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The Real Exchange Rate under Alternative Nominal Exchange Rate Regimes

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Abstract

The real exchange rate is defined as the relative price of tradable goods to nontradable goods. Its equilibrium value is modified by real disturbances emerging in the goods market on the supply or demand side. The real shock analyzed in the paper is an expenditure-switching fiscal policy. The subsequent change in the real exchange rate takes place independently on the underlying nominal exchange rate regime. The difference between fixed and flexible nominal exchange rates concerns only the proper mix of flexibility of the absolute price levels of tradables and nontradables.

I. Introduction

The real exchange rate measures the relative price of goods while the nominal exchange rate stands for the relative price of currencies. The most comprehensive definition of the real exchange rate is represented by the ratio of the foreign to the domestic price level, both expressed in terms of the domestic currency. If each price index contains nontradable, exportable and importable goods, a change in the real exchange rate can account for changes in the relative of nontradables in the two countries and for changes in the terms of trade.

In the literature, two types of models are used for the analysis of real exchange rate determination (Camen/Genberg 1989). On the one hand, there are "purely real models" in which markets clear instantanously and where changes in the pattern of production and expenditure give rise to modifications in the equilibrium value of relative prices and of the real exchange rate. On the other hand, there are monetary (or

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macro-oriented) models in which only asset markets continuously clear while there is some stickiness of prices in the goods markets. Consequently, monetary disturbances have also real effects producing changes in the real exchange rate as an outcome of the asymmetry in the speed of adjustment of goods and asset markets.

The choice of the model should be dictated by the purpose of the analysis. If the proclaimed aim consists of the explanation of real exchange rate movements during the recent period of floating exchange rates, the monetary type of model seems to be more appropriate since its assumptions are closer to "reality", If, on the other hand, the purpose of the analysis is concerned with the principle of real exchange rate determination under alternative nominal exchange rate regimes as it is the case with the present paper, the *real model should be used since it concentrates on long-run movements in equilibrium value of the real exchange rate abstracting from short-run price* rigidities. However, it should be noticed that neither type of models (or any others) have provided us until now with a satisfactory understanding of the real exchange rate changes in the "Dollar-Deutschemar-Yen Triangle" over the 1970s and, in particular the 1980s. Under this aspect, even the monetary model is still far away from "reality".[1]

Since we restrict ourselves to a one-country view, the concerned economy must be of the small-open kind of an economy for which the terms of trade are given exogenously. Consequently, the relevant measure of the real exchange rate comprises exclusively the relative price of nontradables of the domestic country. Since, furthermore, we are concerned with the long-run movements in the real exchange rate, only real disturbances will affect them resulting from differential productivity growth rates between tradables and nontradables or from divergent income elasticities of the demand for each category of goods. Under this aspect, the appropriate model of the real exchange rate determination should be based on the Balassa-Samueson reformulation of the purchasing power parity theorem(PPP). A recent support of this model has been provided by Kravis (1986) and his associates in the context of the national income comparison project of

1. "After twenty or thirty years of exchange rate modelling, from the work of Meade and Mundell to the New Classical Economics, we are left with an uncomfortable recognition that our understanding of exchange rate movements is less than satisfactory. Most models have lost their ability to explain what has happened, when exchange rates moved a lot, as in the 1980s. The dollar movements of the 1980s are to open economy macroeconomics what the Great Depression has been to macroeconomics-a baffling, largely unexplained phenomenon. For some approaches the explanation has to rely on mystical productivity shocks, other approaches now use models of asset markets that consciously reject conventional rationality." (Dornbusch 1988, pp. 1-2).

the World Bank.

In Order to simplify the analysis, we assume a non-growing economy. Real shocks arise only from the demand side. We have chosen expeniture-switching fiscal policies as an example for a demand shock in the goods markets. The aim of the analytical exercize is to show that the subsequent change in the real exchange rate takes place independently on the underlying nominal exchange rate regime. The nominal exchange rate regimes are neutral with respect to the real variables including the real exchange rate. The difference between fixed and flexibel nominal exchange rates concerns only the proper mix of flexibility of the absolute price levels of tradables and nontradables. The neutrality properties already have been elaborated by Stockman (1983, 1988). His methodological approach is in terms of general equilibrium analysis whthin a two-period and two-country framework. Our one-country model represents a macroeconomic simplification of the Stockman approach.

In section Ⅱ, the real side of the macro-model is developed. Section Ⅲ treats the effects of various switching fiscal policies on the real exchange rate. In section Ⅳ, the nominal variables are determined. For the case of nominal flexible exchange rates, the money market fixes the equilibrium values for the price levels of tradables and nontradables. Under the hypothesis of fixed nominal exchange rates, the money market determines the equilibrium value for the nominal quanity of money.

Ⅱ. The Model

The real exchange rate (e) is generally defined as

$$e = \frac{EP^{\circ}}{P} = \frac{E}{P} \tag{1}$$

where E = nominal exchange rate

P = domestic price level

P° = foreign price level

and assuming $P^{\circ} = 1$. The domestic price level is a weighted average of the price levels for tradables (P_T) and nontradables (P_N)

$$P = P_T^{\alpha} P_N^{\beta} = P_T^{\alpha} P_N^{\beta} (P_N^{\beta} P_N^{\beta}) = E(1/q)^{\beta} \tag{2}$$

where $\alpha(\beta)$ = share of tradables (nontradables) in total spending

$q = P_T / P_N$.

Formula (2) assumes PPP according to its reformulation by Balassa and Samuelson ($P_T = EP_T^\circ$). By setting also the foreign relative price of nontradables equal to one (implying $P^\circ = P_T^\circ = P_N^\circ = 1$), the real exchange rate of definition (1) can be rewritten as

$$e = q^\beta \tag{3}$$

A second definition concerns real wealth which will be an argument of the demand functions for goods in a similar way as in the models elaborated by Genberg/Kierz kowski (1979), Dornbusch/Fischer(1980), Sachs/Wyplosz (1984) and Khan/Lizondo (1987). Real wealth (w) is the sum of nominal balances (M) and net holdings of foreign interest-bearing assets (F°) expressed in terms of domestic currency (EF°) where both are deflated by the general price level

$$w = \frac{M}{P} + \frac{EF^\circ}{P} = m + F^\circ \tag{4}$$

The demand for real cash balances is conceived as a fraction of total wealth

$$m = k(r^\circ + \hat{E}^e)w \tag{5}$$

Fraction k, in its turn, depends on the domestic interest rate (r). Assuming perfect substitutability between domestic and foreign interest-bearing assets, the domestic interest rate is equal to the foreign interrest rate (r°) under the hypothesis of fixed nominal exchange rates while under the alternative hypothesis it is equal to the foreign interest rate plus the expected rate of nominal depreciation $\hat{E}^e$(where E^e is the expected nominal exchange rate and the symbol "^" over a variable signifies a percentage change). For the moment we treat expected depreciation to be equal to zero. Consequently, the opportunity cost of holding money is constant and accordingly is k. Total wealth and its equilibrium composition can be derved from (4) and (5) as

$$w = \frac{1}{1-k} eF^\circ = \gamma eF^\circ \tag{6}$$

The markets for tradables and nontradables can be written as

$$Y^T(e) - C^T(e, w, \tau) - g^T + r^\circ eF^\circ = eF \tag{7}$$

$$Y^N(e) - C^N(e, w, \tau) - e^{1/\beta} g^N = 0 \tag{8}$$

with $Y_e^T, C_e^N, C_w^T, C_w^N > 0$; $Y_e^N, C_e^T, C_\tau^T, C_\tau^T < 0$

where $Y^T(Y^N)$ = demestic output of tradabes (nontradables)

$C^T(C^N)$ = domestic private expendtures on tradables (nontradables)

$g^T(g^N)$ = public expenditures on tradables (nontradables), both defined in prices of tradables

τ = taxes expressed in prices of tradables

$r^\circ eF^\circ$ = interest receipts from net holdings of foreign assets

q = $e^{1/\beta}$ according to (3)

and where a dot over a variable indicates its derivative with respect to time. Equation (7) illustrates the current account balance. The market for tradables is represented by the domestic excess supply (demand) of tradables, $Y^T - C^T - g^T$, which by the proper nature of a small-open economy is absorbed (satisfied) by abroad. Equation (8) is the equilibrium condition for the market of nontradables which is assumed to clear continuously. Under the hypothesis of a current account imbalance (7) implying a changing stock of outstanding wealth (6), there will be a continuous movement of the real exchange rate in order to clear the market of nontradables (8).

The following assumpions are made with respect to the equation system (7)−(8)

$$g^T + g^N = \tau \,;\, C^T_\tau + C^N_\tau / q = -1 \,;\, (C^N_e - Y^T_e) = -\,(C^N_e \dot{-} Y^T_e)/q \qquad (9)$$

The government budget is in balance ; a tax increase crowds-out completely private expenitures ; a change in the real exchange rate creates a substitution effect on the supply and demand side of goods and a wealth effect on the demand side (there is a full substitution effect as well on the production side as on expenditures as far as the composition of both categories of goods is concerned). It should be remembered that we are dealing with a stationary economy without any investment and in which there are only temporary savings or dissavings depeniding on the target level of wealth.

In Figure 1, the equilibrium schedules for the current account balance (CA=0) and for the market of nontradables (NN) are traced.[2] Due to the assumption of full price flexibility in the goods markets, the economy is always on the point of the NN schedule.

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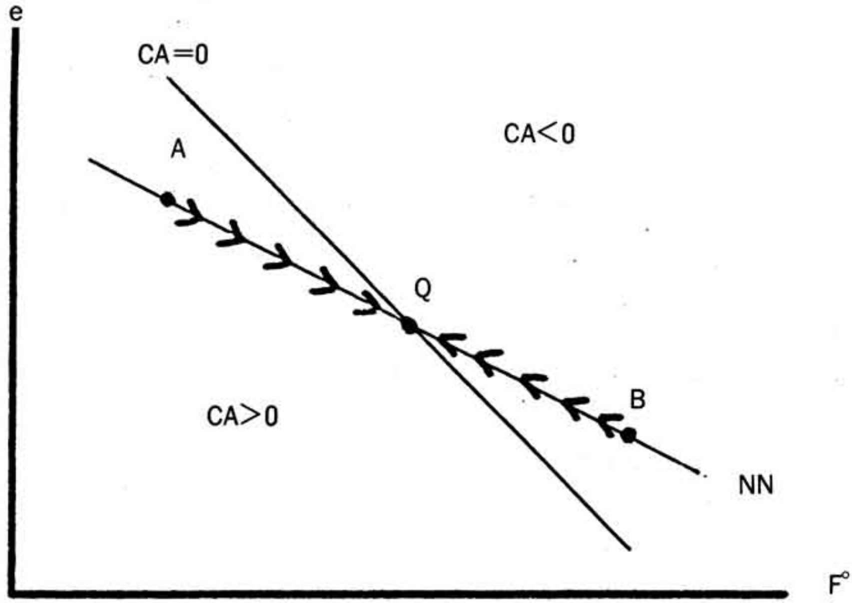
2. The slope of the schedules is

$$\frac{de}{dF^\circ}_{CA=0} = \frac{(C^T_w\gamma - r^\circ)e}{(C^T_e - Y^T_e) + (C^T_w\gamma - r^\circ)F^\circ} \gtrless 0$$

$$\frac{de}{dF^\circ}_{NN} = \frac{C^T_w\gamma e}{(C^N_e - Y^N_e) + C^T_w\gamma F^\circ + e^{\pi/\beta} g^N / \beta} < 0$$

Figure 1



Assume that we are at point A. The current account is in surplus increasing the stock of wealth. The demand for nontradables rises and the market is cleared by a real apprecitation. In the opposite case of point B, there is a current account deficit involving a decline in wealth and subsequently in the demand for nontradables. Consequently, a real depeciation takes place in order to clear the market of nontradables. An essential stability condition concerns the respective slopes of both schedules. CA = 0 has to be steeper than NN since otherwise point A (B) would be a situation where the current account produces a deficit (surplus). Under the condition $C^T_W \gamma > r^\circ$, the stationary economy moves from point A or B towards its full stock equilibrium Q.

Ⅲ. Switching Fiscal Policies

By definition, real disturbances emerge in the goods market either on the supply side or on the demand side. To the extent that they create a disequilibrum in the market for nontradables, a change in the equilibrium value of the real exchange rate must necessarily take place. Assume, for instance, that there is an excess demand for nontradables caused either by a supply or demand shock. The excess demand can be satisfied only by domestic production since by the proper nature of nontradables, they cannot be provided by international trade. The initial adjustment in terms of a lower demand and higher supply of nontradables must come from the exchange rate mechanism in terms of a real appreciation eliminating the excess demand through the substitution effect

$[(C_e^N - Y_e^N)de]$, through the wealth-value effect $[(C_w^N \gamma F^\circ de]$ and through the evaluation effect of government expenditures on nontradables $[(g^N/\beta)de]$. Subequently, via a current account surplus, the wealth-volume effect comes into operation $[(C_w^N \gamma_e dF^\circ]$ which exercizes upward pressure on the demand for nontradables involving a further real appreciation.

As examples of real deisturbaces we have chosen demand shocks emanating from the public sector (see Table 1 which is derived from the Appendix). By using the hypothesis of a balanced budget, two types of fiscal policy are examined. Depending on whether they create an excess demand or an excess supply in the market for nontradables, they provoke either a real appreciation or a real deprectation, respectively. Figure 2 resumes their final impact on the real exchange rate and on the outstanding volume of foreign assets under the assumption of an unchanged real value of total wealth. The schedule $\dot{w} = 0$ represents a rectangular hyperbola. The initial equilibrium is located at point Q. The first first type of fiscal policy concerns a switch whithin total

Figure 2

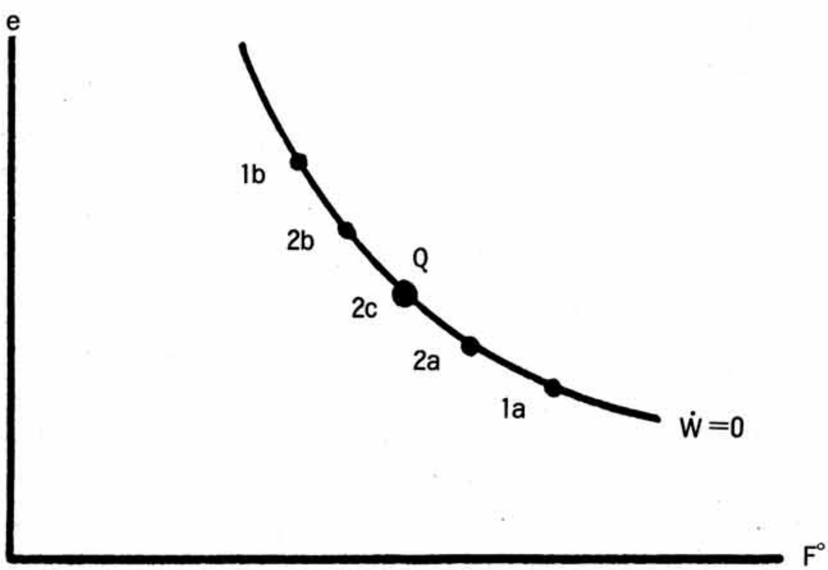


Table 1
Effects of Switching Fiscal Policies

Types of Fiscal Policy	Effect on RealExchange Rate de	Effect on Cumulative Current Account e dF°	Total Wealth Effect $dw=\gamma(F^{\circ}de+edF^{\circ})$
1. Switch of Public Expenditures Pattern			
a. towards nontradables $dg^N=-dg^T$	$\frac{C_w^T\gamma-r^{\circ}+C_w^N\gamma}{\Delta}dg^N<0$	$\frac{(C_w^T\gamma-r^{\circ}+C_w^N\gamma)F^{\circ}+g^N/\beta}{\Delta}dg^N>0$	$\frac{\gamma g^N/\beta}{\Delta}dg^N>0$
2. Tax-Financed Increase of Public Expenditures			
a. on nontradables $dg^N=d\tau$ $(C_\tau^N=C_\tau^T)$	$\frac{(1+C_\tau^N)(C_w^T\gamma-r^{\circ})-C_\tau^N C_w^N\gamma}{\Delta}dg^N<0$	$\frac{(1+C_\tau^N)(C_w^T\gamma-r^{\circ})F^{\circ}-C_\tau^N(C_w^N\gamma F^{\circ}+g^N/\beta}{\Delta}dg^N>0$	$\frac{-\gamma C_\tau^N g^N}{\Delta}dg^N>0$
b. on tradables $dg^N=d\tau$ $(C_\tau^N=C_\tau^T)$	$\frac{(1+C_\tau^N)(C_w^N\gamma-C_\tau^N(C_w^T\gamma-\gamma^{\circ})}{\Delta}dg^T>0$	$-\frac{C_\tau^N(C_w^T\gamma-r^{\circ})F^{\circ}+(1+C_\tau^N(C_w^N\gamma F^{\circ}+g^N/\beta)}{\Delta}dg^T<0$	$\frac{-\gamma(1+C_\tau^N)g^N/\beta}{\Delta}dg^T<0$

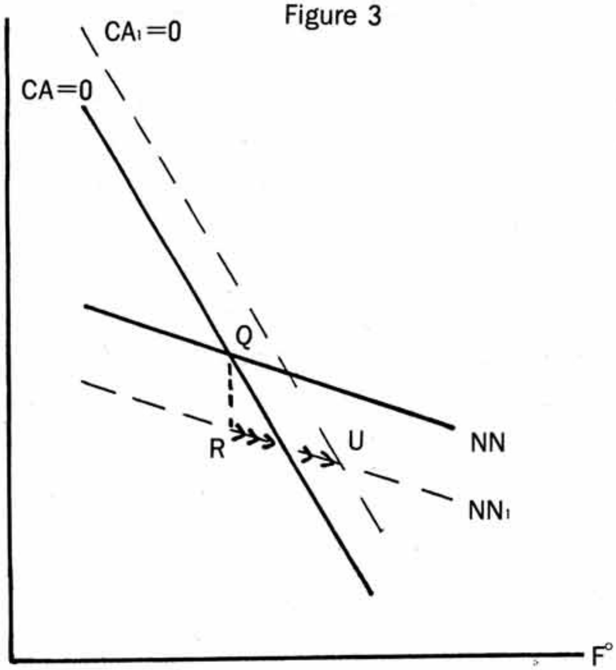
$\Delta=(C_e^N-Y_e^N)(C_w^T\gamma-r^{\circ}+C_w^N\gamma)+(C_w^T\gamma-r^{\circ})g^N/\beta>0.$

government expenditures either in favor of nontradables (creating an excess demand for nontradables ; case 1a) or in favor of tradables (creating an excess supply of non-tradables ; case 1b). The modification in the first case and a real depreciation in the second case. This outcome would also have happened, if the private sector had changed its consumption pattern along the same lines. The second type of fiscal policy deals with tax-financed increases of public expenditures which are used either for buying non-tradables (case 2a) or tradables (case 2b). The necessary change in the real exchange rate, downwards (2a) or upwards (2b), is less pronounced than in the cases 1a and 1b, since the private demand for both categories of goods is reduced as a consequence of lower disposable income. Under the extreme hypothesis (case 2c) according to which goverment spends the additional expenditures on both types of goods and the private secotr reduces its consumption in exactly the same way, the real exchange rate remains unchaged.

It should be noticed that the real exchange rate would behave in the same way with a bond-financed increase in government expenditrues as in the case of a tax-financed increase provided that we work with the hypothesis of the Ricardian equivalence theorem (Frenkel /Razin 1987). To the extent that the future service of the additional debt is financed by increased future taxes, consumers' disposable permanent income falls and the decrease in their consumption brings about additional domestic savings which are sufficient to finance the budget deficit. If the budget deficit is caused by additional government expenditures which are oriented mainly towards the purchase of non-tradables while the private sector reduces its consumption outlays on tradables and non-tradables, there will still be an excess demand in the market for nontradables which will be eliminated by a real appreciation.

The results of Table 1 concern the long-run outcome. The adjustment process is descrided in Figure 3 where we illustrate case 1a. The initial equilibrium is again at point Q. The increase in public expenditures for nontradables shifts the NN schedule downwards to NN_1 and the corresponding decline in public purchases of tradables shifs the $CA = 0$ schedule upwards to $CA_1 = 0$. The immediate impact is point R : a real appreciation which clears the market of nontradables. The movement from Q to R is the combined outcome of two effects : the substitution effect of the relative price change reducing the demand for nontradables and raising the supply of nontradables ; secondly, the wealth-value effect of the real appreciation ($F^{\circ}de$) reinforces the decline of private expenditures for nontradables. As far as the domestic demand and supply of tradables are concerned, there is an excess supply of tradables at point R. The excess supply

Figure 3



arises from the assumed decrease of public expenditures on tradables being partly offset by the substitution effect of the real appreciation on the demand and supply side of tradables but reinforced by the wealth-value effec operating on the demand side of tradables. At point R, a current account suplus operating on the demand side of tradabes. At point R, a current account surplus emerges creating now the wealth-volume effect (e dF°) on the demand for both categories of goods. With respect to the market of nontradables, private consumption tises and clearing of the market necessitates a further real appreciation The adjustment process moves over time R towards U. At. U, the wealth level is slightly higher than the former real wealth at Q. The ultimate rate of real apprecition reflects the now expenditure pattern provoked by governement action and consequently also the new production pattern in terms of a higher production of nontradables and a lower production of tradables.[3]

3. The shift of resources from the production sector of tradables towards the production sector of nontradables may also depend on the specific time profile of the switching fiscal policy, i.e. whether it is temporary or permanent, whether it takes place at proesent time or in the future and, consequently, whether it is anticipated or not. On the other hand, the feasibility of the intersectoral movement of the factors of production depends on the nature of the production function. If labor is the only factor of production, the resource shift would be easier to realize (Penati 1987) than in the case of labor plus capital under the assumption of a non-growing economy (Obstfeld 1988).

Ⅳ. Monetary Adjustments

As in the previous section, we shall distinguish between the long-run effects variables. As an example of a change in the real exchange rate, we shall refer to the case of a real appreciation as exposed in the last paragraph (case 1a).

As far as the long-run is concerned, the real quantity of money remains unchanged, provided that the arguments of the demand function for real cash balances (5) remain unaffected. First of all, we shall abstract from the long-run rise in total real wealth (dw). Consequently, in this hypotheical long-run and differentiation among nominal exchange rate regimes, we would have the following evolution for the nominal quantity of money, the general pirce level and the nominal exchange rate

$$\hat{m} = \hat{M} - \hat{P} = \hat{M} - \hat{E} + \beta\hat{q} = 0 \quad (10)$$

Flexible Nominal Exchange Rates ($\hat{M} = 0$) $\hat{E} = \hat{\beta}$ and $\hat{P} = 0$ (10a)

Fixed Nominal Exchange Rates ($\hat{E} = 0$) $\hat{M} = \beta\hat{q}$ and $\hat{P} = -\beta\hat{q}$) (10b)

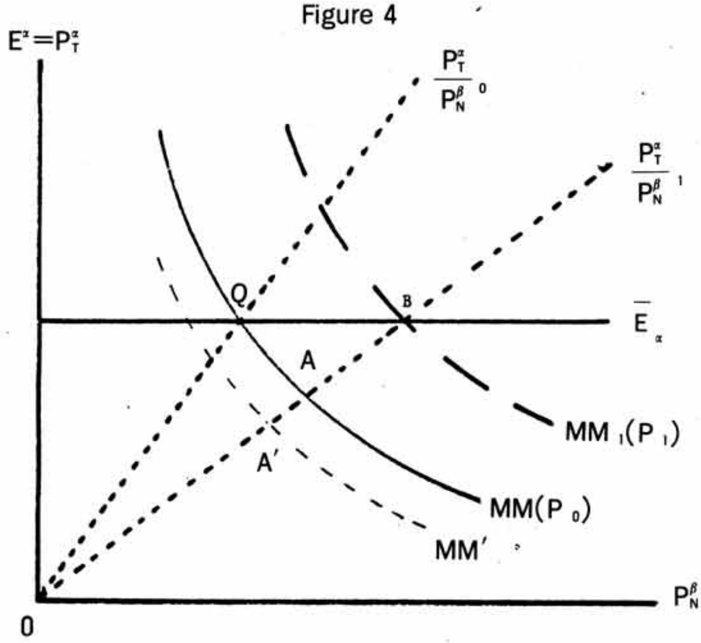
The value for $\hat{P}$ has been derived from (2) and according to (3) $\beta\hat{q}$ is equal to $\hat{e}$.

The difference between both nominal exchange rate regimes could be characterized-in the presence of changes in the equilibrium real exchange rate-as such that under floationg rates the nominal quantity of money(and, thus, the general price level) remains unchanged whereas under fixed rates the nominal quantity of money (and, by this, the general price level) have to be modified.

With flexibel nominal exchange rates (10a), the price level of nontradables goes up and the price level of tradables decreases such that the general price level remains constant. Consequently, the nominal appreciation is lower (by β percent) than the real appreciation in terms of q. Under fixed nomial exchange rates (10b), the price level of tradables remains unchanged by definition such that the real appreciation is brought about by the increase in the price level of nontradables ($\hat{P}_N = -\hat{q}$) implying and increase in the general price level (by$-\beta\hat{q}$). Consequently, for a given quantity of money, there will be an excess demand for real balances (in equation (5), m is lower than kw). actual real balances are lower than desired ones implying simultaneously a fall in real wealth. The wealth effect operates on the demand side for goods reucing temporarily the demand for tradables and nontradables and creating a temporary current account surplus (besides the one which emerges as a consequence of the real appreciation discussed in section Ⅲ). This current account surplus is not used for asset accumulation (F°), but for satisfying the higher nominal demand for money ($\hat{M}$). Consequently, the the above current account surplus corresponds to a balance of payments surplus increasing international reserves and, by this, the nominal quantity of money until $\hat{M}-\beta\hat{q}$.

The difference between the two nominal exchange rate regimes is illustrated in Figure 4. The MM schedule (a rectangular hyperbola) reflects the initial equilibrium condition in the money market producing the general price level P_0 for a given nominal quantity of money. P_0 can be realized by various combinations of P_T and P_N. Any situation located rightwards (leftwards) to MM indicates and excess demand (supply) in the money market. The initial monetary equilibrium is at the intersection point Q of the MM schedule with the $O(P^{\alpha}_T/P^{\beta}_N)_0$ ray (whose slope measures the relative price of nontradables and, by this, the real exchange rate). A real appreciation rotates the ray towards $O\,(P^{\alpha}_T/P^{\beta}_N)_1$. Under floating exchange rates, the new monetary equilibrium is established at point A while under fixed rates it will be at B. At point B, there is an excess demand for real cash balances creating a balance of payments surplus which shifts gradually the MM schedule towards MM_1.[4]

Figure 4



4. Since there is a production shift towards more nontradables and correspondingly less tradables, α has declined and β has risen. Consequently, the horizontal line $\overline{E}_{\alpha}$ representing fixed nominal exchange rates will shift slightly downwards for our case of a real appreciation.

Until now we have abstracted from the long-run rise in total real wealth which increases the demand for real cash balances along (5) in both exchange rate regimes. The equation system (10) has to be modified in the following way

$$\hat{m} = \hat{M} - \hat{P} = \hat{M} - \hat{E} + \beta\hat{q} = \hat{w} \quad (11)$$

Flexible Nominal Exchange Rates ($\hat{M} = 0$) $\hat{E} = \beta\hat{q} - \hat{w}$ and $\hat{P} = -\hat{w}$ (11a)

Fixed Nominal Exchange Rates ($\hat{\bar{M}} = 0$) $\hat{M} = -\beta\hat{q} + \hat{w}$ and $\hat{P} = -\beta\hat{q}$ (11b)

In terms of Figure 4, the long-run rise in desired cash balances (due to $\hat{w}$) shifts the original equilibrium schedule of the money market, $MM(P_0)$, towards MM′ under both exchange rate regimes. The new monetary equilibrium will be at A′ (instead of A) for flexible rates and it remains at B for fixed rates. In the first case the nominal appreciation is higher and in the second case the temporary balance of payments suplus must be higher.

As far as the proper adjustment period towards the long-run is concerned, there will be transitory changes in nominal variables, but only within the the regime of flexible nominal exchange rates, since there may be an additional rise in the demand for real cash balances during the transition period. By wirting differently the demand function for money (5) and by assuming interest rate parity

$$m = k(r^{\circ} + \hat{E}^{e})w = k(r^{\circ} + \hat{E}^{e})(m + eF^{\circ}) = e(r^{\circ} + \hat{E}^{e})eF^{\circ} \quad (5a)$$

with $\theta = k/(1-k)$ and $\theta' = \frac{\partial\theta}{\partial\hat{E}^{e}} < 0$

we can observe that the domestic interest rate falls when there is the expectation of a nominal appreciation ($\hat{E}^{e} < 0$) with the consequence of a raising demand for real cash balances.

In principle, during the adjustment period, the equilibrium level for real cash balances and, by this, the necessary chang in the general price level (for $\hat{M} = 0$) varies for two reasons according to the following interpretation of (5a) in terms of percentage changes

$$\hat{m} - \hat{P} = \hat{\theta}\, d\hat{E}^{e} + \hat{e} + \hat{F}^{\circ}$$

At the very beginning of the adjustment period, $\hat{e}$ is negative, $\hat{F}^{\circ}$ is zero and $\hat{\theta}\, d\hat{E}^{e}$ is positive. To the extent that $(\hat{\theta}\, d\hat{E}^{e} + \hat{e}) > 0$, desired real cash balances increase. They nomic policies. Under fixed exchange rates, economic policies are under the pressure of balance of payments constraints which are les pronounced under floating rates. Or, in other terms, the flexible nominal exchang rate regime may have modified the constraints as they were perceived by policy makers having given rise to more policy action. These two advanced reasons still require testing.

Appendix

The total differential of the current account (7) which is assumed to be in equilibrium and of the equilibrium condition of the market for nontradables (8) is written under the hypothesis of (9) as

$$de = -\frac{C^T_W\gamma - r^\circ}{\Delta}dg^N + \frac{C^T_W\gamma}{\Delta}dg^N - \frac{C^N_\tau(C^T_W\gamma - r^\circ) - C^T_\tau C^N_w\gamma}{\Delta}d\tau \qquad (A1)$$

$$edF^\circ = \frac{(C^T_W\gamma - r^\circ)F^\circ - (C^N_e - Y^N_e)}{\Delta}dg^N - \frac{C^T_W\gamma F^\circ + g^N/\beta + (C^N_e - Y^N_e)}{\Delta}dg^T$$

$$+ \frac{C^N_\tau[C^T_W\gamma - r^\circ)F^\circ - (C^N_e - Y^N_e)] - C^T_\tau[C^T_W\gamma F^\circ + g^N/\beta + (C^N_e - Y^N_e]}{\Delta}d\tau \qquad (A2)$$

$$\Delta = (C^N_e - Y^N_e)(C^T_W\gamma - r^\circ + C^T_W\gamma) + (C^T_W\gamma - r^\circ)g^N/\beta > 0$$

We have assumed that the intial value of q (and e) was equal to one such that

$$C^T_\tau + C^N_\tau = -1\,;\ (C^T_e - Y^T_e) = -1(C^N_e - Y^N_e) \qquad (9a)$$

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