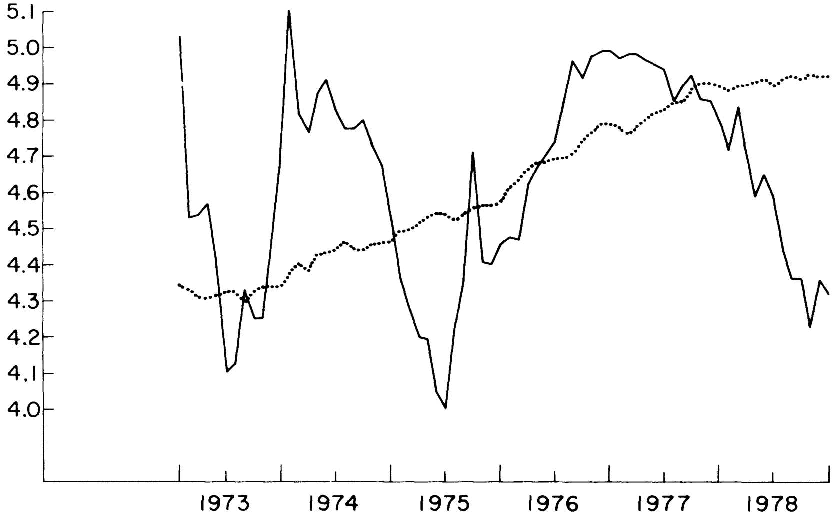

FIG. 1

similar to the success of purchasing power parity. There remain substantial short-run variations in exchange rates unexplained by the monetary models.

In the explanations of exchange rate fluctuations proposed by Dornbusch (1976*a,* 1976*b*) and Mussa (1976), the prices of goods available to people in one country change relative to prices of those same goods in another country because domestic nominal prices are temporarily fixed in each country and a monetary shock causes a change in the exchange rate. A nominal shock therefore causes a change in relative goods prices in those models, even if real supplies and demands for goods are unaffected. Other economists (e.g., Balassa 1964) have emphasized changes in the relative prices of traded and nontraded goods. The relative price change that was emphasized most in the traditional literature on foreign exchange markets was the terms of trade.[7] Krueger (1969) noted that the traditional theory viewed the terms of trade as "the key variable," and the terms of trade also play an important role in the explanation presented by Friedman and Schwartz (1963) of deviations from pur-

[7] See Keynes (1930), Haberler (1949), Robinson (1949), and Machlup (1976). Keynes (1930, pp. 73–74) criticized the purchasing power parity hypothesis for assuming that the terms of trade are constant and suggested that variations in the terms of trade constitute "one of the greatest difficulties in the way of the maintenance of a country's external equilibrium."

chasing power parity during the U.S. greenback era, from the Civil War to 1879.[8] According to the price indexes reported in Graham (1922), the simple correlation coefficient between the log deviation from purchasing power parity (measured with general price indexes in the United States and the United Kingdom and with the greenback price of gold, to which the pound sterling was pegged) and the log terms of trade (measured with export price indexes converted at the current exchange rate) is −.68, calculated with 13 annual observations from 1866 through 1878.[9] The simple correlation coefficients between the monthly percentage changes in the exchange rate with the dollar and the monthly percentage change in the terms of trade (measured as the ratio of the domestic export price index divided by the import price index to the U.S. export price index divided by the U.S. import price index) from January 1974 through July 1977 are −.29 for the Canadian dollar, −.16 for the French franc, −.33 for the deutsche mark, −.15 for the lira, .21 for the yen, and −.24 for the guilder.[10] Dornbusch and Krugman (1976) have also presented evidence of this correlation, while Isard (1977) and Kravis and Lipsey (1978) have presented evidence that the exchange rate is correlated with changes in the terms of trade of even disaggregated categories of goods.[11] While the correlation between the exchange rate and the terms of trade is clear, the interpretation is not. In order to examine the equilibrium relationship between the exchange rate and the terms of trade, the next section presents a model in which both are endogenous.

[8] During the Civil War, U.S. cotton exports were cut off, resulting in a rise in the price of gold (foreign exchange) relative to purchasing power parity by 20 percent and affecting the terms of trade. After the Civil War, as the supply of goods for export rose again and reduced the terms of trade, the domestic currency appreciated from about 20 percent below purchasing power parity to about 10 percent above purchasing power parity. Later movements in the exchange rate may also have been related to changes in the terms of trade. See Friedman and Schwartz (1963, pp. 65–78).

[9] The sign indicates that currency depreciations are associated with increases in the relative price of a country's exports. This result does not seem to be due to spurious correlation induced by using the exchange rate in calculating the terms of trade, since the simple correlation between the log deviation from purchasing power parity and the log of the ratio of export price indexes, *not* converted at the exchange rate, is −.77, and the correlation between the log of the exchange rate and the log deviation from purchasing power parity, which would be negative if there were spurious correlation, is in fact .24.

[10] The number of monthly observations is 43, so the implied t-statistics are −1.9, −1.0, −2.2, −.9, 1.4, and −1.6.

[11] In Stockman (1979) I have outlined an explanation of why equilibrium models can be consistent with this evidence from disaggregated price data. Also, the terms of trade can apparently account for some of the residual variation in monetary models of the exchange rate (see Stockman 1978*b*).

III. A Model

Overview and Individual Optimization Problems

Consider a world with two countries, two goods, and two moneys. People in country one produce only good one but consume both goods one and two; people in country two produce only good two but consume both goods. Thus there is a complete specialization in production, and trade allows people to consume both goods.

Let $\{M_1^s, M_2^s\}_t$ be the nominal quantities of moneys one and two that have been issued by the governments of those countries and are used within those countries for domestic transactions. Let $\{P_1, P_2\}_t$ be the sequence of the money-one price of good one and the money-two price of good two, and let e_t be the price of money two in terms of money one. (I will refer to country one as the domestic country, so e is the price of foreign exchange.)

First suppose that M_1/P_1 and M_2/P_2 are constant over time (because demanders of each money want to maintain a money stock with constant purchasing power in terms of the corresponding good). The relative price of good one in terms of good two is $T \equiv P_1/eP_2$. Suppose now that a relative demand shift occurs: The demand for good one falls, the demand for good two rises, and the demands for moneys are unchanged. The ensuing fall in the terms of trade, T, must occur (solely) through a rise in the exchange rate, e, corresponding to a depreciation of domestic money.

By allowing money demands to depend on interest rates or expected inflation rates, one could study the effects of new information about future rates of monetary growth and inflation on the current exchange rate and price level, as in Mussa (1976) or Wilson (1979).[12] The effects depend on the serial-correlation properties of money and inflation, the interest or expected-inflation elasticity of the demand for money, etc. I will abstract from these important issues in order to concentrate on the relation between the exchange rate and relative prices. The model presented below introduces transactions and precautionary reasons for holding money and relaxes the assumption above that the real demand for money, in terms of the export good, is constant. The proposition illustrated above—that a shift in supplies or demands for goods induces a change in the exchange rate—continues to hold. But the result is generalized: A change in the relative price T due to a shift in supplies or demands for goods will

[12] Note that if prices adjust freely, then new information about future inflation affects current exchange rates and prices proportionally, so that no deviation from purchasing power parity results. Wilson (1979) examines the issue in a Dornbusch-type model with a slowly adjusting price level.

occur *partially* through a change in e and partially through changes in P_1 and P_2.

Another characteristic of the simple model above should be noted now. Since money supply changes have proportional effects on e and P_1/P_2, if the ratio of nominal money supplies is independent of the terms of trade, then the exchange rate will have greater variance than the nominal price ratio. In the model about to be presented, this result may or may not hold, depending on parameter values. However, deviations from purchasing power parity in this model may be autocorrelated even when due to temporary, serially independent shocks.

Let "individual one" be a representative individual in country one. He maximizes the quantity

$$E\left[\sum_{t=0}^{\infty} \beta^t U^1(c^1_{1t}, c^1_{2t})\right] \tag{1}$$

where $\{c^1_1, c^1_2\}_t$ is the sequence of individual one's consumption of goods one and two, $U^1(\cdot)$ is the current-period utility function of individual one, $\beta \in (0, 1)$ is a discount term, and E is an expected value operator.

Similarly, there is a representative individual in country two who maximizes the quantity

$$E\left[\sum_{t=0}^{\infty} \beta^t U^2(c^2_{1t}, c^2_{2t})\right] \tag{2}$$

where $\{c^2_1, c^2_2\}_t$ is the stochastic process describing individual two's consumption of goods one and two, $U^2(\cdot)$ (which need not be the same function as $U^1[\cdot]$) gives current-period utility of individual two, and β and E are as described before.

Production of goods one (in country one) and two (in country two) is exogenously given by the stochastic process $\{y_1, y_2\}_t$. Neither good is storable. Assume the process $\{y_1, y_2\}_t$ is generated by independent realizations of a random vector y_t from a stationary probability distribution with cumulative distribution function $F_y(\cdot)$, so the randomness in production is independent over time. The assumptions that output is exogenous, that goods are nonstorable, that production is specialized, and that shocks to production are independent both across goods and over time could all be relaxed with no important change in the results.

International transactions could in principle involve the use of either money for payments. Empirically, roughly two-thirds of international trade contracts appear to be denominated in the seller's currency (Grassman 1973). The choice of a currency for payments in international trade should depend on costs (in terms of depreciation uncompensated by interest payments on money) of holding each money and differential transactions costs in handling alternative currencies.[13] I assume here that all international transactions are financed with the seller's currency.

Since people demand foreign exchange because they want to purchase foreign goods or assets, the demand for foreign exchange is a derived demand. This was recognized in the traditional exchange rate literature.[14] The traditional elasticities approach formalized the derived demand for foreign exchange in a static model and developed specific formulas for certain cases (e.g., the Marshall-Lerner condition). The formulas obtained depended on the particular assumptions (Mundell 1971, pp. 94–97), but a unifying characteristic of the elasticity models was that they derived the demand for foreign exchange from the demand for foreign goods.

The demands for moneys can be derived from the demands for goods by specifying a simple transactions technology that prevents individuals from engaging in barter. The transactions technology involves a "liquidity constraint" on individual behavior that attempts to reflect the facts that money is held between the transactions for which it is used and that transactions would be more costly without money. The liquidity constraint in this paper requires that goods be purchased with money and that this money be held before it is spent. Expenditures during any period must be financed out of money available at the beginning of the period.[15] This ensures that an indi-

[13] If there are freely tradable international bonds with permissible short selling, then portfolio risks of currencies are irrelevant for money demands because the risk of each currency can be bought and sold in the bond market, thereby separating the decision to hold the money from the decision to hold the risk of the money. Risk elements then only affect bond holdings, not money holdings (see Fama and Farber 1977 and Stockman 1978*a*).

[14] References to the derived characteristic of demand for foreign exchange can be found in Cassel (1922, p. 138), Haberler (1949), Robinson (1949, p. 83), Friedman (1953, pp. 159, 162), Friedman and Schwartz (1963, pp. 161, 590, n. 35), Machlup (1972, pp. 29 ff.; 1976, pp. 111, 115, 119), and Mikesell and Furth (1974, pp. 6–17, 57).

[15] The formulation of the transactions technology used here is similar to that of Lucas (1977) and is one version of the formulation proposed by Clower (1967). Grandmont and Younes (1972, 1973) use a similar but more general formulation that allows some fraction of current income or other assets to be spent in the current period. The transactions technology in this paper is adopted as one way of introducing a transactions demand (and, due to uncertainty, a precautionary demand) for money into an optimization model. An alternative way to introduce money would be with an overlapping-generations model where money is the only store of value, as in Kareken and Wallace (1978). The transactions technology method permits the introduction of other assets (see Stockman 1978*b*) by asserting that only money—not bonds or capital—can be used to pay for goods, although it never addresses the source of this asymmetry.

vidual cannot sell his output for money and instantaneously spend that money for goods; that is, he cannot barter. He carries his receipts from current sales of output into the next period.

Since imports must be financed with foreign exchange (foreign money), the transactions technology applied to imports results in a demand for foreign exchange that is derived from the demand for imports. People, as importers, hold positive balances of foreign exchange, which they have purchased on the foreign exchange market at the price e.

Let the sequence of events each period be the following: The representative individual in country one enters each period with some domestic money, M_1^1, which he may use for domestic purchases, and some foreign exchange, M_2^1, for importing purposes. The superscripts denote the holder of the money (individual one or two); the subscripts denote money one or money two. Individual one then harvests his output, y_1, and takes it to market. (Individual two takes y_2 to market.) He observes the current equilibrium prices (p_1, p_2, and e) at which all trades take place. He purchases consumption goods, obtains the receipts from his sales, then goes to the foreign exchange market to purchase (or sell) foreign exchange to carry into the next period.[16]

Each period individual one chooses consumption of good one, c_1^1; consumption of good two, c_2^1; end-of-period holdings of domestic money (one), $M_1^{1\prime}$; and end-of-period holdings of foreign exchange, $M_2^{1\prime}$, subject to the constraints

$$p_1y_1 + M_1^1 + \tau_1 + eM_2^1 - p_1c_1^1 - ep_2c_2^1 - M_1^{1\prime} - eM_2^{1\prime} = 0, \qquad (3a)$$

$$p_1c_1^1 \leq M_1^1 + \tau_1, \qquad (3b)$$

$$p_2c_2^1 \leq M_2^1, \qquad (3c)$$

where M_1^1 and M_2^1 are predetermined (by last period's choices); y_1 is his output, which he sells at the price p_1 in terms of money one; and τ_1 and τ_2 are realizations of a stochastic process $\{\tau_1, \tau_2\}_t$ representing transfer payments of money one to individual one and of money two to individual two. (These are taxes if they take negative values.) These transfers occur overnight (between periods) and are available with other initial money holdings to finance current consumption. Equation (3a) is a budget constraint while (3b) and (3c) are liquidity constraints imposed by the assumed transactions technology. They state that current purchases of domestic goods are limited by initial holdings of domestic money and current imports are limited by initial

[16] Note that this individual receives payment for the sales of his own good after he has purchased goods this period; his current receipts are not available for financing current consumption. Note also that, as in other highly aggregated models, the individual is assumed to purchase on the market the goods he consumes.

holdings of foreign exchange. The analogous constraints for individual two's optimization problem are

$$ep_2y_2 + M_1^2 + eM_2^2 + e\tau_2 - p_1c_1^2 - ep_2c_2^2 - M_1^{2\prime} - eM_2^{2\prime} = 0, \quad (4a)$$

$$p_1c_1^2 \leqslant M_1^2, \quad (4b)$$

$$p_2c_2^2 \leqslant M_2^2 + \tau_2. \quad (4c)$$

The Role of the Government

The governments of each country have two roles: They determine $\{\tau_1, \tau_2\}_t$, the money supply changes financed by transfers to or taxes from their residents, and they may intervene in the foreign exchange market by buying or selling foreign exchange. Let θ_t denote purchases of money two with money one by the combined actions of the two governments on the foreign exchange market. The policies of the two governments can then be summarized by the stochastic process $\{\tau_1, \tau_2, \theta\}_t$.[17]

Let M_1^s and M_2^s denote the nominal quantities of moneys one and two outstanding at the beginning of the period. Then

$$\begin{aligned} M_1^s &= M_1^1 + \tau_1 + M_1^2, \\ M_2^s &= M_2^1 + M_2^2 + \tau_2. \end{aligned} \quad (5)$$

At the end of the period the nominal money supplies are

$$\begin{aligned} M_1^{s\prime} &= M_1^s + \theta, \\ M_2^{s\prime} &= M_2^s - \frac{1}{e}\theta, \end{aligned} \quad (6)$$

where θ is the foreign exchange market intervention undertaken by governments during the period. At the beginning of the following period nominal money supplies are

$$M_1^{s\prime} + \tau_1' \quad \text{and} \quad M_2^{s\prime} + \tau_2', \quad (7)$$

where the transfers τ_1' and τ_2' occur between periods.

[17] I assume that $\{\theta\}_t$ is the result of a joint decision of the governments of countries one and two. I therefore avoid game-theoretic aspects of the decisions to intervene in the foreign exchange market. Further, it is a matter of indifference (to this model) which country conducts the foreign exchange market intervention. If one country has insufficient reserves (of foreign currency) to sell all the foreign money that the intervention decision requires, the other country can always conduct the intervention since it can print the asset to be sold on the foreign exchange market. That is, there cannot be an international liquidity or reserve problem within this model. Such problems presumably arise in the real world because countries are unable to agree on a choice of $\{\tau_1, \tau_2, \theta\}_t$ and are unwilling to cooperate in the foreign exchange market operations required to achieve a target θ.

Let γ_j^i, $(i, j) = 1, 2$, denote the fraction of money j held by residents of country i. Notice that $\gamma_1^1 + \gamma_1^2 = 1 = \gamma_2^1 + \gamma_2^2$. These allocation parameters are endogenously determined.

Prices

At the beginning of any period the state of the world can be described completely by the state vector

$$s = (y_1, y_2, \gamma_1^1, \gamma_2^1, M_1^s, M_2^s, \theta) \tag{8}$$

and the probability distribution functions $F_y(\cdot)$, $F_t(\cdot)$, and $F_\theta(\cdot)$ which generate the stochastic processes $\{y_1, y_2\}$, $\{t_1, t_2\}$, and θ. Let $F(\cdot)$ denote the joint cumulative probability distribution function of these variables. The state vector s includes current outputs of each good, the nominal supplies of each money at the beginning of the period and their allocations, and the extent of government intervention in foreign exchange markets. A complete account of the state of the world includes both s and $F(\cdot)$, which individuals use to form their expectations about the future.

Individuals choose consumptions and end-of-period asset holdings to maximize (1) or (2) subject to (3) or (4). The equilibrium conditions require that all markets clear:

$$\begin{aligned} c_1^1 + c_1^2 &= y_1, \\ c_2^1 + c_2^2 &= y_2, \\ M_1^{1\prime} + M_1^{2\prime} &= M_1^{s\prime}, \\ M_2^{1\prime} + M_2^{2\prime} &= M_2^{s\prime}. \end{aligned} \tag{9}$$

As only three of these four markets are independent, there are three prices, p_1, p_2, and e, that adjust each period to ensure equilibrium.

The demand functions of individual one for consumption and end-of-period money holdings depend on the prices he faces, p_1, p_2, and e; his initial money holdings, M_1^1 and M_2^1; his current income, y_1 (in terms of good one); and his beliefs about future prices and incomes. Given these beliefs about the future (which enter through the expected value operator in [1] and [2]), individual one's behavior can be described by the optimal policy or demand functions

$$c^1 = c^1(p_1, p_2, e, M_1^1 + \tau_1, M_2^1, y_1), \tag{10}$$

where $c^\prime$ is the vector $(c_1^1, c_2^1, M_1^{1\prime}, M_2^{1\prime})$. Similar demand functions describe individual two's behavior:

$$c^2 = c^2(p_1, p_2, e, M_1^2, M_2^2 + \tau_2, y_2), \tag{11}$$

where $c^2 = (c_1^2, c_2^2, M_1^{2\prime}, M_2^{2\prime})$.

The equilibrium price vector $p = (p_1, p_2, e)$, therefore, depends on (from [9], [10], and [11]) $M_1^1 + \tau_1, M_2^1, M_1^2, M_2^2 + \tau_2, y_1, y_2, M_1^{s\prime}$, and $M_2^{s\prime}$. So, using (5), (6), and the definition of γ_j^i, the price vector p depends on y_1, y_2, γ_1^1, γ_2^1, M_1^s, M_2^s, and θ, which are the elements of the state vector s. Let $p = \phi(s)$ give prices as a fixed function of the state of the world. The problem is now to investigate the function $\phi(\cdot)$ and the behavior of prices as the state vector changes over time.

Dynamics

Prices of goods and foreign exchange change over time as the state vector changes, and this relation is summarized by the function $\phi(s)$. The state vector changes for two reasons. First, new disturbances occur exogenously on initial money supplies, foreign exchange market intervention, and outputs (real incomes). Second, γ_1^1 and γ_2^1 change over time as people optimally adjust to past disturbances and to changes in expectations about the future. Given the expectations held by individuals about future variables and the exogenous transfers of taxes that will occur after the end of this period, the demand function and resulting market prices determine next period's allocation parameters $\gamma_1^{1\prime}$ and $\gamma_2^{1\prime}$.

Next period's state vector is

$$s' = \left[y_1', y_2', \frac{z_1^{1\prime}(s) + \tau_1'}{M_1^s + \tau_1' + \theta}, \frac{z_2^{1\prime}(s)}{M_2^s + \tau_2' - (1/e)\theta}, M_1^s + \tau_1' + \theta, M_2^s + \tau_2' - \frac{\theta}{e}, \theta'\right],$$

where $z_j^{1\prime}(s) = Z_j^{1\prime}[s, \phi(s)]$, $j = 1, 2$, and where $Z_j^{1\prime}[s, \phi(s)]$ is the (average) *aggregate* choice by people in country one of end-of-period balances of money j given s and $p = \phi(s)$. So s' depends on $y_1', y_2', \tau_1', \tau_2'$, θ', and s, given the function $\phi(\cdot)$. That is,

$$s' = G(s, w'), \tag{12}$$

where $w' = (y_1', y_2', \tau_1', \tau_2', \theta')$. So the time path of goods prices and the exchange rate are determined by $p' = \phi(s') = \phi[G(s, w')] =$ function (s, w'). A similar line of reasoning shows that the price that will prevail j periods into the future is a function of the current state vector and the shocks $w', w'', \ldots, w^{(j)}$.

Expectations

The model can be completed with rational expectations imposed through the expected value operators in (1) and (2). Given the expectations held by individuals about the future values of the variables, individuals will be able to formulate demand functions, and prices will adjust to clear markets. These prices depend on the state of the world. However, the prices that occur in each state of the world affect expectations about future prices and therefore affect the demand functions today.

Before defining rational expectations it is useful to rewrite the individuals' optimization problems. Define an indirect utility function $V^1(\cdot)$ by the maximum value attained by the objective function in the solution to the problem

$$V^1(M_1^1 + \tau_1, M_2^{1\prime}, y_1, p) = \max \{U^1(c_1^1, c_2^1) + \beta \int V^1[M_1^{1\prime} + \tau_1', M_2^{1\prime}, y_1', \phi^e(s')]dF(w')\} \quad (13)$$

where maximization is with respect to $(c_1^1, c_2^1, M_1^{1\prime}, M_2^{1\prime})$ and subject to the constraints (3), and where $\phi^e(\cdot)$ maps the space of state vectors into the space of price vectors. Equation (13) says that individual one maximizes current-period utility plus the discounted expected value of future utilities given that he knows he will continue to behave optimally in the future. The optimization problem of individual two can be similarly reformulated. His indirect utility function will be

$$V^2(M_1^2, M_2^2 + \tau_2, y_2, p) = \max \{U^2(c_1^2, c_2^2) + \beta \int V^2[M_1^{2\prime}, M_2^{2\prime} + \tau_2', y_2', \phi^e(s')]dF(w')\} \quad (14)$$

where maximization is with respect to $(c_1^2, c_2^2, M_1^{2\prime}, M_2^{2\prime})$ and subject to the constraints (4).

Each individual may be assumed to have rational expectations in the following sense: (1) The function $F(\cdot)$ in (13) and (14) is the cumulative probability distribution function describing the behavior of $w \equiv (y_1, y_2, \tau_1, \tau_2, \theta)$, defined earlier. (2) The function $\phi^e(\cdot)$ in (13) and (14) is the same function $\phi(\cdot)$ that guarantees market clearing each period. (3) The individual knows that s' is determined by (12).

I assume that the information available to each individual includes the current state vector s. Each individual, since he knows s and $F(w')$, also knows the induced probability distribution function on s' and therefore the induced probability distribution on $p' = \phi(s')$. His current behavior is based on these expectations.

Each individual takes next period's state vector s' as exogenous to his own decisions (and random). Included in s' are $z_1^{1\prime}(s)$ and $z_2^{1\prime}(s)$ on which the individual has, through his knowledge of s and $G(\cdot)$, perfect foresight. This is a result of the individual's knowledge of the *aggregate* decisions that are made today in state of the world s. Now each individual chooses his own end-of-period balances optimally *given* $z_1^{1\prime}$ and $z_2^{1\prime}$. But $z_1^{1\prime}$ and $z_2^{1\prime}$ are just the (average) aggregates of the choices of all these individuals. It can be verified that, by construction of the Markov process $G(\cdot)$, the market-clearing prices $\phi(s)$ ensure that the consistency requirements

$$M_1^{1\prime}[\underline{s}, \phi(\underline{s})] = Z_1^{1\prime}[\underline{s}, \phi(\underline{s})] \tag{15}$$

and

$$M_2^{1\prime}[\underline{s}, \phi(\underline{s})] = Z_2^{1\prime}[\underline{s}, \phi(\underline{s})]$$

are met.

Equilibrium

An equilibrium requires both that people maximize expected utility given rational expectations, that is, that the demand functions solve (13) and (14) when $\phi^e(\cdot)$ is replaced by $\phi(\cdot)$ and s' by $G(s, w')$, where $G(\cdot)$ is such that (15) holds, and that prices clear markets, that is, that the equilibrium conditions (9) hold when the demand functions are inserted. It is straightforward to examine the consumer optimization problem *given* the behavior of prices as a function of the state vector (summarized by the function ϕ); the process generating the dynamic behavior of the state vector (summarized by the function G and the probability distribution function F); and, of course, the current state vector (see Stockman 1978*b*). The demand functions obtained from the maximization problem have some ambiguous signs for the usual reasons—wealth and substitution effects are not always reinforcing. But if substitution effects generally dominate wealth effects and both goods are normal, then increases in initial holdings of either money or in current income result in increases in the demand for both goods and both moneys. Increases in p_1 result in a decreased demand for good one but increases in the demand for the other good (in the absence of strong complementarity) and increases in the demand for both moneys. Increases in p_2 increase the demand for both moneys and the demand for good one while decreasing the demand for good two. Increases in the exchange rate, e, induce increases in the demand for good one and money one and decreases in the demand for good two and money two.[18] As each individual chooses consumption and money holdings taking as *given* the relation between prices and the state vector and the process generating changes in the state vector, the aggregate behavior of these individuals affects the things that each individual takes as given. While anticipations about the random part of the state vector are rational in the sense that the probability distribution on the exogenous variables is known, anticipations about the

[18] Some of these effects become zero when the liquidity constraints become binding as equalities. The optimization problem is analyzed in more detail in Stockman 1978*b*.

elements of next period's state vector that are the result of (aggregate) individual choices made today are rational in the sense that the individual knows with certainty these aggregate choices and makes his own plans accordingly. As all individuals do this, their choices *form* the aggregate choice that each takes as given. Market equilibrium therefore requires that both (9) and (15) hold.[19]

IV. Implications of the Model

Effect of a Real Shock

The initial effect of a real supply shock can be obtained by differentiating the equilibrium conditions (9). If the output of good one is increased, holding everything else constant including individuals' expectations of the probability distributions on future exogenous variables, then one obtains the exchange rate change

$$\begin{aligned} de = \frac{1}{\Delta}\{&(c_{2_{p_1}}M'_{1_{p_2}} - c_{2_{p_2}}M'_{1_{p_1}})(1 - c^1_{1_{y_1}}) \\ &- (c_{1_{p_2}}M'_{1_{p_1}} - c_{1_{p_1}}M'_{1_{p_2}})c^1_{2_{y_1}} \\ &- (c_{1_{p_1}}c_{2_{p_2}} - c_{1_{p_2}}c_{2_{p_1}})M^{1'}_{1_{y_1}}\}dy_1 \end{aligned}$$

where $c_{1_{p_1}} \equiv \dfrac{\partial c^1_1}{\partial p_1} + \dfrac{\partial c^2_1}{\partial p_1}$ and so on, and

$$\begin{aligned} \Delta \equiv\ & c_{1_{p_1}}c_{2_{p_2}}M'_{1_e} + c_{1_{p_2}}c_{2_e}M'_{1_{p_1}} + c_{1_e}c_{2_{p_1}}M'_{1_{p_2}} - c_{1_{p_2}}c_{2_{p_1}}M'_{1_e} \\ &- c_{1_e}c_{2_{p_2}}M'_{1_e} - c_{2_e}c_{1_{p_1}}M'_{1_{p_2}} \end{aligned}$$

[19] I have not been able to characterize the full steady-state solution to the model in the infinite-horizon case. The problem is the following: There are functions $V^1(\cdot)$, $V^2(\cdot)$, $d^1(\cdot)$, and $d^2(\cdot)$ with the desired properties for *each* $\phi(\cdot)$ and $G(\cdot)$, and there is some $\phi(\cdot)$ that satisfies (9) (the equilibrium conditions) for each $d^1(\cdot)$, $d^2(\cdot)$, and $G(\cdot)$. So the set of functions (17) with the desired properties exists if there is a function $G(\cdot)$ satisfying (15). Denote $z' \equiv G^*(s)$, a subvector of $s' = G(s, w')$ since z' does not depend on w', but only on choices made today, prior to the realization of new shocks. Current prices for each $F(\cdot)$ depend on both the state of the world s and the function $G^*(\cdot)$. Denote this correspondence by $\rho[s, G^*(\cdot)]$. The problem is to find a function $\bar{G}^*(\cdot)$ from the space of the state vector to R^2_+ such that

$$\begin{pmatrix} M^{1'}_1\{s, \rho[s, \bar{G}^*(s)]; \bar{G}^*(s)\} \\ M^{1'}_2\{s, \rho[s, \bar{G}^*(s)]; \bar{G}^*(s)\} \end{pmatrix} = \bar{G}^*(s).$$

Then (15) will hold with $\phi(s) \equiv \rho[s, \bar{G}^*(s)]$. Unfortunately, the above equation that implicitly gives $\bar{G}^*(\cdot)$ is a fixed point problem in a space of *functions* and little is known (by me) about its solution. However, the equilibrium can be described for an n-period version of the model for arbitrary n. It seems unlikely that the properties of the steady-state equilibrium, if it exists, will be different from the equilibrium of an n-period version of the model, for which an equilibrium *does* exist (Stockman 1978*b*).

or

$$\frac{de}{dy_1} = a_1 + a_2 c_{1_{y_1}}^1 + a_3 c_{2_{y_1}}^1 + a_4 M_{1_{y_1}}^{1'}.$$

The effect of a change in income on the demand for domestic money, *given* p_1, p_2, and e, is captured in the fourth term, which gives the consequent appreciation of the exchange rate. This is the term emphasized in the monetary approach to the exchange rate and balance of payments. The first term, which does not depend on income elasticities of demand, gives the effect on the exchange rate as the relative price of goods changes due to an increase in the supply of good one. This term is generally positive (the exception obviously being a case in which income effects of a price change dominate substitution effects). The second and third terms give the effect on e of changes in the demands for each good induced by the change in income. These terms comprise two effects. First, *given* the demands for moneys (as in the example at the beginning of Section III), shifts in demands for goods due to a change in income may induce a change in the relative prices of goods and hence in the exchange rate. Second, the budget constraint guarantees that, given $c_{2_{y_1}}^1$ and $M_{1_{y_1}}^{1'}$, the larger $c_{1_{y_1}}^1$ the smaller the increase in the demand for foreign exchange as income rises, therefore the larger the appreciation of domestic money due to a rise in y_1. Note that the magnitude of the exchange rate change, which is associated with the relative price change caused by the supply shock, depends (in a somewhat complicated way) on the elasticities of demand for both goods and moneys.

A similar expression can be derived for the change in the exchange rate due to an increase in y_2. These expressions give the changes in the exchange rate and prices of goods *given* the other elements of the state vector. They may be regarded as expressions for the change in prices, from one period to the next as a new realization of y is realized, that would occur if the only change in s were the change in y. But this will not generally be the case: Aside from changes in money supplies through transfer payments and the extent of government transactions on the foreign exchange market, γ_1^1 and γ_2^1 will generally change over time, reflecting changes in the international distribution of wealth occurring through international capital flows.[20] Windfall gains in income will be dissipated slowly over time and will cause s to change even in the absence of new shocks (in a manner somewhat analogous to the process described in Dornbusch [1976*c*]), as described by the Markov process $G(\cdot)$. The terms of trade will change slowly over time

[20] In this paper these are money flows. The model can be extended to include domestic and foreign bonds as in Stockman (1978*b*).

and the deviation from purchasing power parity will persist, though diminish, over time. So deviations from purchasing power parity may be autocorrelated even when the underlying shocks are serially independent.

A Special Case

Suppose y, τ, and θ are perfectly predictable; in particular let y be a constant vector and $\tau_1 = \tau_2 = \theta = 0$. Then the optimization problem of representative individual one can be represented by $V^1[M_1^1, M_2^1, y_1, \phi(s)] = \max\{U^1(c_1^1, c_2^1) + \beta V^1[M_1^{1\prime}, M_2^{1\prime}, y_1, \phi(s')]\}$ subject to (3). The path of the state vector is determined by $s_{t+1} = G(s_t, \bar{y}, 0) \equiv H(s_t)$, where $\bar{y}$ is the fixed value of the output vector. This is a special case of (12). If this difference equation has a solution $\bar{s}$ then this vector characterizes the steady state of this special case of the model. The issue is what determines the steady-state level of goods prices and the exchange rate.

In this special case neither individual will find it useful to hold precautionary money balances. When each individual spends his entire initial money holdings on goods, the prices of goods follow a simple quantity theory: $M_1^s = p_1 y_1$ and $M_2^s = p_2 y_2$.

The first-order conditions for the representative individuals' optimization problems become (with superscripts omitted)

$$\begin{aligned}\lambda_0 = \frac{U_1(c_1, c_2)}{p_1} - \lambda_1 &= \frac{U_2(c_1, c_2)}{ep_2} - \lambda_2\frac{1}{e} \\ &= \beta V_1[M_1', M_2', \bar{y}, \phi(\bar{s})] \\ &= \frac{1}{e}\beta V_2[M_1', M_2', \bar{y}, \phi(\bar{s})].\end{aligned}$$

The last equality shows that the exchange rate is equal to the ratio of the marginal values of each money for purchasing goods next period. The exchange rate can also be expressed in terms of the current-period variable by using the above first-order conditions, the budget constraint, and the definition of $V(\cdot)$ to show that $\lambda_1 = \lambda_2/e$. Hence $U_1/p_1 = U_2/ep_2$ in this special case, and the exchange rate can be written as

$$e = \frac{M_1^s}{M_2^s}\frac{y_2}{y_1}\frac{U_2}{U_1} = \frac{p_1}{p_2}\frac{U_2}{U_1}.$$

That is, the exchange rate is related to nominal money supplies, real outputs, and the marginal rate of substitution in consumption between foreign and domestic goods. Both real and nominal variables affect the exchange rate. If a ratio of production price indexes is used

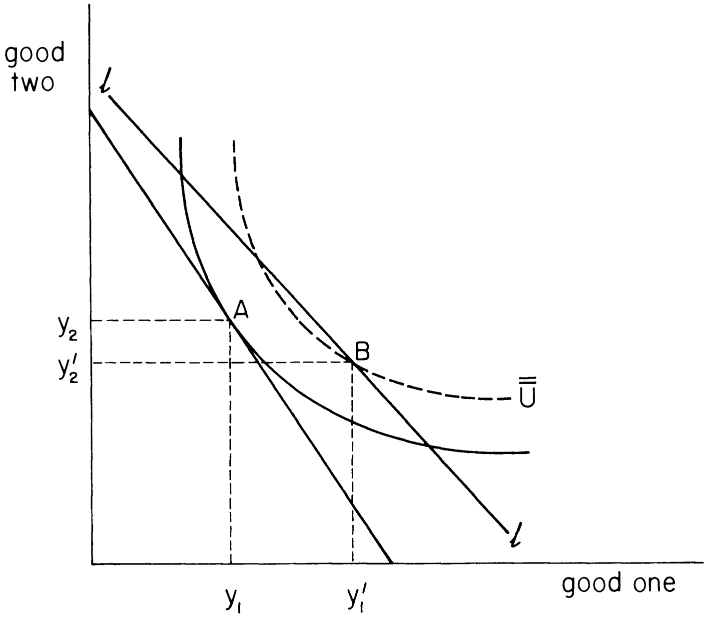

FIG. 2

to calculate purchasing power parity, then deviations of the exchange rate from this value can occur through changes in the marginal rate of substitution between the goods.

A change in the terms of trade will generally occur through changes in each of p_1, p_2, and e. Suppose that equilibrium initially occurs at point A in figure 2. Then let production conditions (endowments) change so that the new production point is B. Given nominal money supplies, the new values of p_1 and p_2 are determined by M_1^s/y_1' and M_1^s/y_2'. Suppose that *at the old exchange rate* this results in a relative price p_1/ep_2 shown by the slope of line ℓ through the equilibrium point B. The highest indifference curve that can be attained at B is $\bar{\bar{U}}$ (I am assuming for simplicity that the utility functions of the two representative individuals are identical and homothetic). If the exchange rate were unchanged, people would attempt to move along a budget line ℓ to a preferred position by purchasing less of good one and more of good two. Individuals in country one therefore increase their demand for foreign exchange to purchase these imports; individuals in country two supply less foreign exchange because of their reduced demand for country one's good at this relative price. Consequently, the price of money two in terms of money one will rise until the relative price of good one, p_1/ep_2, has fallen to a point where ℓ is tangent to $\bar{\bar{U}}$ at B. Then the foreign exchange market (and each goods market) clears. The change in the terms of trade has been divided between changes in nominal export prices and the exchange rate.

Suppose the utility function of each individual is $U = 5(c_1 + c_2) - (c_1^2 + c_2^2) + 5c_1c_2$. Suppose that initial production is at $y_1 = 2, y_2 = 3$. Now let production change to $y_2 = 3, y_2 = 2$. Initially the relative price of the two goods is 16/9. Now, since each nominal price is determined by a simple quantity theory with unit velocity, the exchange rate is

$$e = \frac{M_1^s}{M_2^s}\frac{3}{2}\frac{9}{16} \propto \frac{27}{32}.$$

With the production change and constant money supplies, the exchange rate becomes proportional to 2/3 times 16/9, or 32/27. The new relative price of good one in terms of good two is 9/16. The money-one price of good one is reduced by about one-half, while the money-two price of good two is increased by about one-third. The increase in the exchange rate of about two-fifths accounts for the remainder of the reduction in the relative price of good one by about two-thirds. The depreciation of money one is associated in this example with a "worsening" of country one's terms of trade, that is, a decrease in the relative price of its export good.

Other things the same, the lower the marginal rate of substitution between goods one and two the larger the depreciation of money one relative to money two required for equilibrium. If the marginal rate of substitution between the goods is greater in the long run than in the short run then the exchange rate will depreciate more in the short run than in the long run even if production remains at point B. This "overshooting" by the exchange rate of its long-run value resembles a conclusion reached by Dornbusch, but here it can occur as an *equilibrium* phenomenon.

While a change in the terms of trade is associated with a change in the exchange rate, government exchange market transactions cannot succeed at affecting the terms of trade. If the government of country one were to attempt to depreciate domestic money by purchasing foreign money on the foreign exchange market, M_2^s would fall and M_1^s would rise. As a result, p_1 and e would rise and p_2 would fall, but p_1/ep_2 would remain approximately unchanged. (The qualifier is necessary because of the distribution effects associated with changes in the values of moneys caused by the government transactions.) The reason that government exchange market transactions cannot exploit the relationship between the exchange rate and the terms of trade is that the exchange rate change did not "cause" the terms of trade change (although it may appear that way to some people living in this hypothetical world) but was merely one way in which the terms of trade change occurred.

A producer of good one (individual one) may reasonably regard the exchange rate increase as undesirable in the sense that he would prefer to be producing a relatively more valuable good. These same individuals would be roughly indifferent to a change in the exchange rate that was accompanied by changes in all other nominal prices. In an extended model in which people are uncertain about whether an exchange rate change is associated with a "real" or "nominal" disturbance, people may reasonably be concerned about *any* exchange rate change, since people will rationally impute some part of that change to real factors and some part to nominal factors. Although in this model people were assumed to know the current state vector, in a more general model with incomplete current information, monetary changes, including those due to foreign exchange market operations, might have some real effects. It seems unlikely, however, that such a model would imply that monetary policy could have any systematic effect on relative prices that could provide a theoretical justification for any particular government foreign exchange market policy.

If the government of country one were to peg the exchange rate, then figure 1 would be unchanged but nominal money supplies would change by $dM_1^s + edM_2^s = 0$, M_1^s rising in the example above. Thus p_1 and p_2 would change proportionally to the money supply changes in addition to the changes due to the real disturbance. So p_1 will rise more than if the exchange rate had been flexible and money supplies constant, and p_2 will fall more than in that case. The deviation from purchasing power parity will, therefore, be roughly the same under either exchange rate system, although in the flexible exchange rate case it will occur partially through exchange rate changes while in the pegged exchange rate case it will occur solely through changes in nominal export prices.

V. Conclusions

There are two interpretations of the relationship between changes in the terms of trade and changes in the exchange rate. According to one interpretation, the forces that cause the change in the exchange rate also cause a change in the terms of trade because prices of goods do not adjust to clear markets. The change in relative prices is therefore a disequilibrium phenomenon. This interpretation can be found in Dornbusch (1976*a*, 1976*b*), Dornbusch and Krugman (1976), and Isard (1977). Another version of the disequilibrium interpretation can be found in Negishi (1968) and Kemp (1969, chap. 14). This version begins with a two-country, two-good, two-money model with complete specialization in production and formally differentiates the system with respect to the exchange rate, allowing prices to change but not allowing asset stocks to change. That is, the exchange rate is assumed to change even though no policy variables have changed: There is no change in either money supply and there are no government foreign exchange market actions. This "short-run" analysis allows one to derive some of the formulas presented by earlier foreign exchange market theorists. The associated "long-run analysis" involves changes in policy variables and hence money supplies, but then either the elasticities of demand and supply of goods have *no effect* on the final equilibrium or they affect it only insofar as shifts in demand cause changes in real incomes and hence changes in the demands for domestic moneys (Mussa 1974).

This paper has presented an alternative *equilibrium* interpretation of the elasticity approach to the foreign exchange market and of the relation between the terms of trade and the exchange rate. Domestic money is demanded because it provides the particular services of allowing people to transact (cheaply) in domestic markets to purchase goods, and foreign exchange is demanded by importers because it is used to finance imports, purchase foreign assets, and so on. Other things the same, the demand for foreign exchange depends on the exchange rate. But as Friedman (1953, pp. 159–60) noted: "The changes continuously taking place in the conditions of international trade alter the 'other things' and so the desirabilities of using the currencies of various countries for each of the purposes listed. The aggregate effect is at one time to increase, at another to decrease, the amount of a country's currency demanded at any given rate of exchange relative to the amount offered for sale at that rate."

Real supply and demand shocks affect both relative prices and the derived demand for foreign exchange. A shock that increases the demand for Japanese television sets may also increase the derived demand for yen to import those sets, so the derived demand for foreign exchange is affected as people substitute between domestic and foreign goods (Machlup 1972, p. 35). Friedman and Schwartz (1963, p. 78), in explaining why the U.S. dollar did not depreciate by even more than it did during the greenback era, suggest that economic growth improved "the competitive position of the United States in exports more than it had expanded its demand for imports, which is to say, had increased the demand for U.S. dollars by foreigners (to buy U.S. exports) more than it had increased the demand for foreign currency by U.S. residents (to buy imports). The effect of such a shift in comparative advantage would be to raise the value of the U.S. currency in terms of foreign currencies at which trade would balance," that is, relative to purchasing power parity. The changes in the demand for foreign exchange that result from real supply and demand shocks affect the equilibrium exchange rate. Therefore changes in the terms of trade are associated with changes in the exchange rate.

This paper has shown that deviations from purchasing power parity and exchange rate volatility can be consistent with an equilibrium framework with strong roots in traditional theory of foreign exchange markets (e.g., Friedman 1953 and Machlup 1972). The theory also accounts for a correlation between the exchange rate and the terms of trade. In contrast to pure monetary models of the exchange rate, the theory provides a rationale behind the frequently encountered popular statements that appreciation of a currency is related to a fall in the country's import prices and a rise in the foreign price of its exports, and that a balance of trade deficit or the anticipation of a balance of trade deficit may be associated with a currency depreciation. Since changes in relative prices occur partially through changes in exchange rates, people may care about the level of the exchange rate in the sense that they care about the relative price of domestic and foreign export goods. People may blame a relative price change on the exchange rate for the same reason they may blame inflation on whatever good happened to suffer the greatest relative price increase during the inflation. Since exchange rate changes are simply one of the ways in which the terms of trade change occurs, the equilibrium version of the elasticities approach leads to an entirely different interpretation of the correlation between the exchange rate (or deviations from purchasing power parity) and the terms of trade than is suggested by the disequilibrium models.

While changes in the terms of trade occur partially through changes in the exchange rate, not all changes in the exchange rate are associated with changes in the terms of trade. A currency reform in one country that left unchanged the distribution of wealth would change the price of foreign exchange along with all other nominal prices. In this sense, changes in the exchange rate may be caused by either real or monetary factors.

It follows that government foreign exchange market policies will not be able to exploit the relationship between the exchange rate and the terms of trade in order to achieve a desired terms of or balance of trade. If the relationship between the exchange rate and the terms of trade is due to shifts in the underlying real supplies and demands for foreign or domestic goods, it will not be substantially affected by government foreign exchange market transactions. When a change in the exchange rate is due to such changes in real conditions, government foreign exchange market policies can reverse the change in the exchange rate only by affecting general price levels—it cannot reverse the changes in real conditions that originally caused the exchange rate movement. Other policies such as tariffs, quotas, and controls on foreign exchange transactions may affect the exchange rate indirectly by directly affecting the terms of trade (Cassel 1922, pp. 147–62; Friedman 1953, pp. 167–69) but foreign exchange market transactions cannot be used as a tool by policymakers to exploit the exchange rate–terms of trade correlation.

There appear to be several types of empirical evidence that could be used to discriminate between the equilibrium explanation of exchange rate determination presented in this paper and the disequilibrium explanations that were discussed above, short of estimating an entire general equilibrium structural model. First, the equilibrium theory implies that deviations from purchasing power parity and changes in the terms of trade are essentially real phenomena that will not be systematically related to the exchange rate system (except insofar as different exchange rate systems are associated with different characteristics of monetary policy—e.g., greater variability in the unanticipated component of the money supply might be associated with greater variability of relative prices along the lines of Barro [1976]). Ignoring the distribution effects of money supply changes and the consequent effects on relative prices, a change in the money supply affects the exchange rate only by affecting the general level of nominal variables and cannot reverse the change in real factors that caused the changes in the terms of trade and the exchange rate. Government monetary or exchange rate policy can, therefore, only add a nominally induced change in the exchange rate to a relative-price-induced change in the exchange rate and, hence, cannot affect the terms of trade or the deviation from purchasing power parity. In pairs of countries with relatively greater differences in monetary policies and inflation rates, a greater fraction of exchange rate changes will be due to monetary rather than real changes and the correlation between the exchange rate and the terms of trade will be less pronounced, but the terms of trade and the deviations from purchasing power parity will be unaffected.

Second, the expected rate of change of the exchange rate, as revealed on the forward foreign exchange market (Stockman 1978*a*) should be related to anticipated changes in the terms of trade or factors associated with the terms of trade as well as to the anticipated inflation differential. (This may explain the widely discussed role of the recent U.S. trade deficits in affecting the performance of the dollar on foreign exchange markets.) Third, applied work on the "real side of international trade" should, according to the equilibrium theory, be able to explain relative prices of goods in international trade without making important reference to monetary variables or to the exchange rate system. The exchange rate should enter such studies only as part of measured relative prices.

Further work on the theory presented here might focus on a more detailed characterization of the properties of the equilibrium exchange rate. Another extension would be to include more goods or introduce information, search, or transportation costs that prevent perfect arbitrage in the markets for each good. Other extensions might involve an explicit consideration of prior contracting in international trade or the separation of individual consumers and firms that import foreign goods.

If the theory presented here is true, then government foreign exchange market and monetary policy cannot exploit the relationship between the exchange rate and the terms of trade. Government policies should therefore be directed at other goals not discussed in this paper, such as minimizing the amount of noise in the signals carried by market prices. The choice of a pegged versus flexible exchange rate system can then be based on the classic arguments for each system, such as disciplining the monetary authorities or minimizing adjustment costs (Friedman's "daylight-savings-time" argument) or choosing some rate of inflation that may differ from the foreign rate. A persuasive argument for flexible rates might be to eliminate a constraint on monetary policy in order to make that policy steady and predictable. Although people may quite rationally care about the level of the exchange rate, its changes are only associated with, not causes of, the relative price changes which are really important.

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