

ACCOMMODATION IN THE INTERNATIONAL CAPITAL MARKETS
AND THE
RECYCLING OF OIL FUNDS

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1. Introduction

The radical increase of the price of oil at the end of 1973 has brought about a transfer of wealth from the oil importing countries to the oil exporting countries. This transfer was effected both by a transfer of goods in the spot market and by a transfer of claims for future goods ("bonds" or financial assets) in the financial markets. The first type of transfer may be referred to as "paying" for oil while the second type of transfer may be referred to as "financing" oil.¹ The transfer of claims for future goods, "financing," is also called recycling. A further distinction is drawn between primary and secondary recycling.² Primary recycling refers to the direct transfer of claims on future goods (financial assets hereafter termed "bonds") between an oil importing country and an oil exporting country, while secondary recycling refers to accomodating exchanges of bonds among oil importing countries which facilitate an otherwise unattainable flow of oil from exporters to importers. The recycling process takes place in a multilateral trade world, and some secondary recycling may be accomodated by exchanges of goods in the spot markets.

The relationship between primary and secondary recycling in the capital markets as well as the accomodating movements in the goods market are discussed in a context of an adjustment process. It is argued that time for adjustment is necessary for both oil importing and oil exporting countries. An international capital market with international financial intermediation is an essential part of a smooth adjustment process. The observed quantities of traded oil, as well as the estimated short- and long-term elasticities of demand for oil do reflect the effectiveness of the international capital market in supplying adjustment services.

The nature of the adjustment process as well as the function of the capital markets in this respect are presented in Section 2. In Section 3 a simple model is presented to indicate the contribution of effective multi-lateral trade in capital assets on the flow and the prices of oil. The available empirical evidence on recycling and the nature of the adjustment process are described and analyzed in Section 4.

2. Adjustment in the International Capital Market.

Assume a world with two groups of countries. One group of countries consists of net oil exporters and the other group consists of net oil importers. If for some reason the relative price which the oil exporting countries can command for their oil has risen, this will change the allocation of real income, and wealth, between the two groups of countries. The spending or the consumption of the two groups will change in obvious directions. The extent and the rate of the change will depend on how they view the long-term redistribution of real income resulting from the change in the relative price of oil as well as on the cost of the adjustment as a function of its rate over time. If the demand for oil in the importing countries is given exogenously and is completely price inelastic, and if the current, post-increase, real price of oil is believed to be constant from now on, then the resulting long-term transfer of real income at time t will be $\hat{\Delta Y}(t) = Q'(t) \cdot (p^*(t) - \bar{p})$ where $Q'(t)$ is the exogenous quantity of imported oil at (t) and $(p^*(t) - \bar{p})$ is the change in the price following the increase. The wealth transfer would simply be the present value of the $\hat{\Delta Y}(t)$ for all future periods. This however is not the case. Both the oil importing and the oil exporting countries may view the current,

first period, transfer of real income $\hat{\Delta Y}(1) = Q(1) \cdot (p^*(1) - \bar{p})$ as reflecting both permanent and transitory elements. This perception may be based on two basic arguments. The increase in the price of oil was not fully anticipated and it takes time to adjust the spending (or the consumption) of the oil importing countries to the new relative prices. This is even more so given the intermediate nature of oil in the production function. New investments have to be made to adjust both production and consumption to the new relative price of oil while existing capital in place may still be utilized. Given these changes, the demand for oil will become more elastic and the permanent real income transfer at period t , $\Delta Y(t)$, will be smaller than the one estimated for an economy which has not adjusted fully to the relative price of oil. Another possible reason for viewing the permanent transfer of wealth as smaller than it would seem to be given immediate post-increase data are doubts with respect to the stability of the new price. If the monopolistic position of the oil exporting cartel will be eroded, maybe by new technologies by competition in the oil market, or by internal strife, the future prices will be lower than today's price and again it will imply decreasing $\Delta Y(t)$'s and thus a smaller wealth transfer.

The transitory element in the present period transfer of real income from the oil importing countries to the oil exporting countries gives rise to both primary and secondary recycling. The oil importing countries realize that the current period drop in real income includes a component of transitory loss, and thus they would like to borrow and by that to transfer income from the future periods to the current period in order to reduce transitory changes in consumption. Also while adjusting production processes to the new relative price of oil they still maintain the pre-increase system of production and consumption and thus keep an inelastic demand for oil in

the short term. The oil exporting countries also realize that they have a component of transitory gain, and they would like to adjust their spending (consumption) over time by shifting consumption from the current to future periods. They also realize that the inelastic demand which they face now is a short-term phenomenon. Consequently they would like, as a group, to lend. The international capital market is the efficient way to meet the needs of both groups.

Time for adjustment to the new distribution of wealth following the cartelization of the oil production will be needed even in the absence of transitory elements. A downward adjustment in spending, even in response to a permanent change in income, cannot be achieved in the short run without substantial unemployment. Time may be needed to accommodate the necessary permanent changes with lower economic and social cost. Time is also needed to effectively adjust consumption upward in the oil exporting countries. A limited physical infrastructure may limit the absorptive capacity of imports in the short run. Markets for new products and services both in the private and in the public sectors have to be developed. Internal investment (capital formation) can be viewed as a function of investment in preceding periods. Given that the preference function of the oil exporting countries can be written as $U = U(C_t)$ where C_t is both public and private consumption including capital goods, and where distributional effects are disregarded, it is assumed that $\partial U / \partial C_t > 0$, $\partial^2 U / \partial C_t^2 < 0$, but also that $U_t = e^{g_t} (U(C_t))$. In words, the marginal utility of consumption is decreasing at any instant of time but the actual values of the first and the second derivatives are a function of time. As time proceeds the "absorptive capacity" constraint is less binding, given a rate of growth $g_t > 0$.³

3. Bilateral Trade, Multilateral Trade and the Flow of Oil.

The simplest and most straight-forward process of adjustment in the international capital market is by a bilateral exchange of capital assets, or in other words by borrowing and lending. In a two-country world in which one country is a net oil exporter and one country is a net oil importer, primary recycling (direct bilateral borrowing and lending) will suffice to provide both for the transitory elements and the needed time for optimal rate of change. However, once more than two countries are introduced primary recycling alone may be sub-optimal. It is a common belief that a multilateral trade solution is preferable in terms of welfare to a series of bilateral trade arrangements. The same argument carries to the trade in financial assets and will favor a mixture of primary and secondary recycling as a mechanism for adjustment.

The precise nature of the process of multilateral trade can be described in a simple full employment paradigm as follows.

Assume a three country world. One country is a net oil exporter (country X) and the other two countries, 1 and 2, are net oil importers. Within each one of the three countries there are three all-inclusive markets. One market is for oil and the other two markets are for other goods and bonds. Let us assume that the importing countries specialize in one type of good and one type of bond respectively, and that the oil exporting country produces no other goods and no bonds. Assume further that trade in oil, in goods and in bonds can take place only on a bilateral basis between the oil exporting country and each one of the oil importing countries. No trade is allowed between the two oil importing countries.

In such a world of "pure" primary recycling the world excess demand for oil can be defined as a function of the relative prices in the two importing countries, i.e.,

$$E_{x1} = E_{x1}(P_x/g1, P_x/b1) \quad (1)$$

and

$$E_{x2} = E_{x2}(P_x/g2, P_x/b2) \quad (2)$$

where

$$E_{xj} \equiv \text{excess demand for oil in country } j \text{ measured in some unit of account.}$$

$$P_x/gj \equiv \text{price of oil in terms of good } j, j=1,2 \text{ importing countries.}$$

$$P_x/bj \equiv \text{price of oil in terms of bond } j, j=1,2 \text{ importing countries.}$$

Bonds are risky as they are defined here as claims on future goods and thus share the risk characteristics associated with the future relative price of such goods.

The excess demand for goods and bonds can be defined as:

$$E_{gj} = E_{gj}(P_{gj}/x, P_{gj}/bj); j = 1, 2 \text{ importing countries.} \quad (3)$$

$$E_{bj} = E_{bj}(P_{bj}/x, P_{bj}/gj); j = 1, 2 \text{ importing countries.} \quad (4)$$

where

$$E_{gj} = \text{excess demand for other goods in country } j$$

$$E_{bj} = \text{excess demand for bonds in country } j$$

all measured in some unit of account, and

$$P_{gj}/x = (P_x/gj)^{-1}$$

$$P_{bj}/x = (P_x/bj)^{-1}$$

$$P_{bj}/gj = (P_{gj}/bj)^{-1}$$

Given our assumption of the bilateral nature of the trade in oil (where one country is a net exporter and the other two are net importers), and because the three markets are all inclusive it follows that:

$$E_{xj} > 0 \quad j = 1, 2 \text{ importing countries}$$

$$E_{gj} \leq 0 \quad j = 1, 2 \text{ importing countries}$$

$$E_{bj} \leq 0 \quad j = 1, 2 \text{ importing countries}$$

and
$$E_{gj} + E_{bj} < 0 \quad j = 1, 2 \text{ importing countries.}$$

For the exporting country (country X) the excess demand for oil is negative (net exporter) and equal in value terms to the sum of the oil exporter's excess demands for goods and bonds of the two importing countries 1 and 2. In equilibrium the system maintains

$$E_{oil} + E_{goods} + E_{bonds} = 0, \text{ in value terms.}$$

However, given the assumptions on the bilateral nature of trade, equation (5) is just the sum of equations (1) to (4). The export flow of oil, by country x, $-E_x^X$, in physical terms, is equal to

$$E_{x1} + E_{x2} = -E_x^X. \quad (6)$$

Once the assumptions on exporter-importer bilateralism are dropped, and multilateral transactions are allowed there will be a demand for goods and bonds between the two oil importing countries, and the relative prices of goods and bonds in terms of oil may differ from those specified above. Triangular transactions may take place and the equilibrium condition (5) will include terms for the excess demand of country 1 for good 2, or the excess demand of country 2 for bond 1. Country X, the oil exporting country, may now ship oil to country 1 and acquire good 2 (the good which country 2 produces) in exchange. Multilateral trade will give rise to secondary recycling both in terms of goods and in terms of bonds.⁴ The effect of multilateral trade on the flow of oil between exporting and importing countries will depend on the price and income elasticities in three countries.

The fact that the oil exporting country has a monopoly position changes the precise conditions under which the physical flow of oil will increase, but not the general nature of the solution. To the extent that multilateral transactions effectively shift outward the demand for oil, and given a zero marginal cost of oil, the physical flow of oil will increase. The only case where a monopolist would not behave in this manner is where a cutback in physical production of oil, and thus a change in the relative price of oil, will affect the relative price of other goods in a favorable way. That is, given the preferences of the monopolist he can affect the relative prices of his consumption by cutting back the quantity of oil supplied. Assuming no such changes in relative prices of other goods, the direction of the changes in the flow of oil resulting from allowing multilateral trade will be the same under monopoly or in a competitive market. Therefore, the derivation of the general equilibrium model in the Appendix does not deal explicitly with a monopoly situation. However, before we move to the general solution let us illustrate the nature of the process by which a triangular trade may accommodate a larger flow of oil between the trading partners.

Suppose that country 1 is Germany, country 2 is Italy, and country X is Saudi Arabia. Let the three goods be steamshovels, wine, and oil respectively. Under what we have defined as bilateral trade Germany trades steamshovels to Saudi Arabia for oil. Prior to the trade each country had an excess demand for the other's good. By assumption, no trade occurs between Germany and Italy. Also no trade occurs between Italy and Saudi Arabia as the latter has no desire for wine at any price. In the multilateral case, Italy trades wine to Germany, which does consume wine, for steamshovels. Then Italy trades the newly acquired steamshovels for Saudi oil.

The same argument applies for financial assets ("bonds") which are viewed here as claims on future goods. By allowing free movement of assets in international capital markets the trading countries can transact more optimally by acquiring financial assets which are better suited to their optimal consumption over time. As the distribution of such financial assets among the importing countries will not correspond, in general, to the distribution of excess demands for oil, some "secondary recycling" of goods and bonds may increase the world trade in oil.

In the context of a three-country, three-goods general equilibrium model with full employment it can be shown that multilateral trade opportunities will result in a higher volume of trade. Such a model indicates the different components of the total changes in the supply of oil by the oil exporter. The components we must consider are the income and substitution effects on consumption, and the concomitant substitution effects in production in our general equilibrium framework, (see the Appendix for a complete description of the model).

These results are shown in equation (7), where ΔE_x^x is the total change, in a comparative statics context, in the physical supply of oil coming from country X after multilateral trade is allowed (between countries 1 and 2).

For reasons of exposition country superscripts will replace the country subscripts.

$$\Delta E_x^x = (\eta^1 + \pi^1 + \epsilon^1) (\Delta P_{g1/x}^1) E_x^1 + (\eta^2 + \pi^2 + \epsilon^2) (\Delta P_{g2/x}^2) E_x^2 \quad (7)$$

where:

$\eta_j \equiv$ country j price elasticity of oil import demand (with respect to $P_{gj/x}^j$).

$\pi^j \equiv$ country j marginal propensity to consume of its imported good (oil) with respect to a change in its real income.

$\epsilon^j \equiv$ country j price elasticity of export supply (with respect to $P_{gj/x}^j$).

Thus η^j captures the country j substitution in consumption effect with respect to a change in the relative price of its exportable, g_j . Likewise π^j represents the real income effect on the country j demand for oil. The change in relative prices also implies a substitution in production effect in country j as captured by ϵ^j .

Equation (7) expresses the change in the supply flow of oil from the oil exporter in terms of the parameters of the importing countries with whom multilateral trade is now allowed. We need only evaluate the right hand side of (7) to determine the conditions under which $\Delta E_x^x > 0$, i.e. country X increases its supply of oil to world markets under multilateral trade. We have:

$\eta^j > 0$ by definition and our demand assumption.

$\pi^j > 0$ by ruling out inferior goods.

$\epsilon^j > 0$ by our production assumption, i.e. if the relative price of our exportable increases then we produce more of it.

$\Delta P_{gj/x}^j > 0$ by our assumption that all goods are gross substitutes.

$E_x^j > 0$ by assumption (i.e. trade exists).

These conditions imply $\Delta E_x^x > 0$, i.e. accomodating flows (via multilateral trade) of goods and financial assets among importing countries 1 and 2 help cause an increase in the supply of oil from country X .

4. Paying for and Financing of Oil--Some Empirical Observations:

The prededing analysis suggests that by providing adjustment services, both for transitory elements and for a slower rate of change, international capital markets allow for a higher volume of trade in oil. The adjustment was carried out by direct exchanges in capital assets (borrowing and lending) between exporters and importers, as well as by accomodating flows of goods

and bonds among importers of oil. The actual magnitude of the accomodating flows in 1974 and the first quarter of 1975 is estimated here. This is done as an indication of the extent by which the actual trade in oil between OPEC members and the major importing countries was facilitated by these adjustment flows. However, before we proceed to examine the data, two caveats have to be stressed. First, the data represent only five quarters and although it is true that most of the adjustment may have taken place during this period, the data may contain errors and reflect some indecision on the part of the exporting and the importing countries. Second, the data reflect some adjustments which took place in markets other than the capital or the goods markets. This is true in particular with regard to the labor market as some of the adjustment was carried out by unemployment.

In Table 1 the balance of trade of the six major oil importing countries with OPEC is presented. All the six countries run a trade deficit which means that some "financing" of oil should take place.

Table 1

Balance of Trade of Six Major Oil Importing Countries with OPEC Members 1973-1975:1

	<u>1973</u>	<u>1974</u>	<u>1974:1</u>	<u>1974:2</u>	<u>1974:3</u>	<u>1974:4</u>	<u>1975:1</u>
U.S.	-1.2	-10.0	-1.5	-2.7	-3.3	-2.5	-2.2
U.K.	-1.7	-6.1	-1.5	-1.9	-1.3	-1.4	-0.9
W. Germany	-1.7	-5.4	-1.4	-1.4	-1.3	-1.3	-0.6
Japan	-4.7	-16.0	-3.6	-4.7	-3.9	-3.8	-3.5
France	-2.0	-7.2	-1.5	-1.9	-2.0	-1.8	-1.3
Italy	-2.2	-7.2	-1.5	-2.0	-2.1	-1.6	-1.0
TOTAL	-13.5	-51.9	-11.0	-14.6	-13.9	-12.4	-9.5

(Sources: Direction of Trade and International Financial Statistics)

The proportion of direct trade in exchange for oil vary among the six major importing countries as is shown in Table 2 below.

Table 2

Flows of Trade between OPEC and Six Major Importing Countries 1973:1975:1

Current Dollars in Billions

	<u>1973</u>	<u>1974</u>	<u>1974:1</u>	<u>1974:2</u>	<u>1974:3</u>	<u>1974:4</u>	<u>1975:1</u>
<u>U.S.</u>							
(1) Imports from OPEC	5.0	17.0	2.7	4.4	5.1	4.8	4.7
(2) Exports to OPEC	3.8	7.0	1.2	1.7	1.8	2.3	2.5
(2) as % of (1)	76.0	41.0	-	-	-	-	53.0
<u>U.K.</u>							
(1) Imports from OPEC	3.7	8.9	2.0	2.5	2.1	2.3	2.0
(2) Exports to OPEC	2.0	2.8	.5	.6	.8	.9	1.1
(2) as % of (1)	54.0	31.0	-	-	-	-	55.0
<u>West Germany</u>							
(1) Imports from OPEC	4.0	9.2	2.1	2.3	2.4	2.4	2.0
(2) Exports to OPEC	2.3	3.8	.7	.9	1.1	1.1	1.4
(2) as % of (1)	57.0	41.0	-	-	-	-	70.0
<u>Japan</u>							
(1) Imports from OPEC	7.5	21.6	4.5	5.9	5.5	5.7	5.4
(2) Exports to OPEC	2.8	5.6	.9	1.2	1.6	1.9	1.9
(2) as % of (1)	37.0	26.0	-	-	-	-	35.0
<u>France</u>							
(1) Imports from OPEC	3.9	10.3	2.1	2.6	2.8	2.8	2.5
(2) Exports to OPEC	1.9	3.1	.6	.7	.8	1.0	1.2
(2) as % of (1)	49.0	31.0	-	-	-	-	48.0
<u>Italy</u>							
(1) Imports from OPEC	3.4	9.5	1.9	2.5	2.7	2.4	1.8
(2) Exports to OPEC	1.2	2.3	.4	.5	.6	.8	.8
(2) as % of (1)	36.0	24.0	-	-	-	-	45.0

(Source: Direction of Trade)

Tables 1 and 2 together present the amount of oil to be financed by each one of the six major importing countries in money terms and as a percentage of the total trade in oil. This summary is presented in Table 3 below.

Table 3
"Financing" Oil - Six Major Importing Countries
(Sources: Tables 1 and 2)

	<u>1973</u>		<u>1974</u>		<u>1975:1</u>	
	<u>Billions of \$</u>	<u>% of Trade</u>	<u>Billions of \$</u>	<u>% of Trade</u>	<u>Billions of \$</u>	<u>% of Trade</u>
U.S.	1.2	24	10.0	59	2.2	47
U.K.	1.7	46	6.1	69	.9	45
W. Germany	1.7	43	5.4	59	.7	30
Japan	4.7	63	16.0	74	3.5	65
France	2.0	51	7.2	69	1.3	52
Italy	2.2	64	7.2	76	1.0	55

The actual "financing" of the flow of oil was accomplished both by "primary recycling" and by "secondary recycling" in terms of goods and of financial assets. On the aggregate in 1974 the 51.9 billion dollar deficit of the six major importing countries was partially offset by a 29.9 billion dollar trade surplus with the other non-OPEC countries (including trade among the six importing countries). The balance of trade of the six importing countries with the non-OPEC countries is presented in Table 4.

Table 4
Balance of Trade of Six Major Oil Importing Countries with Other Non-OPEC Countries

	Current Dollars in Billions						
	<u>1973</u>	<u>1974</u>	<u>1974:1</u>	<u>1974:2</u>	<u>1974:3</u>	<u>1974:4</u>	<u>1975:1</u>
U.S.	3.2	7.6	3.1	2.2	0.0	2.3	4.8
U.K.	-6.7	-9.4	-2.5	-2.3	-2.4	-2.2	-2.1
W. Germany	14.4	25.0	6.3	6.2	5.7	6.8	3.7
Japan	3.4	9.4	0.0	1.7	3.4	4.3	2.3
France	1.1	0.8	-0.2	0.0	0.2	0.8	0.7
Italy	<u>-3.4</u>	<u>-3.5</u>	<u>-1.6</u>	<u>-1.0</u>	<u>-0.5</u>	<u>-0.4</u>	<u>0.1</u>
TOTAL	12.0	29.9	5.1	6.8	6.4	11.6	9.5

(Sources: Directions of Trade and International Financial Statistics)

The total row in Table 4 reflects the net position of the six major industrialized countries vis-a-vis OPEC which was accomplished both by inter-six

accommodating flows as well as by exchanges with the non-six, non-OPEC group. The distribution of net positions among the three groups is presented in Table 5.

Table 5

Trade Position of the Major Groups in the World 1973-1974

Current Dollars in Billions

	<u>1973</u>	<u>1974</u>	<u>1974:1</u>	<u>1974:2</u>	<u>1974:3</u>	<u>1974:4</u>
Total OPEC Surplus	23.0	100.5	27.6	27.5	24.6	22.3
OPEC Surplus (Def.) w/non-Six	9.5	48.6	16.6	12.9	10.7	9.9
Six Surplus (Def.) with non-OPEC, non-Six	12.0	29.9	5.1	6.8	6.4	11.6
Total Surplus (Def.) of non OPEC, non-Six	(21.5)	(78.5)	(21.7)	(19.7)	(17.1)	(21.5)

(Source: International Financial Statistics)

Of the six major oil importing countries, West Germany was able to finance all of its oil imports by exporting goods to non-OPEC members. In effect, Germany's trade surplus of non-OPEC trade amounts to almost half of the aggregate oil deficit of the six countries vis-a-vis OPEC. Japan and the U.S. accommodated part of their oil-related deficit by export to non-OPEC countries. Italy and the U.K. have maintained a trade deficit with the other non-OPEC countries in addition to their oil-related deficit. Italy and the U.K. have financed their total trade deficit by the sale of financial assets. The U.K. sold capital assets directly to the oil exporting countries (primary recycling), while Italy sold capital assets mostly to the U.S. and West Germany (secondary recycling). In general the aggregate trade deficit of the six major importing countries was financed mostly by the sale of financial assets (net sales of 18.4 billion dollars) while the rest was financed by an increase in the international reserves (3.6 billion dollars).

The net transfer of capital assets to the exporting countries, the primary recycling of the group of six, was facilitated by substantial accomodating transactions within the six major oil importing countries as is evident from the data presented in Table 6 below.

Table 6

Computed* Capital Flows of Six Major Oil Importing Countries 1973-1974
Current dollars, billions

	<u>1973</u>	<u>1974</u>
U.S.	-3.2	0.7
U.K.	7.5	15.1
W. Germany	-22.0	-18.9
Japan	7.5	5.3
France	2.4	6.0
Italy	<u>5.3</u>	<u>10.2</u>
TOTAL	-2.5	18.4

(Sources: Directons of Trade and International Financial Statistics)

*Computed as a balance of payments' residual.

The data presented in Tables 4, 5 and 6 suggest that the increased expenditure of the six countries on OPEC oil, from 13.5 billion dollars in 1973 to 51.9 billion dollars in 1974, was partially adjusted by accomodating flows of trade in goods and in financial assets. The accomodating transactions were distributed unevenly among the six in terms of goods and in terms of financial assets to reflect both their comparative advantage and the preferences of OPEC.

APPENDIX

We present here a three-country, three-good general equilibrium model of trade in oil. We use the same notation as in the text of our article.

Assume each country can produce at least some oil (or vector of energy) and both countries 1 and X can produce at least some of good 1 (but not good 2). Country 2 produces good 2 (but not good 1). We can describe the constant returns to scale production functions, F^j , of each country as:

$$G_x^1 = F^1(G_1^1) \quad (A1)$$

$$G_x^2 = F^2(G_2^2) \quad (A2)$$

$$G_x^x = F^3(G_1^3) \quad (A3)$$

where G_i^j represents the production quantity of good i in country j , with $G_i^j \geq 0$, $dF^j/dG_i^j < 0$ and $d^2F^j/dG_i^{j2} < 0$, $\forall i, j$.

Let C_i^j denote the consumption of good i in country j , then

$$E_i^j \equiv C_i^j - G_i^j \quad (A4)$$

Each country possesses the respective social utility function across all three goods

$$U^1 \equiv U^1(C_1^1, C_2^1, C_x^1) \quad (A5)$$

$$U^2 \equiv U^2(C_1^2, C_2^2, C_x^2) \quad (A6)$$

$$U^x \equiv U^3(C_1^3, C_2^3, C_x^3) \quad (A7)$$

where:

$$\partial U^j / \partial C_i^j > 0 \text{ and } \partial^2 U^j / \partial C_i^{j2} < 0, \forall i, j.$$

Define the social marginal rate of substitution of good i for good k in country

$$V_{ik}^j \text{ as: } \equiv (\partial U^j / \partial C_i^j) / (\partial U^j / \partial C_k^j), \text{ where } i, k = 1, 2, 3, \text{ and } i \neq k \quad (A8)$$

We do not require equality of relative prices across countries. Thus there are nine price ratios, $P_{gi/gk}^j$, $v_{j,i,k}$ and $i \neq k$. Four equations can describe these price relationships where $P_{ik}^j \equiv P_{gi/gk}^j$:

$$P_{1x}^1 = K_1^1 (P_{1x}^2) \quad (A9)$$

$$P_{1x}^2 = K_1^2 (P_{1x}^3) \quad (A10)$$

$$P_{2x}^1 = K_2^1 (P_{2x}^2) \quad (A11)$$

$$P_{2x}^2 = K_2^2 (P_{2x}^3) \quad (A12)$$

Excess demand is a function of all commodity prices, thus $E_i^j \equiv E_i^j(P_{1x}^j, P_{2x}^j)$, $\forall i, j$.

Assume that the domestic economy of each country is organized in a competitive fashion so that the commodity price ratio is tangent to both the production transformation curve and the social indifference hyperplane of that country. These competitive situations can be described as follows:

$$P_{1x}^1 = - dF^1/dG_1^1 \quad (A13)$$

$$P_{2x}^2 = - dF^2/dG_2^2 \quad (A14)$$

$$P_{1x}^x = - dF^x/dG_1^x \quad (A15)$$

$$P_{ik}^j = v_{ik}^j, v_{j,i,k} \text{ and } i \neq k. \quad (A16)$$

The budget constraint for each country is:

$$P_{1x}^1 E_1^1 + P_{2x}^1 E_2^1 + E_x^1 = 0. \quad (A17)$$

$$P_{1x}^2 E_1^2 + P_{2x}^2 E_2^2 + E_x^2 = 0 \quad (A18)$$

$$P_{1x}^x E_1^x + P_{2x}^x E_2^x + E_x^x = 0 \quad (A19)$$

where oil is used as numeraire.

World trade equilibrium implies:

$$\sum_j E_1^j = 0 \quad (A20)$$

$$\sum_j E_2^j = 0 \quad (A21)$$

$$\sum_j E_x^j = 0 \quad (A22)$$

We have the following thirty three endogenous variables to be determined in this model: $G_x^1, C_x^2, G_x^x, G_1^1, G_1^x, G_2^2$, nine in C_i^j , nine in E_i^j , and nine in P_{ik}^j for $\forall j, i, k$ and $i \neq k$. There are altogether thirty four equations in our model as follows: (A1), (A2), (A3), nine in (A4), (A9) through (A15), nine in (A16), and (A17) through (A22). We have thirty four equations in thirty three variables. By invoking Walras' Law, we can drop one of the equations since it can be derived from the remaining ones. For example, equation (A22) can be derived from equation (A17)-(A21) assuming $P_{ik}^j > 0$. We thus have a deterministic system.

In the bilateral trade case (no trade between countries 1 and 2), equilibrium implies:

$$E_1^1 < 0, E_2^2 < 0, E_x^x < 0, E_x^1 > 0, E_x^2 > 0, E_1^x > 0, E_2^x > 0, \text{ and } E_2^1 = E_1^2 = 0.$$

Our purpose now is to show under what conditions the opening of (multilateral) trade between countries 1 and 2 will increase the excess supply, E_x^x , of oil from country X. We assume all goods are gross substitutes, thus multilateral trade implies:

$$E_2^1 > 0, E_1^2 > 0, \Delta P_{1x}^1 > 0 \quad \text{and} \quad \Delta P_{2x}^2 > 0.$$

where Δ is the change operator. The other relationships listed above still hold.

We want to determine the ultimate comparative statics effect on ΔE_x^x in the new multilateral trade equilibrium. We thus must consider the income and substitution effects on consumption and the concomitant substitution effects in production in all three countries in our general equilibrium framework. Following Jones [4] and Takayama [5] we can analyze this trade adjustment process by means of total elasticities. Define:

$\eta^j \equiv (-\partial C_x^j / \partial P_{xi}^j) \cdot (P_{xi}^j / E_x^j) \equiv$ Jones' relative price elasticity of oil import demand of country j . This represents the country j substitution in consumption of oil with respect to a change in the relative price of its export, good i , assuming real income fixed.

$\pi_x^j \equiv \partial C_x^j / \partial Y^j \equiv$ Country j ' marginal propensity to consume of the imported good, x , with respect to a change in real income Y^j . This represents the income effect.

$\epsilon^j \equiv (dG_i^j / dP_{xi}^j) \cdot (P_{xi}^j / E_i^j) \equiv$ Jones' relative price elasticity of substitution in production of country j 's exportable, good i .

We note here that all derivatives are evaluated at the original (bilateral trade) equilibrium point, we assume fixed factor endowments, and that adjustments in production and factor markets are instantaneous. We also know:

$\eta^j \geq 0$ by definition and demand assumption.

$\pi_x^j \geq 0$ by ruling out inferior goods

$\epsilon^j \geq 0$ by definition and production assumption.

We may now perform the comparative statics analysis. We will express ΔE_x^x in terms of the parameters of countries 1 and 2. Initially, let $P_1^j = P_x^j = P_{1x}^j = 1$ by choice of units in bilateral trade equilibrium. Then it can be shown that the change in real income of oil-importing country j due to price changes (after multilateral trade is allowed) is equal to $E_i^x dP_i^j - E_x^j dP_x^j$ where good i is country j 's exportable. The real income change due to country j output changes is equal to $dG_i^j + dG_x^j$. Adding these two change effects yields the total real income change:

$$dY^j = E_i^x dP_i^j - E_x^j dP_x^j + dG_i^j + dG_x^j \quad (A23)$$

Competitive domestic production equilibrium implies $dG_i^j / dG_x^j = -P_x^j / P_i^j = -1$. Thus from bilateral trade equilibrium and substituting, we may rewrite equation (A23) as:

$$\text{as:} \quad dY^j = E_x^j \Delta P_{ix}^j \quad (A24)$$

Using (A24), for the consumption side of the economy in each oil importing country we can express both income and substitution effects as follows:

$$\Delta E_x^1 + \Delta G_x^1 = \Delta P_{1x}^1 (\eta^1 + \pi^1) E_x^1 \quad (A25)$$

$$\Delta E_x^2 + \Delta G_x^2 = \Delta P_{2x}^2 (\eta^2 + \pi^2) E_x^2 \quad (A26)$$

For the production side of the economy, the change in relative prices implies:

$$\Delta G_x^1 = -\epsilon^1 E_x^1 \Delta P_{1x}^1 \quad (A27)$$

$$\Delta G_x^2 = -\epsilon^2 E_x^2 \Delta P_{2x}^2 \quad (A28)$$

Substituting (A27) and (A28) into (A25) and (A26) respectively, rearranging terms and adding (A25) to (A26) where we recall that equilibrium implies

$\Delta E_x^x = \Delta E_x^1 + \Delta E_x^2$, we have:

$$\Delta E_x^x = (\eta^1 + \pi^1 + \epsilon^1) E_x^1 \Delta P_{1x}^1 + (\eta^2 + \pi^2 + \epsilon^2) E_x^2 \Delta P_{2x}^2 \quad (A29)$$

Equation (A29) is the total change in the physical quantity of oil supplied by country X after multilateral trade is allowed. Thus $\Delta E_x^x > 0$ implies that accomodating flows of goods and financial assets between countries 1 and 2 will mean an increase in the supply of oil by country X. We know: $\Delta P_{ix}^j > 0$ by our assumption of gross substitutes and $E_x^1 > 0$ and $E_x^2 > 0$ by the assumption that trade exists. Thus (A29) implies $E_x^x > 0$.

A more complicated version of (A29) which explicitly shows the separate effects of bonds (financial assets) and goods may be briefly outlined. Let B_j be the (importing) country j "production" of its bonds (claims on future goods). Then (A1) - (A2) would be respecified as: $G_x^j = F^j(G_i^j, B_j)$. Then (A5) - (A7) would be rewritten as:

$$U^j \equiv U^j(C_1^j, C_2^j, C_x^j, B_1, B_2)$$

where:

$$\partial U^j / \partial C_i^j > 0, \partial^2 U^j / \partial C_i^j{}^2 < 0, \partial U^j / \partial B_j > 0, \text{ and } \partial^2 U^j / \partial B_j^2 < 0.$$

Equation (A8) would also hold for substitution between spot goods and bonds (future goods).

For (A9)-(A12) we would now have eight of these price relationships:

e.g. $P_{B_1 x}^1 \equiv K_{B_1}^1 (P_{B_1}^2 x)$. The domestic competitive equilibrium relationships, (A13)-(A16) also hold.

The country budget constraints become:

$$P_{1x}^j E_1^j + P_{2x}^j E_2^j + P_{B_1 x}^j E_{B_1}^j + P_{B_2 x}^j E_{B_2}^j + E_x^j = 0$$

where oil is used as numeraire. In world trade equilibrium we will have:

$$\sum_j E_1^j = 0, \quad \sum_j E_2^j = 0, \quad \sum_j E_{B_1}^j = 0, \quad \sum_j E_{B_2}^j = 0, \quad \sum_j E_x^j = 0.$$

We thus have sixty eight endogenous variables in sixty nine equations. Again, by Walras' Law, we have a deterministic system.

FOOTNOTES

1. The terms "paying" and "financing" oil were coined by Alexander [3].
2. See Alexander [2].
3. This point is developed further in Agmon, Lessard and Pindyck [1].
4. Since bonds are risky, the existence of multilateral exchange of them in secondary markets will allow increased diversification by individual portfolio holders across countries. This point is more fully developed in "Capital Markets, Portfolio Adjustments, and the Pricing of Oil by an OPEC Member", by T. Agmon, D. Lessard and J. Paddock, forthcoming working paper, M.I.T. World Oil Project, 1976.

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*These two papers by S.S. Alexander are combined and published as a background paper in Paying for Energy: Report of the Twentieth Century Fund Task Force on the International Oil Crisis, McGraw - Hill Book Co., New York, 1975, p. 33.