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Traded Goods Consumption Smoothing and the Random Walk Behavior of the Real Exchange Rate

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Conventional explanations of the near random walk behavior of real exchange rates rely on near random walk behavior in the underlying fundamentals (e.g., tastes and technology). The present paper offers an alternative rationale, based on a fixed factor neoclassical model with traded and nontraded goods. The basic idea is that with open capital markets, agents can smooth their consumption of tradeables in the face of transitory traded goods productivity shocks. Agents cannot smooth nontraded goods productivity shocks, but if these are relatively small (as is often argued to be the case) then traded goods consumption smoothing will lead to smoothing of the intra-temporal price of traded and nontraded goods. The (near) random walk implications of the model for the real exchange rate are in stark contrast to the empirical predictions of the classic Balassa-Samuelson model.

The paper applies the model to the yen/dollar exchange rate over the floating rate period.

I. Introduction

The past decade has witnessed the development of an extensive theoretical literature on dynamic micro-foundation-based models of the real exchange rate.[1] These new neoclassical models typically emphasize the effects of real factors such as productivity, government spending, taxes, and the terms of trade. However, although the new inter-temporal models have almost completely supplanted older Keynesian models in the theoretical exchange rate literature, far less effort has been devoted to using the models to derive testable empirical implications.[2] The present paper attempts to see whether the

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[1]One of the seminal papers in this area is Obstfeld (1982). For an analysis of the effects of fiscal policy and a broader discussion of the literature on new neoclassical models, see Frankel and Razin (1987).

[2]Froot and Rogoff (1991a, b) test a new neoclassical model of government spending on data for the fixed-rate Bretton Woods period and for the semi-fixed exchange rates of the European monetary system. Ahmed (1987) tests a model which distinguishes between exportables and importables on historical data for Britain during the gold standard. A number of authors have used simulation techniques to try to parameterize new neoclassical models: see, for example, Stockman and Tesar (1991).

intertemporal consumption smoothing behavior emphasized in new neoclassical models might offer some insight into the near random walk behavior of real exchange rates, particularly with regard to the fluctuations caused by movements in the relative price of nontraded goods.[3]

It has long been recognized that the real exchange rate may (approximately) follow a random walk if the underlying fundamental factors governing tastes and technology themselves (approximately) follow a random walk. But this rationale is not very compelling empirically since many of the variables suggested by the major theories of exchange rate determination tend to have significant mean-reverting components. However, in the fixed factor/open capital markets model developed here, movements in the relative price of nontraded goods can be relatively long-lasting (or in some cases permanent) even if the underlying shocks have trend components or are highly transitory.

The basic rationale is that with open capital markets, agents can smooth their consumption of tradeables in the face of transitory traded goods productivity shocks; as a consequence the intra-temporal price of traded and nontraded goods is smoothed as well. The random walk implication of the model is in stark contrast to the empirical predictions of the classic Balassa-Samuelson model, which predicts that countries with high growth trends in traded goods production will have an upward trending real exchange rate. I offer an alternative interpretation of previous empirical evidence in support of the Balassa-Samuelson model, showing that similar results can arise in the context of the model presented here for countries with relatively closed international capital markets. The two classes of models, however, have very different predictions concerning the effects of government spending on the real exchange rate. In the Balassa-Samuelson framework, factors are assumed perfectly mobile across sectors so that government spending shocks have no effects on relative prices. In the present model, aggregate demand as well as aggregate supply shocks can be important.

The model developed here can also be used to examine how capital market liberalization affects the volatility of the relative price of nontraded goods. Interestingly, the direction of the effect is ambiguous and depends on the underlying stochastic process for traded goods productivity. For processes that are stationary in levels, the opening of capital markets can actually reduce the variance of real exchange rate changes. They are damped because with open capital markets, agents can smooth their consumption of traded goods so that fluctuations in the intra-temporal price of nontraded goods do not need to be as large as they would otherwise. The opening of capital markets has the

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[3]The real exchange rate is the relative price of home and foreign goods. It depends, of course, on two different relative prices: the price of non-tradeables in terms of tradeables, and the price of imports in terms of exports (the terms of trade). The theoretical framework developed in the present study focuses entirely on fluctuations in the real exchange rate arising from fluctuations in the relative price of nontraded goods. Part of the justification for this simplification is that the relative price of nontraded goods has changed more sharply in Japan than in other major industrialized countries over the floating rate period, and part is that allows one to demonstrate some important implications of consumption smoothing for the real exchange rate.

opposite effect if traded goods productivity shocks are stationary in growth rates. The time series evidence for U.S.-Japanese manufacturing producivity differentials is broadly consistent with the latter case and indeed, real yen/dollar volatility was significantly higher over the 1980s after Japanese capital market liberalization than it was over the 1970s.

Section VI applies the model to quarterly data for the real yen/dollar exchange rate for the period 1975:Q1-1990:Q3. The model correctly predicts that traded goods productivity shocks will not be helpful in forecasting the real exchange rate. But this is not too difficult a test to pass since, as is well known, it is very difficult to find any structural model that explains exchange rate movements ex-post much less predicts them ex-ante.[4] A more convincing confirmation of the theory would be to find that lagged values of the government consumption spending do help in forecasting. Government consumption spending tends to fall heavily on nontraded goods and its effects therefore cannot be smoothed intertemporally. Unfortunately, the data offer no such positive evidence, although this failure does not constitute a decisive rejection of the model since government spending shocks themselves appear borderline nonstationary.

Interestingly, a number of variables suggested by the theory have strong contemporaneous correlations with the real yen/dollar exchange rate, including government spending, manufacturing productivity, and oil prices (another productivity shock). However, in the structural regressions, only innovations to oil prices enter significantly, and this effect is not significant over the second half of the sample. (This finding is consistent with Japan's success over the past two decades in dramatically reducing its consumption of oil.)

Overall, the empirical application of the model to yen/dollar time series data can only be described as a modest success, though this is to be expected in any attempt to explain fluctuations in an asset price. Part of the problem, no doubt, is that the model does not explain fluctuations in the real exchange rate arising from changes in the terms of trade, except for oil prices. Nevertheless, the analysis appears to be a useful first step towards extracting clearly-defined testable hypotheses using new neoclassical exchange rate models, particularly those that emphasize the traded-nontraded goods dichotomy.

II. The Model

In this section I present an intertemporal model of the real exchange rate and the current account that emphasizes the distinction between traded and nontraded goods, and can be used to analyze the effects of government consumption spending and productivity shocks. The present approach is closely related to that employed in a number of earlier theoretical studies, including Dornbusch (1983), Stockman and Tesar (1990), and

[4]See Meese and Rogoff (1983, 1988).

Froot and Rogoff (1991a), among others. None of these earlier papers, however, emphasizes the empirical implications of the model for explaining the near random walk behavior of real exchange rates.

Throughout, I will assume that the economy under examination is small in the sense that its actions do not affect the world interest rate.

A. Production

The economy produces two types of goods domestically, traded "T" and nontraded "N." The production functions for the two types of goods are given by

$$Y_{Tt} = A_{Tt} L_{Tt}^{\theta T} K_{Tt}^{1-\theta T} \tag{1a}$$

$$Y_{Nt} = A_{Nt} L_{Nt}^{\theta N} K_{Nt}^{1-\theta N} \tag{1b}$$

where Y_T and Y_N are output of the traded and nontraded goods respectively, while L_I, K_I, and A_I are labor, capital and stochastic productivity shocks in sector I. Except where noted, it will be assumed that capital and labor are fixed within each sector, so that there is no inter-sectoral mobility within the country.

B. Utility

The country is inhabited by a representative agent with a time-separable utility function given by

$$V_t = E_t \sum_{s=0}^{\infty} \beta^{s-t} \left[\frac{(C_{Ns}^{\alpha} C_{Ts}^{1-\alpha})^{1-\gamma}}{1-\gamma} \right] \tag{2}$$

where E is the expectations operator, β is the subjective rate discount rate, and C_{It} is period-t consumption of good I; γ is the inverse of the elasticity of intertemporal substitution.

C. International Borrowing and Lending

Both the government and private citizens have free access to world capital markets, in which they can trade noncontingent bonds at gross interest rate R (measured, of course, in terms of tradeables).[5] I will assume that government expenditure is financed by non-distortionary lump-sum taxes, so that Ricardian equivalence holds (that is, holding the path of government spending constant, deficit financing has no real effects). Therefore, without loss of generality, one can integrate the government's budget constraint into the individual's budget constraint. Using this simplification, the representative

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[5]It is quite plausible to assume that risk to nontraded goods production is nondiversifiable; the assumption that idiosyncratic traded goods productivity shocks cannot be diversified away in world capital markets is more debatable. As with Hall's (1978) random walk consumption model, allowing for diversification would cause the random walk property to disappear.

individual's intertemporal budget constraint is given by

$$F_{t+1} = R(F_t + Z_{Tt} - C_{Tt} - P_tC_{Nt} - G_{Tt} - P_t G_{Nt}) \tag{3}$$

where F_t is the representative agent's holdings of foreign assets entering period t, R the gross world real interest rate (measured in tradeables), P is the relative price of non-traded goods in terms of traded goods, and Z_T denotes total income from domestic production (measured in terms of tradeables). G_T represents government consumption of tradeables, and G_{Nt} is government consumption of nontraded goods. It is assumed that government consumption does not affect the utility of private consumption, and that $R\beta = 1$.[6]

Since by definition, there is no way to exchange nontraded goods intertemporally, domestic consumption of nontraded goods must equal domestic output of nontraded goods each period, so

$$Y_{Nt} = C_{Nt} + G_{Nt} \tag{4}$$

Assuming open capital markets, traded goods consumption can, of course, be smoothed intertemporally. Using the flow budget constraint (3), the market equilibrium condition (4) and imposing the usual no-Ponzi-scheme assumption, one can derive the intertemporal budget constraint for the country as a whole:

$$\sum_{s=0}^{\infty} \frac{C_{Ts}}{R^{s-t}} = F_t + \sum_{s=0}^{\infty} \frac{Y_{Ts} - G_{Ts}}{R^{s-t}} \tag{5}$$

D. First-Order Conditions

The first-order conditions for the individual's maximization problem imply that the period t price of nontraded goods, P_t, depends on the relative domestic *consumption* of the two goods:

$$P_t = \frac{\alpha C_{Tt}}{(1-\alpha)C_{Nt}} \tag{6}$$

The subsequent discussion will sometimes use the terms "real exchange rate" and "relative price of nontraded goods" interchangeably, as the consumption-based CPI deflator for the Cobb-Douglas intra-temporal utility function embedded in (2) is simply P^{α}. In this "Scandinavian" model, of course, the relative price of imports and exports — the terms of trade — are assumed constant, so changes in the relative price of nontraded goods constitute the only source of fluctuations in the real exchange rate.

Since nontraded goods consumption in each period depends only on current-period supply, equations (4) and (6) can be combined to obtain:

[6]See Obstfeld (1982) for a discussion of the case in which the rate of time preference is endogneous.

$$P_t = \frac{\alpha C_{Tt}}{(1-\alpha)(Y_{Nt}-G_{Nt})} \tag{7}$$

Government spending on nontraded goods tends to bid up the price of nontraded goods by reducing the net supply available to the private sector. The first-order conditions with respect to traded goods consumption imply that agents smooth expected marginal utility over time:

$$(C_{Nt}/C_{Tt})^{\alpha} \cdot (C_{Nt}^{\alpha} C_{Tt}^{1-\alpha})^{-\gamma} = \beta R E_t (C_{Nt+1}/C_{Tt+1})^{\alpha} \cdot (C_{Nt+1}^{\alpha} C_{Tt+1}^{1-\alpha})^{-\gamma} \tag{8}$$

III. Real Exchange Determination in the Classic Balassa-Samuelson Model

Before examining the behavior of real exchange rates implied by the "fixed factor/open capital markets model," it is instructive to review the classic model of real exchange rates developed by Balassa (1964) and Samuelson (1964). In contrast to the present setup in which capital and labor in each sector are fixed, their model assumes instantaneous equilibrating flows of capital and labor across sectors domestically. With perfect international capital mobility and frictionless movements of labor and capital across sectors, the relative price of non-tradeables is determined entirely by the production side of the model; characteristics of the individual's utility function and the level of government consumption spending have no effect.[7]

With perfect intersectoral mobility, profit maximization implies

$$R = (1-\theta_T) A_T (K_T/L_T)^{-\theta_T} = P(1-\theta_N) A_N (K_N/L_N)^{-\theta_N} \tag{9}$$

$$W = \theta_T A_T (K_T/L_T)^{1-\theta_T} = P\theta_N A_N (K_N/L_N)^{1-\theta_N} \tag{10}$$

where W is the wage rate, and time subscripts have been deleted. Note that given international capital mobility, the capital-labor ratio in the traded goods sector, K_T/L_T, is tied by the first equation in (9). The wage rate is in turn determined by the first equation in (10). The remaining two equations in (9) and (10) then determine K_N/L_N and P.

Logarithmically differentiating (9) and (10), one can easily obtain the classic Balassa-Samuelson result

$$dp = (\theta_N/\theta_T) da_T - da_N \tag{11}$$

where d denotes differentials and lower case letters denote logarithms.

[7]For a more complete discussion of the conditions under which government spending affects the real exchange rate in this class of models, see Froot and Rogoff (1991b). The result that the real exchange rate is independent of aggregate demand factors depends critically on the assumption of open capital markets, and not just on factor mobility.

Balassa and Samuelson argued that in fast-growing economies, productivity growth in the traded goods sector tends to be much higher than in the nontraded goods sector, and therefore the relative price of nontraded goods tends to rise quickly. Note that in the Balassa-Samuelson model, it does not matter whether productivity disturbances are anticipated or unanticipated, since there is instantaneous factor mobility and the real exchange rate is independent of aggregate demand factors. Thus a perfectly anticipated trend productivity differential translates into a perfectly anticipated trend movement in the relative price of traded goods.[8]

The Balassa-Samuelson framework underpins Hsieh's (1982) and Marston's (1987) analyses of the long-term real appreciation of the yen; productivity in the Japanese manufacturing sector has historically tended to be far above that of her major industrialized-country trading partners.[9] The same framework is, of course, also central to the Kravis-Heston-Summers (1991) methodology for comparing real incomes across countries.

It is interesting to note that even if factors of production are not instantaneously mobile across sectors, a relationship similar to (11) holds if the country's capital markets are closed to international borrowing and lending. In this case, of course, even "traded" goods cannot be traded intertemporally, and the intertemporal consumption smoothing equation (8) is replaced by the market clearing condition

$$Y_{Tt} = C_{Tt} + G_{Tt} \tag{12}$$

Combining (12) with equation (7) one obtains

$$dp \cong \zeta_T da_T - \zeta_N da_N - [(\zeta_T - 1)dg_T - (\zeta_N - 1)dg_N] \tag{13}$$

where ζ_I is the ratio of output to consumption in sector I. Productivity shocks have effects isomorphic to the Balassa-Samuelson model. However, in the fixed factor/closed capital markets model, aggregate demand shocks (changes in government spending) matter as well as aggregate supply shocks. Note that in (13) a general rise in government spending will cause p to rise provided that government spending falls relatively more heavily on nontraded goods than does private spending. Adjusting for the distinction between anticipated and unanticipated changes, this basic result extends to the open capital markets model considered below.

One can argue that for many countries the assumptions underlying (13) may be a closer approximation to reality than the assumptions underlying (11). Most of the evidence that has been presented in support of the Balassa-Samuelson hypothesis is from countries with relatively closed capital markets and with significant impediments to factor

[8] The term θ_N/θ_T appears in (11) since if nontraded goods are relatively more labor intensive, then a rise in a_T tends to bid up wages, and therefore nontraded goods prices must rise relatively more.

[9] Yoshikawa's (1990) model of the real exchange rate is also closely related to the Belassa-Samuelson approach.

mobility. For the case of Japan, the topic of the later empirical analyses, capital markets are much more open today than they were in the 1950s and 1960s, and implicit lifetime employment contracts imply relatively low labor mobility.

IV. Real Exchange Rate Determination in the Fixed Factpr/Open Capital Markets Model

I now return to the case where factors are sector specific. As we shall see shortly, the real exchange rate behaves very differently in this case than it does in either the Balassa-Samuelson model, or the in fixed factor/closed capital markets model. Assuming homoskedasticity of the underlying productivity shocks (the A_J's), one can approximate the Euler condition (8) by[10]

$$E_t(c_{Tt+1}-c_{Tt}) \cong \frac{\alpha(1-\gamma)}{\gamma+\alpha(1-\gamma)} E_t(c_{Nt+1}-c_{Nt}) \tag{14}$$

where I have used the fact that $R\beta = 1$. Note that if nontraded goods consumption is fixed, then (14) reduces to a logarithmic approximation to Hall's (1978) random walk consumption model; here only in traded goods. This fact has immediate implications for the behavior of the real exchange rate. Taking logarithms of both sides of the price equation (6), one obtains simply $p_t = c_{Tt} - c_{Nt} + \log(\alpha/(1-\alpha))$, so that

$$p_{t+1} - p_t = (c_{Tt+1} - c_{Nt+1}) - (c_{Tt} - c_{Nt}) \tag{15}$$

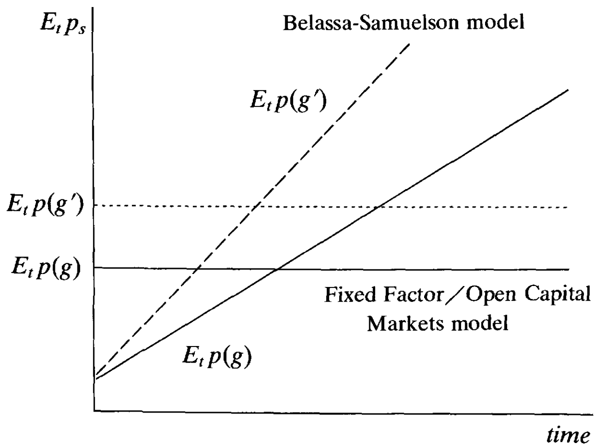
Taken together, equations (14) and (15) imply that barring shocks to the supply of nontraded goods available for private consumption, the log real exchange rate would follow a random walk,*regardless of the serial correlation properties of the shocks to traded goods productivity*. By the same logic, even if there is trend productivity growth in the traded goods sector, there will not necessarily be any trend in the real exchange rate.

Figure 1 graphs the expected path of nontraded goods prices under the assumption that there is trend productivity growth in the manufacturing sector($A_{Tt+1}/A_{Tt} = g$), with all other exogenous variables held constant. The upward sloping solid line gives the path of nontraded goods prices predicted by the either the Balassa-Samuelson model, or the fixed factor/closed capital markets model. The horizontal line gives the path predicted by the fixed factor/open capital markets model. The dashed lines give the response in each case to an *unanticipated* upward shift in the trend productivity growth from g to g'. Note that in the fixed factor/open capital markets model, the real exchange rate can be

[10]In (14), the variables are to be interpreted as deviations from trends. The most important assumption underlying the linearization is homoskedasticity, so that the variance terms in the Taylor series approximations are constant. See Campbell (1991) for a general approach to log-linearizing real business cycle models. The same general results obtained here for the log real exchange rate could be obtained for the level by using a quadratic approximation as in Hall (1978).

Figure 1

The Expected Path of the Relative Price of Nontraded Goods in the Presence of Trend Growth in Manufacturing Productivity



Legend: $E_t p(g)$ is the expected path for the log of the relative price of nontraded goods in the presence of a $g\%$ rate of growth in traded goods productivity ($A_{Tt+1}/A_t = g$), all other exogenous variables held constant. $p(g')$ gives the revised expected path for prices in the face of an unanticipated increase in trend traded goods productivity growth from g to g'.

more volatile than in the Balassa-Samuelson model; we shall investigate this issue more systematically in section VI below. Anticipated traded goods productivity shocks have no effect whatsoever in the fixed factor / open capital markets model, whereas in the Balassa-Samuelson model, anticipated and unanticipated shocks both matter, and in fact have identical effects.

Obviously, the assumption that all factors are sector-specific is reasonable only in the short- and possibly the medium-run; many factors of production are clearly going to be mobile over the long run. But the central point here can readily be generalized to the case where factors are subject to convex costs of adjustment. Even if shocks to traded goods are highly transitory, they will induce long-lasting movements in the real exchange rate. Clearly, though, the model here is more appropriate for looking at monthly or quarterly movements in the real exchange rate rather fluctuations over five to ten year intervals when factor mobility is likely to be quite significant. Further insights into the fixed factor / open capital markets framework can be gained by further linearizations of the model, and I now turn to this task.

V. A Log-Linear Empirical Model

Consistent with the log-linearization of the Euler condition (8), it is assumed that the shocks to both traded and nontraded goods productivity are lognormally distributed with homoskedastic disturbance terms:[11]

$$a_{Nt+1} = \varphi a_{Nt} + \varepsilon_{Nt} \tag{16a}$$

$$a_{Tt+1} = \rho a_{Tt} + \varepsilon_{Tt} \tag{16b}$$

where $0 \leq \varphi$, $\rho \leq 1$, and the ε's are drawn from independent (across time and across sectors) disturbance terms. We will temporarily abstract from shocks to government spending, and focus on the special case in which φ=1. If (the log of) nontraded goods consumption follows a random walk, then the real interest rate is constant, and by (14), there is no tendency for any "tilt" in the anticipated path of traded goods consumption.[12]

If there is no trend in nontraded goods consumption, then the intertemporal budget constraint (5) holds in logarithms to a first-order approximation.[13] Assuming that φ=1, and making use of (14) and (16b), one obtains:

$$c_{Tt+1} - c_{Tt} = \frac{R-1}{R-\rho}(a_{Tt+1} - \rho a_{Tt}) \tag{17}$$

where G_T has been normalized to zero for convenience. If nontraded goods consumption follows a random walk, then innovations to consumption (in deviations from mean) depend only on unanticipated changes in lifetime traded goods income. With φ=1, (15), (16a) and (17) imply

$$p_{t+1}-p_t = \frac{R-1}{R-\rho}(a_{Tt+1} - \rho a_{Tt}) - (a_{Nt+1} - a_{Nt}) \tag{18}$$

Though the focus of this study is the relative price of traded goods, it should be observed that the model also implies an equation for the current account, CA.

$$CA_t = F_{t+1} - F_t = (R-1)F_t + R(Y_{Tt} - C_{Tt}) \tag{19}$$

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[11]For convenience, we normalize so that $Y = A$ in both sectors.

[12]It is important to observe that similar conclusions would hold under the assumption that $\gamma = 1$, so that the intertemporal elasticity of substitution equals one. As equation (14) illustrates, the path of nontraded goods consumption does not affect traded goods consumption, and one can obtain estimating equations analogous to (19), (21) and (22) below.

[13]Introducing a trend would only have the effect of modifying the discount factor r in the logarithmic approximation. Strictly speaking, the approximations applied here are precise only for the first differences of the variables since traded goods consumption is nonstationary. Equation (18) can be derived directly without the intermediate step of equation (17).

where equation (19) abstracts from government expenditures on traded goods. Using (8), and taking a linear (rather than a log-linear) approximation yields

$$CA_t \cong R\left(Y_{Tt} - \bar{Y}_{Tt}\right) \tag{20}$$

where $\bar{Y}$ is simply the expected present discounted value of lifetime traded goods income.[14]

Introducing government spending is straightforward, provided government spending on nontraded goods also follows a logarithmic random walk. With random walk government spending on nontraded goods, equation (18) becomes

$$p_{t+1}-p_t = \frac{R-1}{R-\rho}(a_{Tt+1} - \rho a_{Tt}) - \zeta_N(a_{Nt+1}-a_{Nt}) + (\zeta_N - 1)(g_{Nt+1}-g_{Nt}) \tag{21}$$

where ζ_N is the ratio of nontraded goods output to nontraded goods consumption. Equation (21) constitutes one of the central empirical equations of the model.

Finally, the analysis can be extended to allow for $\varphi<1$, so that shocks to nontraded goods shocks are temporary. In this case, in addition to the direct effect on prices through (6), shocks to nontraded goods production also affect the real consumption-based interest rate thereby "tilting" the path of traded goods consumption; both anticipated and unanticipated nontraded goods consumption affect changes in the real exchange rate. Equation (18) becomes:[15]

$$p_{t+1}-p_t = \frac{R-1}{R-\rho}(a_{Tt+1} - \rho a_{Tt}) - \pi_1(a_{Nt+1}-a_{Nt}) + \pi_2(a_{Nt+1}-\varphi a_{Nt}) \tag{22}$$

The current account equation (20) is similarly modified to incorporate shocks to nontraded goods, although since that is not our central focus, I will omit formal discussion of this case.

VI. Effects of Capital Market Integration

It is interesting to compare equations (13) and (21) to determine the relative volatility of the real exchange rate under open versus closed capital markets. Assuming (a) that the government's share of nontraded goods consumption is the same under both regimes (so that ζ_N is the same in both (13) and (21)), and (b) that either g_N and a_N follow random walks ($\varphi = 1$) or the elasticity of intertemporal substitution $(1/\gamma)$ is one,then it follows that shocks to nontraded goods consumption and government spending on nontraded goods have exactly the same effect under either regime. This is not, however, generally

[14] Ahmed (1986) derives a similar equation.

[15] From (14), one can see that a temporary rise in nontraded goods productivity can either lower or raise the current traded goods consumption (relative to future consumption), depending on the sign of $1 - \gamma$. We shall assume that $\gamma < 1$, so that $\pi_1, \pi_2 > 0$.

the case with shocks to traded goods productivity, a_T. Considering only shocks to traded goods productivity, then with fixed factors, the variance of changes in the real exchange rate under closed capital markets can easily be shown to be

$$\text{var}\,(p_{t+1} - p_t)^{\text{closed}} = 2\sigma_T^2/(1+\rho) \tag{23}$$

where σ_T^2 is the var ε_T, and σ_N^2 has been set equal to zero for convenience.[16] Similarly, one can calculate the variance of changes in the real exchange rate under open capital markets using (21):

$$\text{var}\,(p_{t+1} - p_t)^{\text{open}} = \left(\frac{R-1}{R-\rho}\right)^2 \sigma_T^2 \tag{24}$$

Clearly, when $\rho = 1$, the RHS (right-hand side) of both (23) and (24) equal σ_T^2. The two are exactly the same when $\rho = 1$ since the consumption smoothing channel becomes irrelevant when shocks to productivity are permanent.[17] When $\rho = 0$, then clearly var$^{\text{open}}$ < var$^{\text{closed}}$, and indeed this is the case for any $\rho < 1$. Why are changes in the real exchange rate *less* volatile under open capital markets when productivity shocks are temporary? The answer is simply that the effect of temporary shocks to traded goods consumption are smoothed out under open capital markets, and therefore relative consumption of traded and nontraded goods is relatively more stable. On the other hand, when $\rho > 1$, so that there is a unit root in traded goods productivity, agents' ability to borrow off future income growth magnifies the effects of productivity shocks.

To make this case more precise, suppose that we replace (16b) with the process

$$a_{Tt} - a_{Tt-1} = v\,(a_{Tt-1} - a_{Tt-2}) + \varepsilon_{Tt} \qquad v < 1 \tag{25}$$

a process which is stationary in first differences. Under (25), changes in the growth rate of productivity are temporary, but changes to the level do not tend to damp out over time. Under (25),

$$\text{var}\,(p_{t+1} - p_t)^{\text{closed}} = \sigma_T^2/(1 - v^2) \tag{26}$$

To calculate the variance of real exchange rate changes under open capital markets, it is necessary to first calculate the unanticipated change in lifetime income associated with a productivity shock. It is straightforward to show that equation (17) is replaced by

$$c_{Tt+1} - c_{Tt} = \frac{R}{R-v}[(a_{Tt+1} - a_{Tt}) - v\,(a_{Tt} - a_{Tt-1})] \tag{27}$$

[16]In deriving this result, we use the fact that $a_{Tt} - a_{Tt-1} = (\rho - 1)a_{Tt-1} + \varepsilon_{Tt}$, and that var $a_T = \sigma_T^2/(1 - \rho^2)$.

[17]The variance of the real exchange rate under open and closed capital markets would not in general be the same under random walk productivity, however, if investment were introduced into the analysis.

Using (27) to substitute into (15), one can derive

$$\operatorname{var}(p_{t+1} - p_t)^{\text{open}} = \left(\frac{R}{R-v}\right)^2 \sigma_T^2 \tag{28}$$

Comparing the RHS of (27) with the RHS of (26), we find that for $0 < v < 1$, $\text{var}^{\text{open}} > \text{var}^{\text{closed}}$. Traded goods consumption reacts sharply to productivity shocks when growth rates are positively correlated. Higher income today signals even higher income in the future.

In sum, the effect of opening capital markets on real exchange rate volatility depends critically on the time series properties of the underlying shocks to traded goods productivity. In the presence of temporary shock to the level of traded goods productivity, agents can use open capital markets to smooth out their consumption of traded goods. This in turn leads to a smoother relative price of nontraded goods (by equation (6)). But when agents perceive that a positive shock to productivity signals a higher rate of future traded goods productivity income growth, they will use open capital markets to increase traded goods consumption by more than the increase in current income. Consumption smoothing in this case amplifies the volatility of nontraded goods prices.

Finally, note that if factors of production are perfectly mobile across sectors as in the Balassa-Samuelson model, then government spending will no longer have any real effects once capital markets are fully liberalized.

VII. An Empirical Application of the Model to the Yen/Dollar Exchange Rate, 1975 – 1990

In this section, I will apply the open-capital markets/fixed-factors model to study quarterly data for the yen/dollar exchange rate over the floating rate period, 1975 to 1990. As discussed at the end of section IV, the application to quarterly data makes more sense than an application to very long-term data in which the assumption of fixed factors would be a far less good approximation.

The case of the U.S. and Japan is interesting in that the two countries have experienced very different patterns in productivity growth, differ in their vulnerability to oil shocks (at least over the first part of the sample), and have had rather different trends in government consumption spending. The main rationale for constructing the sample period to begin in 1975 is to abstract from any transition dynamics associated with the breakdown of Bretton Woods. Also, however, the year 1975 marked a notable change in Japanese fiscal policy with the issuance of "deficit bonds" and more generally a relaxation of deficit constraints. (See Ito (1991) for a discussion of the evolution of Japanese fiscal policy.)

In the version of the model used for empirical estimation, the real yen/dollar exchange rate is assumed to depend on the difference between U.S. variables and their

Japanese counterparts. The ratio of consolidated government consumption spending to GNP is used to proxy for G. The reason for focusing on government consumption spending is that in the class of models considered here, the effects on the real exchange rate of government investment are ambiguous theoretically. (Nevertheless, some results for government investment, however, will be considered.) Productivity in the traded goods sector is captured using data on output per man hour published by the U.S. Bureau of Labor Statistics. A drawback to this measure of productivity is that it does not control for differences in investment rates, but on the other hand it avoids the many difficulties involved in measuring capital stocks.

The real exchange rate is measured using CPI deflators. (Similar results for WPI deflators, some of which are also reported.) Clearly, the CPI real exchange rate incorporates both the relative price of nontraded goods and the terms of trade, whereas the theoretical model in the text deals only with the former. Terms of trade fluctuations have, of course, proved almost intractable to model empirically (see, for example, Meese and Rogoff (1988)). Obviously, the model will only succeed on time series data if its ability to explain nontraded goods fluctuations is sufficient to filter through the noise created by terms of trade shocks.

I do make some attempt to control for terms of trade shocks by including the world market price of oil (proxied by the quarterly average spot price of Saudi Arabian Light, deflated by the U.S. CPI)[18] in some of the regressions; I will take up shortly the issue of how the oil variable might also be interpreted as another kind of productivity shock in the model.

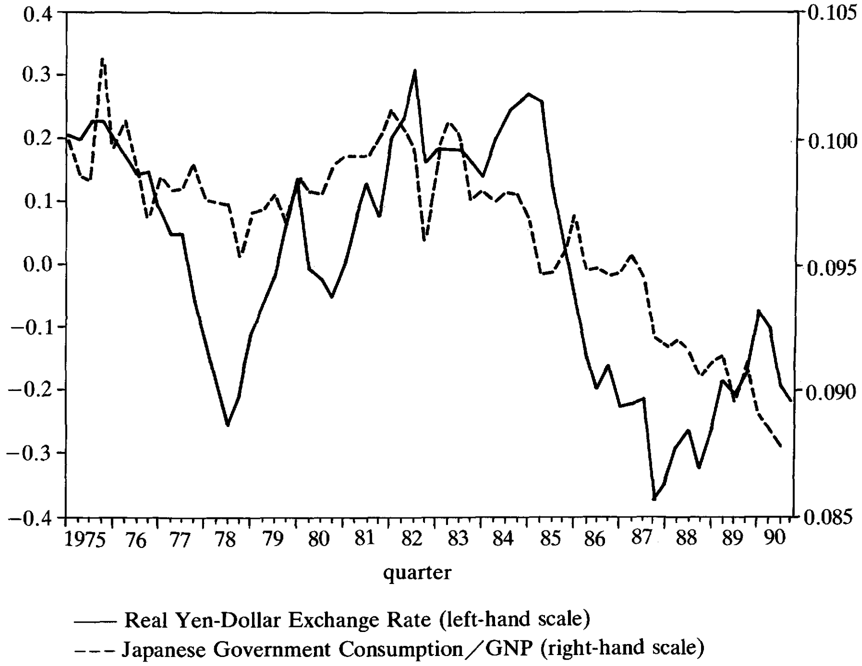
Before turning to the regression results, it is interesting to first examine the graphs in Figures 2-7, which plot the log real exchange rate against some of the key variables suggested by the model: government consumption spending, and productivity differentials (output per man hour in manufacturing). Figure 2 presents the ratio of Japanese government consumption to GNP versus the real (CPI) yen/dollar exchange rate, using quarterly data 1975:Q1-1990:Q3.[19] The two variables exhibit a striking positive correlation. If it were the case that government spending is traded goods intensive, then this evidence would tend to support the model developed here. Unfortunately, the opposite appears to be the case. Indeed, the Management and Coordination Agency's input-

[18]Data on exchange rates, WPIs, CPIs, real and nominal GNPs, nominal government consumption spending, and the U.S. current account and U.S. government debt are from IFS statistics. Data on Labor Productivity in manufacturing are from the BLS; (data for Japan from the BOJ was also used where noted). All other data are from the Bank of Japan data base. Government consumption and investment spending for Japan have been adjusted to remove accounting anomalies due to the import of gold in the mid 1980s for issuance of coins commemorating the former emperor.

[19]If one constructs figures corresponding to Figures 2 through 7 using WPIs instead of CPIs to construct real exchange rates, the results are quite similar. The WPI real exchange rate is slightly flatter; it has not appreciated as much as the CPI real exchange rate. The difference between the two series over the flexible rate period, however, is not nearly as striking as was the case in the 1950s and 1960s.

Figure 2

Real (CPI) Yen-Dollar Exchange Rate vs. Japanese Government Consumption/GNP



output table for Japan indicates that Japanese government consumption spending falls more heavily on nontraded goods than does private spending. In the context of the model, this fact strongly suggests that rises in Japanese government spending should tend to appreciate rather than depreciate the real yen exchange rate.[20] (A rise in the exchange rate here denotes a depreciation of the yen.)

One possible explanation for the observed correlation between the CPI real exchange rate and the government consumption/income ratio is that it might be caused by a price effect which would disappear if one separately deflated government consumption and income. The rationale is that government consumption spending is more heavily towards nontraded goods than is GNP. Figure 3 plots the CPI real exchange rate against the ratio of real Japanese government consumption spending to real GNP, using separate (seasonally-adjusted) deflators constructed by the Economic Planning Agency.[21] The correlation is slightly weaker than for the ratio of the two nominal variables in Figure 2,

[20]I am grateful to Michiko Kinefuchi for pointing out this data to me.

[21]Seasonally unadjusted deflators for government consumption spending and GNP are also available. The non-seasonally adjusted deflator for government consumption spending is extremely volatile.

Figure 3

Real (CPI) Yen-Dollar Rate vs. Real Japanese Government Consumption/Real GNP

—— Real (CPI) Yen-Dollar Exchange Rate (left-hand scale)
--- Real Japan Government Consumption/Real GNP (right-hand scale)

but still not in the theoretically-predicted direction.[22]

The simple correlations of the real exchange rate with Japanese government spending are quite interesting but a two-country version of the model would, of course, require putting in the difference between U.S. and Japanese government consumption spending.[23] As Figure 4 illustrates, this variable performs heroically until 1986. When U.S. government spending is relatively high, the yen depreciates. However, the correlation sharply reverses after that. Most of the regressions below are based on U.S. minus Japanese variables.

Figure 5 gives the correlation between real Japanese government investment/real GNP and the real CPI exchange rate. Curiously, however, the negative simple correlation between government investment and the real exchange rate is more in line with the theoretical model than is government consumption spending, even though the share of traded goods is larger in investment spending. One possible explanation for the anoma-

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[22]Another possible explanation is that higher government spending implies a higher level of distorting taxes, thereby decreasing economy-wide efficiency.

[23]The United States does not explicitly separate out government investment and government consumption in its national income accounts. The data used here are based on *IFS*; however, the Japanese variable should probably be considered more accurate.

Figure 4

Real (CPI) Yen-Dollar Rate vs. U.S.–Japan Government Consumption/GNP Ratios

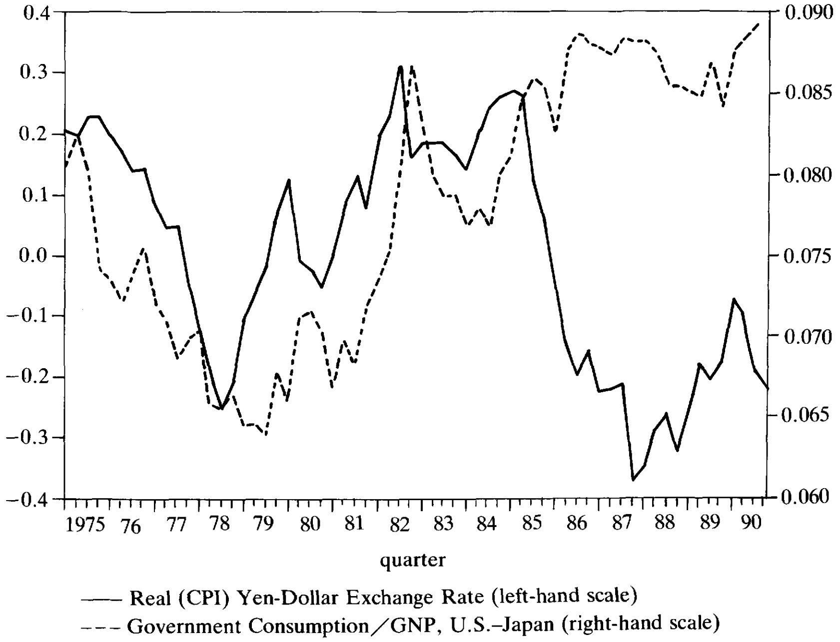
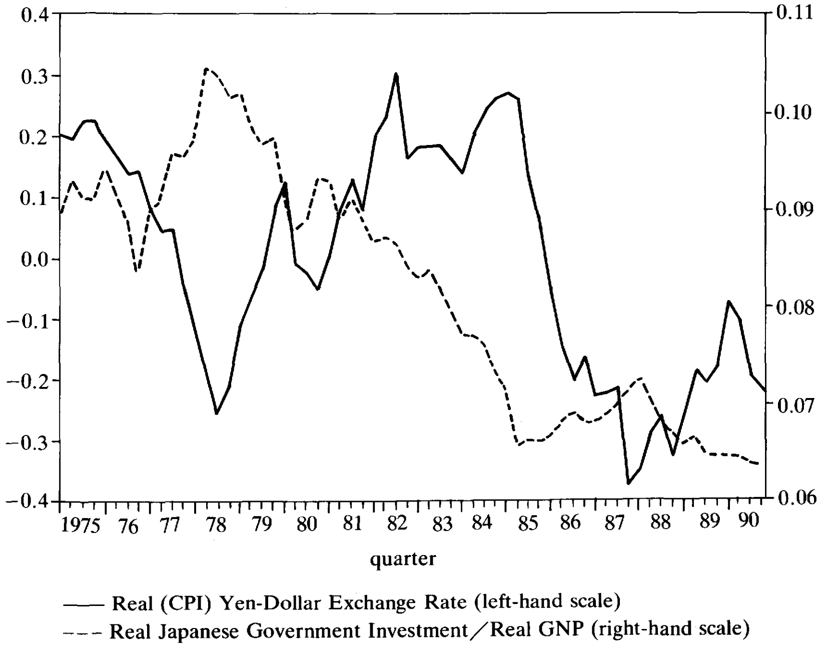


Figure 5

Real (CPI) Yen-Dollar Rate vs. Real Japanese Government Investment/Real GNP



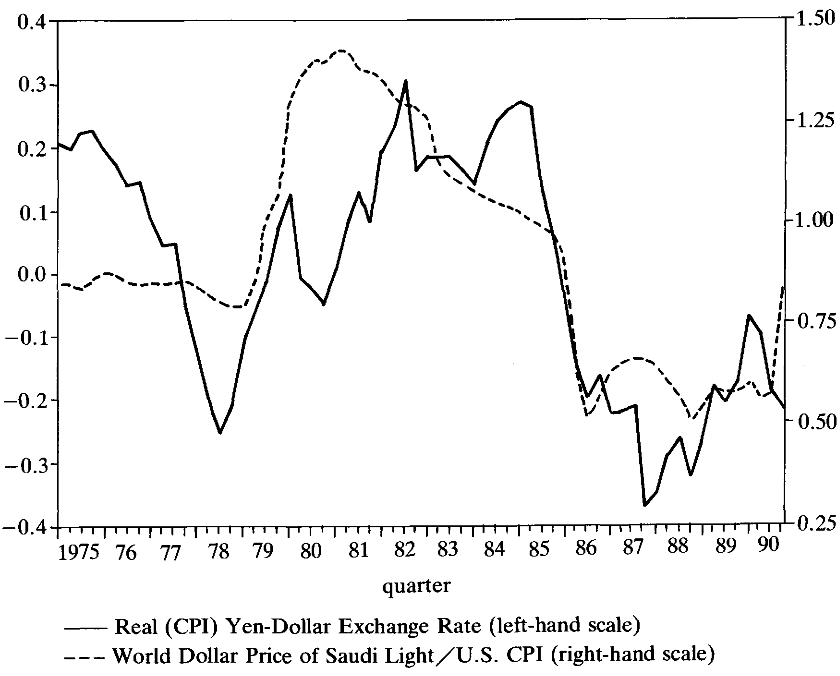
lous government spending correlations is that Japanese fiscal policy is reacts endogenously to the exchange rate.[24]

Figure 6 plots the yen/dollar exchange rate against the world real price of oil. (An index of the dollar price of Saudi Arabian Light divided by the U.S. CPI.) Though a rise in oil prices is likely to reduce productivity in both the traded and nontraded goods sector (in terms of the model, both a_T and a_N fall), it seems likely that the effect on traded goods productivity would be larger. Of course, oil shocks have effects in the same direction for the United States, but for the first part of the sample anyway, the effect was likely stronger for Japan. Oil and raw materials accounted for a significant share of Japanese imports: 66.7% in 1980. However, this share dropped dramatically over the course of the 1980s, and had fallen to 36.3% by 1990.[25]

Finally, Figure 7 plots the real exchange rate against the log of the ratio of labor productivity in the U.S. versus Japan (BLS data). Both variables exhibit a downward

Figure 6

Real (CPI) Yen-Dollar Exchange Rate vs. World Real Price of Oil

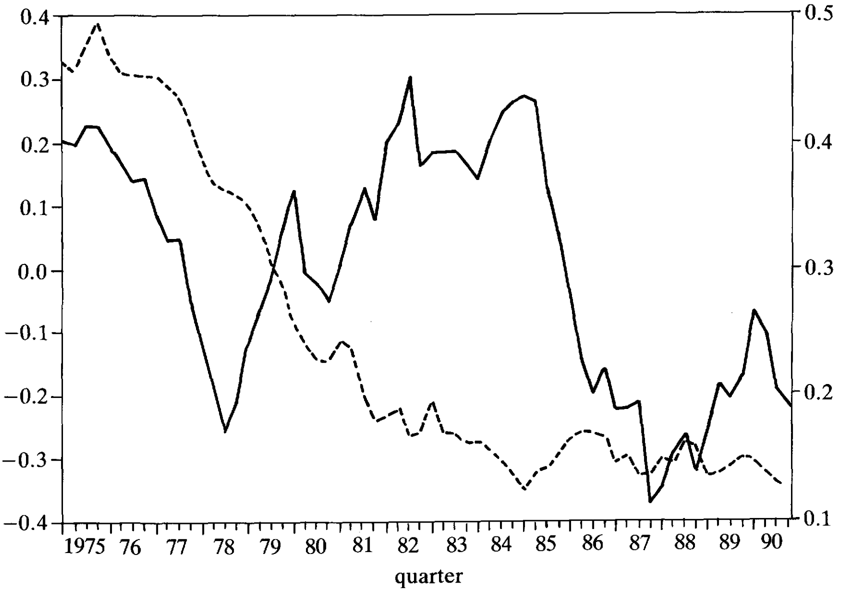


[24]Asako, Ito and Sakamoto (1991) argue that their empirical work supports the view that the Japanese government uses fiscal policy in counter-cyclical fashion.

[25]See Japanese Tariff Association, "Summary Report on Japan," 1991. I am grateful to my colleagues at the Bank of Japan for this reference.

Figure 7

Real (CPI) Yen-Dollar Rate vs. U.S. – Japan Labor Productivity in Manufacturing



—— Real (CPI) Yen-Dollar Exchange Rate (left-hand scale)
--- Ratio of U.S. to Japanese Labor Productivity in Manufacturing, BLS (right-hand scale)

long-run trend, but it is not obvious from the figure whether there is much correlation at higher frequencies. Indeed, in the results below on quarterly data, the productivity differentials provide very little explanatory power.

Before estimating a structural version of the model, we first examine some time series properties of the variables in the Figures. Table 1a reports the results of Augmented Dickey-Fuller unit root tests on the key variables used in the real exchange rate regressions; q is the logarithm of the real exchange rate. Using MacKinnon's (1990) table of critical values, one cannot reject the hypothesis of a unit root in the real exchange rate; this result holds for both the CPI and the WPI real exchange rates, and is not sensitive to detrending. To see whether this property is a peculiarity of the yen/dollar rate, results for the yen / DM are also included. There too, one cannot reject the hypothesis of a unit root in the real exchange rate. In the Table, G denotes the difference between the ratio of foreign (U.S.) government consumption spending to GNP versus domestic (Japanese) government consumption spending to GNP. For the yen/dollar, one can reject the hypothesis of a unit root in $\hat{a}$, which denotes the difference in productivity growth *rates* in manufacturing (formed using logarithms). One cannot, however, reject the hypothesis of a unit root in G. (Results for oil prices are reported

Table 1a
Unit Root Tests on the Real Exchange Rate and Related Variables, 1975:Q1-1990:Q4

$$X_t - X_{t-1} = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 (X_{t-1} - X_{t-2}) + \alpha_3 (X_{t-2} - X_{t-3})$$

(Augmented Dickey-Fuller test)
MacKinnon Critical Values: 1% = −3.5
5% = −2.9
10% = −2.6

	U.S. – Japan	Germany – Japan
q^{CPI}	−1.70	−1.69
q^{WPI}	−1.71	−2.19
G	−0.86	−4.34*
$\hat{a}$	−4.16*	−4.58*

Notes: Null hypothesis that there is a unit root in series can be rejected at 1% level of significande.

Table 1b
Test that Real Exchange Rate and Government Consumption Income Ratio are Cointegrated

(U.S. – Japan: Test on residuals of cointegrating vector same as Table 1a above)

MacKinnon Critical Values for Cointegration Test: 1% = −4.08
5% = −3.44
10% = −3.12

	U.S. – Japan
q^{CPI}. G	−1.33
q^{WPI}. G	−1.25

shortly in Table 3.) The results are the same in the case of the mark/yen except that one can reject the null hypothesis of a unit root in the difference of the government consumption spending/GNP ratios. Table 1b contains tests of the hypothesis that government consumption and the real exchange rate are co-integrated as the theory might suggest; the null hypothesis that they are not co-integrated cannot, however, be rejected.

Table 2 tests what is perhaps the most robust prediction of the fixed factor/open capital markets model: lagged innovations to traded goods productivity should not help predict the real exchange rate. In Table 2, "Dx" denotes $x_t - x_{t-1}$. Only the most parsimonious versions of the regressions are reported, with the change in the real exchange rate on the left-hand side, and the once lagged changes in the (would-be) explanatory variables on the right-hand side. None of the right-hand side variables enters significantly. The results appear extremely robust to including additional lags of the explanatory variables, we well as to including lags of the real exchange rate on the right-hand side.

Anyone familiar with earlier research on empirical real exchange rate equations will not be too taken aback by this evidence.[26] The good news is that the results on oil shocks

Table 2
Tests of Hypothesis that Variables Relating to Traded Goods Productivity Do Not Help Predict the Real Exchange Rate,*
1975:Q1-1990:Q4

	(U.S. – Japan)		(3 : 1 Weights U.S. – Germany)	
	Dq^{CPI}	Dq^{WPI}	Dq^{CPI}	Dq^{CPI}
C	−0.007	−0.004	−0.007	−0.003
	(0.008)	(0.01)	(0.005)	(0.007)
$D\hat{a}_{t-1}$	0.47	0.53	0.43	0.51
	(0.51)	(0.47)	(0.42)	(0.34)
$D^{Oil}{}_{-1}$	0.04	0.04	0.001	−0.0005
	(0.14)	(0.132)	(0.001)	(0.001)
$D.G_{-1}$	1.37	0.95	0.12	0.2
	(3.21)	(3.02)	(0.2)	(0.2)
D.W.:	1.58	1.83	1.51	1.70
R^2:	0.02	0.02	0.02	0.05

Notes: Standard errors in parentheses. Variables are U.S. (U.S./Germany) minus Japan.

[26]See Meese and Rogoff (1983, 1988).

and manufacturing productivity are consistent with the theoretical predictions of our model; theoretically, shocks to traded goods productivity should not help forecast the real exchange rate. The bad news is that lagged G does not help predict the exchange rate either, even though G falls heavily on nontraded goods and therefore could in principle help explain the real exchange rate. One rationalization of the results in Table 2 is that G might not help explain the real exchange rate if most of the shocks to G are permanent, and there does appear to be a unit root in the government spending variable. However, there also appears to be a small but significant degree of serial correlation in the first difference of G so this explanation is not entirely satisfactory. Results for a trade weighted-average of the yen against the dollar and the mark are also reported in Table 2; the resuslts are similar.[27]

Although the main focus of the empirical part of this study is the real exchange rate,

Table 3a
Tests of Hypothesis that Current Account Depends Only on Shocks to Traded Goods Productivity, 1975:Q1-1990:Q2
U.S. - Japan

	CA			*DCA*	
C	−47 (30)	−44 (29)	*C*		
Oil	0.39** (0.13)	0.51** (0.13)	D^{Oil}	0.38** (0.13)	0.43** (0.14)
$\hat{a}$	35 (49)	10 (51)	*D*	34 (46)	22 (48)
G	−179 (315)	−378 (298)	*DG*	−103 (304)	−161 (306)
Debt		166 (63)	*Debt*		118 (87)
ρ:	0.94 (0.05)	0.82 (0.09)			
D.W.:	2.10	2.14	D.W.:	2.14	2.28
R^2:	0.94	0.94	R^2:	0.14	0.16

** indicates significance at 5% level.

[27]The weighted average exchange rate results reported in Table 2 are based on the dollar price of Saudi Arabian oil; the results are similar for the real price.

Table 3b

i) Test for Unit Root in Current Account, Oil Price and Debt Ratios 1975:Q1-1990:Q2

CA:	−1.00
Oil:	−1.61
Debt:	−2.29

MacKinnon Critical Values:	1% = −3.54
	5% = −2.9
	10% = −2.6

ii) Test that *CA*, *Oil*, $\hat{a}$, *G*, are Cointegrated

CA, *Oil*: −1.54

MacKinnon Critical Values:	1% = −4.1
	5% = −3.4
	10% = −3.3

CA, *Oil*, $\hat{a}$, *G*: −2.59

MacKinnon Critical Values:	1% = −4.9
	5% = −4.3
	10% = −3.9

the model also generates predictions for the current account. (It must be noted, however, that the model presented here does not explicitly account for investment, so the current account results reported here must be viewed with caution.[28]) If either the elasticity of intertemporal substitution is one or if consumption of nontraded goods follows a random walk, then the current account should only depend on shocks to traded goods productivity and government consumption of traded goods; this hypothesis is embodied in equation (21). Table 3a contains regressions of the difference between the U.S. and Japanese current accounts (measured in dollars[29]) versus productivity growth differentials, the world real price of oil, and differentials in government consumption and debt ratios. The

[28]See Glick and Rogoff (1992) for a cross-country empirical analysis of the impact of unanticipated productivity and government spending changes on the current account and investment.

[29]Similar results are obtained when the current account differential is deflated by the U.S. CPI.

real price of oil is highly significant whether the regressions are run in levels (allowing for an AR (1) error) or in first differences; neither productivity nor govenment consumption spending enter significantly, however. In the theoretical model developed above, Ricardian equivalence holds and the relative (consolidated) government debt stocks should not matter. Nevertheless, debt ratios do enter significantly in the AR (1) regression though not in the differenced (0, 1, 0) regression. These results are not qualitatively affected by including lagged RHS variables, or by using lagged government consumption, productivity growth shock, and oil prices as instrumental variables (using Fair's method).

As Figure 8 illustrates, there is a strong positive correlation between the U.S.-Japanese current account differential and world oil prices; a high real price of oil tends to worsen the Japanese current account relative to the U.S. current account. In Table 3b, however, although one cannot reject the hypothesis of a unit root in either oil or the current account differential, the two series do not appear to be co-integrated either.

I now turn to investigating more structural implications of the fixed factor/open capital markets real exchange rate model. In the theoretical model, whereas perfectly anticipated shocks do not lead to changes in the real exchange rate, unanticipated shocks do. To separate out the unanticipated component of productivity shocks, I use the autoregressions reported in Table 4. For both oil and manufacturing productivity, a

Figure 8

U.S. – Japan Current Account Difference vs. World Real Price of Oil

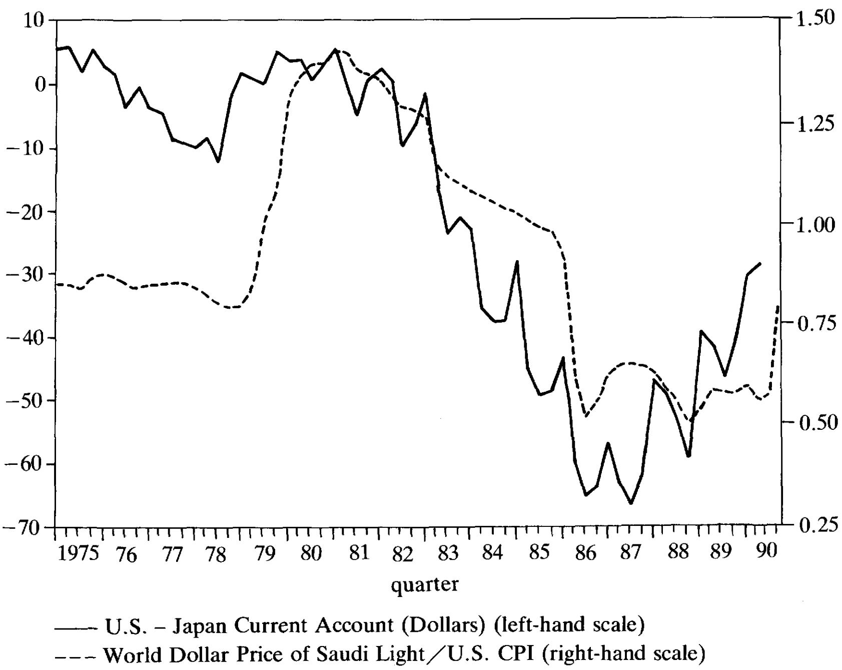


Table 4

Regressions to form $\overline{Y}_T$, $\overline{G}_N$, $\overline{Oil}$, 1975:Q1-1990:Q2

	$\hat{a}$
C	−0.0041
	(0.0019)
$\hat{a}_{t-1}$	0.234
	(0.125)
D.W.:	1.92
R^2:	0.06

	$D^{Oil}{}_t$
C	
$D^{Oil}{}_{t-1}$	0.54
	(0.13)
D.W:	1.59
R^2:	0.22

simple (1, 1, 0) process fits the data fairly well.[30] The residuals from these regressions were used to proxy for unanticipated changes in lifetime traded goods income.[31]

For results over the full sample in Table 5, the coefficient on the innovation to the world real price of oil is of the correct sign and is highly significant; the unanticipated change in the price of oil gives a somewhat better fit than simply including the change in the price of oil. However, neither the productivity differential innovations or the government consumption spending differential ($G_t - G_{t-1}$) appear important.[32] As the Table indicates, the results are the same for the WPI real exchange rate. The results are also robust to including more lags of the exogenous variables, and to including a measure of unanticipated government consumption spending.[33] Table 5 also reports results using Japanese real investment spending in place of the government consumption variable. The coefficient is of the correct minus sign (since it is Japan only) but is not significant.

The right half of Table 5 presents results for the latter half of the sample period, 1981:Q1 to 1990:Q3. Despite the apparent high correlation between oil and the real exchange rate evidenced in Figure 6, the coefficient on the oil shock loses its statistical significance over the latter part of the sample. The decline in the importance of the oil variable is consistent with the fact that Japan has been much more successful than the United States in reducing in its dependence on imported oil, as discussed above.

Finally, note that although productivity trends in the same general direction as the real exchange rate, the statistical relationship between the two variables appears very

[30]One can, in principle, obtain more efficient coefficient estimates by estimating the parameters in Tables 4 and 5 jointly and imposing the nonlinear cross-equation restrictions. I did not attempt this, however.

[31]It is interesting to note that for the oil price, the most consistently significant variable, the results are fairly similar when simply the level of the price of oil is used instead of the innovation.

[32]The results are qualitatively similar if one uses just Japanese government consumption spending instead of U.S. – Japan, despite the strong correlation exhibited in Figure 2. G enters significantly only if oil is excluded.

[33]Unanticipated government consumption ⁄ GNP shocks were formed using a (1, 1, 0) (AR in the first difference) regression for G.

Table 5
Changes in the Real Yen-Dollar Exchange Rate Versus Innovations to Productivity Growth, World Dollar Oil Prices, and Changes in Government Spending

Dq_c	1975:Q1-1990:Q3 Dq^{CPI}		1981:Q1-1990:Q3 Dq^{CPI}	
$\overline{\hat{a}_t} - E_{t-1}\overline{\hat{q}_t}$	−0.07	−0.04	−0.6	−0.7
	(0.64)	(0.63)	(0.83)	(0.84)
$\overline{Oil_t} - E_{t-1}\overline{Oil_t}$	0.35**	0.32**	0.24	0.24
	(0.16)	(0.16)	(0.21)	(0.21)
$G_t - G_{t-1}$	−1.6		−3.7	
	(3.4)		(4.5)	
$GI_t - GI_{t-1}$		−3.56		−5.4
		(3.31)		(6.3)
D.W.:	1.69	1.74	1.81	1.91
R^2:	0.10	0.10	0.07	0.07

** indicates significance at 5% level.

weak throughout the sample. A possible explanation of this fact may be that although the productivity differential shares the same trend as the real exchange rate, it is also extremely volatile and sensitive to cyclical fluctuations. This noise may obscure the underlying correlation.

The empirical analysis thus far has assumed open capital markets; however, as we have already argued this assumption may be strained for Japan for the early floating rate period. It is interesting to ask whether the results developed in section V might be applied to look at the difference in exchange rate volatility before and after the opening of Japan's capital markets. It is true that the dismantling of capital controls was an extended process that began in the 1970s, so there is no clear breaking point.[34] But it is still interesting to compare the 1970s with the 1980s.

For Japan, real exchange rate volatility clearly rose in the 1980s from the 1970s. Over the entire sample period, the standard deviation for quarterly changes in the logarithm of the real yen/dollar rate was 6.3%. For the period 1974:Q1 to 1979:Q4, the

[34]For an early discussion of the lifting of Japanese capital market restrictions, see Frankel (1984). Fukao (1990) and Ito (1991) contain useful chronologies of the gradual relaxation of controls on Japanese capital markets.

standard deviation was 5.2%; it rose to 6.9% for period 1980:Q1 to 1990:Q4.[35] Though obviously the framework here is unlikely to account for the entire rise in volatility, the model does appear broadly consistent with it. Table 4 contains some evidence that there is serial correlation in the growth rate of manufacturing productivity differentials, which from equations (26) – (28) is consistent with having higher volatility of the real exchange rate under open capital markets. However, results on stationarity of time series can be fairly sensitive to methods of detrending, etc., so a more complete test of the model's implications for open versus closed capital markets really requires looking at broader range of country experiences.

VIII. Conclusions

The present paper offers a methodology for investigating the effects of productivity disturbances and government spending shocks on the real exchange rate. The theory offers a novel explanation of the near random walk behavior of exchange rates, and also offers a framework for studying the effects of capital market liberalization on the volatility of the relative price of traded and nontraded goods.

The empirical part of the paper, which applies the open capital markets / fixed factor model to the yen / dollar exchange over the period 1975:Q1 to 1990:Q3, is only a modest success. The results are indeed consistent with the central theoretical prediction of the model that even if the shocks to traded goods productivity (proxied by oil prices and productivity in manufacturing) are serially correlated, these variables cannot help predict the real exchange rate under fully open capital markets. The real exchange rate should, however, generally respond to unanticipated shocks to traded goods productivity. For the early part of the sample, the evidence suggests that unanticipated changes in the world real price of oil did indeed tend to cause the yen to depreciate against the dollar; this result was consistent with oil shocks having a greater impact on traded goods productivity than on nontraded goods productivity, and with Japan having a higher dependence on imported oil than the United States. Over time, however, Japan has significantly reduced its dependence on imported oil, and the correlation between unanticipated oil shocks and the real exchange rate becomes insignificant over the latter part of the sample.

There does appear to be some correlation between government consumption spending and the real exchange rate but it is not of the sign redicted by the simple version of the model tested here. One possible explanation for this anomalous correlation is that traded goods productivity shocks simultaneously cause the price of government spending to rise

[35]Rogoff (1991) presents more detailed evidence on the evolution of exchange rate volatility (concentrating however on nominal exchange rate volatility). The evidence generally suggests that the volatility of the nominal yen / dollar rate rose at the beginning of the 1980s, but has remained relatively stable since then.

and the real exchange rate to appreciate. However, the negative correlation remains when nominal government spending and nominal spending are deflated separately. An alternative explanation, but one not explored here, is that Japanese fiscal policy is endogenous and reacts to the exchange rate.

The correlation between labor productivity differentials and the real exchange rate, which has been emphasized in a number of earlier studies, is evidently apparent only over very long time periods, longer than the sixteen-year floating period studied here. This observation is completely consistent with the theoretical model developed here; to the extent traded goods productivity growth is anticipated, it will not help explain changes in the real exchange rate.

Finally, the model is broadly consistent with the fact that real exchange rate volatility was higher in the 1980s after capital market liberalization than it was in the 1970s. The model suggests that this will be the case if traded goods productivity shocks are stationary in growth rates, which is broadly consistent with the data. However, further testing of the model on a broader cross-section of capital market liberalization experiences is necessary before drawing any strong conclusions concerning this channel.

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