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Keskusteluaiheita
Discussion papers

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TERMS-OF-TRADE, REAL EXCHANGE RATES, AND THE ECONOMIC STRUCTURE

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1. Introduction

The traditional approach to the open economy macroeconomics (elasticities approach) assumes that the country is specialized in production and generalized in consumption.[1] In models based on this approach the terms of trade is equal to the real exchange rate. Provided that certain conditions between the relevant demand and supply elasticities are fulfilled, an increase in foreign demand will call for exchange rate appreciation or a balance of payments surplus depending on the exchange rate regime and capital mobility. With unemployment and domestic wages fixed an increase in export demand will increase domestic production and employment through the Keynesian multiplier mechanism. A discrete devaluation would imply a surplus on the current account provided again that certain conditions (Marshall-Lerner condition) are fulfilled because export demand increases and import demand decreases. As a consequence employment would increase or, if there were full employment initially, there would be domestic inflation that would return the terms of trade (or the real exchange rate or the 'international price competitiveness') to the earlier level.

The monetary approach to open economy macroeconomics takes an opposite view to the traditional approach as far as the structure of the economy is concerned. In the most simple models based on this approach the country produces only one internationally traded good, the price of which is determined in the world market and hence is given to a small country.[2] In this model there are no direct export and import functions. Under fixed exchange rates net export is determined by the disequilibrium in the market for money balances, where the supply of money adjusts endogeneously through the reserve flows. Under flexible exchange rates net export is zero, and the exchange rate adjusts to restore macroeconomic equilibrium. The real exchange rate remains constant in both cases. International business cycle has no direct effect on our trade flows. Indirect effects may arise if the international business cycle affects the world market price of traded goods.

There are numerous extensions to this basic model that take into account certain structural features of the economy, notably the distinction between the traded goods sector and the non-traded goods sector.[3] In some models a distinction is made between exportables and importables, and some models take into account imported raw materials. In most of these models, however, there is little or no room for direct links from the international business cycle to the volume of exports of a small country.

In this paper I propose a model which, in a way, is a synthesis of the traditional approach emphasizing the role of foreign income in the determination of the volume of exports, and the monetary approach emphasizing the exogeneoity of the foreign currency price of traded goods. Specifically, I assume that the country produces two goods, a specialized export good and a conventional traded good. The world market price of the export good and the volume of exports is determined by the world demand for our exports and our supply of this good. The world market price of the traded good is given, and our production of traded goods is determined by the real wage only. The demand for labor depends on the product wage of each sector. In equilibrium the demand for real balances must be equal to the existing stock of real balances. Depending on the exchange rate regime an adjustment to exogenous shocks takes place either through nominal exchange rate changes or through changes in nominal money supply. I am especially interested in the effects of the international business cycle on domestic developments, but the effects of other kinds os shocks can be studied as well.

With flexible wages an increase in foreign demand for our exports unambiguously implies an improvement in the terms-of-trade and a real appreciation of our currency, which is proportionately less than the improvement in the terms-of-trade. Despite real appreciation the nominal exchange rate may appreciate or depreciate depending on the relevant elasticities and the share of the labor force employed and the share of the national income produced by the export sector.

If the nominal wage is fixed or rigid downwards and the exchange rate is flexible, then a decline in the foreign demand for our exports may cause unemployment or, in certain situations, also excess demand for labor. With fixed real wage a decline in export demand will always cause classical unemployment. If, however, the nominal wage is indexed to the domestic currency price of the export good, or if monetary and fiscal policies are targeted to keep the profitability of the export sector constant, then a decline in world demand can, in fact, create excess demand for labor.

2. The model: flexible wages

The country produces two goods, an export good and a traded good. The export good is sold in the world market, and its domestic consumption is neglible. World demand for the export good depends negatively on its dollar price, p_X^*, relative to the dollar price of other traded goods, $p_T^* = 1$, and positively on world income, y^*. The supply of this good depends negatively on the product wage, w/ep_X^*, where w is the nominal wage and e the nominal exchange rate (price of one unit of foreign currency (dollar) in terms of domestic money). The intercept of the world demand curve and our supply curve determines the dollar price of the export good as well as the quantity produced (and exported)[4] :

(1) $$D_X\,(\underset{-}{p_X^*},\ \underset{+}{y^*}) = S_X\,(\underset{-}{w/ep_X^*}) \ .$$

The supply of the traded good depends negatively on the product wage, w/e,

(2) $$S_T = S_T\,(\underset{-}{w/e}) \ .$$

Because the demand for traded good is, in principle, infinite at given dollar prices, $p_T^* = 1$, w/e alone determines the production of traded goods at home.

Because $p_T^* = 1$ and the domestic consumption consists only of traded goods w/e is also the real wage. If the weight of our export good is small in the foreign price index, then w/e also measures the real exchange rate.

The labor force is mobile between the two sectors, and the demand for labor by each sector depends negatively on the product wage. Full employment prevails when the total demand for labor is equal to the supply of labor, which is assumed to depend positively on the real wage[5] :

$$(3) \qquad \underset{-}{L_X^d (w/ep_X^*)} + \underset{-}{L_T^d (w/e)} = \underset{+}{L^S (w/e)} \ .$$

Equations (1) and (3) determine the equilibrium real wage and the equilibrium dollar price of the export good or, in this case, the terms-of-trade.

In figure 1 the XX-schedule shows those combinations of real wage and terms of trade at which the export sector is in equilibrium. The slope of the curve is $(\varepsilon_X^d + \varepsilon_X^S)/\varepsilon_X^S \geq 1$, where ε_X^d and ε_X^S stand for the demand and supply elasticities, respectively. The XX-schedule is the steeper the higher is the demand elasticity and the smaller is the supply elasticity. An increase in foreign income will shift the XX-curve to the right.

The LL-schedule presents those combinations of real wage and terms of trade at which the labor market is in equilibrium. The slope of the schedule is $\alpha\gamma_X/(\alpha\gamma_X + (1-\alpha)\ \gamma_T + \delta) < 1$, where α is the share of the labor force employed by the export sector, γ_X and γ_T are the elasticities of the demand for labor by each sector with respect to the product wage, and δ is the elasticity of the supply of labor with respect to the real wage. The LL-schedule is the steeper the higher is the share of the labor force employed by the export sector.

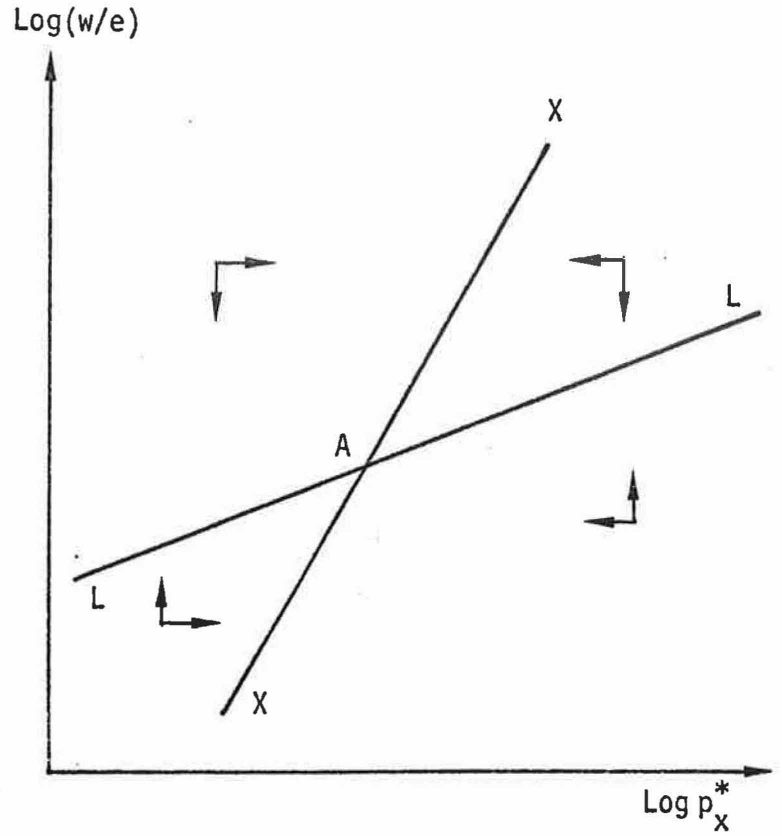

Figure 1. The equilibrium terms-of-trade and the real wage.

To the left of the XX-schedule there is excess demand for our exports, and therefore our terms of trade improves. Above the LL-schedule there is excess supply of labor, and therefore the real wage tends to decline.

If $\alpha = 0$, then the XX-schedule disappears and the LL-schedule becomes horizontal implying that there is only one real wage consistent with full employment in a country that produces conventional traded goods only. If $\varepsilon_X^d = \infty$, the terms of trade would become exogenous, i.e. the small country assumption would be valid also for our export goods (cf. models with the distinction between exportables and importables)[6]. If $\alpha = 1$ and $\delta = 0$, then the terms-of-trade and the real exchange rate would move proportionately as in the traditional model.

As seen from figure 1, an increase in foreign income calls for the improvement in the terms of trade and an increase in real wages or, in this case, real appreciation. The rise in real wages is proportionately less than the improvement in the terms of trade, which means that the product wage of the export sector declines, employment in the export sector increases and the volume of exports grows. The rise in real wage implies the loss of 'competitiveness' for other industries, and therefore their employment and production declines.

So far we have said nothing about what happens to the nominal wage and the nominal exchange rate, nor what happens to real income.

Assume that nominal expenditure is determined by the nominal money supply, h, multiplied by the velocity of money, v. In equilibrium this has to be equal to nominal income, which is equal to the value of production of the export sector, $ep_x^* S_x (w/ep_x^*)$, plus the value of production of the traded goods sector, $eS_T(w/e)$. This equilibrium condition can be written as follows

$$(4) \qquad p_x^* S_x (w/ep_x^*) + S_T(w/e) = vh/e,$$

where the velocity v is assumed to be constant. The left hand side of equation (4) measures the real national income.

When the real wage and the terms of trade are determined by equations (1) and (3) it remains for equation (4) to determine equilibrium real balances.

It is readily seen that with flexible exchange rates and flexible wages, an increase in nominal money supply will immediately cause proportionate nominal depreciation and proportionate wage inflation leaving the real variables untouched. Under fixed exchange rates this adjustment would take place through reserve outflow which would eliminate the excess supply of money. A discrete devaluation would cause a proportionate increase in nominal wages, reduce real balances and hence create a temporary balance-of-payments surplus. In these respects the model reproduces the neutrality properties of the simple monetary model in the absence of capital flows.

It is more interesting to see what happens to nominal variables when foreign income and therefore the demand for our exports increases. To study this let us draw those combinations of the real wage and the terms of trade at which real income is equal to any given stock of real balances multiplied by the constant velocity. (HH-schedule). The HH-schedule shifts downwards when real income and hence the required real balances increase. The slope of the HH-schedule is $\beta(1 + \varepsilon_X^S)/(\beta\varepsilon_X^S + (1 - \beta)\varepsilon_T^S) > 0$, where β is the share of national income produced by the export sector, and where ε_X^S and ε_T^S are the supply elasticity of the export sector and the traded goods sector, respectively.

The critical issue is whether the HH-schedule intercepts the LL-schedule from below or from above. It will be steeper than the LL-schedule if the share of the value added produced by the export sector is sufficiently high relative to the share of the labor force employed by this sector. (The formal condition is more complicated and depends also an various elasticities, see the Appendix). In this case the real appreciation caused by an increase in export demand would be accompanied by an increase in real income and nominal appreciation, if the exchange rate is flexible and the nominal money supply is kept constant. Under fixed exchange rate the required increase in real balances would be brought about through balance of payments surpluses (see figure 2a).

If, however, the HH-schedule intercepts the LL-schedule from above, then an increase in export demand would, despite of real appreciation, cause nominal depreciation or, under fixed exchange rates, a balance-of-payments deficit (cf. figure 2b). This would happen if the export sector employs a great share of the country's labor force relative to the share of the national income produced by that sector. In this case the nominal wage rises excessively so that nominal depreciation

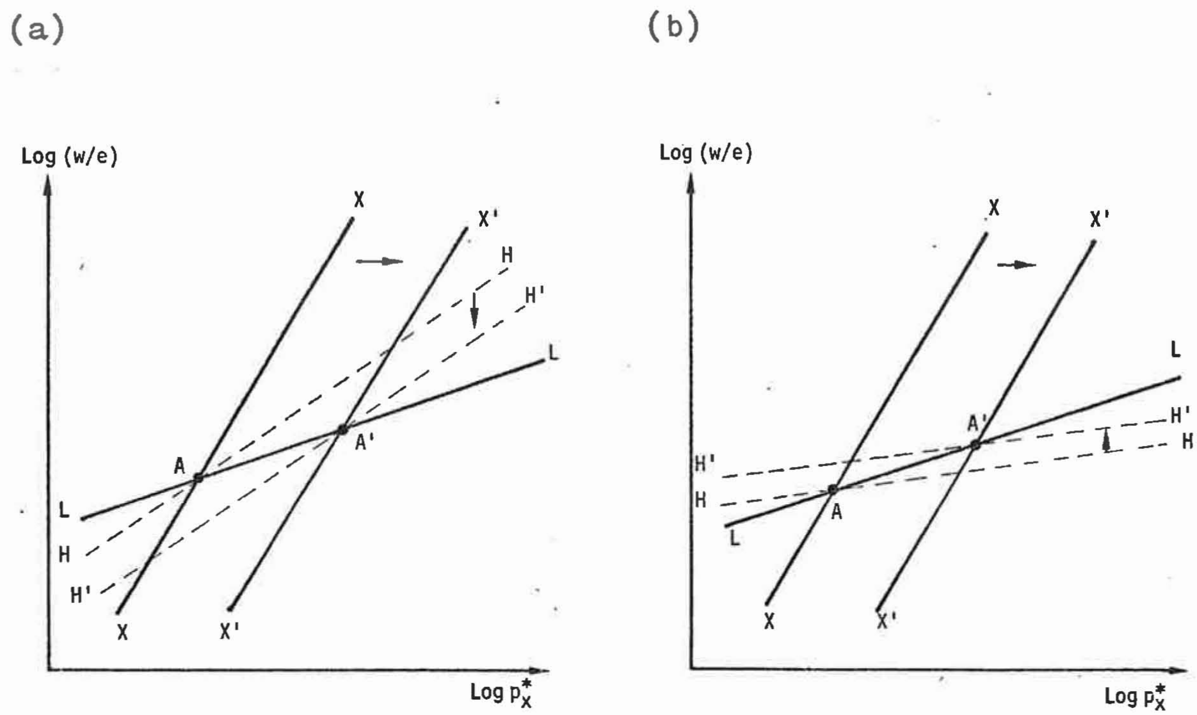

Figure 2. The effects of an increase in export demand.

(a) Increase in real income; nominal appreciation or current account surplus.

(b) Decrease in real income; nominal depreciation or current account deficit.

is needed to bring the real wage to the level consistent with full employment.

If the HH-curve is sufficiently steep there is a possibility that the nominal appreciation is so high that a reduction in nominal wages is required to restore the competitiveness of the traded goods sector.

These results are summarized in table 1.

Table 1. The effects of an increase in export demand

Effect		Exchange rate regime	Condition
P_X^*	rises	flexible fixed	always
w/e	rises	flexible fixed	always
h/e	rises	flexible fixed	
e	decreases	flexible	if $\beta\,(1+\varepsilon_X^S)/\varepsilon > \alpha\gamma_X/(\gamma+\delta)$
h	rises	fixed	
w	rises	flexible fixed	if $\beta\,(1+\varepsilon_X^S)/(1+\varepsilon) < \alpha\gamma_X/(\gamma+\delta)$

α = the share of the labor force employed by the export sector;
β = the share of the national income produced by the export sector;
$\varepsilon = \beta\varepsilon_X^S + (1-\beta)\varepsilon_T^S$: weighted average of the supply elasticities;
$\gamma = \alpha\gamma_X + (1-\alpha)\gamma_R$: weighted average of the labor demand elasticities.

3. Wage rigidity and indexation

Next assume that the nominal wage is fixed or rigid downwards and that the country faces a decline in the demand for exports. Exchange rate is flexible and nominal money supply is constant. In this case the system is underdetermined. There are three equations, but only two independent variables. Because we assume that firms always produce up to the point where the marginal product of labor is equal to the product wage, then labor market equilibrium cannot be guaranteed if there is no change in monetary policy.

We redraw the equilibrium schedules (1), (3) and (4) onto the $(p_X^*, \frac{1}{e})$-space. The XX-schedule and the LL-schedule have the same slope as above but the HH-schedule becomes flatter; its slope is now $\beta(1 + \varepsilon_X^S)/(1 + \varepsilon)$, where $\varepsilon = \beta\varepsilon_X^S + (1 - \beta)\varepsilon_T^S$ is the weighted supply elasticity. The equilibrium exchange rate and terms of trade are determined by the intercept of the XX-schedule and the HH-schedule. As seen from figure 3, a decline in the export demand implies a deterioration in the terms of trade and a depreciation of the currency. If the new HH-locus is flatter than the LL-locus then the nominal depreciation is insufficient to reduce real wages enough to maintain full employment. The condition for this outcome is that $\beta(1 + \varepsilon_X^S)/(1 + \varepsilon) < \alpha\gamma_X/\gamma$, which is the same condition that gave an increase in the nominal wage in response to an increase in export demand under wage flexibility.

If the new HH-locus is steeper than the LL-locus then a downturn in the international business cycle will in fact depreciate the currency excessively so that there will be excess demand for labor. This would happen if the export sector is very important for the country's real income but less important for its employment.

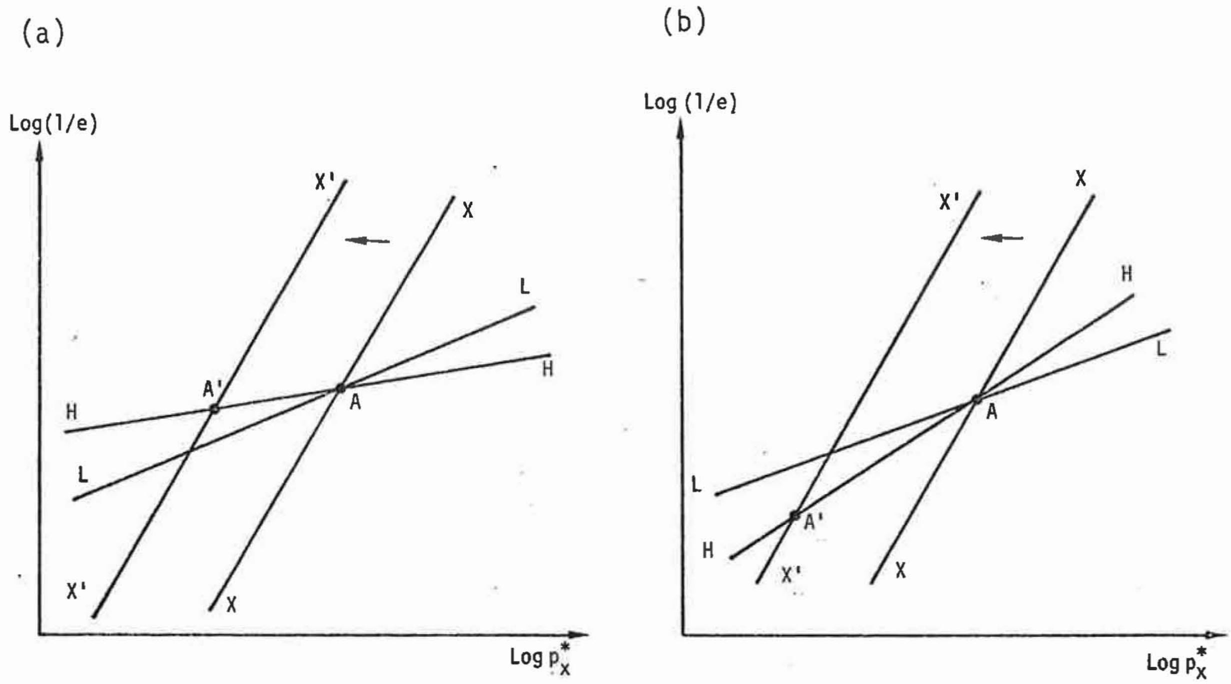

Figure 3. The effects of a decrease in export demand with the fixed nominal wage.

(a) unemployment; (b) excess demand for labor.

In both cases monetary policy could be used to restore the equilibrium in the labor market. For example, unemployment outcome would call for an increase in nominal money supply, which would imply further depreciation and further reduction in real wages.

If the real wage, w/e, is fixed, as it would be in a fully indexed economy, then a decline in the export demand will cause a deterioration in the terms of trade. The supply of the export good declines while the supply of the traded good remains constant. The real income declines, and the real balances have to decline. In other words, the XX-schedule shifts to the left, and the HH-schedule has to shift upwards. Their intercept is above the LL-curve, which unambiguously implies unemployment.

By a similar argument an international boom will create excess demand for labor.

Assume next that the nominal wage is indexed to the terms-of-trade adjusted price index in such a way that the product wage of the export sector, w/ep_x^*, is constant. The production and employment of the export sector will also remain constant independently of what happens abroad. A decline in world demand would then cause a deterioration in the terms-of-trade and a proportionate decline in the real wage. A decline in the real wage will increase the demand for labor by the traded good sector and decrease the supply of labor implying excess demand for labor. Real balances may increase or decrease depending on the relative slopes of the HH-schedule and the LL-schedule (see Figure 4). An upturn in the international business cycle will reverse the process eventually leading to unemployment.

It is seen that full indexation without adjustment to the terms-of-trade makes the domestic economy procyclically sensitive to the international business cycle, when the domestic cyclical situation is measured by the disequilibrium in the labor market. On the other hand, if the nominal wage is indexed with full adjustment to the terms-of-trade, then the domestic economy will behave countercyclically with respect to the international business cycle[7] .

This suggests that the indexation rule allowing only for partial adjustment to the terms-of-trade would insulate the domestic employment from the fluctuations in world demand. This is, indeed, the case if the adjustment coefficent ϕ in the indexation formula

$$(5) \qquad \log w = \log e + \phi \log p_x^*$$

is chosen to be equal to the slope of the LL-curve, $\phi = \alpha\gamma_x/(\gamma + \delta)$. Then the real wage and the terms of trade will move in a proper way to guarantee the equilibrium in the labor market. In fact, this formula makes the economy behave in exactly the same way as it would with full wage flexibility.

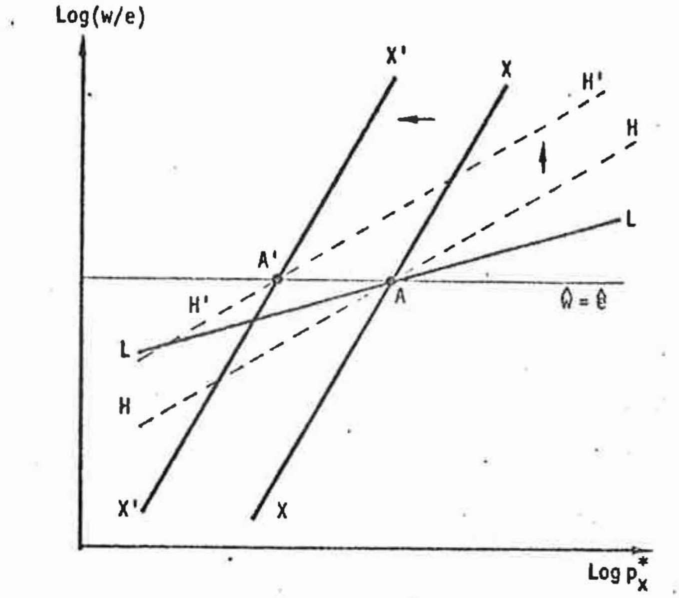

Figure 4. The effects of a decline in export demand with the real wage w/e fixed.

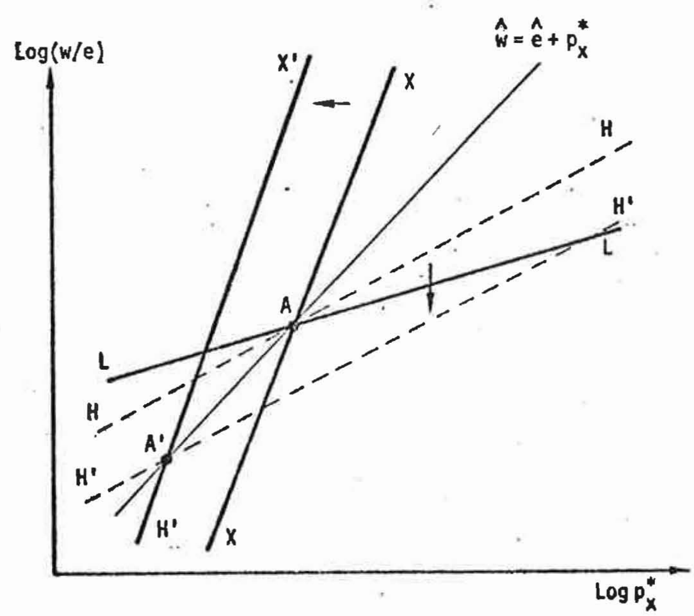

Figure 5. The effects of a decline in export demand with the product wage of the export sector w/ep^*_X fixed.

4. Conclusions

The point of departure in this paper has been the recognizion of the fact that the traded good is not a Hicksian composite good in the sense that the relative prices of individual components remain constant over the international business cycle. If this is the case then external shocks may affect the profitability of different industries asymmetrically, which means that general macroeconomic policies may not be sufficient to insulate the domestic economy from the effects of the international business cycle.

The analysis shows that, in general, the effects of the international business cycle on the domestic economy are ambiguous. Domestic real income may fluctuate procyclically or countercyclically depending on the contributions of the two sectors to national income and to total employment. If there are wage rigidities and frictions in the mobility of labor between the two sectors, then there will be fluctuations in employment.

These kind of structural assumptions may not be relevant for all countries but certainly are for such a country like Finland, where the forest based industries play in important role for the country´s exports and where the dollar price of lumber, pulp and paper has a tendency to increase relative to the prices of manufactured goods during an international boom and decrease during an international recession. Australia is another country where the structure of the economy perhaps makes an assumption of the Hicksian composite good inappropriate, taking into account the important role of agricultural products and minerals for her exports[8] .

The paper also points out the interrelationships between the macro-economic policy problem and the industrial policy problem especially in situations where the shocks turn out to be of permanent nature[9].

NOTES

1 Cf. Dornbusch (1980, Ch. 4).

2 Johnson (1972); Dornbusch (1980, Ch. 7).

3 Prachowny (1975); Korkman (1980); Dornbusch (1980, Chs. 5-8).

4 It can be assumed that the country as a whole faces a downward sloping demand curve for its specialized exports but each individual firm producing these goods operates in a competitive environment. Alternatively, one could assume that the export sector as a whole behaves as a single monopoly, in which case the equilibrium price and quantity would be determined by the equality of the marginal revenue curve determined by the world demand curve and the marginal cost curve of the export sector. Qualitative results would be similar in both cases as far as the aims of the present paper are concerned.

5 Nothing essential would change if we assumed a fixed labor supply or even a backward bending labor supply curve provided that the negative labor supply elasticity remains sufficiently small.

6 Qualitative results would be the same even in the case when $\varepsilon_x^d = \infty$ assuming that the world market price of the export good tends to increase relative to the price of other traded good when there is an upturn in the international business cycle, and decrease when there is an international recession. This relative price movement is likely if the export good is a relatively homogeneous primary good.

7 A change in the terms-of-trade created by a change in export demand is a supply shock in the sense that it requires a change in the structure of production. With real wage rigidity or with full indexation external demand shocks have a destabilizing effect on domestic unemployment. In this respect these results correspond to those by Gray (1976) and Fischer (1977) on the effects of wage indexation in response to supply shocks.

8 For the Australian experience, see Porter (1978)

9 Cf. Corden (1980).

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APPENDIX

1. The Model

Behavioural equations:

(A.1) $S_x = S_x(w/ep_x^*)$ (supply of export goods)

$$\partial \log S_x / \partial \log (w/ep_x^*) = - \varepsilon_x^s$$

(A.2) $S_T = S_T\ (w/e)$ (supply of traded goods)

$$\partial \log S_T / \partial \log (w/e) = - \varepsilon_T^S$$

(A.3) $D_x = D_x\ (p_x^*, y^*)$ (demand for export goods)

$$\partial \log D_x / \partial \log p_x^* = - \varepsilon_x^d \quad ; \quad \partial \log D_x / \partial \log y^* = \eta^*$$

(A.4) $L_x = L_x\ (w/ep_x^*)$ (demand for labor by the export sector)

$$\partial \log L_x / \partial \log (e/ep_x^*) = - \gamma_x$$

(A.5) $L_T = L_T\ (w/e)$ (demand for labor by the traded goods sector)

$$\partial \log L_T / \partial \log (w/e) = - \gamma_T$$

(A.6) $L = L\ (w/e)$ (supply of labor)

$$\partial \log L / \partial \log (w/e) = \delta$$

(A.7) $h^d/e = (1/v)\ y$ (demand for money) where w = nominal wage

e = nominal exchange rate (price of foreign currency in terms of domestic money)
= domestic consumer price level

p_x^* = foreign currency price of the export good

y^* = world real income

v = constant velocity of money

$y = p_x^* S_x + S_T$ = domestic real income

Equilibrium conditions:

A.8) $D_x (p_x^*, y^*) - S_x (w/ep_x^*) = 0$ (export goods market)

A.9) $L_x (w/ep_x^*) + L_T (w/e) - (L (w/e) = 0$ (labor market)

(A.10) $p_x^* S_x (w/ep_x^*) + S_T (w/e) = vh/e$ (money market and the foreign exchange market)

where h is the nominal money supply.

Total differentiation of (A.8) - (A.10) gives

(A.11) $\varepsilon_x^d \hat{p}_x^* - \varepsilon_x^S (\hat{w} - \hat{e} - \hat{p}_x^*) = \eta^* \hat{y}^* \equiv \hat{z}^*$

(A.12) $- \alpha\gamma_x (\hat{w} - \hat{e} - \hat{p}_x^*) - (1 - \alpha) \gamma_T (\hat{w} - \hat{e}) - \delta (\hat{w} - \hat{e}) = 0$

(A.13) $\beta [\hat{p}_x^* - \varepsilon_x^S (\hat{w} - \hat{e} - p_x^*)] - (1 - \beta)\varepsilon_T^S (\hat{w} - \hat{e}) - (\hat{h} - \hat{e}) = 0,$

where the hat over the variable denotes the logarithmic differential, $\hat{x} = d \log x = dx/x$, and where

$\alpha = L_X/(L_X + L_T)$ (share of the labor force employed by the export sector)

$\beta = p_X^* S_X/(p_X^* S_X + S_T)$ (share of the national income produced by the export sector)

The elasticities ε_X^d, ε_X^S, ε_T^S, γ_X, γ_T, $\delta > 0$ are defined above. Note that if the production function $q_i = F_i(L)$, $i = x,T$, is "well-behaved", $F_i'(L) > 0$, $F_i''(L) < 0$, than the elasticity of supply with respect to the product wage is smaller than the elasticity of the demand for labor, $\varepsilon_i^S < \gamma_i$.

(A.11)- (A.13) give the slopes of the equilibrium schedules in Figure 1:

$$\left.\frac{d \log (w/e)}{d \log p_X^*}\right|_{XX} = \frac{\varepsilon_X^S + \varepsilon_X^d}{\varepsilon_X^S} \geq 1$$

$$0 \leq \left.\frac{d \log (w/e)}{d \log p_X^*}\right|_{LL} = \frac{\alpha\gamma_X}{\gamma + \delta} \leq 1$$

$$0 < \left.\frac{d \log (w/e)}{d \log p_X^*}\right|_{HH} = \frac{\beta (1 + \varepsilon_X^S)}{\varepsilon}$$

where

$$\gamma = \alpha\gamma_X + (1 - \alpha)\gamma_T$$

$$\varepsilon = \beta\varepsilon_X^S + (1 - \beta)\varepsilon_T^S$$

are the weighted labor demand elasticity and the weighted supply elasticity, respectively.

2. Flexible wages

Solution for real variables

(A.11) - (A.13) form a block-recursive system of equations

$$\begin{bmatrix} -(\varepsilon_x^s + \varepsilon_x^d) & \varepsilon_x^s & 0 \\ \alpha\gamma_x & -(\gamma+\delta) & 0 \\ \beta(1+\varepsilon_x^s) & -\varepsilon & -1 \end{bmatrix} \begin{bmatrix} \hat{p}_x^* \\ \hat{w} - \hat{e} \\ \hat{h} - \hat{e} \end{bmatrix} = \begin{bmatrix} -\hat{z}^* \\ 0 \\ 0 \end{bmatrix}$$

Use the first two eqqations to solve for the terms-of-trade and the real wage and then the last equation to solve for real balances. The effects of a change in export demand are

$$\text{(A.14)} \quad \frac{d \log p_x^*}{d \log z^*} = \frac{\gamma + \delta}{J_1} > 0$$

$$\text{(A.15)} \quad \frac{d \log (w/e)}{d \log z^*} = \frac{\alpha\gamma_x}{J_1} > 0$$

$$\text{(A.16)} \quad \frac{d \log (h/e)}{d \log z^*} = \frac{(\gamma + \delta)\, \beta\, (1 + \varepsilon_x^s) - \varepsilon\alpha\gamma_x}{J_1} \gtrless 0$$

where

$$J_1 = (\gamma + \delta)\, (\varepsilon_x^s + \varepsilon_x^d) - \varepsilon_x^s \alpha\gamma_x > 0.$$

Fixed exchange rates ($\hat{e} = 0$)

(A.17) $$\frac{d \log h}{d \log z^*} = \frac{d \log (h/e)}{d \log z^*}$$

(A.18) $$\frac{d \log w}{d \log Z^*} = \frac{d \log (w/e)}{d \log z^*}$$

Flexible exchange rates ($\hat{h} = 0$)

(A.19) $$\frac{d \log e}{d \log Z^*} = \frac{\varepsilon\alpha\gamma_x - (\gamma + \delta)\, \beta\, (1 + \varepsilon_x^S)}{J} \gtrless 0$$

(A.20) $$\frac{d \log w}{d \log Z^*} = \frac{\alpha\gamma_x(1 + \varepsilon) - (\gamma + \delta)\, \beta\, (1 + \varepsilon_x^S)}{J} \gtrless 0$$

3. Fixed nominal wage and flexible exchange rate ($\hat{h} = 0$)

Solve (A.11) and (A.13) for the nominal exchange rate and the terms of trade

$$\begin{bmatrix} \varepsilon_x^d + \varepsilon_x^S & \varepsilon_x^S \\ \beta(1 + \varepsilon_x^S) & 1 + \varepsilon \end{bmatrix} \begin{bmatrix} \hat{p}_x^* \\ \hat{e} \end{bmatrix} = \begin{bmatrix} \hat{z}^* \\ 0 \end{bmatrix}$$

(A.21) $$\frac{d \log p_x^*}{d \log z^*} = \frac{1+\varepsilon}{J_2} > 0$$

$$\text{(A.22)} \quad \frac{d \log e}{d \log Z^*} = \frac{-\beta(1 + \varepsilon_x^S)}{J_2} < 0$$

where $J_2 = (1 + \varepsilon)(\varepsilon_x^d + \varepsilon_x^S) - \beta (1 + \varepsilon_x^S) \varepsilon_x^S > 0$

Use (A.12) to see the effect of a change in export demand on the labor market equilibrium. A decline in world demand for our exports will cause unemployment if (cf. A.18).

$$\text{(A.23)} \quad \alpha\gamma_x (1 + \varepsilon) - (\gamma + \delta) \beta (1 + \varepsilon_x^S) > 0 .$$

4. Fixed real wage

$\hat{w} = \hat{e}$

Eq. (A.11) determines the terms-of-trade and (A.13) determines the required change in real balances

$$\text{(A.24)} \quad \frac{d \log p_x^*}{d \log \bar{z}^*} = \frac{1}{\varepsilon_x^S + \varepsilon_x^d} > 0$$

$$\text{(A.25)} \quad \frac{d \log (h/e)}{d \log z^*} = \frac{\beta(1 + \varepsilon_x^S)}{\varepsilon_x^S + \varepsilon_x^S} > 0$$

Eq. (12) gives the change in the demand for labor by the export sector

$$\text{(A.26)} \quad \frac{d \log L_x}{d \log z^*} = \frac{\alpha\gamma_x}{\varepsilon_x^S + \varepsilon_x^d} > 0 .$$

$\hat{w} = \hat{e} + \hat{p}_x^*$

Use eq. (A.11) to solve for p_x^* and w/e, which have to move in the same proportion. Then use (A.13) to solve for the change in real balances

$$\text{(A.26)} \qquad \frac{d \log p_x^*}{d \log Z^*} = \frac{d \log (w/e)}{d \log Z^*} = \frac{1}{\varepsilon_x^d} > 0$$

$$\text{(A.27)} \qquad \frac{d \log (h/e)}{d \log Z^*} = \frac{\beta - (1 - \beta)\, \varepsilon_T^S}{\varepsilon_x^d} \gtrless 0$$

The changes in the demand for labor by the traded goods sector and the supply of labor are

$$\text{(A.28)} \qquad \frac{d \log L_T}{d \log z^*} = - \frac{(1 - \alpha)\, \gamma_T}{\varepsilon_x^d} \lessgtr 0$$

$$\text{(A.29)} \qquad \frac{d \log L}{d \log z^*} = \frac{\delta}{\varepsilon_x^d} > 0 \quad \text{if} \quad \delta > 0 \,.$$

$\hat{w} = \hat{e} + \phi\, p_x^*$

Use (A.11) and the indexation formula to solve for the real wage and the terms-of-trade

$$\begin{bmatrix} -(\varepsilon_x^d + \varepsilon_x^S) & \varepsilon_x^S \\ \phi & -1 \end{bmatrix} \begin{bmatrix} \hat{p}_x^* \\ \hat{w} - \hat{e} \end{bmatrix} = \begin{bmatrix} -\hat{Z}^* \\ 0 \end{bmatrix}$$

$$\text{(A.30)} \quad \frac{d \log p_X^*}{d \log z^*} = \frac{1}{J_3} > 0$$

$$\text{(A.31)} \quad \frac{d \log (w/e)}{d \log z^*} = \frac{\phi \varepsilon_X^S}{J_3} > 0$$

where

$$J_3 = (\varepsilon_X^d + \varepsilon_X^S) - \phi \varepsilon_X^S > 0 \quad \text{if } \phi \leq 1$$

The change in the excess demand for labor is

$$\frac{d \log (L_X + L_T)}{d \log z^*} - \frac{d \log L}{d \log z^*}$$

$$= \frac{\alpha \gamma_X - \phi \varepsilon_X (\gamma + \delta)}{J_3} \gtrless 0 \qquad \text{if } \phi \gtrless \frac{\alpha \gamma_X}{\gamma + \delta} .$$