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ABSTRACT

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The analysis highlights the role of structural asymmetries between oil importers in accounting for differences in trade balance responses. A number of structural differences are isolated in turn in order to determine their influence on the final goods terms of trade, which is the key factor in affecting relative trade balance positions.

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STRUCTURAL DIFFERENCES AND MACROECONOMIC ADJUSTMENT TO OIL PRICE INCREASES IN A THREE-COUNTRY MODEL

by Nancy Peregrim Marion and Lars E. O. Svensson

1. Introduction

In this paper a three-country model based on intertemporal maximizing behavior is constructed in order to analyze the effects of oil price increases on welfare levels and trade balance positions. The model can also be used to assess the effects of oil price increases on the world interest rate, on the final goods terms of trade between oil importers (what is sometimes called the real (external) exchange rate), and on output, investment and savings levels, oil imports, wages, and consumption at each date.

The theoretical interest in these effects is derived, of course, from the substantial oil price increases that have occurred over the last eight years, the resulting large surpluses in OPEC's trade balances, the corresponding overall deficits in the rest of the world vis-à-vis OPEC, and the differential macroeconomic adjustment among oil importers.

There is by now an extensive literature on the macroeconomic effects of oil price increases. However, this literature mostly relies on a static, small economy analysis that keeps world interest rates and traded goods prices fixed following an oil price increase. Such a partial-equilibrium and non-intertemporal approach is limiting and could be misleading. Moreover, such a single-economy framework cannot be used to study the differential responses of oil importers to oil price increases.[1]

Three-country world equilibrium models have recently been constructed by Schmid (1980) and Sachs (1980), but they differ considerably from the one developed here. Schmid's model of OPEC and two OECD oil importers is within the monetary-approach-to-the-balance-of-payments tradition and lacks an explicit treatment of the intertemporal choices involved in saving and investment behavior that are so crucial to what we think is a proper analysis of the current account response to oil price increases. In fact, there is no capital accumulation in his model nor is there a role for the world interest rate. In addition, he assumes that both oil importers produce the same final goods, and so ignores the expenditure-switching effects from relative price changes induced by oil price increases.

Sachs' model of OPEC and two industrial oil importers, on the other hand, is intertemporal in nature and gives an important role to capital accumulation and the world interest rate in the macroeconomic adjustment process. However, his model is not used to examine changes in welfare levels and relative trade positions that result from oil price increases. Moreover, it is too complicated to solve analytically, and is instead examined by simulation methods.

The two-period three-country model developed below is analytically tractable and easily manipulated and interpreted. It relies on the dual approach, characterized by the use of expenditure and GDP functions. Such an approach is formally equivalent to traditional ones which use utility and production functions, but it has some practical advantages, among them notational simplicity. Our way of applying the dual approach has been very much inspired by Dixit and Norman (1980).

The model is used primarily to isolate the determinants of changes in welfare levels and of changes in trade balance positions when there are oil price increases. It shows that welfare levels are influenced by direct oil terms of trade effects, final goods terms of trade effects and intertemporal terms of trade effects. Relative trade balance positions among oil importers are influenced by these same terms of trade effects and also by a consumption-wealth effect and substitution effects in consumption and investment.

The model also highlights the role of structural asymmetries between oil importers in accounting for differences in trade balance responses. A number of structural differences are isolated in turn in order to determine their influence on the final goods terms of trade, which is the key factor in affecting relative trade balance positions.

It is shown that oil price increases can worsen the relative trade position of the more oil dependent importer by deteriorating its final goods terms of trade. Oil price increases also cause a final goods terms of trade deterioration for the oil importer with the larger net creditor or smaller net debtor position in the first period, for the oil importer with more flexible wages in the first period, and under plausible conditions, for the oil importer with the smaller marginal propensity to save. Finally, oil price increases deteriorate the final goods terms of trade of the oil importer with the smaller degree of substitutability in oil and can hence worsen its relative trade position.

The rest of the paper is organized as follows. The three-country model is set out in Section 2. In Section 3, world equilibrium is defined. The effects of an oil price increase on welfare levels, trade balances, world interest rates, and the relative price of final goods are derived. Section 4 analyzes in turn the role of five structural asymmetries which influence the final goods terms of trade and hence the relative trade balance response of oil importers. These structural asymmetries are (1) the degree of oil dependence, (2) the net creditor or debtor position, (3) the marginal propensity to save, (4) the employment response and (5) the degree of substitutability in oil. Section 5 provides some concluding remarks.

2. The home country, the foreign country and OPEC

Consider a world of three countries in an intertemporal framework. Call the three countries the home country, the foreign country and OPEC. There are two dates, indexed t = 1 and 2.

At date 1 three goods are produced: (1) home final goods, produced exclusively in the home country, (2) foreign final goods, produced exclusively in the foreign country, and (3) oil, produced exclusively in OPEC. At date 2, two goods are produced: a common final good is produced in the home and foreign countries,[2] and oil in OPEC. Imported oil is used as an input in production in the home and foreign countries. It is neither consumed nor stored.

At date 1 the non-OPEC countries consume home and foreign goods. They can also use their own-produced good for investment purposes in order to increase their capital stocks at date 2. To capture the lag in OPEC consumption of its oil revenues, we invoke the extreme assumption that there is no OPEC consumption at date 1.[3] At date 2 all three countries consume final goods.

All three countries can trade goods on the world market at each date. They also have access to a common world credit market.

OPEC exogenously sets oil prices in terms of home goods at date 1 and in terms of final goods at date 2.[4] The price of foreign goods in terms of home goods and the home goods rate of interest are endogenously determined.

Let us now examine the behavior of the home country, modeling first its production side. Let $x^t = f^t(k^t, \ell^t, z^t)$ denote its well-behaved concave production function at date t, where x^t is output of home goods, k^t the home country's capital stock, ℓ^t its employment level, and z^t its input (import) of oil. The representative firm operates competitively. It is then convenient to represent the production side by means of the revenue, or GDP, functions,[5] $Y^t(P_h^t, Q^t, k^t, \ell^t)$, defined as

$$(2.1) \qquad Y^t(P_h^t, Q^t, k^t, \ell^t) = \max \{P_h^t x^t - Q^t z^t: \; x^t = f^t(k^t, \ell^t, x^t)\},$$

where P_h^1 and Q^1 are the nominal spot prices of home goods and oil at date 1, measured in some arbitrary unit of account, and $P_h^2 = P^2$ and Q^2 are the nominal spot prices of final goods and oil at date 2.

Throughout the rest of the paper we shall use home goods as the numeraire at date 1 and final goods as the numeraire at date 2, and we shall hence normalize $P_h^1 = P^2 = 1$. We let $q^1 = Q^1/P_h^1$ represent the date 1 oil price relative to home goods at date 1 and $q^2 = Q^2/P^2$ represent the date 2 oil price relative to final goods at date 2. Then, $Y^t(1, q^t, k^t, \ell^t)$ is GDP, or national value added, measured in home goods at date 1 and final goods at date 2.

We use standard properties of GDP functions to express home goods supply, the home country's import of oil and its demand price for labor as

$$(2.2) \qquad x^t = Y_1^t, \quad z^t = -Y_q^t, \quad w^t = Y_\ell^t,$$

where Y_1^t, Y_q^t, Y_k^t and Y_ℓ^t denote the partials of the GDP function (Y_1^t denotes $\partial Y^t/\partial P_h^t$), and w^t represents the date t wage relative to home goods at date 1 and relative to final goods at date 2.

With respect to employment, we assume that labor is fixed in total supply within the home country. Initially, flexible wages ensure a given full employment level, ℓ^t, at each date. The full-employment assumption will be relaxed in Section 4.4.

With respect to capital, the home country's capital stock at date 1, k^1, is predetermined and exogenously given. Its capital stock at date 2, k^2, can be augmented by investment of home goods at date 1, i^1. Thus

$$(2.3) \qquad k^2 = k^1 + i^1$$

At date 2 there is no investment.

We can derive the home country's investment function in the following manner. We denote the home goods discount factor by δ which is identical to $1/(1 + r)$, where r is the home goods rate of interest. The home country's <u>investment</u> (demand) <u>function</u>, $I^1(1, \delta, q^2, k^1, \ell^2)$, is then, under competitive conditions, given by the level of investment that maximizes the difference between the present value of GDP at date 2 and the cost of investment at date 1, i.e., the solution to the problem

$$\max_{i^1} \{\delta Y^2(1, q^2, k^1 + i^1, \ell^2) - i^1\}. \tag{2.4}$$

The investment function hence fulfills the first-order condition

$$\delta Y_k^2(1, q^2, k^1 + I^1(1,\delta,q^2, k^1, \ell^2),\ell^2) = 1, \tag{2.5}$$

which says that firms invest up to the point where the present value of the marginal product of capital in date 2 production equals the price of capital goods at date 1.

To examine the properties of the investment function, we differentiate (2.5), which gives the derivatives

$$\begin{aligned} I_\delta^1 &= - Y_k^2 / \delta Y^2{}_{kk} && > 0, \\ I_q^1 &= - Y_{kq}^2 / Y_{kk}^2 && < 0, \\ I_k^1 &= -1, \text{ and} && \\ I_\ell^1 &= -Y_{k\ell}^2 / Y_{kk}^2 && > 0, \end{aligned} \tag{2.6}$$

where $Y_{kq}^2 = \partial^2 Y^2/\partial q^2 \partial k^2$, $Y_{kk}^2 = \partial^2 Y^2/\partial (k^2)^2$, and $I_\delta^1 = \partial I^1/\partial \delta$, etc. The derivative I_δ^1 is positive, since by the concavity of the

GDP function in the capital stock the second order partial Y^2_{kk} is negative. The partial I^1_q is negative if capital and oil are complements. Similarly, the derivative I^1_ℓ is positive if capital and labor are complements. Throughout we shall assume that capital and oil, and capital and labor, are indeed complements. This is so if the production function fulfills the non-restrictive condition that all its cross partials $f^t_{k\ell}$, f^t_{kz}, and $f^t_{\ell z}$ are positive.[6]

Let us next consider the home country's demand side. We assume that the home country can be represented by a well-behaved utility function $U(c^1_h, c^1_f, c^2)$, where c^1_h, c^1_f, c^2 are the home country's consumption of home goods and foreign goods at date 1 and of final goods at date 2. Households seek to maximize utility subject to the constraint that present-value expenditures do not exceed present-value income. Define the corresponding (present value) expenditure function[7] as

$$(2.7)\quad E(P^1_h, P^1_f, DP^2, u) \equiv$$

$$\min_{c^1_h, c^1_f, c^2} \{P^1_h c^1_h + P^1_f c^1_f + DP^2 c^2 : U(c^1_h, c^1_f, c^2) \geq u\},$$

where P^1_f is the nominal spot price of foreign goods at date 1, and D is the nominal discount factor, equal to one over one plus the nominal rate of interest. The expenditure function gives the minimum present value of expenditure on consumption required to reach a target utility level, u, at given prices.

Choosing date 1 home goods as numeraire, letting the relative price of foreign goods in terms of home goods be denoted by p, where $p = P^1_f/P^1_h$ (the real exchange rate), and recalling that the home goods discount factor δ is equal to DP^2/P_h^1, we can use the linear homogeneity property of the expenditure function to write (2.7) as $E(1, p, \delta, u)$, the present-value of expenditure on consumption measured in date 1 home goods.

A standard property of the expenditure function is that its partial with respect to the price of a good equals the Hicksian compensated demand function for that good. Hence

$$(2.8) \quad c_h^1 = E_1, \; c_f^1 = E_p \text{ and } c^2 = E_\delta,$$

where E_1, E_p and E_δ denote the partials of the expenditure function.

Consider next a competitive equilibrium for the home country, which can be represented by the intertemporal budget constraint

$$(2.9) \quad E(1, p, \delta, u) + I^1(1, \delta, q^2, \ell^2) =$$

$$= Y^1(1, q^1, \ell^1) + \delta Y^2(1, q^2, I^1(1, \delta, q^2, \ell^2), \ell^2),$$

where we have suppressed the given capital stock k^1 at date 1.

The budget constraint states that the present value of expenditure on consumption and investment equals the present value of GDP over the two dates. It can be understood as expressing the welfare level u as an implicit function of oil prices, the price of foreign goods, the discount factor, and the employment levels. Given this welfare level, output of final goods, oil imports and wages are given by (2.2), consumption at each date is given by (2.8), and investment is given by the investment function.

The budget constraint can alternatively be written as equating the present value of expenditure on consumption to the home country's <u>wealth</u>, W, defined as

$$(2.10)\quad W = (Y^1 - I^1) + \delta Y^2,$$

which is the sum of GDP at date 1, net of investment, and the present value of GDP at date 2.

The home country's trade balances at dates 1 and 2, b^1 and b^2, are defined as

$$(2.11)\quad b^1 = Y^1 - E_1 - pE_p - I^1 \text{ and } b^2 = Y^2 - E_\delta.$$

From (2.9) and the homogeneity of the expenditure function it follows that the trade balances fulfill

$$(2.12)\quad b^1 + \delta b^2 = 0,$$

i.e., trade is balanced in present-value terms over time but not necessarily at each date.

As can be seen from inspection of (2.11), the home country's trade surplus at date 1 is equal to <u>GDP</u> (Y^1) <u>minus domestic absorption</u> ($E_1 + pE_p + I^1$) at date 1. Alternatively, the trade surplus represents the excess of <u>domestic saving</u> ($Y^1 - E_1 - pE_p$) <u>over investment</u> (I^1).

Since there is no initial debt and hence no interest payments at date 1, the trade surplus at date 1 is also equal to the current-account surplus and represents the net accumulation of foreign assets. Finally, since GDP at date 1 equals output, x^1, minus the value of oil input, q^1z^1, the trade surplus can be written as exports $(x^1 - c_h^1 - i^1)$ minus the value of imports $(pc_f^1 + q^1z^1)$. In summary, (2.11) incorporates all the basic definitions of the trade (current-account) balance, and each of these measures is based on intertemporal maximizing behavior and is determined by the same set of factors.

Let us now examine the foreign country, which behaves much like the home country. Its variables and functions will be denoted by a star superscript.

The foreign country produces foreign goods at date 1 and final goods at date 2 using capital, labor and imported oil. Let $Y^{*t}(p^t, q^t, k^{*t}, \ell^{*t})$ denote its GDP functions, where we note that at date 1 the first argument in the GDP function is the relative price of foreign goods. The foreign country's output, oil import and wage rate at the two dates are given by

(2.13) $$x^{*1} = Y^{*1}_p(p, q^1),\ z^{*1} = -Y^{*1}_q(p, q^1),\ w^{*1} = Y^{*1}_\ell(p, q^1);\ \text{and}$$

$$x^{*2} = Y^{*2}_1(1, q^2, k^{*2}),\quad z^{*2} = -Y^{*2}_q(1, q^2, k^{*2}),$$

$$w^{*2} = Y^{*2}_\ell(1, q^2, k^{*2}),$$

where we have suppressed labor inputs and the date 1 capital input due to the constant level of (full) employment at each date and the exogenously given date 1 capital stock.

The foreign country can invest foreign goods at date 1 to increase its capital stock at date 2. Its investment demand function, $I^{*1}(p, \delta, q^2, k^{*1}, \ell^{*2})$, will fulfill

$$\delta Y_k^{*2}(1, q^2, k^{*1} + I^{*1}(p, \delta, q^2, k^{*1}, \ell^{*2}), \ell^{*2}) = p. \tag{2.14}$$

The derivative of the investment function with respect to the price of foreign goods is

$$I_p^{*1} = 1/Y_{kk}^{*2} < 0, \tag{2.15}$$

and the other derivatives of (2.14) are given by expressions analogous to (2.6)

The foreign country's demand side is represented by its expenditure function $E^*(1, p, \delta, u^*)$, where the consumption levels are given by

$$c_h^{*1} = E_1^*, \quad c_f^{*1} = E_p^*, \quad \text{and } c^{*2} = E_\delta. \tag{2.16}$$

Its intertemporal budget constraint, expressed in terms of home goods, is

$$\begin{aligned} &E^*(1, p, \delta, u^*) + pI^{*1}(p, \delta, q^2) = \\ &= Y^{*1}(p, q^1) + \delta Y^{*2}(1, q^2, I^{*1}(p, \delta, q^2)), \end{aligned} \tag{2.17}$$

where we have suppressed labor inputs and the date 1 capital stock. Alternatively, the budget constraint can be written as equating the foreign country's present-value expenditures on consumption to its wealth, W^*, where

(2.18) $$W^* = (Y^{*1} - pI^{*1}) + \delta Y^{*2}.$$

The foreign country's trade balances at dates 1 and 2 are

(2.19) $$b^{*1} = Y^{*1} - E_1^* - pE_p^* - pI^{*1} \quad \text{and} \quad b^{*2} = Y^{*2} - E_\delta^*,$$

which by (2.17) and the homogeneity of the expenditure function fulfill

(2.20) $$b^{*1} + \delta b^{*2} = 0.$$

Finally, let us examine OPEC. We assume that OPEC exogenously sets oil prices q^1 and q^2 and supplies the quantity of oil in each period which will satisfy world (home and foreign) demand at the announced oil prices. OPEC production of oil requires negligible resources. No final goods production takes place in OPEC. All OPEC consumption is confined to date 2. Denoting OPEC variables with an "o" superscript, we can write OPEC's intertemporal budget constraint as

(2.21) $$\delta c^{o2} = q^1 x^{o1} + \delta q^2 x^{o2} = W^o,$$

where c^{o2} is OPEC's consumption of final goods at date 2, and x^{o1} and x^{o2} are the outputs of OPEC oil at the two dates, which are equivalent to the oil imports of the home and foreign countries at the two dates. Hence, the present value of OPEC's consumption equals the present value of its oil production, i.e. OPEC's wealth, W^o.

OPEC's trade balances at the two dates are given by

$$(2.22)\qquad b^{o1} = q^1x^{o1} > 0 \quad \text{and} \quad b^{o2} = q^2x^{o2} - c^{o2} < 0,$$

which by (2.21) fulfill

$$(2.23)\qquad b^{o1} + \delta b^{o2} = 0.$$

3. World Equilibrium and Oil Prices Increases

In a world equilibrium, the oil market and final goods markets are in equilibrium at each date. The complete model is described by equations (3.1)-(3.8):

$$(3.1)\qquad \begin{aligned} &E(1,\ p,\ \delta,\ u) + I^1(1,\ \delta,\ q^2) = \\ &= Y^1(1,\ q^1) + \delta Y^2(1,\ q^2,\ I^1(1,\ \delta,\ q^2)), \end{aligned}$$

$$(3.2)\qquad \begin{aligned} &E^*(1,\ p,\ \delta,\ u^*) + pI^{*1}(p,\ \delta,\ q^2) = \\ &= Y^{*1}(p,\ q^1) + \delta Y^{*2}(1,\ q^2,\ I^{*1}(p,\ \delta,\ q^2)), \end{aligned}$$

$$(3.3)\qquad \delta c^{o2} = q^1x^{o1} + \delta q^2x^{o2},$$

$$(3.4)\qquad z^1(1,\ q^1) + z^{*1}(p,\ q^1) = x^{o1},$$

$$(3.5)\qquad z^2(1,\ q^2,\ I^1(1,\ \delta,\ q^2)) + z^{*2}(1,\ q^2,\ I^{*1}(p,\ \delta,\ q^2)) = x^{o2},$$

$$(3.6)\qquad E_1 + E_1^* + I^1 = x^1(1,\ q^1),$$

$$(3.7) \qquad E_p + E_p^* + I^{*1} = x^{*1}(p, q^1), \quad \text{and}$$

$$(3.8) \qquad E_\delta + E_\delta^* + c^{o2} = = x^2(1, q^2, I^1(1, \delta, q^2)) + x^{*2}(1, q^2, I^{*1}(p, \delta, q^2)).$$

The model consists of the budget constraints, (3.1)-(3.3), oil market equilibrium at dates 1 and 2, (3.4) and (3.5), market equilibrium for date 1 home goods, (3.6), date 1 foreign goods, (3.7), and date 2 final goods, (3.8).

For exogenous oil prices q^1 and q^2, the eight equations (3.1)-(3.8) determine seven endogenous variables, u, u^*, c^{o2}, x^{o1}, x^{o2}, p and δ. By Walras' Law, one of the equations is redundant. We shall disregard (3.8), the market for date 2 final goods.

The solution to (3.1)-(3.8) can be substituted into (2.11), (2.19) and (2.22) to determine the trade balances for each country. In equilibrium, the date 1 trade balances will of course sum to zero. For easy reference, we restate these trade balance specifications:

$$(3.9) \qquad \begin{aligned} b^1 &= Y^1 - E_1 - pE_p - I^1, \\ b^{*1} &= Y^{*1} - E_1^* - pE_p^* - pI^{*1}, \\ b^{o1} &= q^1 x^{o1}, \quad \text{and} \end{aligned}$$

$$(3.10) \qquad b^1 + b^{*1} + b^{o1} = 0.$$

To calculate the effects of oil price increases, $dq^t \geq 0$, on welfare levels and trade balances with flexible wages and constant employment levels at each date, we first differentiate (3.1) and (3.2), which after some manipulations gives the change in welfare levels in the home country and in the foreign country

$$(3.11) \qquad E_u du = - z^1 dq^1 - \delta z^2 dq^2 - c_f^1 dp + b^2 d\delta \quad \text{and}$$

$$(3.12) \qquad E_u^* du^* = - z^{*1} dq^1 - \delta z^{*2} dq^2 + c_f^1 dp + b^{*2} d\delta .$$

The expressions E_u and E_u^* in (3.11) and (3.12) are the partials of the expenditure functions with respect to the welfare levels; they equal the inverse of the marginal utilities of wealth and are positive.

Let us first look at the home country's change in welfare. We see that the change in welfare, du, is proportional to the sum of the present value of the static oil terms of trade effects, $-z^t dq^t$, the static final goods term of trade effect, $-c_f^1 dp$, and an intertemporal terms of trade effect, $b^2 d\delta$. An increase in today's oil price has a direct negative effect on welfare. An increase in future oil prices also reduces welfare. In addition, an increase in present or future oil prices alters the relative price of foreign goods and affects the interest rate. If foreign goods prices should rise, the home country suffers a static terms-of trade deterioration which reduces welfare. If the interest rate should fall ($d\delta > 0$), the home country experiences a welfare gain (loss) if it is a net borrower (lender) in date 1. Thus the net impact on the home country's welfare depends in part on how oil price increases affect foreign goods prices and interest rates and whether or not the country is a net borrower or lender in date 1. We also see that the degree of substitutability in production between oil, capital, and labor has no direct (first-order) effect on the home country's welfare.

The expression for the foreign country's change in welfare is analogous, except that the final goods terms of trade effect is of opposite sign.

Differentiating (3.3) gives the change in OPEC's date 2 consumption (and welfare)

$$(3.13)\quad \delta dc^{o2} = (x^{o1}dq^{1} + \delta x^{o2}dq^{2}) + (q^{1}dx^{o1} + \delta q^{2}dx^{o2}) + b^{o2}d\delta \;.$$

OPEC's change in welfare is proportional to the sum of the static oil terms of trade effects and an intertemporal terms of trade effect, although with signs opposite to the sum of those for the home and foreign countries. In addition there is an <u>oil quantity effect</u>, $q^{1}dx^{o1} + \delta q^{2}dx^{o2}$, consisting of a change in the present value of oil revenues due to the change in the home and foreign countries' oil imports, evaluated at constant oil prices. This oil quantity effect depends on the degree of substitutability in production between oil, capital, and labor, which hence directly influences the change in OPEC welfare. The static oil terms of trade effects are positive, the intertemporal terms of trade effect may be of any sign, and the oil quantity effects are likely to be negative.

Let us, somewhat loosely, speak of the sum of the left hand sides of (3.11) - (3.13) as expressing the (wealth equivalent) change in <u>world welfare</u>. It is given by

$$(3.14)\quad E_u du + E^*_u du^* + \delta dc^{o2} = q^1 dx^{o1} + \delta q^2 dx^{o2},$$

and consists of the oil quantity effect only. The terms of trade effects are like transfers between the three countries, and they cancel from the world point of view. Thus world welfare falls to the extent that the present value of the home and foreign countries' oil imports decrease when evaluated at constant oil prices.

To determine the effect of oil price increases on the trade balances, we differentiate (3.9), which after some manipulations yields

$$(3.15)\quad db^1 = - z^1 dq^1 - c^1_f dp - C^1_W(- z^1 dq^1 - \delta z^2 dq^2 - c^1_f dp + b^2 d\delta)$$
$$- (E_{1p} + pE_{pp})dp - (E_{1\delta} + pE_{p\delta})d\delta - dI^1,$$

$$(3.16)\quad db^{*1} = - z^{*1} dq^1 + c^1_f dp - C^{*1}_W(- z^{*1} dq^1 - \delta z^{*2} dq^2 + c^1_f dp + b^{*2} d\delta)$$
$$- (E^*_{1p} + pE^*_{pp})dp - (E^*_{1\delta} + pE^*_{p\delta})d\delta - pdI^{*1}, \quad \text{and}$$

$$(3.17)\quad db^{o1} = x^{o1} dq^1 + q^1 dx^{o1} \;;$$

where the changes in investment are given by

$$(3.18)\quad dI^1 = I^1_q dq^2 + I^1_\delta d\delta \text{ and}$$

$$(3.19)\quad dI^{*1} = I^{*1}_{q}\,dq^{2} + I^{*1}_{p}\,dp + I^{*1}_{\delta}\,d\delta\ ;$$

and where C^1_W is the home country's aggregate marginal propensity to consume at date 1 (out of wealth), which is positive and less than one if consumption is normal at both dates. The expressions E_{1p} and E_{pp} are its Hicksian static substitution effects on date 1 consumption of home and foreign goods given a change in the foreign goods price, and $E_{1\delta}$ and $E_{p\delta}$ are the Hicksian intertemporal consumption substitution effects, etc.

Let us first look at the change in the home country's trade balance at date 1. There are six determinants of the trade balance response. The first term on the right-hand side of (3.15) is a direct oil terms of trade effect on date 1 GDP caused by an increase in date 1 oil prices. An increase in today's oil prices has a negative effect on date 1 GDP and thus worsens the trade balance.

The second term in (3.15) is the final goods terms of trade effect; any increase in p causes a terms of trade deterioration at home vis à vis the foreign oil importer and worsens the home country's trade balance.

The third term is a consumption wealth effect caused by the change in welfare that accompanies oil price increases. If the home country suffers a welfare loss as a result of oil price increases, household expenditures will fall. This drop in absorption improves the trade balance. The bracketed expression in the second term is the wealth equivalent of the change in the home country's welfare, given by (3.11).

The fourth term on the right-hand side of (3.15) represents a date 1 final goods consumption substitution effect. If oil price increases should raise foreign goods prices, households will shift their expenditures away from foreign goods and toward home goods. If own-substitution effects dominate cross-substitution effects, then net expenditures will fall, improving the trade balance.

The fifth term in (3.15) is an intertemporal consumption substitution effect. An increase in the discount factor boosts household absorption of date 1 goods and worsens the trade balance.

The last term consists of investment substitution effects. If the increase in oil prices lowers interest rates, investment demand is stimulated. This increase in absorption hurts the trade balance. An increase in date 2 oil prices also alters the marginal profitability of investment. If capital and oil are complements in date 2 production, an increase in future oil prices will lower the marginal product of capital. This leads to a drop in investment demand which improves the trade balance.

It is readily seen from (3.16) that the same six determinants affect the foreign country's date 1 trade balance. There are two important differences in the direction of effect, however. First, any increase in p causes a final goods terms of trade gain for the foreign country ($c_f^1\, dp > 0$) while causing a loss for the home country. Second, an increase in p also has an effect on investment behavior in the foreign country that is absent in the home country.

This latter difference appears because the two countries use country-specific capital, and it would disappear if the two countries employed the same capital goods in date 2.

Let us now study the endogenous changes in the discount factor and the price of foreign goods caused by oil price increases. Differentiating (3.6) and (3.7), making use of (3.11) and (3.12) and manipulating, we get

$$\text{(3.20)} \quad \begin{bmatrix} d_{h\delta} & d_{hp} \\ d_{f\delta} & d_{fp} \end{bmatrix} \begin{bmatrix} d\delta \\ dp \end{bmatrix} = \begin{bmatrix} s_h \\ s_f \end{bmatrix} \quad)$$

where on the left hand side $d_{h\delta}$ is the partial of the world excess demand for home goods with respect to the discount factor, d_{hp} is the partial with respect to the price of foreign goods, and $d_{f\delta}$ and d_{fp} denote the corresponding partials of the world excess demand for foreign goods. On the right hand side, s_h is the change in the world excess supply of home goods following the oil price increase, given constant discount factor and price of foreign goods, and s_f is the corresponding change in the world excess supply of foreign goods. The partials in (3.20) are given by the somewhat cumbersome yet easily interpreted expressions

$$d_{h\delta} = E_{1\delta} + E^*_{1\delta} + I^1_\delta + c^1_{hW} b^2 + c^{*1}_{hW} b^{*2} > 0,$$

$$d_{hp} = E_{1p} + E^*_{1p} + (c^{*1}_{hW} - c^1_{hW}) c^1_f > 0,$$

$$d_{f\delta} = E_{p\delta} + E^*_{p\delta} + I^{*1}_\delta + c^1_{fW} b^2 + c^{*1}_{fW} b^{*2} > 0,$$

$$(3.21) \quad d_{fp} = E_{pp} + E^*_{pp} + I^{*1}_p - x^{*1}_p + (c^{*1}_{fW} - c^1_{fW}) c^1_f < 0,$$

$$s_h = x^1_q dq^1 - I^1_q dq^2 + c^1_{hW}(z^1 dq^1 + \delta z^2 dq^2)$$

$$+ c^{*1}_{hW}(z^{*1} dq^1 + \delta z^{*2} dq^2) > 0, \quad \text{and}$$

$$s_f = x^{*1}_q dq^1 - I^{*1}_q dq^2 + c^1_{fW}(z^1 dq^1 + \delta z^2 dq^2)$$

$$+ c^{*1}_{fW}(z^{*1} dq^1 + \delta z^{*2} dq^2) > 0,$$

where c^1_{hW} and c^1_{fW} are the home country's marginal propensities to consume home and foreign goods out of wealth at date 1.

We assume gross substitutability, which is sufficient for stability.[3] We also assume that oil price increases lead to excess supply (at constant discount factor and foreign goods price) of both home and foreign goods. The latter assumption holds if the negative substitution effects on output, $x^1_q dq^1$ and $x^{*1}_q dq^1$, are dominated by the other effects, which are all positive.

The solution to (3.20) is

$$(3.22) \quad d\delta = (\underset{-}{d_{fp}} \underset{+}{s_h} - \underset{+}{d_{hp}} \underset{+}{s_f})/\underset{-}{\Delta} > 0 \quad \text{and}$$

$$(3.23) \quad dp = (\underset{+}{d_{h\delta}} \underset{+}{s_f} - \underset{+}{d_{f\delta}} \underset{+}{s_h})/\underset{-}{\Delta} \gtrless 0,$$

where Δ is the determinant

$$(3.24) \qquad \Delta = \underset{+}{d_{h\delta}}\underset{-}{d_{fp}} - \underset{+}{d_{hp}}\underset{+}{d_{f\delta}} < 0.$$

The discount factor unambiguously increases in response to oil price increases. This response occurs regardless of whether the oil price increase is <u>temporary</u> ($dq^1 > 0$, $dq^2 = 0$), <u>permanent</u> (dq^1, $dq^2 > 0$), or expected to occur in the future ($dq^1 = 0$, $dq^2 > 0$). The intuitive explanation is straightforward. At a constant discount factor and price of foreign goods, the excess supply of both home and foreign goods at date 1 brought about by higher oil prices implies by Walras' Law an excess demand for final goods at date 2. Hence the price of final goods at date 2, the discount factor, must rise. Put differently, excess supply of both home and foreign goods at date 1 implies excess saving at date 1, which bids down the interest rate.

The change in the price of foreign goods is in general of ambiguous sign. By rewriting (3.23) we get

$$(3.25) \qquad dp = \left(\frac{s_f}{s_h} - \frac{d_{f\delta}}{d_{h\delta}}\right)\underset{+}{d_{h\delta}}\ \underset{+}{s_h}/\underset{-}{\Delta}.$$

It follows that the sign of the price change is given by

$$(3.26) \qquad \text{sign } dp = \text{sign } \left(\frac{d_{f\delta}}{d_{h\delta}} - \frac{s_f}{s_h}\right).$$

This expression can be nicely interpreted. The ratio $(d_{f\delta}/d_{h\delta})$ gives the relative world excess demand for foreign goods from the change in the discount factor, at constant foreign goods prices.

The ratio (s_f/s_h) gives the relative world excess supply of foreign goods from the oil price increases, at constant discount factor and foreign goods price. If this relative world excess demand for foreign goods exceeds this relative world excess supply, the price of foreign goods must rise.

4. Differences in structure, the price of foreign goods, and the relative trade balance response

Clearly, if the home and foreign countries are alike in every respect, there will be no change in the foreign goods price, and the two oil importers will have identical trade balance responses to exogenous oil price increases. In this section we look at how structural differences between the home and foreign countries influence the foreign goods price response to oil price increases. We also examine how structural asymmetries can account for differences in the relative trade balance response.

A number of structural asymmetries can be examined in order to assess their impact on the final goods terms of trade (p) when there are oil price increases. We choose to focus on five which are widely thought to be important and/or which are amenable to future empirical testing. The five structural characteristics are (1) the degree of oil dependence, (2) the net creditor or debtor position, (3) the marginal propensity to save, (4) the employment response, and (5) the degree of substitutability in production. We shall examine the implications of each structural asymmetry in turn.

Our method will be to assume that the home and foreign countries are identical except in one respect at a time. Let the initial situation be one where the relative price of foreign goods equals unity,

(4.1) $p = 1.$

We start by assuming that the home and foreign countries have the same bias towards their own good, in the sense that their marginal propensities to consume home and foreign goods at date 1 fulfill

(4.2) $c^{1}_{hW} = c^{*1}_{fW} > c^{1}_{fW} = c^{*1}_{hW}.$

It follows from (4.1) and (4.2) that their aggregate propensities to consume at date 1 are the same,

(4.3) $C^{1}_{W} = c^{1}_{hW} + c^{1}_{fW} = c^{*1}_{fW} + c^{*1}_{hW} = C^{*1}_{W}$.

4.1 The degree of oil dependence

The conventional view is that oil price increases cause larger trade balance deteriorations in those economies that are heavily dependent on oil imports. This view has been challenged recently by Sachs (1981), who argues that differential dependence on oil imports has little effect on relative trade positions if the oil price shock is perceived as permanent, but does matter if the shock is temporary. The analysis below suggests that the degree of oil dependence does influence the trade-balance response to all types of oil price increases, whether temporary, permanent or future, but that oil dependence is just part of the story.

Suppose that the home country is more oil dependent in each period than the foreign country, in the sense that

(4.4) $z^t > z^{*t}$ for $t = 1, 2.$

The two countries are alike in all other relevant respects. That is, we assume that

$$(4.5)\quad E_{1\delta} = E^*_{p\delta},\ \ E_{p\delta} = E^*_{1\delta},\ \ I^1_\delta = I^{*1}_\delta,\ \ b^2 = b^{*2},\ \ x^1_q = x^{*1}_q, \text{ and } I^1_q = I^{*1}_q.$$

It follows from (3.21) and (4.2) - (4.5) that

$$(4.6)\quad d_{f\delta} = d_{h\delta} > 0 \text{ and}$$

$$s_h - s_f = (c^1_{hW} - c^1_{fW})[(z^1 - z^{*1})dq^1 + \delta(z^2 - z^{*2})dq^2] > 0.$$

Hence,

$$(4.7)\quad \frac{d_{f\delta}}{d_{h\delta}} - \frac{s_f}{s_h} = 1 - \frac{s_f}{s_h} > 0,$$

and from (3.26) it follows that the foreign goods price rises. The country with the higher degree of oil dependence suffers a final goods terms-of-trade deterioration. The intuitive reason is straightforward. The country with the higher degree of oil dependence faces a greater welfare loss when oil prices rise. Consequently at date 1 the drop in demand for home goods is greater than the drop in demand for foreign goods. The relative excess supply of home goods that results put upward pressure on p.

To examine the relative trade balance response to oil price increases when there is an asymmetry in oil dependence, we combine (3.15), (3.16), (4.1), (4.3) and (4.5) in order to write

$$(4.8)\quad db^1 - db^{*1} = -\underset{(+)}{(z^1 - z^{*1})}dq^1 - C_W^1[-\underset{(+)}{(z^1 - z^{*1})}dq^1 - \delta\underset{(+)}{(z^2 - z^{*2})}dq^2] - \underset{(+)}{(1 - C_W^1)}\underset{(+)}{2c_f^1}\,dp + \underset{(-)}{pI_p^{*1}}\underset{(+)}{dp}.$$

Since the home country is more oil dependent, it faces a higher value of oil imports when oil prices increase. This causes a negative direct effect on the relative trade balance, represented by the first term on the right hand side of (4.8). But the home country also experiences a greater welfare loss when oil prices rise and hence a greater drop in absorption. This causes a positive consumption wealth effect on the relative trade balance, represented by the second term on the right hand side of (4.8). The net of these two effects is ambiguous.

Consider for a moment the effect of a temporary oil price increase. This disturbance has a negative direct effect on the relative trade balance and a smaller positive consumption wealth effect. Hence the temporary oil price increase worsens the relative trade balance for constant p.

A future oil price increase has only a positive consumption wealth effect and hence improves the relative trade balance for constant p. Finally, a permanent oil price increase has both a negative direct effect and a positive consumption wealth effect, with an ambiguous impact on the relative trade balance for constant p.

Now suppose that oil imports and oil price increases are the same in both periods for each country, but oil imports still differ across countries. That is,

$$(4.9) \quad z^1 = z^2 = z, \quad z^{*1} = z^{*2} = z^*, \quad dq^1 = dq^2 = dq, \quad \text{and} \quad z > z^*.$$

Substituting (4.9) into (4.8) we see that at constant p the relative trade balance response to permanent oil price increases is

$$(4.10) \quad db^1 - db^{*1} = (C_W^1 - C_W^2)(z - z^*)\delta dq$$

where $C_W^2 = (1 - C_W^1)/\delta$. If the home country's aggregate marginal propensity to consume is the same at both dates, i.e. $C_W^1 = C_W^2$, then permanent oil price increases will have no effect on relative trade positions, regardless of the asymmetry in oil dependence. This is Sachs' (1981) story. But as soon as we relax the restrictive assumptions in (4.9) and as soon as we allow for the endogenous change in the foreign goods price, this strong result fails to hold.

Returning to (4.8), we see that the increase in the foreign goods price generated by higher oil prices has three additional effects on the relative trade balance. It has a negative direct effect, a smaller positive consumption wealth effect (both represented by the third term on the right hand side of (4.8)) and a negative investment effect. The latter effect is due to the country-specific capital used at home and abroad; an increase in p raises the cost of investment goods in the foreign country and hence reduces foreign absorption at the first date. This investment effect worsens the relative trade balance; however, it would disappear if both countries used the same capital goods in production.

We conclude that temporary and permanent oil price increases which worsen importers' trade balances will have graver consequences for the relatively oil-dependent importers.

Of course, oil importers are apt to differ in a number of structural characteristics which influence p, so the correlation between oil dependence and the relative trade balance response is likely to be missed unless these other asymmetries are also taken into account.

4.2 The net creditor or debtor position

Now suppose the two oil importers are similar in all relevant respects except for their net lending positions. Specifically, we assume

(4.11) $b^1 > b^{*1}$,

which by (2.12) and (2.20) implies

(4.12) $b^2 < b^{*2}$.

It follows that

(4.13) $d_{h\delta} < d_{f\delta}$ and $s_h = s_f$.

From (3.26) and (4.13) it follows that the foreign goods price increases. The home country, with the larger net creditor position or smaller net debtor position in date 1, faces an additional final goods terms of trade deterioration in response to oil price increases.

The rationale is intuitive. Oil price increases raise the discount factor, and the drop in the real interest rate causes a larger welfare loss for the home country with its larger net creditor position in date 1. It experiences the greater negative consumption wealth effect, so on net there will be a greater excess supply of home goods relative to foreign goods in date 1. This puts upward pressure on p.

The relative trade balance response is given by

$$(4.14) \quad db^1 - db^{*1} = -\underset{(-)}{C_W^1}\underset{(+)}{(b^2 - b^{*2})}d\delta - (1 - C_W^1)2\underset{(+)}{c_f^1}dp + \underset{(-)(+)}{pI_p^{*1}}dp.$$

Since the endogenous increase in the discount factor causes a larger welfare loss for the home country in date 1, it has a positive consumption wealth effect on the relative trade balance, represented by the first term on the right hand side of (4.14). The endogenous increase in the foreign goods price, i.e. the deterioration of the home country's final goods terms of trade, has a negative direct effect on the relative trade balance and a smaller positive consumption wealth effect, both of which are represented by the second term in (4.14), and a negative investment effect. Hence when two oil importers are identical in all relevant respects except for their net lending positions, the relative trade balance response to oil price increases cannot be determined without knowledge of specific parameter values.

4.3 The marginal propensity to save

Suppose that at date 1 the home country has a smaller marginal propensity to save, and hence a large propensity to consume, than the foreign country. Assume that the two countries still have the same relative bias in consumption towards their own good. We represent these assumptions by

$$(4.15)\quad C_W^{*1} = \alpha C_W^1 \text{ with } 0 < \alpha < 1, \text{ and } c_{fW}^{*1} = \alpha c_{hW}^1 > c_{hW}^{*1} = \alpha c_{fW}^1.$$

Let the countries be alike in all other relevant aspects. It follows that

$$(4.16)\quad d_{h\delta} - d_{f\delta} = (1 - \alpha)(c_{hW}^1 - c_{fW}^1)b^2 > 0 \text{ and}$$

$$s_h - s_f = (1 - \alpha)(c_{hW}^1 - c_{fW}^1)(z^1 dq^1 + \delta z^2 dq^2) > 0,$$

since $c_{hW}^1 > c_{fW}^1$. From (3.26) and (4.16), it follows that the effect on the foreign goods price is <u>ambiguous</u>.

The effect of a temporary oil price increase on the foreign goods price can be determined, however. Let s_{h1} and s_{f1} represent the change in world excess supply of home goods and foreign goods, respectively, given an increase in date 1 oil price alone, where from (3.21) we can write

$$(4.17)\quad s_{h1} = (x_q^1 + c_{hW}^1 z^1 + c_{hW}^{*1} z^{*1})dq^1 > 0 \text{ and}$$

$$s_{f1} = (x_q^{*1} + c_{fW}^1 z^1 + c_{fW}^{*1} z^{*1})dq^1 > 0.$$

Then from (3.26) it follows, with some manipulation, that

$$(4.18)\quad \text{sign } dp = \text{sign } (d_{f\delta} s_{h1} - d_{h\delta} s_{f1})$$

$$= \text{sign } \underset{(+)}{(c_{hW}^1 - c_{fW}^1)}\underset{(+)}{(1 - \alpha)}[\underset{(+)}{(E_{1\delta} + E_{p\delta} + I_\delta^1)}z^1 - \underset{(-)}{x_q^1}\underset{(+)}{b^2}] > 0\ ,$$

i.e., the foreign goods price increases. The home country, with the smaller marginal propensity to save, faces a final goods terms of trade deterioration when there is a temporary oil price increase. This is because for a given loss in welfare caused by the oil price increase, the drop in demand for home goods will exceed the drop in demand for foreign goods. The relative excess supply of home goods that results puts upward pressure on the foreign goods price.

The effect of a future oil price increase on the foreign goods price is indeterminate. As before, if the home country has the smaller marginal propensity to save at date 1, a given welfare loss will cause a drop in demand for home goods that exceeds the drop in demand for foreign goods. This tends to put upward pressure on p. However, the expected increase in future oil prices also reduces investment demand for date 1 goods, releasing more of them for date 1 consumption. With the smaller marginal propensity to save, the home country will experience the smaller excess supply of domestic goods when investment demand is curtailed. This puts downward pressure on p. Only if this investment effect is dominated can we say the oil importer with the smaller marginal propensity to save date 1 goods will suffer a final goods terms of trade loss when there are future oil price increases or current oil price increases of a permanent nature.

When the two oil importers differ only in their marginal propensities to save at date 1, the relative trade balance response is given by

$$(4.19)\quad db^1 - db^{*1} = -\underset{(+)}{(C_W^1 - C_W^{*1})}(-z^1dq^1 - \delta z^2dq^2) - \underset{(+)}{(C_W^1 - C_W^{*1})}\underset{(+)}{b^2}d\delta$$

$$- \underset{(-)}{(C_W^1 + C_W^{*1} - 2)}\underset{(+/-)}{(-c_f^1)}dp + \underset{(-)(+/-)}{pI_p^{*1}}dp.$$

Oil price increases have a direct negative effect on welfare ($- z^1dq^1 - \delta z^2dq^2 < 0$) in both countries. Since the home country has the smaller marginal propensity to save, it will respond with a greater cut in absorption and this will have a positive effect on the relative trade balance, represented by the first term on the right hand side of (4.19). The endogenous increase in the discount factor will have a positive effect on welfare in both countries since both have the same trade deficit in date 1. But the home country, with its larger marginal propensity to consume, will respond with a greater increase in absorption, and this will have a negative effect on the relative trade balance, represented by the second term in (4.19). If the net welfare effect is negative, oil price increases will have a positive effect on the relative trade balance for constant p. Since the change in the foreign goods price can be in either direction, we cannot determine its effect on the relative trade balance. Consequently, when two oil importers are alike in all relevant respects except for their marginal propensities to save, we cannot calculate the relative trade balance response to oil price increases without knowing specific parameter values.

4.4 The employment response

So far we have assumed flexible wages and full employment at each date in the home and foreign countries. In this section we shall examine the consequences of rigid wages and variable employment at the first date in the home country. We maintain the assumption of flexible wages and full employment at the first date in the foreign country, and in both countries at the second date.

Let us now look at employment in the home country at date 1. First, suppose that the wage is fixed in terms of home goods at the first date, i.e., wages are indexed to the GDP deflator. The level of employment is then given by the condition that the demand price for labor, Y_{ℓ}^{1}, equals the wage. Hence, the date 1 employment function, $L^{1}(w^{1}, q^{1}, k^{1})$, is defined by

$$(4.20) \quad Y_{\ell}^{1}(1, q^{1}, k^{1}, L^{1}(w^{1}, q^{1}, k^{1})) = w^{1},$$

where w^{1} is the wage in terms of date 1 home goods.

Differentiating (4.20), we get the derivatives

$$(4.21) \quad \begin{aligned} & L_{w}^{1} = 1/Y_{\ell\ell}^{1} < 0, \quad L_{q}^{1} = - Y_{\ell q}^{1}/Y_{\ell\ell}^{1} < 0, \quad \text{and} \\ & L_{k}^{1} = - Y_{\ell k}^{1}/Y_{\ell\ell}^{1} > 0, \end{aligned}$$

where the second order derivative $Y_{\ell\ell}^{1}$ is negative by the concavity of the GDP function. Hence employment at date 1 is always a decreasing function of the real wage, a decreasing function of the oil price at date 1 by the assumption of complementarity between oil and labor, and an increasing function of the capital stock by the assumption of complementary between capital and labor. With real wages fixed in terms of home goods at date 1, the change in the home country's date 1 employment level in response to an oil price increase will hence be given by

$$(4.22) \quad d\ell^{1} = L_{q}^{1}dq^{1} < 0,$$

i.e. employment at date 1 decreases.

With the endogenous change in the home country's employment given by (4.22), its welfare change in (3.11) is modified to

$$(4.23)\quad E_u du = w^1\, d\ell^1 - z^1 dq^1 - \delta z^2 dq^2 - c_f^1 dp + b^2 d\delta ,$$

where $d\ell^1$ is given by (4.22). The change in welfare now includes a negative employment effect, $w^1 d\ell^1$, the change in GDP due to the change in employment.

The change in the home country's trade balance is modified from (3.15) to

$$(4.24)\quad db^1 = w^1 d\ell^1 - z^1 dq^1 - c_f^1 dp - C_W^1(w^1 d\ell^1 - z^1 dq^1 - \delta z^2 dq^2 - c_f^1 dp + b^2 d\delta)$$

$$- (E_{1p} + pE_{pp})dp - (E_{1\delta} + pE_{p\delta})d\delta - dI^1.$$

The changes in excess supplies of home and foreign goods are now given by

$$(4.25)\quad s_h = x_\ell^1 d\ell^1 + x_q^1 dq^1 - I_q^1 dq^2 + c_{hW}^1(- w^1 d\ell^1 + z^1 dq^1 + \delta z^2 dq^2)$$

$$+ c_{hW}^{*1}(z^{*1} dq^1 + \delta z^{*2} dq^2), \text{ and}$$

$$s_f = x_q^{*1} dq^1 - I_q^{*1} dq^2 + c_{fW}^1(- w^1 d\ell^1 + z^1 dq^1 + \delta z^2 dq^2)$$

$$+ c_{fW}^{*1}(z^{*1} dq^1 + \delta z^{*2} dq^2).$$

Assuming that the home and foreign countries are alike in all relevant aspects except for the employment response, we have

$$(4.26)\quad d_{h\delta} = d_{f\delta} > 0 \text{ and}$$

$$s_h - s_f = [x_\ell^1 - (c_{hW}^1 - c_{fW}^1)\, w^1] d\ell^1 < 0,$$

since $x_\ell^1 - w^1 = x_\ell^1 - Y_\ell^1 = q^1 z_\ell^1 > 0$, $0 < c_{hW}^1 - c_{fW}^1 < 1$, and $d\ell^1 < 0$.

By (3.23) and (4.26) we can write

$$(4.27)\quad dp = \underset{(+)}{d_{h\delta}}\underset{(+)}{(s_f - s_h)}/\underset{(-)}{\Delta} < 0,$$

which says that the foreign goods price falls.

Since oil price increases cause a drop in the home country's employment level at date 1, there is a greater drop in the production of home goods relative to the production of foreign goods. The relative excess supply of foreign goods which results puts downward pressure on p. Consequently, the oil importer with rigid real wages experiences a final goods terms of trade gain when there are oil price increases. This effect is counter to the negative employment effect. Which effects dominates depends, of course, on the specific parameters.

The relative trade balance will be given by

$$(4.28)\quad db^1 - db^{*1} = \underset{(+)}{(1 - C_W^1)}\, w^1 \underset{(-)}{d\ell^1} - \underset{(+)}{(1 - C_W^1)} 2c_f^1 \underset{(-)}{dp} + \underset{(-)}{pI_p^{*1}} \underset{(-)}{dp}$$

where (4.28) is the difference between (4.24) and (3.16).

When wages are rigid in the home country, oil price increases reduce employment and cause a bigger drop in home GDP relative to foreign GDP. This causes a negative direct plus consumption-wealth effect on the relative trade balance, represented by the first term on the right hand side of (4.28). The improvement in the home country's final goods terms of trade causes a positive direct plus consumption-wealth effect on the relative trade balance, given by the second term in (4.28), and a positive investment effect. Consequently there is no direct correlation between the degree of wage rigidity and the response of the relative trade balance to oil price increases.

Consider next a case where the date 1 wage in the home country is fixed in terms of a consumer price index (CPI) rather than in home goods. Let ω^1 denote this given real wage, in terms of the CPI. Let the price index $\pi^1(1, p)$ denote the date 1 CPI, in terms of home goods. It is a function of the price of home goods (normalized to unity) and the price of foreign goods (p). Then the wage in terms of home goods will be a function, $w^1(1, p, \omega^1)$, defined by

$$(4.29) \quad w^1(1, p, \omega^1) = \pi^1(1, p)\omega^1.$$

It has the obvious properties

$$(4.30) \quad \begin{aligned} w^1_p &= \pi^1_p \omega^1 > 0 \quad \text{and} \\ w^1_\omega &= \pi^1 > 0. \end{aligned}$$

The wage in terms of home goods is an increasing function of the price of foreign goods and the CPI wage rate.[9]

In this case, the home country's employment level at date 1 will simply be given by $L^1(w^1(1, p, \omega^1), q^1, k^1)$, i.e. by substituting the wage function (4.29) into the employment function defined in (4.20). It follows that the change in employment will be given by

$$(4.31) \quad d\ell^1 = \underset{(-)}{L^1_q} dq^1 + \underset{(-)(+)}{L^1_w w^1_p} dp \gtrless 0.$$

In addition to the direct effect of an oil price increase, there is now an effect through the change in the wage rate. Should the foreign price fall, the wage in home goods falls, and this increases employment. Hence, the overall effect of an oil price increase on employment is now ambiguous.

By the same argument as above it can indeed be shown that the foreign goods price does unambiguously fall. ($d\ell^1$ in (4.25) and (4.26) is simply replaced by $L_q^1 dq^1$.) If then the overall change in employment is positive, we see that both the employment effect and the final goods terms of trade effects on home welfare are positive in (4.23). Also, the relative trade balance in (4.28) is unambiguously positive.

Does it follow that it is always better for the home country to have the wage fixed in terms of a CPI rather than in home goods? No, since with wages fixed according to a CPI, the supply of home goods is more elastic with respect to the price of foreign goods. Hence the fall in the foreign goods price is smaller with given CPI wages than with given home goods wages. Thus the final goods terms of trade gain is smaller with CPI wages, although the employment effect is less negative or even positive.

4.5 The degree of substitution

Suppose that the two oil importers are identical in every relevant respect except for the degree of substitutability in production between oil and domestic capital and labor. We assume that the home country has less such substitutability at date 1 so that it experiences a smaller absolute response in the full employment level of output of home goods to an oil price increase. That is, we assume

$$(4.32)\quad x_q^{*1} < x_q^1 < 0,$$

recalling that both responses are negative.[10]

It follows that

$$(4.33)\quad d_{f\delta} = d_{h\delta} > 0 \quad \text{and}$$

$$s_h - s_f = (x_q^1 - x_q^{*1})dq^1 > 0.$$

By (3.23) and (4.33) we can write

$$(4.34)\quad dp = \underset{(+)}{d_{h\delta}}\underset{(-)}{(s_f - s_h)}/\underset{(-)}{\Delta} > 0,$$

which says that the foreign goods price <u>increases</u>. With a given level of employment and capital stock utilization in each country at date 1, the home country, with the smaller degree of substitutability in oil, faces a smaller decline in production at date 1. The relative excess supply of home goods that results puts upward pressure on p. Hence, the country with less substitutability in production suffers a final goods terms of trade loss.

The relative trade balance response is

$$(4.35)\quad db^1 - db^{*1} = -2\underset{(+)}{(1 - C_w^1)}\underset{(+)}{c_f^1}dp + p\underset{(-)(+)}{I_p^{*1}dp} < 0.$$

The deterioration in the home country's final goods terms of trade has a negative direct plus consumption-wealth effect on the relative trade balance, represented by the first term on the right hand side of (4.35), and a negative investment effect. Hence oil price increases worsen the relative trade balance response; the oil importer with the smaller degree of substitutability in oil suffers a greater negative effect on its trade balance.

5. Conclusion

This paper represents the first attempt in the literature to construct an explicitly intertemporal three-country model in order to analyze the effects of oil price increases on countries' welfare levels and relative trade balance positions. The model uses aggregates which are consistent with maximizing behavior and yields a rich array of analytically tractable results.

For instance, the determinants of changes in welfare levels and of changes in trade balance positions when there are oil price increases are readily isolated. Changes in output levels, oil imports, investment, employment, wages, saving and consumption can also be calculated for individual oil importing countries. The three-country world equilibrium model also takes account of the feedback effects of higher oil prices on the world interest rate and the final goods terms of trade between oil importers (the real exchange rate).

One important finding is that structural asymmetries between oil importers cause oil price increases to alter the final goods terms of trade in systemmatic ways, and these movements in the final goods terms of trade play a crucial role in determining an oil importer's relative trade balance position in the face of oil price increases. Despite some recent thought to the contrary, the degree of oil dependence does influence a country's relative trade balance position. So does a country's degree of substitutability in oil. Other structural characteristics, such as a country's relative international lending position, its relative marginal propensity to save, and its degree of wage flexibility in the short run also alter the final goods terms of trade in predictable ways and influence an oil importer's relative trade balance position.

In short, the model presented here allows us to analyze some important general equilibrium interrelationships in detail and to study the differential macroeconomic adjustment of oil importers to oil price increases.

Footnotes

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1. For partial equilibrium analyses of effects of oil price increases that emphasize intertemporal aspects, see Bruno (1981), Marion (1981), Obstfeld (1980), Sachs (1981), and Svensson (1981). Dixit (1981) presents a very neat intertemporal general equilibrium model of trade in goods, capital, and oil, but concentrates on other issues than those of the present paper.

2. The assumption of a common final good at date 2 greatly simplifies the analysis and makes possible intuitive explanations of the results to follow. It is also warranted since we are mainly interested in the date 1 final goods price and relative trade balance responses. Precise conditions on the countries' preferences and/or technologies can also be found under which home and foreign goods at date 2 could be rigorously aggregated into one aggregate final good at date 2. See Svensson and Razin (1981) and Svensson (1981) for such analyses applied to the study of trade balance responses.

3. What is necessary for the results below is the reasonable assumption that OPEC's marginal propensity to consume at the first date is smaller than that of the home and foreign countries. Assuming that there is

zero OPEC consumption at the first date however greatly simplifies the analysis.

4. For the implications of an endogenous OPEC policy that maximizes OPEC welfare, or of an OPEC policy which sets oil prices at each date in terms of date 2 final goods, see Marion and Svensson (1981, in progress).

5. The GDP function is also called the value-added, the restricted profit, the variable profit, the GNP, or the revenue function. A comprehensive reference is Bruno (1978) or Diewert (1974). See Varian (1978) for a micro-textbook using this and similar dual functions, and Bruno (1973), Chipman (1972), Dixit and Norman (1980), Khang (1971), and Woodland (1981) for their use in international trade theory.

6. Note that complements in this sense is not a very restrictive assumption. This definition of complements/substitutes is different from the ones usually employed in the literature. Complements/substitutes are mostly defined, in analogy with the definition of Hicksian complements/substitutes in consumption, from the sign of the partial of the demand for a factor with respect to the price of another factor, at constant output level. See Berndt and Wood (1979) for a thorough discussion of such Hicksian complementarity/substitutability between oil and other factors. Factors can be Hicksian substitutes and yet complements in our sense. This is indeed the case with the specific separable technologies discussed by Berndt and Wood, when $x = f(g(k, e), h(\ell, m))$, $f(\cdot)$, $g(\cdot)$ and $h(\cdot)$ are linearly homogenous, e is energy input, and m is input of non-energy materials.

A frequently assumed technology is one that is weakly separable in oil and a capital-labor composite factor. Then we have $x = f(v(k, \ell), z)$, where $f(\cdot)$ and $v(\cdot)$ are linearly homogenous. It is readily checked that for these technologies, capital, labor and oil are complements in our sense.

7. See Deaton and Muellbauer (1980), Diewert (1974), Dixit and Norman (1980), Varian (1978), or Woodland (1981) for properties and uses of the expenditure function.

8. The assumption of gross substitutability implies that $d_{hp} > 0$ and $d_{fp} < 0$, that is, an increase in the price of foreign goods raises the world excess demand for home goods and reduces the world excess demand for foreign goods. Similarly, it implies $d_{h\delta} > 0$ and $d_{f\delta} > 0$.

9. By standard properties of a price index, $p\pi^1_p/\pi^1$ equals the share of final goods in date 1 consumption expenditure.

10. Assume that date 1 production of home goods is separable between an aggregate of domestic capital and labor, $v(k, \ell)$, and oil input, z. That is, the production function fulfills $x = f(k, \ell, z) = g(v(k, \ell), z)$. Note that if $g(\cdot)$ and $v(\cdot)$ are constant returns to scale, so is $f(\cdot)$. In particular, with this technology, frequently assumed in the literature, capital, labor and oil are all complements in the sense of having positive cross partials.

With full employment of labor, only x and z vary. By standard results we have $\hat{x} = \theta\hat{z}$ and $\hat{z} = -\gamma\hat{q}$, where $\hat{x}$ denotes the rate of change dx/x, etc., θ is the cost share of oil in the value of output of home goods, and γ (defined positive) is the elasticity of demand for oil with respect to the relative oil price. Furthermore, γ equals $\sigma/(1 - \theta)$, where σ is the elasticity of substitution between oil and the domestic aggregate factor v. Hence, we have $\hat{x} = - [\theta/(1 - \theta)]\sigma\hat{q}$, and it follows that for a given oil price increase and a given output level, the absolute response in output is smaller the smaller the elasticity of substitution.

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