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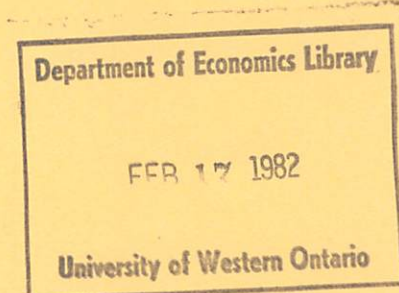
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This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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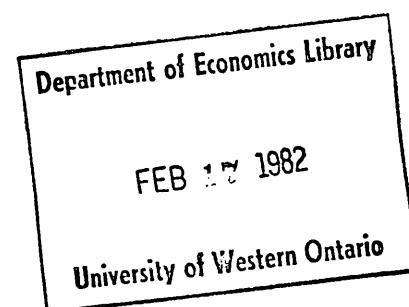
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INTERNATIONAL DIFFERENCES IN RESPONSE TO  
COMMON EXTERNAL SHOCKS: THE ROLE OF  
PURCHASING POWER PARITY

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To be presented at the Vth International Conference of the  
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...readers of Keynes from 1915 to 1930 generally held simultaneously the view that PPP was a trivial truism of arbitrage *and* besides was quite untrue.

P.A. Samuelson, 1964

## 1. Introduction

The 1970's witnessed a return to flexible exchange rates by most industrialized nations. The behavior of this system has revealed a number of surprises and has stimulated a large volume of theoretical and empirical research on the nature of exchange rate determination. One of the puzzles that has emerged from the experience of the 1970's is the large variability of nominal exchange rates, variability in excess of that explained by developments in commonly-held "fundamental determinants". In particular, many bilateral exchange rates displayed a variability far in excess of that of the respective national price levels, leading to what Jacob Frenkel [4] describes as "The Collapse of Purchasing Power Parities During the 1970's". Frenkel summarizes the facts in stating that "During the 1970's short-run changes in exchange rates bore little relationship to short-run differentials in national inflation rates, and frequently, divergences from purchasing power parities have been cumulative".

Our surprise at these events is not that "PPP has collapsed" but rather that others have been surprised by the collapse. PPP is, after all, nothing but the open economy implication of money neutrality -- if the absolute level of all prices in one country changes proportionately without affecting any price ratios or real magnitudes, these changes will be accompanied by a proportionate change in the exchange rate. During the 1970's exchange rates were buffeted by real forces which could

not be expected to conform to the "neutral money" condition required by PPP. This last statement, we feel, is neither controversial nor novel. Nevertheless, we believe it still to be pertinent in light of the prevalence and persistence of PPP-oriented views about current levels of exchange rates. These "PPP views" are perhaps suggested most strongly by the prominence of the terms "over-valued" and "under-valued" to describe currencies for which the actual exchange rate is, respectively, below or above its PPP value. Our contention is that these PPP views are highly misleading.

It is not grossly inaccurate to characterize prevailing conventional wisdom about PPP in the following two propositions:

- (1) PPP does not hold in the short run.
- (2) There are strong tendencies towards PPP so that it does hold in the long run.

The force of the second of these is its implication that one should expect actual exchange rates to converge towards their PPP values, and hence that comparing relative national price levels is a useful guide to the formation of exchange rate expectations.<sup>1</sup>

While it should be obvious that there is no reason to expect arbitrage activity to cause price indexes to be equal when measured in a common currency<sup>2</sup> -- this being the implication of PPP -- there is nevertheless a tendency to treat discrepancies from PPP "as if"

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1. Of course, even if PPP were a valid long-run theory, it alone would not be sufficient to determine what variables adjust to establish PPP in the long run.

2. The index number issue has led to most explanations of PPP failures being cast in terms of relative price changes either in terms of the external (import-export) or internal (traded-nontraded) terms of trade. See, e.g., Balassa, [ 1 ], Frenkel, [ 4 ], or Usher, [ 8 ].

they are due to arbitrage failures, and the long-run tendency to PPP is viewed as the long-run operation of the "law of one price".

This paper presents a framework in which the "law of one price" obtains at all times, yet national price levels are determined in a manner that involves factors other than those reflected in nominal exchange rates. In much of the paper we abstract from the index number issue by assuming that there is only one good consumed in each country.

The key to the separation of developments in national price levels from those in exchange rates is the specification that goods which enter into international trade are not directly consumed. Traded goods require the application of domestic value-added prior to being consumed so that, in any particular country, final goods are produced using internationally traded "middle products" plus domestic labor.<sup>3</sup> Arbitrage in traded middle products is perfect so that the law of one price applies to any individual such middle product.

In applying this model, we hope to identify one set of factors which can lead to systematic and persistent deviations from PPP as well as to identify situations where actual and PPP exchange rates might move in opposite directions.

In order to fix ideas prior to the development of the details of the model, it is worth examining the basic framework more explicitly. Consider two countries, each small in relation to the rest of the world, facing a common disturbance in the form of an exogenous increase in

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3. The term "middle products" and the analytical framework on the real side used throughout this paper were first introduced in K. Sanyal and R. Jones, [7].

the "world price" of a particular middle product, good A. The law of one price ensures that in each country the change in the respective internal price of A ( $p_A$  and  $p_A^*$ ) equals the sum of the change in the respective nominal exchange rate ( $E$  and  $E^*$ ) plus the (common) change in the world price of A measured in terms of a third currency ( $\bar{p}_A$ ).<sup>4</sup>

Hence

$$(1.1) \quad (\hat{p}_A - \hat{p}_A^*) = (\hat{E} - \hat{E}^*) \equiv e$$

where  $e$  is the bilateral exchange rate between the two countries and a " $\hat{\phantom{x}}$ " indicates a percentage change.

In each country, the change in the price of its final product ( $\hat{p}_0$  and  $\hat{p}_0^*$ ) will reflect both the change in the own-price of the middle product and the change in the price of domestic value-added. If the structures of the two economies differ such that the changes in own-prices of domestic value-added differ, then  $p_0/p_A$  will change relative to  $p_0^*/p_A^*$ . Hence, using (1.1),  $(\hat{p}_0 - \hat{p}_0^*)$  will differ from  $\hat{e}$ . The former, being a comparison of national price levels, is what might be termed the change in the PPP exchange rate; that is, it is the change in the exchange rate that would be expected if PPP were to be maintained. The approach taken in this paper focuses on structural aspects of the economy which cause the equilibrium exchange rate<sup>5</sup> to change relative to the PPP rate. The change in the relationship between the PPP and equilibrium exchange rates is captured by the variable  $\mu$  defined as  $(E/p_0)/(E^*/p_0^*)$ , so that

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4. Variables that refer to the foreign country will have an asterisk while those that refer to the rest of the world will have a bar over them.

5. And the actual exchange rate since ours is an equilibrium model.

$$(1.2) \quad \hat{\mu} \equiv \hat{e} - (\hat{p}_0 - \hat{p}_0^*)$$

The term  $\hat{\mu}$  is derived in the context of a model in which labor is used to produce middle products in the "Input Tier" of the economy and to produce final products in the "Output Tier" of the economy. International trade allows the composition of middle products produced in the Input Tier to differ from that of the middle products used as factors of production in the Output Tier, although if trade is balanced, the aggregate value of each bundle is the same. Labor is allocated between tiers to ensure full employment at a common wage rate. The model provides a solution for domestic wages and the exchange rate; unit costs then determine domestic prices.

The focus of the analysis is on structural, or real, characteristics of the economy; behind the scenes there is a monetary equilibrium implied. The behavior of the monetary sector is downplayed since disturbances arising from that sector, or accommodation occurring in that sector, give rise in the long run to price changes which of course do conform to PPP. Our focus is on disturbances which involve the possibility of relative price changes.<sup>6</sup>

The plan of the paper is as follows. In sections 2 and 3 we examine a particularly simple version of the model in which only one good is produced in each tier of the economy. Trade is important because the middle product used in the Output Tier in the production

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6. Monetary factors may of course influence relative prices and hence "distort PPP in the short run". We discuss this explicitly in the context of fixed-exchange rates in the next section. Our formal analysis of flexible exchange rates is restricted to long-run solutions, but the approach could readily be extended to allow for short-run phenomena of the type emphasized, for example, by Dornbusch, [3], or Buiter and Purvis, [2].



of final consumption goods is different from the middle product produced in the Input Tier. In Section 2 this model is analyzed for fixed exchange rates while Section 3 deals with the flexible exchange rate case. The next two sections are used to explore the implications of elaborating the model to allow for the production of more than one good in the respective tiers. In section 4 the analysis incorporates production of the import-competing middle product so that not all middle-product inputs used in the Output Tier need to be imported. In section 5 an additional activity is introduced into the Output Tier; only at this stage, with the introduction of a second consumption good, does the conventional "index number" aspect of the PPP theory arise. Finally, some brief conclusions are offered in section 6.

## 2. Fixed Exchange Rates

In this section we examine two small economies, each linked via fixed exchange rates to a large outside world. These two economies have sufficiently similar production structures that in the Input Tier of each economy a single production process produces a commodity,  $x_B$ , with the input of a fixed amount of resource  $V_B$  ( $V_B^*$  abroad) and labor  $L_I$  ( $L_I^*$  abroad). In each country the entire volume of output of  $B$  is assumed to be exported to the rest of the world in exchange for imports of a product,  $A$ , not locally produced. Prices of both middle products in terms of the world currency ( $\bar{p}_A$  and  $\bar{p}_B$ ) are assumed to be exogenous.

In the Output Tier of each economy  $A$  is combined with labor to produce quantity  $x_0$  ( $x_0^*$  abroad) of a single, final, consumption item. Both economies are assumed to respond to the same external shock:

a rise in the world price of A, with the world price of middle product B assumed constant. Given fixed exchange rates and the law of one price,  $\hat{p}_A = \hat{p}_A = \hat{p}_A^*$ .

The deterioration in the terms of trade is absorbed in each country by a cutback in real consumption and a reallocation of labor between the Input and Output Tiers of the economy. In the home country,

$$L_I + L_0 = L,$$

where  $L$  is the total supply of labor and  $L_0$  is the allocation of labor to the Output Tier. Continued full employment requires:

$$(2.1) \quad \lambda_{LI} \hat{L}_I + \lambda_{L0} \hat{L}_0 = 0$$

where  $\lambda_{LI}$  is the fraction of the home country's labor force allocated to the Input Tier (to produce  $x_B$ ). The demand for labor in the Input Tier is related to the wage rate in B units,  $w/p_B$ , by a downward sloping schedule showing labor's marginal product. Letting  $\gamma_I$  express the elasticity of this schedule (defined so as to be positive),

$$(2.2) \quad \hat{L}_I = -\gamma_I (\hat{w} - \hat{p}_B).$$

In the Output Tier the demand for labor depends upon the intensity with which it is used per unit output,  $a_{L0}$ , and the scale of output of the final consumable,  $x_0$ . The relative change in the demand for  $L_0$  is thus:

$$(2.3) \quad \hat{L}_0 = \hat{a}_{L0} + \hat{x}_0.$$

Further,  $a_{L0}$  will fall if the wage rate rises relative to the price of the other input used to produce the consumption good,  $p_A$ . Indeed,

if  $\theta_{A0}$  denotes the share of final output required as payments to obtain A on world markets and  $\sigma_0$  is the elasticity of substitution in the Output Tier,<sup>7</sup>

$$(2.4) \quad \hat{a}_{L0} = -\theta_{A0}\sigma_0(\hat{w} - \hat{p}_A).$$

#### A. Accommodating Monetary Policy

In this subsection we assume that in each country the quantity of money is adjusted to keep current spending levels equal to the level of income. Thus the change in real consumption at home,  $\hat{x}_0$ , equals the deterioration in home real income,  $\hat{y}$ . That deterioration is given by the fraction of national income devoted to imports of A,  $\theta_{A0}$  times the rise in  $p_A$ , so we have

$$(2.5) \quad \hat{x}_0 = -\theta_{A0}\hat{p}_A.$$

At a constant wage, the rise in  $\bar{p}_A$  creates two opposing forces on the demand for labour in the Output Tier. Equation (2.4) shows the increase in  $L_0$  resulting from the substitution away from the more expensive input A while equation (2.5) shows the reduction in  $L_0$  resulting from the contraction in output of final goods in response to the decline in real income. The demand for labor in the output tier may rise or fall at the initial wage depending upon which effect dominates. In equilibrium the fixed labor force reallocates itself between the two tiers; this determines the response of the home wage rate to the change in the world price of A:

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7. Equation (2.4) is obtained by solving the unit-cost minimization condition,  $\theta_{L0}\hat{a}_{L0} + \theta_{A0}\hat{a}_{A0} = 0$ , and the definition of  $\sigma_0$  as  $(\hat{a}_{A0} - \hat{a}_{L0})$  divided by  $(\hat{w} - \hat{p}_A)$ .

$$(2.6) \quad \frac{\hat{w}}{p_A} = \frac{\lambda_{LO} \theta_{AO} (\sigma_0 - 1)}{\lambda_{LI} \gamma_I + \lambda_{LO} \theta_{AO} \sigma_0} = \frac{\alpha_1}{\omega_1}$$

The numerator of equation (2.6),  $\alpha_1$ , is positive if  $\sigma_0$  is greater than one, thus indicating that the substitution effect outweighs the income effect. In that case the increase in  $p_A$  creates an excess demand for labor in the Output Tier at the initial wage, and the wage rate rises in the new equilibrium. If  $\sigma_0$  were less than one, the negative income effect dominates and the wage rate would fall. The denominator in equation (2.6),  $\omega_1$ , reveals the two ways in which the demand for labor would rise if the wage rate were to fall by one percent;  $\gamma_I$  shows the increased demand in the Input Tier and  $\theta_{AO} \sigma_0$  the greater reliance on labor in the Output Tier.<sup>8</sup> A "flexible" economy, meaning one with large elasticities and hence a large  $\omega$ , will have damped wage responses relative to a "rigid" economy with low elasticities  $\gamma_I$  and  $\sigma_0$ . A low enough value for  $\sigma_0$  (i.e.,  $\sigma_0 < 1$ ) will lead to  $\hat{w}$  less than zero.

From equation (2.6) it can be seen that should the wage rate rise, it would rise by proportionately less than the world price of middle product A since  $\alpha_1$  is less than  $\omega_1$ . Indeed, the real wage, a comparison of w with final output price p<sub>0</sub>, must fall. By the competitive profit conditions in the Output Tier,

$$(2.7) \quad \hat{p}_0 = \theta_{LO} \hat{w} + \theta_{AO} \hat{p}_A,$$

so that with  $\hat{w}$  less than  $\hat{p}_A$ ,  $\hat{w}$  must also be less than  $\hat{p}_0$ , a weighted

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8. Subscripts have been attached to the  $\alpha$  and  $\omega$  terms because subsequent variations introduced in this model cause slight alterations in these expressions.

average of  $\hat{w}$  and  $\hat{p}_A$ . These relationships are shown in (2.8) and Figure 1.

$$(2.8) \quad \frac{\hat{p}_0}{\hat{p}_A} = \left\{ \theta_{L0} \frac{\alpha_1}{\omega_1} + \theta_{A0} \right\}.$$

An elasticity of substitution less than one would cause the wage rate to fall. As illustrated by point E in Figure 1, a small enough value for  $\sigma_0$  might even cause an actual reduction in the price level,  $p_0$ . The critical value for  $\sigma_0$  at E is given by:

$$\sigma_0 = \theta_{L0} - \frac{\lambda_{LI}\gamma_I}{\lambda_{L0}} < 1.$$

Sufficient flexibility in the Input Tier, reflected in a high value for  $\gamma_I$ , could make this critical value negative, ruling out a fall in  $p_0$ . But lack of technological flexibility in both Tiers, in the form of low values for  $\gamma_I$  and  $\sigma_0$ , could cause the increase in world  $p_A$  to prove "deflationary".

Suppose both the home and foreign countries are importers of A, and that each requires the same value of A per dollar's worth of output (so that  $\theta_{A0}$  equals  $\theta_{A0}^*$  and  $\theta_{L0}$  equals  $\theta_{L0}^*$ ). Nonetheless, differences in technology could require the two countries' price levels to react differently in the face of a common external shock. Indeed, a value of  $\sigma_0$  exceeding unity and  $\sigma_0^*$  falling short of unity would mean that the increase in world  $\bar{p}_A$  leads to a higher wage rate at home but a lower wage abroad. If  $\sigma_0^*$  were small enough, the foreign country's price level could fall in response to the same shock that caused the domestic price level to rise.

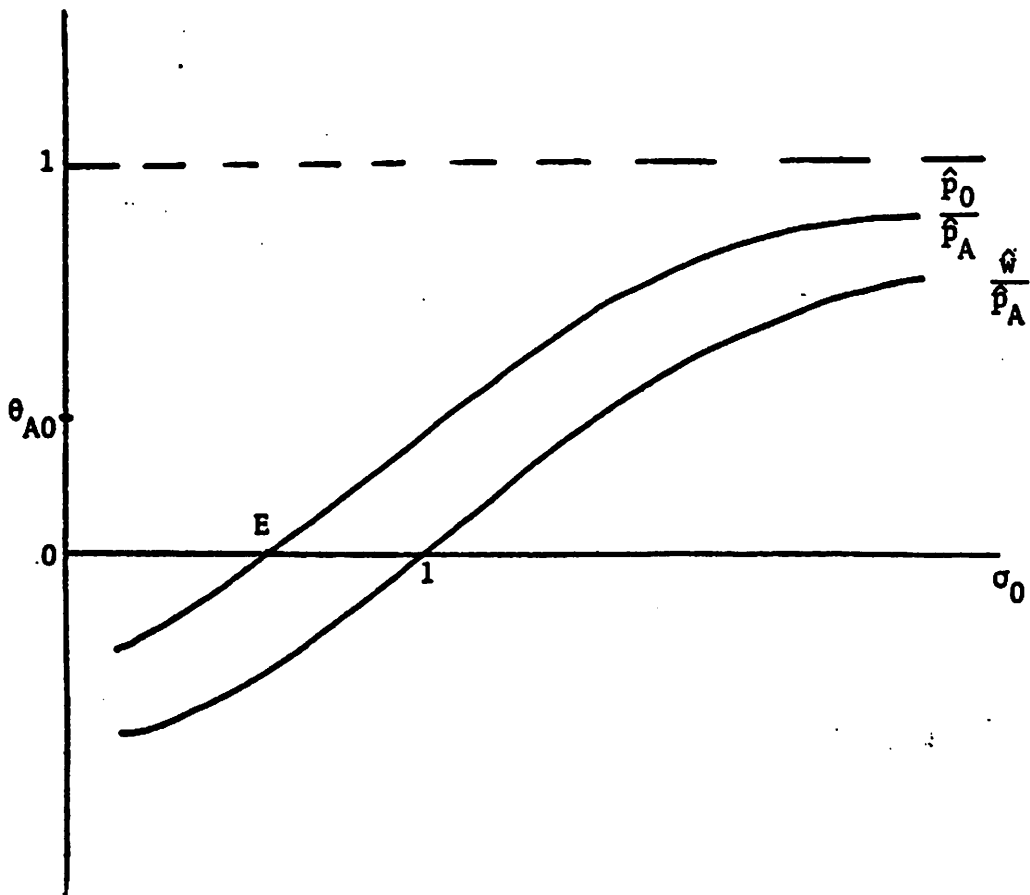


Figure 1

Domestic Wage and Output Price Responses with Monetary Accommodation

B. No Monetary Accommodation

In Figure 1 the determinants of the change in wages and prices all reflect real characteristics of the supply side of the economy. With fixed exchange rates, monetary forces can create a violation of the equality between spending and income if the domestic money supply is initially kept fixed in the face of the rise in the world price of imported input,  $\underline{A}$ . Let  $\underline{Z}$  denote the value of current expenditures,  $p_0x_0$ , as distinct from the monetary value of final income produced,  $\underline{Y}$ . Assume that individuals attempt over the long run to maintain a level of money wealth proportional to the value of income,  $\underline{Y}$ . If from an initial full equilibrium and a given monetary value of wealth the money value of income should rise, we assume that

$$(2.9) \quad \hat{Z} = \xi \hat{Y} \text{ where } 0 < \xi < 1.$$

That is, the monetary value of expenditures would rise, but not by much as nominal income does; some hoarding takes place in an effort to increase the value of wealth towards the higher level appropriate to the higher value of  $\underline{Y}$ .<sup>9</sup>

The change in nominal income,  $\underline{Y}$ , can be broken down into two components,  $\hat{p}_0$  and  $\hat{y}$ . The change in real income,  $\hat{y}$ , is once again given by the degree of trade dependence and the deterioration in the terms of trade,

$$\hat{y} = -\theta_{A0} \hat{p}_A.$$

The change in the price level is shown by (2.7). Combining the real

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9. This procedure follows the analysis in Noman and Jones, [5 ].

and price level changes in the national income reveals that  $\hat{p}_A$  cancels so that

$$(2.10) \quad \hat{Y} = \theta_{LO} \hat{w}.$$

Thus nominal income rises if and only if the wage rate rises. Nominal spending also changes directly with the wage rate, as

$$\hat{x}_0 + \hat{p}_0 = \xi \theta_{LO} \hat{w}.$$

Substitution for the price level change reveals that

$$(2.11) \quad \hat{x}_0 = -\{\theta_{AO} \hat{p}_A + (1-\xi) \theta_{LO} \hat{w}\}.$$

That is, if the wage rate rises there is a "monetary drag" revealed in a trade surplus that causes  $x_0$  to fall further than shown in equation (2.5) when spending was equal to income. With this different solution for changes in consumption of final goods, the market-clearing change in the wage rate becomes

$$(2.12) \quad \frac{\hat{w}}{\hat{p}_A} = \frac{\lambda_{LO} \theta_{AO} (\sigma_0 - 1)}{\lambda_{LI} \gamma_I + \lambda_{LO} [\theta_{AO} \sigma_0 + \theta_{LO} (1-\xi)]} = \frac{\alpha_1}{\omega_2}.$$

The new denominator,  $\omega_2$ , exceeds  $\omega_1$  in equation (2.6), as a reflection of endogenous trade surpluses (if  $\underline{w}$  rises) or deficits (if  $\underline{w}$  falls).

Figure 2 adds two new relationships to those illustrated in Figure 1. The dashed curves show how once again unity is the critical value for the elasticity of substitution in the Output Tier that just balances income and substitution effects to leave wage rates unaltered. If  $\sigma_0$  exceeds unity,  $\underline{w}$  rises. Since nominal income also rises a trade surplus develops as



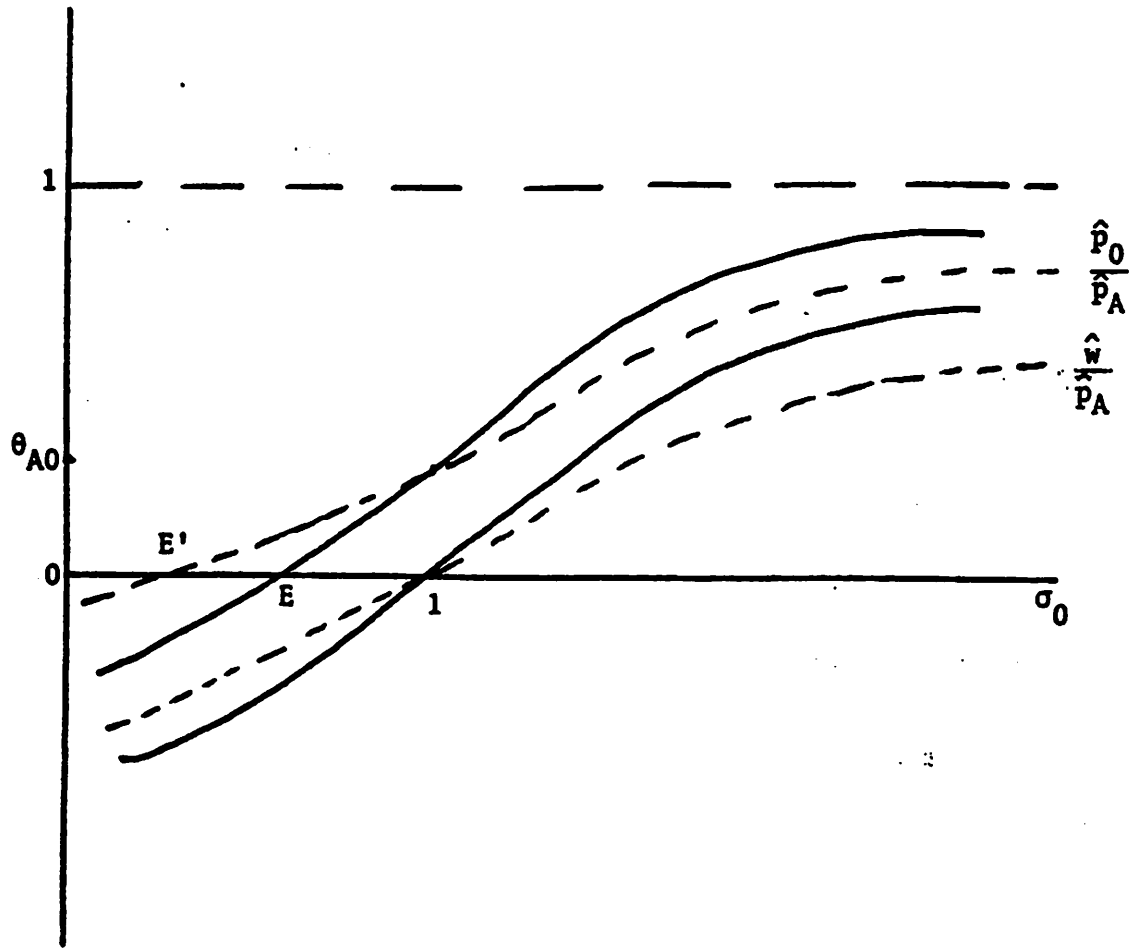


Figure 2

Domestic Wage and Output Price Response with no Monetary Accommodation

spending is cut below income in an attempt to accumulate wealth. This serves to dampen the wage increase. By contrast, for low values of  $\sigma_0$  the wage rate falls. But in this case current wealth levels exceed desired holdings (since  $\underline{Y}$  has fallen), and import deficits help maintain current consumption, thus limiting the retreat of labor to the Input Tier of the economy.

As Figure 2 reveals, with monetary effects cushioning the decline of real consumption should the wage rate fall, it becomes less likely that the rise in the price of imported  $\underline{A}$  on world markets could actually cause the home price level to fall.<sup>10</sup> Furthermore, differences in the rate at which home and foreign residents wish to obtain a new wealth equilibrium (as captured by  $\xi$  and  $\xi^*$ ) join technological differences between the two countries as possible explanations of divergent national price responses to the similar external shock of terms of trade deterioration under a regime of fixed exchange rates.

### 3. Flexible Exchange Rates

In the previous section we showed how in our model national price levels could diverge even under fixed exchange rates and while maintaining the law of one price. The explanation for this lay in the movement of domestic wages, the response of which was shown to be conditioned by monetary factors and their interaction with the current account. In this section we extend the analysis to allow for flexible exchange rates. It is clear that divergent movements in national price

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10. In Figure 2 the value of  $E'$  is given by  $\xi\theta_{L0} - \frac{\lambda_{LI}Y_I}{\lambda_{L0}}$ , less than the critical value  $E$  of Figure 2.

levels measured in terms of their home currencies would not be so surprising with flexible exchange rates. We focus instead on factors which give rise to divergent movements in exchange-rate adjusted price levels; that is, to equilibrium divergences from PPP.

Movements in domestic wages again play an important role, and it is clear that monetary factors as reflected in the current account balance could influence the results. For simplicity, and in order to emphasize the possibility of equilibrium divergences from PPP, we focus on a simple, long-run view of the exchange rate: it adjusts to keep the current account in balance. It is well-known that short-run factors such as deviations from the law of one price and the ability to finance current account imbalances through the capital account might lead to temporary divergences from PPP. Our general framework is readily adaptable to these short-run issues, but we restrict our attention to situations of long-run equilibrium.

Given our assumptions concerning domestic expenditure, in order to balance the current account the exchange rate must adjust so that nominal income is constant.

#### A. Common Real External Disturbances

Such a role for the exchange rate has strong implications for a nation's price level when it is shocked by a rise in the price of imported middle product, A. As before,  $\bar{p}_A$  and  $\bar{p}_B$  represent world currency units so that local  $p_A$  and  $p_B$  are given by  $E\bar{p}_A$  and  $E\bar{p}_B$  respectively. A rise in  $\bar{p}_A$  with  $\bar{p}_B$  constant lowers real income by

$$(3.1) \quad \hat{y} = -\theta_{A0}\hat{p}_A,$$

independent of any change in the exchange rate. Since the change in nominal income,  $\hat{Y}$ , is the sum of  $\hat{y}$  and the change in the price level,  $\hat{p}_0$ , the exchange rate must adjust so that the price level rises:

$$(3.2) \quad \hat{p}_0 = \theta_{A0}\hat{p}_A.$$

This is a strong result, for it implies that despite any differences in technology between two countries importing (and not producing) middle product A, if the share of income devoted to imports is the same, so will be the consequent rise in the national price level. The direction and extent of the change in the exchange rate, however, does depend on further details of the technology.

The change in the price of final output depends upon costs:

$$(3.3) \quad \hat{p}_0 = \theta_{L0}\hat{w} + \theta_{A0}(\hat{E} + \hat{p}_A).$$

Subtraction of (3.2) from (3.3) reveals that:

$$(3.4) \quad \theta_{L0}\hat{w} + \theta_{A0}\hat{E} = 0.$$

The inverse relationship between the wage rate and the exchange rate implied by equation (3.4) is illustrated by the downward sloping curve YY in Figure 3. Suppose equilibrium is initially at point G and that the rise in the world price of A would, at a constant exchange rate, raise the wage rate as shown by point H. If local money supplies are kept constant, such an increase in w would, as we argued in the last section, lead to a current account surplus to reflect the attempt to hoard to accumulate reserves. Under flexible exchange rates the currency

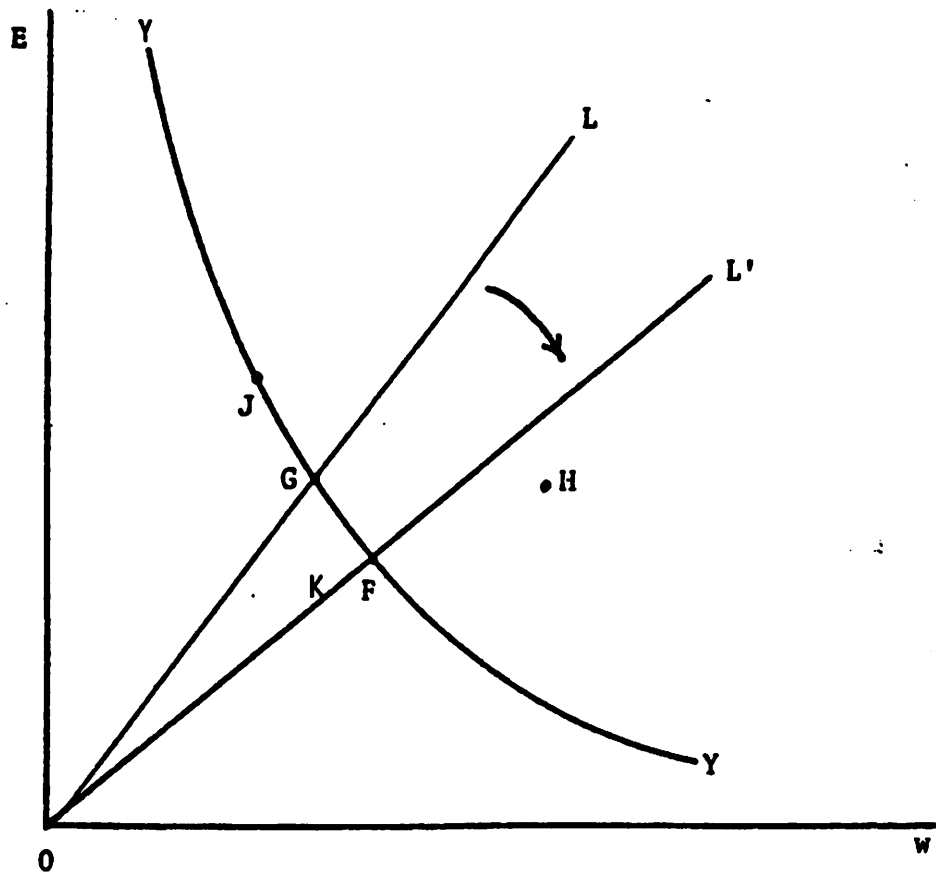


Figure 3

Wage and Exchange Rate Determination

appreciates to cut off the incipient trade surplus, the induced fall in  $p_0$  restoring nominal income.

Details of the technological relationships in the Input and Output tiers of the economy also bear upon the behavior of wages when the terms of trade deteriorate. As before, equation (2.1) gives the condition for labor market clearing. The demand for labour in the Input Tier now depends upon the exchange rate as well as the wage rate since the crucial product wage is  $(w/E\bar{p}_B)$ . With world  $\bar{p}_B$  constant,

$$\hat{L}_I = -\gamma_I(\hat{w}-\hat{E}).$$

Similarly, in the Output Tier,

$$\hat{L}_O = -\theta_{A0}\sigma_0(\hat{w}-\hat{E}-\hat{p}_A) + \hat{x}_0.$$

Real consumption is lowered by the same amount as real income,  $-\theta_{A0}\hat{p}_A$ , so by the condition of the labor market clearing,

$$(3.5) \quad \hat{w} = \hat{E} + \frac{\alpha_1}{\omega_1} \hat{p}_A,$$

where  $\alpha_1$  and  $\omega_1$  are as defined in equation (2.6).

In Figure 3, the proportional relationship between the wage rate and the exchange rate, given the world price of A, that is implied by equation (3.5) is shown as the ray OL. A rise in  $\bar{p}_A$  causes the ray to rotate, clockwise if the elasticity of substitution in the Output Tier exceeds unity ( $\alpha_1 > 0$ ) and counterclockwise if it is less than unity. If  $(\sigma_0-1)$  is positive, labor is drawn into the Output Tier, wages rise, and the rise in nominal income calls forth a currency appreciation (as shown by the new equilibrium at F in Figure 3). If  $(\sigma_0-1)$

is negative, labor is sent into the input tier, wages fall, and the currency depreciates to restore the value of money income (as shown by point J in Figure 3).

Suppose home and foreign countries differ sufficiently in the flexibility of technology in the Output Tier. Specifically, let  $\sigma_0$  exceed unity (so that  $\alpha_1 > 0$ ) and  $\sigma_0^*$  fall short of unity (so that  $\alpha_1^* < 0$ ). The domestic price levels, and hence the PPP rate ( $p_0/p_0^*$ ), depend only upon the extent of trade dependence, so that

$$(3.6) \quad \hat{p}_0 - \hat{p}_0^* = (\theta_{A0} - \theta_{A0}^*) \hat{p}_A.$$

Thus if the fraction of national income represented by imports (and demand) for A is comparable in the home and foreign country, both price levels are driven up by the same relative amount and the PPP rate would remain fixed.

However, the exchange rate between countries, ( $\hat{E}-\hat{E}^*$ ), would not be fixed. In each country equations (3.4) and (3.5) can be solved for the change in the local price of world currency ( $\hat{E}$  and  $\hat{E}^*$ ). Such solutions reveal that:

$$(3.7) \quad (\hat{E}-\hat{E}^*) = - \left\{ \theta_{L0} \frac{\alpha_1}{\omega_1} - \theta_{L0}^* \frac{\alpha_1^*}{\omega_1^*} \right\} \hat{p}_A = \hat{e}$$

If, as supposed in this example,  $\alpha_1$  is positive (reflecting  $\sigma_0 > 1$ ) and  $\alpha_1^*$  is negative (with  $\sigma_0^* < 1$ ), the home country's currency could appreciate sharply relative to the foreign currency. That is, even with the respective price levels responding similarly to the common external shock (thus keeping the PPP exchange rate constant), the country whose technology allows a stronger measure of substitution between

own labor and higher-priced middle product A will find its wage rate driven up and currency appreciated relative to the other country. In Figure 3 if both countries start at G, the deterioration in the terms of trade of each country with the rest of the world sends the home country to F and the foreign country to J.

### B. Comparison with Fixed Exchange Rates

It is interesting to compare these results with those that were derived in section 2 for fixed exchange rates. The total discrepancy,  $\hat{\mu}$ , between changes in the actual exchange rate and the PPP rate, as defined by equation (1.2), is the same in this case as in the fixed exchange rate case with monetary accommodation such that spending equals income. This discrepancy is produced by real differences in the two economies. But the share of the discrepancy born by the PPP rate, on the one hand, and the exchange rate, on the other, differs in the two cases. If exchange rates are free to fluctuate, they absorb the different wage experience in each country, leaving the national price levels to reflect only the degree of dependence on imported middle-product, A, as in equation (3.6). The primary source of differential wage response is found in a difference in the flexibility of input substitution in both the Input and Output Tiers of the economy.

### C. Monetary Disturbances

Before proceeding to some generalizations in the productive structure of this model, we mention that purely monetary disturbances have the expected results on a nation's wage level and exchange rate. For example, suppose the world prices of A and B are inflating at the same rate. If local monetary wealth is undisturbed, the exchange rate must



adjust to keep  $\underline{Y}$  constant. But with no change in the terms of trade (and no change in aggregate output since labor remains fully employed),  $\hat{y} = 0$ , so that the price level,  $p_0$ , is constant. This implies that:

$$(3.8) \quad \theta_{LO}\hat{w} + \theta_{AO}\hat{E} = -\theta_{AO}\hat{p}_A.$$

That is, the  $\bar{Y}$  schedule in Figure 3 would shift downwards as the world inflates.

But the OL ray rotates as well. In the Input Tier

$$\hat{L}_I = -\gamma_I(\hat{w} - \hat{E} - \hat{p}_B),$$

while in the Output Tier

$$\hat{L}_O = -\theta_{AO}\sigma_0(\hat{w} - \hat{E} - \hat{p}_A),$$

since real consumption,  $x_0$ , is undisturbed. By the full-employment condition, (2.1), letting  $\hat{p} = \hat{p}_B = \hat{p}_A$ , we have

$$(3.9) \quad \hat{w} = \hat{E} + \hat{p},$$

so that in Figure 3 the OL ray shifts clockwise. Indeed, (3.8) and (3.9) jointly determine that the exchange rate falls by the same rate as the world price level rises, thus fully insulating the domestic wage rate, as at point K.

If, instead of a rise in world prices, the home country experiences a purely monetary expansion, the OL ray in Figure 3 would remain in position but the money value of produced income, y, would be driven up. This is accommodated by an equi-proportionate increase in the wage rate and exchange rate as the negatively sloped curve in Figure 3 is shifted radially outwards from the origin.

#### 4. Diversity in the Input Tier

The impact on real income of a rise in the price of an imported middle product is to some extent mitigated if local production takes place. In this section we allow each country to produce some middle product A (as well as B) in the Input Tier, but continue to assume that all  $x_B$  is exported in exchange for imports of A, which, in conjunction with local production ( $x_A$ ), is used in the Output Tier to help produce the single non-traded consumption good,  $x_0$ . To be more specific, we assume that at initial prices the value of output in the Input Tier is unchanged, but now local  $x_A$  production replaces some  $x_B$  production. Furthermore,  $x_A$  is produced with labor and a factor specific to its production ( $V_A$ ). Therefore comparisons of two potential initial equilibria, which differ in the extent of import-competing production ( $x_A$ ) presuppose a different mix of specific factors ( $V_A, V_B$ ).

The demand for labor in the Input Tier now depends on the wage rate relative both to  $p_A$  and  $p_B$ . If the world price of A,  $\bar{p}_A$ , rises with  $\bar{p}_B$  constant, as we have been assuming, producers of A in the Input Tier find their demand for labor stimulated. With obvious notation,

$$\hat{L}_A = -\gamma_A(\hat{w} - \hat{E} - \hat{p}_A)$$

and  $\hat{L}_B = -\gamma_B(\hat{w} - \hat{E}),$

so that if  $\lambda_{LA}$  denotes the fraction of the labor force in the Input Tier that is devoted to production of  $x_A$ ,

$$\hat{L}_I = \lambda_{LA}\hat{L}_A + \lambda_{LB}\hat{L}_B$$

or,

$$(4.1) \quad \hat{L}_I = -\gamma_I\{\hat{w} - \hat{E} - \beta_A\hat{p}_A\}$$

$$\text{where } \gamma_I \equiv \lambda_{LA}\gamma_A + \lambda_{LB}\gamma_B$$

$$\text{and } \beta_A \equiv \frac{\lambda_{LA}\gamma_A}{\gamma_I}.$$

The fraction,  $\beta_A$ , answers the following question: If the domestic price of A should rise by one percent and the size of the labor force in the Input Tier is kept constant, by how much would the wage rate rise if  $p_B$  is kept constant?  $\beta_A$  is larger the greater the importance of the A-industry as an employer of labor in the Input Tier and the higher is the elasticity of labor demand in the A-sector,  $\gamma_A$ , relative to  $\gamma_B$ .

The existence of an import-competing sector in the Input Tier also affects the Output Tier's demand for labor since real consumption,  $x_0$ , is not as severely hit by a deterioration in the terms of trade. Let  $\theta_M$  denote the fraction of income devoted to imports of A. Then  $\theta_M$  falls short of  $\theta_{A0}$ , the fraction of income represented by total demand for middle product, A. The expression for the real income (and consumption) loss in (2.5) is replaced by:

$$(4.2) \quad \hat{x}_0 = -\theta_M \hat{p}_A.$$

As before,

$$\hat{a}_{LO} = -\theta_{AO} \sigma_0 (\hat{w} - \hat{E} - \hat{p}_A),$$

so that, by (2.3),

$$(4.3) \quad \hat{L}_0 = -\theta_{AO} \sigma_0 (\hat{w} - \hat{E}) + \theta_{AO} \left( \sigma_0 - \frac{\theta_M}{\theta_{AO}} \right) \hat{p}_A.$$

Substituting (4.1) and (4.3) into the labor-market clearing equation (2.1) reveals that:

$$(4.4) \quad \hat{w} = \hat{E} + \frac{\alpha_2}{\omega_1} \hat{p}_A$$

$$\text{where } \alpha_2 \equiv \beta_A \cdot \lambda_{LI} \gamma_I + \lambda_{LO} \theta_0 \left[ \sigma_0 - \frac{\theta_M}{\theta_{AO}} \right].$$

This solution should be compared to equation (3.5). The existence of an import-competing sector,  $x_A$ , raises the chances that an increase in the world price of A will increase the wage rate (for any given exchange rate) for two reasons. First, a rise in  $p_A$  will directly stimulate demand for labor in the Input Tier (this is the  $\beta_A \cdot \lambda_{LI} \gamma_I$  term in  $\alpha_2$ ). Secondly, the real consumption loss,  $\hat{x}_0$  in (4.2), is less than  $\theta_{AO} \hat{p}_A$ . Thus in  $\alpha_2$  the second term is positive if the substitution term,  $\sigma_0$ , exceeds a fraction,  $\theta_M/\theta_{AO}$ . In terms of the diagram (Figure 4) showing the simultaneous solution for the wage rate and exchange rate, the more self-sufficient is the economy in producing A, the more likely the OL ray is to rotate in a clockwise direction when world  $\bar{p}_A$  rises.

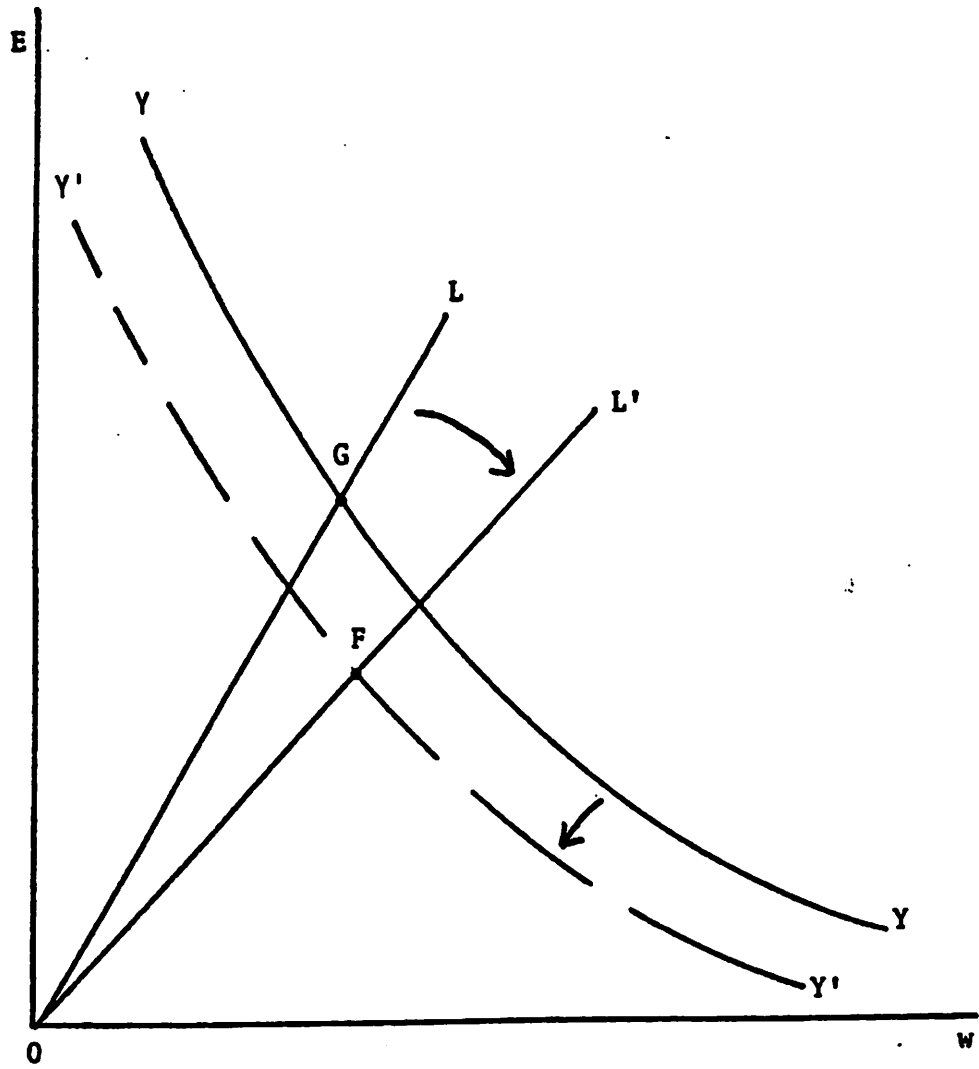


Figure 4

Wage and Exchange Rate Determination with  
Import-Competing Local Production

As before, we assume that the exchange rate adjusts to keep nominal income,  $\underline{Y}$ , from changing. But (3.2) is now replaced by (4.5),

$$(4.5) \quad \hat{p}_0 = \theta_M \hat{p}_A,$$

since the real income loss is proportional to imports, which is less than total (derived) demand for  $\underline{A}$ . The price level is again shown to change as in (3.3) so that subtraction reveals:

$$(4.6) \quad \theta_{LO} \hat{w} + \theta_{AO} \hat{E} = -(\theta_{AO} - \theta_M) \hat{p}_A,$$

With  $\theta_{AO}$  exceeding  $\theta_M$ , this can be interpreted in Figure 4 as a downward shift in the  $\underline{Y}\underline{Y}$  schedule. The diagram reveals that with the  $\underline{OL}$  ray more likely to shift clockwise, and the  $\underline{Y}\underline{Y}$  schedule shifting downwards as the economy approaches self-sufficiency, the home currency is more apt to appreciate, whereas the direction of the wage change seems in doubt. Pushing this to the extreme, suppose the Input Tier is completely dominated by production of  $\underline{A}$ , which is still the only middle product assumed to be required in the Output Tier. The country becomes totally self-sufficient, the exchange rate falls by the same relative amount as the world price of  $\underline{A}$  has risen, completely insulating the wage rate. This is identical to the case of world inflation discussed at the end of Section 3.

If the economy is only partly dependent upon the rest of the world for imports of middle product  $\underline{A}$  instead of totally dependent (as in Section 3), is the wage rate more or less likely to rise when the world price of  $\underline{A}$  rises? Ultimately this depends on the technological characteristics of the new  $x_A$ -industry in the Input Tier compared with the technology in the  $x_B$ -sector,

which, by assumption, is being scaled down as import-competing production rises. Compared to  $x_B$ , if  $x_A$  is (i) labor-intensive, and (ii) has a more elastic demand for labor ( $\gamma_A$  exceeds  $\gamma_B$ ), the rise in  $\bar{p}_A$  is more likely to raise the wage rate than in the case of total dependence on imports.<sup>11</sup>

If home and foreign countries are only partially dependent on imports of A, the rise in  $\bar{p}_A$  affects their PPP rate as in (4.7):

$$(4.7) \quad (\hat{p}_0 - \hat{p}_0^*) = (\theta_M - \theta_M^*) \hat{p}_A.$$

Thus ultimately the PPP rate depends upon real circumstances and, assuming the law of one price for middle product, A, these real circumstances refer only to the degree to which each country relies on imports of A. Any inter-country differences in the extent of import-competing local production affects relative wage rates and, through this route, the exchange rate between the home and foreign country. Thus

$$(4.8) \quad \hat{e} \equiv \hat{E} - \hat{E}^* = - \left\{ [(\theta_{A0} - \theta_M) - (\theta_{A0}^* - \theta_M^*)] + [\theta_{L0} \frac{\alpha_2}{\omega_1} - \theta_{L0}^* \frac{\alpha_2^*}{\omega_1^*}] \right\} \cdot \hat{p}_A$$

<sup>11</sup> Let  $\theta_{AI}$  indicate the share of the  $x_A$ -sector in total output of the Input Tier. Then the expression for the wage rate change relative to  $\hat{p}_A$ , obtained by solving equations (4.4) and (4.6), is

$$\frac{\hat{w}}{\hat{p}_A} = \frac{\theta_{A0}}{\omega_1} \left\{ (\beta_A - \theta_{AI}) \lambda_{LI} \gamma_I + (\sigma_0 - 1) \lambda_{L0} \theta_{A0} \right\}.$$

If no A is produced in the Input Tier, the direction of change in the wage rate depends only on the comparison of  $\sigma_0$  with unity. If some A is produced, this comparison is modified by the term in  $(\beta_A - \theta_{AI})$ . But  $(\beta_A - \theta_{AI})$  equals  $\theta_{AI}$  times

$$\left\{ \frac{\lambda_{LA}}{\theta_{AI}} \cdot \frac{\gamma_A}{\gamma_I} - 1 \right\}.$$

The term  $(\lambda_{LA}/\theta_{AI})$  exceeds unity if  $x_A$  is labor-intensive compared to  $x_B$  (in the sense of labor shares,  $\theta_{LA} > \theta_{LB}$ ). The term  $(\gamma_A/\gamma_I)$  exceeds unity if and only if  $\gamma_A > \gamma_B$ .

Local production of A has tended to insulate the price level in each country from the shock of a world price rise for imported A in each country (compare (4.5) with (3.2)). But the exchange rate between each country and the world currency (in which A is priced) picks up the difference. Comparing home and foreign countries, the total discrepancy,  $\hat{\mu}$ , between the actual exchange rate and the PPP rate, is much as in section 3's model with no import-competing production (save  $\alpha_2$  and  $\alpha_2^*$  replace  $\alpha_1$  and  $\alpha_1^*$ ). But the share of this discrepancy borne by the PPP rate, on the one hand, and the actual (equilibrium) exchange rate, on the other, depends on the relative extent of import-competing productive activity.

#### 5. Diversity in the Output Tier

In preceding sections no role was possible for differences in taste patterns between countries since only one final commodity was consumed. In order to discuss the role of tastes we revert to our earlier simplifications as to production in the Input Tier: each country produces only one middle product, B, which is traded on world markets. Some of its production of B is retained at home to be combined with labor to produce commodity x<sub>2</sub>. The rest of its production of B is exported in exchange for A, which is used only to produce commodity x<sub>1</sub>. As before, we concentrate on the relative impact at home and abroad of an increase in the world price of A.

A country importing A experiences a loss in real income when its terms of trade deteriorate. This real income loss is shown by equation (3.1). Under flexible rates the price index of final consumables,  $p_0$ , must rise by the same amount (shown by equation (3.2)) in order to keep nominal income, Y, unaltered. With two final consumption goods, the change in the price index,  $\hat{p}_0$ , is defined in (5.1),



$$(5.1) \quad \hat{p}_0 \equiv \theta_1 \hat{p}_1 + \theta_2 \hat{p}_2$$

where  $\theta_i$  denotes the share of national income devoted to consumption (and production) of commodity  $i$ . The term  $\theta_{A0}$  refers to the fraction of national income paid for (imports of) middle product,  $A$ . By assumption,  $A$  is only used to produce the first commodity. Let  $\theta_{A1}$  indicate its share of revenue produced by the first commodity so that

$$\theta_{A0} = \theta_{A1} \cdot \theta_1.$$

The change in the PPP rate between home and foreign country, each of whom experiences a rise in its national price level, is

$$(5.2) \quad (\hat{p}_0 - \hat{p}_0^*) = (\theta_{A1} \theta_1 - \theta_{A1}^* \theta_1^*) \hat{p}_A.$$

The role of differences in national taste patterns is thus clearly revealed. Even if the technology of producing the first commodity is roughly comparable between countries, in the sense of  $\theta_{A1}$  and  $\theta_{A1}^*$  being approximately equal, the home price level inflates more than does the foreign to the extent that tastes at home are biased towards the commodity ( $x_1$ ) which uses middle product  $A$  intensively (exclusively, by assumption). At the extreme, the foreign country might consume only the second commodity, in which case its price level is completely insulated from the rise in  $\bar{p}_A$ .

Changes in the PPP rate, however, need not accurately signal changes in the exchange rate between home and foreign currencies. Once again we must turn to two relationships that serve jointly to determine each country's wage rate and exchange rate with the rest of the world. Equation (5.1) defines

the change in the price index. The competitive profit conditions in each sector of the Output Tier ensure that the  $\hat{p}_j$  are linked to changes in costs. If world  $\bar{p}_B$  is assumed constant,

$$(5.3) \quad \begin{aligned} \theta_{L1}\hat{w} + \theta_{A1}(\hat{E} + \hat{p}_A) &= \hat{p}_1 \\ \theta_{L2}\hat{w} + \theta_{B2}\hat{E} &= \hat{p}_2. \end{aligned}$$

Thus the change in the consumer price index can be expressed in terms of the change in the wage rate, the exchange rate, and the world price of middle product A:

$$(5.4) \quad \hat{p}_0 = \theta_{L0}\hat{w} + \theta_{A0}\hat{p}_A + (\theta_{A0} + \theta_{B0})\hat{E}.$$

The exchange rate changes so as to ensure  $p_0$  rises by the amount  $\theta_{A0}\hat{p}_A$  (see equation (3.2)), so that subtraction reveals that:

$$(5.5) \quad \theta_{L0}\hat{w} + (1 - \theta_{L0})\hat{E} = 0.$$

By assuming away any import-competing production of middle product A, we have insured that in the absence of local monetary changes the wage rate and the exchange rate are inversely related as in the  $\Psi\Psi$  curve in Figure 3.

This schedule by itself, of course, does not determine the exchange rate and wage rate separately. Once again it is necessary to investigate the labor-market clearing conditions to obtain the second relationship among wage rate, exchange rate, and the world price of middle product A. With two commodities produced in the Output Tier, this relationship is more complex than in previous sections, so that here we only sketch the principal results.<sup>12</sup>

<sup>12</sup>An explicit analysis of wage determination in a model with two activities in each tier of the economy is found in Sanyal and Jones, [7].

First, note that if consumer tastes are so rigid that  $x_1$  and  $x_2$  are always consumed in fixed proportions, the model is much like that described in section 3 with only one commodity consumed and produced in the Output Tier. In this case the determination of the wage rate is much as in equation (3.5). Explicitly, we would have:

$$(5.6) \quad \hat{w} = \hat{E} + \frac{\alpha_3}{\omega_3} \hat{p}_A$$

$$\text{where } \alpha_3 \equiv \lambda_{L0} \theta_{A1} \lambda_{L1} \left[ \sigma_1 - \frac{\theta_1}{\lambda_{L1}} \right]$$

$$\omega_3 \equiv \lambda_{LI} \gamma_I + \lambda_{L0} [\lambda_{L1} \theta_{A1} \sigma_1 + \lambda_{L2} \theta_{A2} \sigma_2].$$

With two commodities produced in the Output Tier, the expressions for  $\alpha_3$  and  $\omega_3$  are slightly different from the comparable expressions for  $\alpha_1$  and  $\omega_1$  in equation (3.5). Most importantly, A is used only in the first industry so that the OL ray in Figure 3 would rotate clockwise as  $\hat{p}_A$  rises only if  $\sigma_1$  exceeds some critical value. This value now falls short of unity if the first industry (which uses A) is labor intensive. In any case the conflict between substitution and income effect is again apparent.

The case of such rigid taste patterns is extreme. At the opposite end of the spectrum we can imagine tastes captured by downward sloping linear indifference curves, which would insure that if both commodities are consumed,  $p_1/p_2$  must remain constant. In such an event the competitive profit conditions in equation (5.3) can be subtracted from each other to obtain:

$$(5.7) \quad \hat{w} - \hat{E} = - \frac{\theta_{A1}}{(\theta_{L1} - \theta_{L2})} \hat{p}_A.$$

A rise in the world price of A squeezes the first industry which is the sole user of A. As in the theory of effective protection, if relative output prices cannot change, the real return to the factor used intensively in the first industry must fall. Suppose  $\theta_{L1}$  exceeds  $\theta_{L2}$ . This is a way of stating that the first industry is labor-intensive (relative to each industry's requirements of middle products). If so the wage rate (in world currency units) must fall.

The two extreme cases summarized by equations (5.6) and (5.7) are interesting because the more general link among  $\hat{w}$ ,  $\hat{E}$ , and  $\hat{p}_A$  when tastes are captured by smoothly bowed-in indifference curves for the two final consumption goods is a convex combination of these two solutions. Without going into details,<sup>13</sup> let  $\sigma_D$  and  $\sigma_S$  denote, respectively, the elasticities of relative demand and supply for final consumption goods. With  $D_i$  indicating demand and  $x_i$  production,

$$(5.8) \quad \sigma_D \equiv - \frac{(\hat{D}_1 - \hat{D}_2)}{(\hat{p}_1 - \hat{p}_2)}$$

$$\sigma_S \equiv \frac{(\hat{x}_1 - \hat{x}_2)}{(\hat{p}_1 - \hat{p}_2)} .$$

With reference to the extreme solutions shown by (5.6) for the case in which  $\sigma_D = 0$  and (5.7) for the case in which  $\sigma_D = \infty$ , equation (5.9) provides the general solution:

$$(5.9) \quad \hat{w} = \hat{E} + \left\{ \frac{\sigma_S}{\sigma_S + \sigma_D} \left( \frac{\alpha_3}{\omega_3} \right) + \frac{\sigma_D}{\sigma_S + \sigma_D} \left( - \frac{\theta_{A1}}{[\theta_{L1} - \theta_{L2}]} \right) \right\} \hat{p}_A .$$

The weights attached to each extreme case should be familiar from the theory of tax incidence and shifting; they involve the relative strength of the response of demanders and producers to changes in relative prices.

<sup>13</sup>These are spelled out in Sanyal and Jones, [ 7 ].

In the more simple case in which only one commodity is consumed, Figure 3 showed how a rise in world  $\bar{p}_A$  caused the OL ray to rotate along a given YY curve to determine each nation's wage and exchange rate response. Precisely the same procedure is applicable here. Equation (5.5) reveals that the YY curve does not shift, while the coefficient of  $\hat{p}_A$  in (5.9), if positive, would imply a clockwise rotation of the OL ray.

The relevance of national differences in tastes and technologies in determining exchange rates can thus briefly be summarized:

(i) Tastes: The role of taste differences in affecting the PPP rate in equation (5.2) has already been discussed and is traditional in the literature on purchasing power parity. Exchange rates are also affected. Suppose the home country has a taste bias (compared with the foreign country) towards consuming the commodity ( $x_1$ ) which uses middle product A. This tends to make the absolute value of  $\alpha_3$  exceed that of  $\alpha_3^*$ . The sign of  $\alpha_3$  depends on the elasticity of substitution. Suppose both  $\sigma_1$  and  $\sigma_1^*$  are high so that  $\alpha_3$  and  $\alpha_3^*$  are both positive; this tends to rotate OL clockwise as  $\bar{p}_A$  rises. The taste bias is primarily captured in the  $\lambda_{L1}$  term in  $\alpha_3$ ; the fraction of home labor (in the Output Tier) devoted to producing the first commodity is higher than abroad ( $\lambda_{L1} > \lambda_{L1}^*$ ) if tastes are biased as we supposed. Other things equal (and assuming high  $\sigma_1$  and  $\sigma_1^*$ ), such a taste bias would cause E to fall more at home than abroad, or for the home currency to appreciate relative to the foreign. By (1.2) and (5.2) such a taste bias causes a discrepancy between the PPP rate and the exchange rate both because the PPP rate is rising and because the exchange rate is falling. Should elasticities of substitution be small in both countries, the OL ray in Figure 3 would tend to rotate in a counter-clockwise direction, more so at home than abroad so that the home currency depreciates. In this case the PPP rate and the exchange rate move in the same direction.

(ii) Technology: In the Output Tier two features of the technology are crucial. The size of the elasticity of substitution in the sector using the middle product that has risen in price helps determine the direction in which wages move. In addition, a factor intensity comparison between the commodities in the Output Tier is a key feature indicating the impact on wages of the squeeze implied by the rise in  $\bar{p}_A$ . If A is used in the labor-intensive sector at home and the non-labor intensive sector abroad, the rise in  $\bar{p}_A$  will tend to lower  $w$  and raise  $w^*$ . This implies a rise in  $E$ , a fall in  $E^*$ , and therefore a strong depreciation of the home country's currency.

The degree of flexibility of technology in the Input Tier plays a more passive role. Of course large values for  $\gamma_I$  as well as for  $\sigma_1$  and  $\sigma_2$  will tend to increase the elasticity of supply,  $\sigma_S$ , and thus the weight attached to the  $(\frac{\alpha_3}{\omega_3})$  term in brackets in (5.9). As well, large values for  $\gamma_I$  (which increases  $\omega_3$ ) tend to mitigate the extent of the required change in the wage rate, the direction of which depends largely on technology in the Output Tier (both the value of  $\sigma_1$  and factor intensities).

(iii) Interaction of Tastes and Technology: In this paper we have focused on the case in which countries import A and, indeed, in this section there is no import-competing sector of the economy. In general, however, tastes, technology, and factor supplies interact to determine the pattern of trade and degree of dependence upon trade. The impact which a change in world prices has on any nation's price level is (by (4.5)) directly dependent on the pattern and size of the trade flow. Thus the PPP rate depends upon this and essentially nothing else (in the presumed absence of local monetary changes). The exchange rate, however, depends on a different kind of interaction between tastes and technology, that reflected in the relative sizes of

$\sigma_D$  and  $\sigma_S$ . If, say, at home consumers are quite flexible in their taste patterns but inflexible in their ability to substitute inputs, with the opposite bias abroad, equation (5.9) suggests that the movement of  $\underline{w}$  and  $\underline{E}$  depends largely on factor intensities in the Output Tier while that of  $w^*$  and  $E^*$  depends more heavily on the value of the elasticity of substitution in the industry using  $\underline{A}$ . If  $\sigma_1^*$  is high and  $x_1$  labor-intensive at home, a rise in world  $\bar{p}_A$  could send wages rising abroad and dropping at home. With the  $\underline{OL}$  ray in Figure 3 rotating clockwise for the foreign country and counter-clockwise at home, the home currency might suffer a severe depreciation even when the PPP rate might not change much.

## 5. Conclusions

This paper has put forward a view of the relationship between national price levels and exchange rates that is rather different from that traditionally found in the literature. The key organizing principle is that trade occurs only in middle products; final consumption goods contain some local value-added, and the cost of this local value-added is reflected in the domestic price of final goods. International differences in technology and structure cause international differences in responses of local factor rewards in response to common disturbances, creating international differences in movements in exchange rate-adjusted national price levels, reflected in what we have called the PPP discrepancy,  $\hat{\mu}$ .

Under fixed exchange rates, these differences were of course reflected in movements in local currency price levels. Introducing flexible exchange rates, perhaps surprisingly, did not give rise to a different value for  $\hat{\mu}$ . And perhaps more surprisingly was the result that under flexible exchange rates national price levels became very "aggregative" variables, movements in which reflected only changes in aggregate real income. Details of the technical structure of the

economy held implications only for movements in the nominal exchange rates.

Elaborating the model to allow for local production of import-substitutes meant, of course, that the income effects from a deterioration in the terms of trade were mitigated, and the extent of profitable import-competing activity influenced the division of the PPP discrepancy between the price level and the exchange rate. Extension to two consumption goods allowed the introduction of price index problems. Again the response of the PPP rate depends only upon real income effects while the details of tastes and technology are reflected in movements in the nominal exchange rate.

An obvious extension would be to allow for short-run phenomena related to capital mobility and expectations. One approach is that suggested by Dornbusch [3] who treats output prices as "sticky". In the current model real income effects are always negative; with  $P_0$  constant, monetary equilibrium would require that domestic interest rates fall. Hence  $E$  would have to rise relative to its long-run value in order for speculators to expect the domestic appreciation implied by the interest differential. If  $\alpha$  is positive, the long-run equilibrium exchange rate rises; the short-run exchange rate would necessarily overshoot. If  $\alpha$  is negative, the long-run exchange rate would fall and the short-run rate would then necessarily undershoot.

A more interesting possibility is to examine the implications of speculators being "confused, monetarist PPP advocates" who expect actual exchange rate movements in accordance with the PPP rate. Such implications, however, are beyond the scope of the present paper.



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