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SYMMETRICAL AND ASYMMETRICAL ASPECTS OF INTERNATIONAL TRADE WITH CAPITAL AND NATURAL RESOURCE MOBILITY

by

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INTRODUCTION

The "North-South Dialogue" and the calls for a "New International Economic Order" have recently been the major issues of discussion in the international aspects of economic development. The attention is focused on questions of the following kinds: Who sets the rules of the game for international transactions? Who has the power to initiate changes in such rules? The basic hypothesis is that the institutional framework within which international transactions take place has historically been biased in favor of the industrial North against the predominantly primary producing South. This hypothesis of fundamental asymmetry in the workings of the global economic system, based on the well-known writings of Raul Prebish and Hans Singer, has been rigorously formalized in recent interesting papers by M. Kemp and M. Ohyama, and R. Findlay.

Recent events in the world markets for oil and other raw materials (i.e., bauxite), however, have led to the view that the resource-rich countries now have the one-sided collective power to "exploit" and have an interest in exploiting the resource-poor countries. There are now those who believe that the shoe is really on the other foot.

The purpose of the present paper is to highlight this potential new asymmetry in the workings of the world economy and to examine the extent to which the resource-rich and poor countries can, and might, wish to exploit each other. We construct an asymmetric model of the world economy based on the dichotomy between oil consuming nations (OCN) and oil producing nations (OPC). The main features of our model are that each country produces a final consumption good, but OPC also produces a natural resource, oil, which is used as an input in both countries. Capital and oil are internationally mobile, but labor is specific to each country. We analyze several commercial policy interventions (taxes, tarrifs, quotas) which can be used by each country to impoverish the other, and their effect on the world's resource allocation and income distribution. Specifically we analyze the case of an oil export tax and compare it to an oil embargo imposed by OPC. The results of the above model are compared to the Kemp-Ohyama model and to the traditional Hecksher-Ohlin-Mundell models.

II. AN ASYMMETRICAL WORLD ECONOMY

The world is assumed to consist of two countries- oil consuming nations, OCN and oil producing nations, OPC. Each country has a fixed endowment of labor and of capital, which we denote by K. Labor is tied to each region but capital is internationally mobile responding to any differential in the rate of return. Each country produces one consumption good, X, with two factors of production, capital, K, and a natural resource, oil, O. OPC alone extracts O with a specific capital stock K_0.[1] We assume that OCN is a net exporter of X and rents K capital units to OPC, while OPC sells the natural resource, O, to OCN. The world stock of capital (specific to industry X) is fixed at $\hat{K}$.

The production functions of X are respectively:

(1) $$X = \tilde{X}(\bar{K}-K, O) \quad \text{and} \quad X^* = \tilde{X}^*(\bar{K}^* + K, O^*),$$

where * refers to OPC, O is the OCN demand for oil, O* is the OPC demand for oil, $\bar{K}$ and $\bar{K}^*$ are the initial stocks of capital in each country.

The production function of oil is[2]

(2) $$\bar{O} = \bar{O}\,(K_0^S)$$

and the following restrictions are satisfied:[3]

(3) $$\frac{\partial \tilde{X}}{\partial(\bar{K}-K)} > 0, \quad \frac{\partial \tilde{X}}{\partial O} > 0, \quad \frac{\partial^2 \tilde{X}}{\partial(\bar{K}-K)^2} < 0, \quad \frac{\partial^2 \tilde{X}}{\partial O^2} < 0$$

$$\frac{\partial X^*}{\partial(\bar{K}^*+K)} > 0, \quad \frac{\partial \tilde{X}^*}{\partial O^*} > 0, \quad \frac{\partial^2 \tilde{X}}{\partial(\bar{K}-K)\,\partial O} \geq 0, \quad \text{and} \quad \frac{\partial^2 \tilde{X}^*}{\partial(\bar{K}+K)\,\partial O^*} \geq 0$$

and by assumption

(4) $$\hat{K} = \bar{K} + \bar{K}^*$$

Under perfect competition, the following equilibrium conditions hold:

(5) $$r = \frac{\partial \tilde{X}}{\partial(\bar{K}-K)}$$

(6) $$r^* = \frac{\partial \tilde{X}^*}{\partial(\bar{K}^*+K)} = \frac{\partial \bar{O}}{\partial K_0}\, p^*$$

(7) $$P = \frac{\partial \tilde{X}}{\partial O}$$

where r,r* are the rates of return on capital expressed in units of X, while P and P* are the relative prices of oil in terms of X.

By utilizing the conditions (5)-(7) and the production functions (1) and (2), we derive the derived demand functions for oil,

(8) $$O = O\,(P,\ \bar{K}-K) \quad \text{and } O^* = O^*(P^*, \bar{K}^*+K)$$

where conditions (3) imply

(9) $$\frac{\partial O}{\partial P},\ \frac{\partial O^*}{\partial P^*} \leq 0 \quad \text{and} \quad \frac{\partial O}{\partial(\bar{K}+K)},\ \frac{\partial O^*}{\partial(\bar{K}^*+K)} \geq 0$$

and the supply functions of X,

(10) $$X = S(P, \bar{K}-K) \quad \text{and } X^* = S^*(P^*, \bar{K}^*+K)$$

where conditions three imply,

(11) $$\frac{\partial S}{\partial P},\ \frac{\partial S^*}{\partial P^*} \leq 0 \quad \text{and} \quad \frac{\partial S}{\partial(\bar{K}-K)},\ \frac{\partial S^*}{\partial(\bar{K}^*+K)} \geq 0.$$

The budget constraints of the two countries are given by[4]

(12) $$X^d = X - P^*O + r^*K$$

and

(13) $$X^{*d} = X^* + P^*\ (\bar{O}-O^*) - r^*K.$$

III. COMMERCIAL INTERVENTION BY OCN

We assume that OCN imposes an ad valorem tax on capital exports, t, and an export tax, τ, on commodity X.[5] By applying Walras' law and utilizing budget constraints (12) and (13), world equilibrium in all markets can be described by equilibrium in the O and K markets respectively. The former is given by

(14) $$O + O^* = \bar{O}$$

and the latter by world interest arbitrage

(15) $$r = r^*\ (1-t)$$

Furthermore, international commodity arbitrage prevails so that

(16) $P = P^*(1-\tau)$

We turn next to the analysis of stability and derive the condition under which any equilibrium defined by (14) and (15) is stable, namely that the international commodity market and the international capital market, will return to equilibrium, once the initial equilibrium is disturbed. Let us define the adjustment mechanisms in the commodity market and in capital movement as

(17) $\dot{P}^* = g(0+0^*-\bar{0})$

(18) $\dot{K} = f[r^*(1-t)-r]$

where g' and f' are positive and g(0) = f(0) = 0.

These mechanisms imply that if there is excess demand (supply) of oil, its relative price will fall (rise) and if $r^*>r$, capital will flow from OCN to OPC.

The necessary and sufficient conditions for stability require that the determinant of the Jacobian matrix Z of the equilibrium equations (14) and (15) must be positive and its trace negative. From (1), (5), (6) and (16),

$$(19) \quad Z = \begin{bmatrix} \bar{0}(s\eta + s^*\eta^* - \beta) & \lambda^* - \lambda \\ -\bar{0}K[\mu s\eta - (1-t)\mu^* s^*\eta^*] & -P^*r\bar{\varepsilon} \end{bmatrix}$$

where the following notations have been used,

$$\varepsilon \equiv -\left(\frac{\partial r}{\partial 0}\,\frac{\partial 0}{\partial(\bar{K}-K)} + \frac{\partial r}{\partial(\bar{K}-K)}\right)\frac{\bar{K}-K}{r}$$

$$\varepsilon^* \equiv -\left(\frac{\partial r^*}{\partial 0^*}\,\frac{\partial 0^*}{\partial(\bar{K}^*+K)} + \frac{\partial r^*}{\partial(\bar{K}^*+K)}\right)\frac{\bar{K}^*+K}{r}$$

$$s = \frac{0}{\bar{0}} \qquad s^* = \frac{0^*}{\bar{0}}$$

$$\mu \equiv \frac{\partial r}{\partial 0}$$

$$\mu^* \equiv \frac{\partial r^*}{\partial 0^*}$$

$$\delta \equiv \frac{K}{\bar{K}^*-K}$$

$$\delta^* \equiv \frac{K}{\bar{K}^*+K}$$

$$\eta \equiv \frac{\partial 0}{\partial P} \quad \frac{P}{0}$$

$$\eta^* \equiv \frac{\partial 0^*}{\partial P^*} \quad \frac{P^*}{0^*}$$

$$\bar{\varepsilon} \equiv (\delta \varepsilon + \delta \varepsilon^*)$$

$$\lambda \equiv P^* \frac{\partial 0}{\partial(\bar{K}-K)}$$

$$\lambda^* \equiv P^* \frac{\partial 0^*}{\partial(\bar{K}+K)^*}$$

$$\bar{\beta} \equiv \frac{\partial 0}{\partial P^*} \quad \frac{P^*}{\bar{0}}$$

The restrictions on the production functions given in (3) together with (5), (6) and (9) imply the following

(20a) $\mu, \mu^* > 0, \quad \eta, \eta^* \leq 0, \quad \lambda, \lambda^* > 0, \quad \beta > 0$

Moreover, since $K > 0$

(20b) $\delta, \delta^* > 0$

The term in parenthesis in ε and ε^* measures the change in the marginal productivities of capital while the second input, oil, is also allowed to adjust as K changes. Assuming this change to be negative, it then follows that

(20c) $\varepsilon, \varepsilon^* > 0$

also. A sufficient condition for stability implied from Δ, the determinant of Z, is

(21) $\mu s|\eta| < (1-t)\, \mu^* s^* |\eta|^*$

In the special case where $\eta=\eta^*$ and $\mu=\mu^*$, condition (21) becomes

(21') $(1-t)s^* > s$

The necessary and sufficient condition is

$$(22)\qquad -P^*r(s\eta + s^*\eta^* - \beta)\,\bar{\varepsilon} > -K(\lambda^*-\lambda)\,(\mu s\eta - (1-t)\mu^* s^*\eta^*)$$

Again, considering the special case where $\eta=\eta^*$, $\mu=\mu^*$, and $\beta=0$, (22) becomes

$$(22')\qquad \bar{\varepsilon}P^*r > K\mu(\lambda^*-\lambda)(s-(1-t)s^*)$$

We turn now to analyze the effects of a change in the rate of the export tax τ, or the export rental tax t on the world allocation of resources, the distribution of income between OCN and OPC and the terms of trade. Differentiating (14) and (15) totally we obtain

$$(23)\qquad \bar{O}\,(s\eta+s^*\eta^*-\beta)dP^* + (\lambda^*-\lambda)dK = -\frac{1}{1+\tau}\,\bar{O}P^*s\eta d\tau$$

and

$$(24)\qquad -K\bar{O}[\mu s\eta - (1-t)\mu^*s^*\eta^*]dP^* - P^*r(\delta\varepsilon+\delta^*\varepsilon^*)dK = \frac{1}{1+\tau}\,\bar{O}P^*s\eta\mu k d\tau + P^*r^*Kdt$$

whence

$$(25)\qquad \frac{dP^*}{d\tau} = \frac{\bar{O}P^*\eta}{\Delta(1+\tau)}\,[P^*r\bar{\varepsilon} - K\mu(\lambda^*-\lambda)] \gtrless 0$$

$$(26)\qquad \frac{dK}{d\tau} = \frac{\bar{O}P^*\eta K}{\Delta(1+\tau)}\,[\bar{O}s^*\eta^*(\mu+(1-t)\mu^*) - \mu\beta] > 0$$

$$(27)\qquad \frac{dP^*}{dt} = \frac{-P^*r^*K}{\Delta}\,[\lambda^*-\lambda] < 0$$

$$(28)\qquad \frac{dK}{dt} = \frac{\bar{O}P^*r^*K}{\Delta}\,(s\eta + s^*\eta^* - \beta) < 0$$

Equation (25) is the terms of trade response to the OCN imposition of τ. If the sufficient condition for stability (21) holds, then $\frac{dP^*}{d\tau} < 0$, implying that OCN's terms of trade will improve. If (21) does not hold, then the terms of trade can move either way. Thus, a stable perverse result is possible in this framework. The bracketed terms in (25) determine the direction and magnitude of the change in the terms of trade. The term $\bar{\varepsilon}$, which measures the total change in the marginal productivity of capital, is also the inverse measure of the degree of capital movements as a response to interest rate differentials. The term $\lambda^* - \lambda$ is a measure of the distortion created by the system of taxes, namely the differential marginal productivity of capital. More formally, since

$$\lambda^* - \lambda = r^*\left(1 - \frac{1-t}{1+\tau}\right)$$

the distortion is positively related to the level of both taxes. When $t = \tau = 0$, $\lambda^* = \lambda$ and the marginal productivity of capital is equal in the two countries.

When the export tax is imposed, the supply of X facing OPC falls, creating an excess demand for X at the pretax terms of trade. This improves OCN's terms of trade. If the imposition of a tax raises P by more than the terms of trade effect decreases it, then P will rise.[6] Producers of X in OCN have an incentive to contract production, while OPC producers have an incentive to expand it. This increases the world interest differential $r^* - r$ and capital will flow to OPC. The flow of capital will dampen the terms of trade effect. From equation (25) we note that the higher $\bar{\varepsilon}$, the lower is the induced capital mobility as a result of the interest differential, and the greater will be the improvement in the terms of trade. Further, the higher the distortions in the world's allocation of resources, $\lambda^* - \lambda$, the higher the probability that the terms of trade will deteriorate. No matter what happens to the terms of trade, equation (26) insures that capital will always flow from OCN to OPC.[7]

The results (25)-(26) show a marked contrast to the results obtained by Kemp and Ohyama (1978) (henceforth referred to as K-O), and explored by Findlay (1979). The essential difference in structure is that we allow OPC to produce its own consumption good X. In the North-South model of K-O, OPC's sole output is oil, O.[8] Furthermore, K-O assume that capital mobility a la Mundell flows between OCN's X industry and OPC's oil industry, O. Although their results are quite flexible and they note:

> Specifically it can be shown that our conclusions remain valid even if each country produces many consumption goods and many raw materials provided only that the foreign consumption good industries divide into two disjoint subsets, with members of one subset producing only for the home or export market and members of the other subset producing. . . only for the local foreign market.

Our model resembles the current political economy of oil producers and consumers more closely since:

1) The capital employed in the oil industry is specific so that short-run adjustments in the capital stock are unlikely to occur. Variations in oil sales will usually be manifested by changed in inventory or by varying the capital utilization rate rather than by changes in the capital stock.

2) If the natural resource in the K-O model does not employ industrial capital, then no physical capital mobility can occur between countries unless OPC produces its own consumption goods.

Whether or not OPC produces its own consumption goods is critical to the results outlined in (25)-(26). In the K-O model the analysis of "the scope of imperialism" leads to the following results,

(a) The terms of trade of OCN will unambiguously improve,

(b) There will be no reallocation of capital, and

(c) The OCN domestic terms of trade and interest rate are invariant to OCN's policy,

> [point b]. . . displays a remarkable feature of the present model, viz. the invariance of the world allocation of resources and choice of production technique to changes in the rate of export tax and the consequential changes in world prices . . . [Furthermore] it is optimal for the self seeking home country [OCN] to exploit the foreign country [OPC] to the limit. Second the act of exploitation does not involve manipulation of international borrowing and lending. Indeed it is an implication

> of complete exploitation that international indebtedness remains at pre-intervention level . . .[9]

Our model suggests that the full incidence of the OCN export tax does not fall entirely on OPC. Despite the asymmetrical nature of our model, our results contain two important features,

1) There need not be any positive relationship between the tariff and the terms of trade.

2) The direction of the change in the terms of trade is linked to the sufficient condition of stability.

These two theoretical features are similar to the results obtained in an extended version of the Hecksher-Ohlin model developed by Batra (1977) and explored by Das and Lee (1979)[10]

We now proceed to analyze how the export tax (import tariff) affects the world's distribution of income. The OCN budget constraint (12) can be written as

(29) $$y = X^d = S(P,\bar{K}-K) - P^*O(P,\bar{K}-K) + r^*[O^*(P^*,\bar{K}^*+K),\bar{K}^*+K]K$$

where y is OCN's level of real income. Differentiate (29) to obtain,

(30) $$\frac{dy}{d\tau} = P^*r^*\,(1-\delta^*\bar{\varepsilon})\,\frac{dK}{d\tau} + P^*\,(\frac{1}{1+\tau})\,(\alpha X-\bar{O}s\eta P^*) + [\alpha X-O^*s^*\eta^*\mu^*K-\bar{O}sP^*(1-\eta)]\,(\frac{dP^*}{d\tau})$$

Can you show that $\tau_{optimal} > 0$

where $\alpha \equiv \frac{\partial S}{\partial P}\cdot\frac{P}{X} \lesseqgtr 0$. The first term in (30) represents the direct effect of capital mobility upon real income, y. If $\bar{\varepsilon}\delta^*$ is less than unity, then this will raise y. Generally this result is ambiguous because although the stock of invested capital increased, the direction of the change in the marginal product of capital is ambiguous(measured either in terms of X or in terms of oil). The term $\alpha\cdot X$ captures the reduction in real output due to the imposition of the export tax. This has the dual effect of improving income through the terms of trade effect and concommitantly reducing income by restricting the volume of trade. $\bar{O}s\eta P^*$ also has two opposing effects. Since the OCN price of X falls, there are direct gains associated with consumer surplus. This surplus will however be offset by the improvement in terms of trade. The more inelastic the foreign derived demand, the greater are the gains from the tax. Finally the constant term $P^*.\frac{1}{1+\tau}$ $[\alpha X-\bar{O}S\eta P^*]$ will be positive if $\frac{O^*P}{X} > \frac{\alpha}{\eta}$, that is, the share of imports out of domestic value added must be greater than the elasticity of X with respect to input, O.[11,12]

A further point of interest is whether or not a "Meltzer" effect can take place so that the export tax will in fact raise OCN's domestic terms of trade. By differentiating (16) fully and utilizing equation (25), then it can be shown that if the sufficient condition for stability (21) holds then the tax effect will outweigh the terms of trade effect.[13] Several of the salient features above can be summarized with the aid of the following diagram:

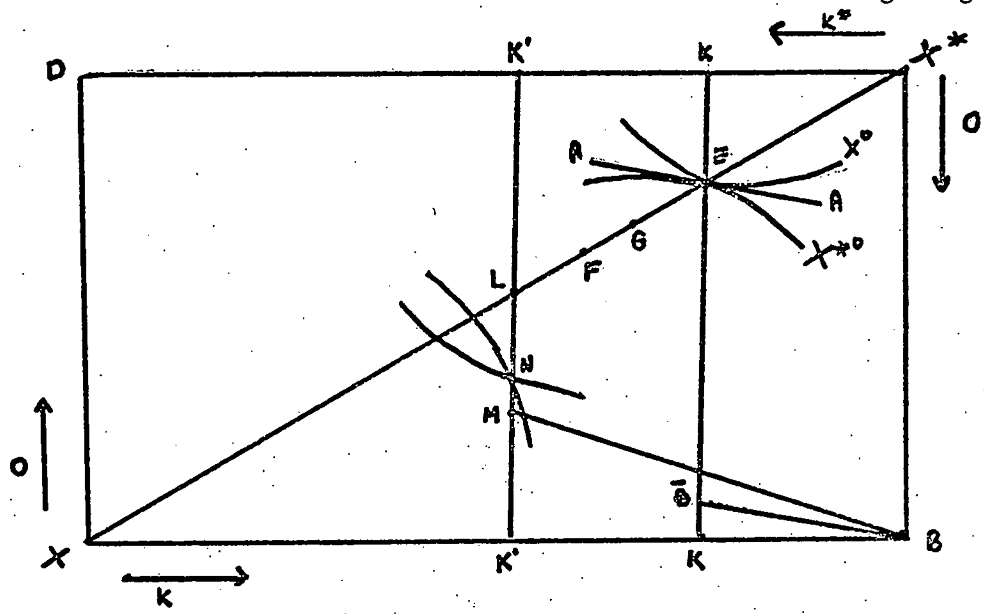

FIGURE 1

DXBX* is the Edgeworth Box. The contract curve is XX*, a straight line providing the countries use the same technology. Pre-intervention production takes place at point E where OCN produced X^0 and OPC X^{*0}. The terms of trade between capital and oil, $\frac{r^*}{P^*}$ are given by the slope of the tangent, AA, passing through point E. BK is the stock of OCN capital invested in OPC. By drawing $B\bar{B}$ parallel to AA and intersecting KK at $\bar{B}$, the components of the balance of payments can be seen. $\bar{B}K$ measures the repatriated interest payments on KB, while $\bar{B}E$ measures the value of X exported to OPC. EK is the value of oil imported by OCN. World consumption takes place at a point southwest of E on contract curve XX*. When OCN imposes the export tax it is unclear what happens to $\frac{r^*}{p^*}$. Assuming this rises, then new production equilibrium will take place at point N, a point lying below the contact curve, west of KK. N is not a Pareto Optimum point and the difference in slopes of the tangents at N reflects the wedge introduced by the export tax. KK' is the increase in OCN investment abroad. By drawing BM parallel to the world rental rate $\frac{r^*}{Pr}$ (the line tangent to OPC's isoquant at N), we obtain point M lying on K'K'. Exports of X have fallen from EK to LM, oil imports from EK to LK' and interest payments have increased from $\bar{B}K$ to MK'.[14]

Direct intervention in the capital market is straightforward. Equations (27) shows that a tax levied on repatriated income will unambiguously improve OCN's terms of trade and discourage capital movements to OPC. From (28) we note that the more elastic η, η^* and β are, the more effective will the capital tax be in discouraging foreign investment. The greater the distortion $\lambda^*-\lambda$, the greater will be the gains from the tax in contrast to the export tax on X. In contrast, K-O obtain the result that although the tax will divert capital away from OPC, it will worsen OCN's terms of trade. In our model the tax reduces the excess capital supply available to OPC, raising the international interest rate and making it more expensive for OPC to produce its own consumption goods. This unequivically improves OCN's terms of trade. In the K-O model, the reduction of capital to OPC makes it more expensive for OPC to produce oil. The relative price of oil rises thus worsening OCN's terms of trade. Furthermore K-O's equivalent of equation (25) for $\frac{dP^*}{d\tau}$ is independent of direct intervention in the capital market,

> . . . the desired degree of exploitation can be achieved by means of an export tax only. The second policy instrument . . . may be used in a supplementary role, but it need not be used. (page 100)

They then state their first proposition,

> Within the framework of the model the resource poor imperial economy can exoloit the resource rich colonial economy to any desired degree and can do this by means of one policy instrument, the export tax. Exploitation involves a redistribution of constant world consumption; it is not accompanied by a reallocation of productive factors. Hence the self regarding imperial economy will choose to fully exploit the colonial economy (page 101).

Our model stressed the importance of implementing both policies simultaneously. As stated earlier, capital mobility offsets the positive gains accrueing to OCN, therefore a capital tax is necessary to choke off this channel. Intuitively, the peculiar asymmetric nature of the K-O model allows OPC no leeway, for to maintain a basic level of subsistence they are entirely dependent on their remuneration from oil sales abroad.

Thus far OPC maintained a passive stance to the OCN intervention. In order to focus on the symmetries and asymmetries we now analyze the case where OPC imposes a system of taxes and OCN does not retaliate.

IV. COMMERCIAL INTERVENTION BY OPC

Suppose that OPC imposed taxes τ^* and t^* on the export of oil and the import of capital services and seeks to set them at levels which maximize its own consumption. To what extent can OPC use its monopoly power in producing oil and increase its consumption above its competitive equilibrium level? Will the asymmetrical model yield symmetry of results with respect to the commercial policies of OPC and OCN?

The world arbitrage conditions are now

(31) $P\ (1-\tau^*) = P^*$

and

(32) $r\ (1+t^*) = r^*$

where τ^* is the tax on oil and t^* is the tax on foreign investment. The world terms of trade (as well as OCN's domestic terms of trade) is now P. We rewrite OCN and OPC budget constraints in terms of P,

(33) $y = X - PO^d + rK = X^d$

and

(34) $y^* = X^* - P(\bar{O}-O^*) - rK = X^{*d}$

By utilizing (33) and (34) together with Walras' law, world equilibrium is fully described again by the equilibrium condition in the oil and capital markets.

Stability requires that the determinent of the Jacobian matrix Z^* of the equilibrium equations (14) and (32) must be positive and its trace negative.

(35) $$Z^* = \begin{bmatrix} \bar{O}(s\eta + s^*\eta^*-\beta) & \lambda^*-\lambda \\ \bar{O}K[(1+t^*)\ \mu s\eta - \mu^* s^*\eta^*] & -Pr^*\bar{\varepsilon} \end{bmatrix}$$

where λ^* and λ are now evaluated at the world terms of trade P. A sufficient condition for stability is that

(36) $\mu s|\eta| < (1+t)\mu^* s^* |\eta|^*$

In the special case where $\eta=\eta^*$ and $\mu=\mu^*$, condition (36) becomes

(36') $s^* > (1+t)s$

The necessary and sufficient condition is

(37) $\bar{\varepsilon}Pr^* > -K\mu(\lambda^*-\lambda)(s^*-(1+t)s)$

Differentiating (14) and (32) totally we obtain

(38) $\bar{O}(s\eta+s^*\eta^*-\beta)dP + (\lambda^*-\lambda)dK = \frac{1}{1-\tau^*}\ \bar{O}P(s^*\eta^*-\beta)\ d\tau^*$

(39) $K\bar{O}\ [(1+t^*)\ \mu s\eta-\mu^* s^*\eta^*]\ dP - Pr^*\ (\delta\varepsilon+\delta^*\varepsilon^*) = \frac{1}{1-\tau^*}\ \bar{O}Ps^*\eta^*\mu^* k d\tau^* + PrKdt$

whence,[15]

$$\frac{dP}{d\tau^*} = -\frac{\bar{O}P\eta^* s^*}{\Delta^*(1-\tau^*)}\,[Pr^*\bar{\varepsilon} - K\mu^*(\lambda^*-\lambda) \gtrless 0 \tag{40}$$

$$\frac{dK}{d\tau^*} = \frac{\bar{O}P\eta^* s^*}{\Delta^*(1-\tau^*)}\,[\bar{s}\,k\eta^*\mu(1-t)] > 0 \tag{41}$$

$$\frac{dP}{dt^*} = \frac{PrK}{\Delta^*}\,(\lambda^* - \lambda) < 0 \tag{42}$$

$$\frac{dK}{dt^*} = \frac{\bar{O}PrK}{\Delta^*}\,(s\eta + s^*\eta^* - \beta) < 0 \tag{43}$$

Despite the asymmetrical structure of the world economy we note from (40) that if the sufficient condition for stability (36) holds than OPC will unambiguously improve its terms of trade. Once again a stable perverse result is possible if (36) does not hold but (37) does. The above result is symmetrical with OCN's commercial intervention. The fact that oil is a factor of production and X a final product does not violate the symmetry of the effect of taxation on the terms of trade. However, (41) suggests that capital will again flow from OCN to OPC. This is an asymmetrical result for it is identical to (26). When OPC imposes an export tax on oil, OPC's domestic price of oil will rise. We should note that the allocation of world resources is identical in the case when OPC imposes an export tax on oil (and improves its terms of trade) to the case when OCN imposes an export tax on the consumption good (and improves its terms of trade). A generalization of this result is that if all traded factors are specialized, the reallocation of factors due to tariff intervention is independent of which country levies the tariff.

Equations (42) and (43) describe the effects of a capital tax on the terms of trade and capital movements respectively. If $t^* > 0$, then OPC terms of trade would deteriorate while capital would move back to OCN. Thus OPC has an incentive to offer a subsidy ($t^* < 0$) to foreign capital. Their terms of trade would improve, since they would expand production of X as the rental on capital fell due to the subsidy.

The above results are different from the K-O model. An export tax t* would improve OPC terms of trade (opposite to our result). This is clearly due to the assumption that OPC does not produce X and that capital in the oil industry is substitutable for capital in the X industry. A rental tax imposed by OPC would make capital more expensive to use in the oil industry and thus will raise the international price of oil.

It is intuitively obvious that the degree of exploitation that can be achieved by OPC depends on the availability of oil substitutes. An optimal policy for OCN would be to increase the elasticity of substitution between K and O. The higher the elasticity of substitution, the more elastic would be the demand for oil by OCN. In the special case when the production function has the CES form, the elasticity of substitution is identical to η, the derived demand elasticity. By differentiating (40) with respect to η it can be seen that the degree to which OPC can improve its terms of trade is negatively related to η. Thus, technological change that will extend the substitution possibilities between oil and other inputs will limit the scope for resource nationalization and reduce the monopoly power of OPC.

V. THE ECONOMICS OF OIL EMBARGO

The analysis of commercial policies by OCN and OPC reveals that although each country has the power to impoverish the other, the scope of economic imperialism and of resource nationalization is limited. Although OPC produces its own consumption good and although it possess the natural resource without which OCN's consumption is pinned to zero, it cannot secure for itself any desired fraction of world consumption simply by choosing a sufficiently high oil export or capital import tax. There is, however, one other type of policy--imposed trade restrictions--which might provide different conclusions, quantitative restrictions. If OPC were to impose an oil embargo on OCN, how would this affect the world allocation of resources, and the distribution of income? In particular, is an oil embargo equivalent to an export tax?[16]

We suppose that OPC imposes a capital import tax t^* and an export oil quota Q and seeks to set them at levels which yield the greatest consumption for its residents.

Omitting detailed derivations, we note that OCN derived demand for oil is now also a function of the oil quota set by OPC. The condition of equilibrium in the world oil market is

$$O^d(P,\bar{K}-K,Q) + O^{*d}(P^*,\bar{K}^*+K) = O^s(P^*) \tag{44}$$

The conditions of arbitrage equilibrium are now

$$r[O^d(P,\bar{K}-K,Q),\bar{K}-K]\,(1+t^*) = r^*[O^{d*}(P^*,\bar{K}^*+K),\bar{K}^*+K] \tag{45}$$

and

$$P = P^* \tag{46}$$

Postulating the same dynamic adjustment mechanisms as (17) and (18), we obtain the identical stability conditions (36) and (37).

Differentiating (44) and (45) totally, we obtain

$$\bar{O}(s\eta+s^*\eta^*-\beta)dP + (\lambda^*-\lambda)dK = -PdQ \tag{47}$$

$$\bar{O}K\,[\mu^*s^*\eta^*-(1+t^*)\mu s\eta]dP - Pr^*(\delta\varepsilon+\delta^*\varepsilon^*)dK = PK\mu(1+t)dQ + PrKdt \tag{48}$$

whence:

$$\frac{dP}{dQ} = \frac{P}{\Delta}\,[Pr\bar{\varepsilon} - K\mu(1+t)(\lambda^*-\lambda)] \gtrless 0 \tag{49}$$

$$\frac{dK}{dQ} = \frac{\bar{O}PK}{\Delta}\,[(1+t)\mu\,(s\eta+s^*\eta^*-\beta) + \mu^*s^*\eta^*-\mu s\eta(1+t)] \gtrless 0 \tag{50}$$

$$\frac{dP}{dt} = -\frac{PrK}{\Delta}\,(\lambda^*-\lambda) < 0 \tag{51}$$

$$\frac{dK}{dt} = \frac{\bar{O}PrK}{\Delta}\,(s\eta+s^*\eta^*-\beta) < 0 \tag{52}$$

Like equation (40), (49) implies that an embargo in the presence of taxation on capital mobility will not unequivocally improve OPC terms of trade. However, if no capital tax is imposed, $\lambda^* = \lambda$, since the quota does not drive a wedge between P and P*. Then

$$\frac{dP}{dQ} = \frac{P^2 r\bar{\varepsilon}}{\Delta} > 0 \tag{53}$$

and OPC terms of trade will definitely improve. Thus in the presence of capital mobility under the assumption that $t \lesssim 0$, a quota will unambiguously improve OPC's terms of trade, whereas an export tax on oil will not. The reason lies in the fact that the embargo equilibrium appears on the world's contract curve in contrast to the tax. It can be seen that the more sensitive is capital mobility to interest differentials (the lower is $\bar{\varepsilon}$), the less will the terms of trade improve. This establishes the non-equivalence between an export tax (import tariff) and an export quota (an import quota) in the above framework. This result is similar to the one obtained by Falvy (1976). In a Heckshér-Ohlin-Mundell model he establishes a non-equivalence between an import tax and an import quota that, as in our model, eminates from the fact that the tariff drives a wedge between home and foreign prices and marginal productivities of capital while a quota does not.[17] As can be seen from equation (51), OPC has an incentive to grant a subsidy to foreign capital as in Section IV. In such a case (53) will only be reinforced.

A further non-equivalence between tax and a quota is the direction of capital mobility. Since all producers of X face a lower price for the consumption good, the effect of a quota on the interest differential is ambiguous and so is the direction of capital flow (see equation (50)). Initially world equilibrium is at point P where OPC is exporting EK units of oil. OPC cuts the supply of oil by DE units, so that only NK' are exported. The world contract curve shifts to XZ as OPC builds up inventory of X*Z. The world X industry now becomes more capital intensive and world equilibrium is located at N. In the above example, the value of repatriated payments falls to LK', as does the value of exports from PM to LN. The capital stock increases by K*K'.[18]

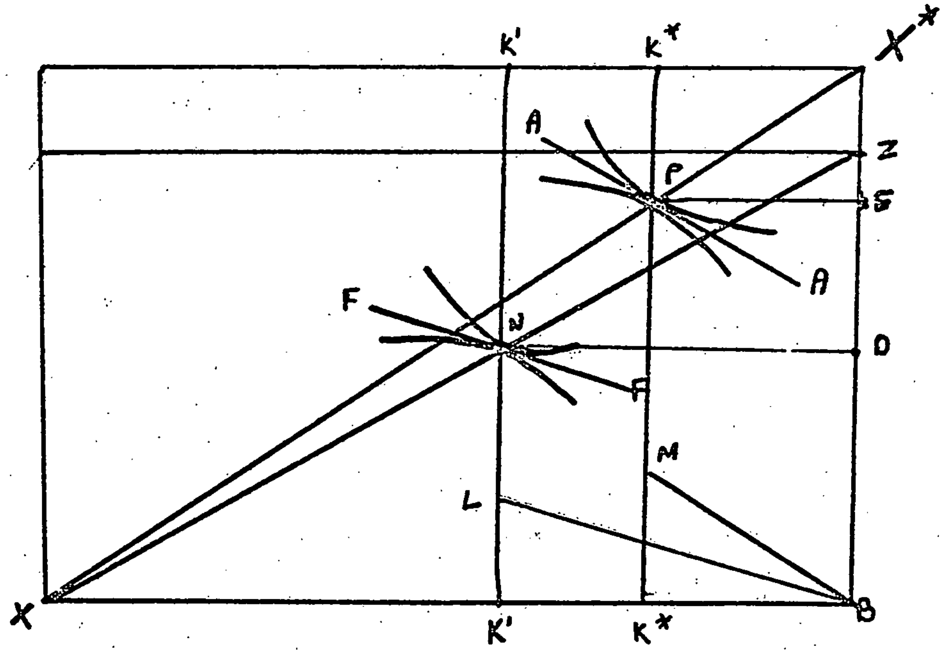

FIGURE 2

From equations (51) and (52) we learn that the effect of a tax on capital imports combined with an oil export quota is eactly identical to the case where an export tax is used instead of a quota. In both cases OPC terms of trade will deteriorate and capital will flow away from OPC into OCN.[19]

CONCLUSIONS

We have investigated several properties of an asymmetrical world economy in which oil is traded for capital services and consumption goods. The direction and magnitude of the terms of trade and capital flows in response to commercial intervention are highly sensitive to the asymmetrical specifications of the economy.[20] When OCN imposes an export tax on the consumption good (equivalent to an import tariff on oil), capital will unambiguously flow to OPC. If the sufficient stability condition holds, then OCN's terms of trade will improve. Analagously, an export tax on oil (import tariff on consumption goods) imposed by OPC will also improve OPC's terms of trade, providing again that the sufficient stability condition holds. But the direction of the capital flow is asymmetrical, for,in the latter case, *capital will again be attracted to OPC*. In both the above cases, the flow of capital is directly related to the world distortion in marginal products of capital.

When compared to the Mundell-Hecksher-Ohlin model, there are similarities and differences. In the latter case capital mobility eliminates trade entirely so that any improvement in the terms of trade is entirely offset by the flow of capital and all prices return to their pre-tariff levels. In our model, capital mobility also offsets the terms of trade, but the degree of offsetting depends on the magnitude of the model's parameters. Only in a special case will the capital mobility offset the terms of trade entirely. In fact, our model allows for the perverse effect, where the capital mobility more than offsets the terms of trade effect. In the Mundell model, the direction of the capital flow depends on the relative intensivities of the factors employed in the taxed sector. In our model, the direction in response to a tax (tariff) is unique.

If OPC implements an oil embargo, OPC's terms of trade will unequivocally improve, providing the capital tax, t, is either zero or negative. It is unclear in which direction capital will flow. These results imply that, in the above asymmetrical framework, an import tariff is not equivalent to a quota, a result established by Falvey (1976) in the traditional two sector model. The main reason lies in the fact that in contrast to the tariff, the embargo does not drive a wedge between domestic and foreign prices. Since an embargo does not distant values of marginal products (in the absence of a capital tax), OPC would be more likely to pursue the quantity restrictions rather than the tax. When a capital and export tax are jointly imposed by OPC, the effect on the terms of trade and the direction and magnitude of capital mobility is identical to the case where an oil embargo is implemented instead of the oil export tax.

Finally a few words about policy proscription for practical men. If OCN countries collude, establishing an international oil consumption cartel, then to improve OCN's terms of trade, OCN must not only levy an export tax, but should implement an accompanying commercial policy prohibiting OCN capital from flowing to OPC. Energy programs designed to increase the degree of substitution between capital and oil will unambiguously improve OCN's terms of trade.

NOTES

1. The specificty implies that this capital is immobile between sectors.
2. Although the stock of capital in oil extraction is fixed, OPC producers may vary the quantity of oil extracted, by changing the degree of utilization of K_0. K_0^S is then services generated by K_0.
3. The OPC production function $\tilde{X}^*$, satisfies the same restrictions.
4. By implication, the marginal propensity to spend is unity, since we have by assumption ruled out savings.
5. The taxes are imposed respectively on P and r. Thus, an export tax is equivalent to a tariff on oil. The proceeds are distributed in a lump-sum fashion to the residents.
6. See page 9.
7. This result contrasts sharply with the neoclassical Hecksher-Ohlin model where the direction of the capital flow depends on the capital labor intensity of the good being taxed.
8. It should be noted that K-O use the name "North-South" whereas we have used "OCN-OPC."
9. Brackets are our own. See K-O op. cit., p. 100.
10. The usual Hecksher-Ohlin model (for example, Kemp (1969)), has the property that the rental rate depends only on the terms of trade, thus changes in the allocation of capital have no effect on the terms of trade. In the Batra model, the price of factors depends directly on factor supplies.
11. This term would be zero if a Cobb Douglas production function is specified.
12. By setting $\frac{dy}{d\tau} = 0$, the optimal tariff may be derived. It will be inversely related to the capital elasticity $\frac{1}{\bar{\varepsilon}}$ and positively related to η^*.
13. $\frac{dp}{d\tau} = \frac{\eta P^*}{\Delta} \quad [P^* r\bar{\varepsilon}(1-s^*(1-\bar{O}t)) - K\mu(\lambda^*-\lambda)s^*t]$

    The above is negative if $P^* r\bar{\varepsilon} > K\mu(\lambda^*-\lambda)$. Even if P rises, capital will still flow from OCN to OPC as indicated by (26)
14. In terms of oil, the volume of exports and oil imports must definitely decrease. However, it is possible for world rental to rise so that production could take place north of L on K'K'. In such a case, BM would be steeper than $B\bar{B}$. The latter will occur if $\bar{\varepsilon}\delta$ is greater than unity. It should be noted that if the numeraire were X, the results would not differ:

Once again the value of oil imports and X exports will unambiguously fall, while the change in interest payments will be uncertain.

15. In deriving (40) and (41), for exposition purposes, we made the assumptions that $\eta = \eta^*$ and $\beta=0$. The results do not change of course when we relax these assumptions.

16. The equivalance of quotas to tariffs has been discussed by Falvey (1976). He demonstrates that in a Mundell-Hecksher-Ohlin model a quota is not equivalent to a tariff for it does not totally eliminate trade and hence it is a more flexible policy tool.

17. In the Hecksher-Ohlin-Mundell model the wedge between home and foreign prices in a case of tariffs is eliminated because capital mobility eliminates completely the trade in goods. In our model the wedge still exists, because mobility of capital does not eliminate trade completely.

18. The equilibrium could take place to the right of KK on contract curve XZ such as point N^*. In such a case rental payments would unambiguously fall. In either case, owners of capital abroad will suffer a real capital loss as world rental rates fall.

19. Note that in the case of an export tax $(\lambda^*-\lambda)$ is a function of τ^*, while in the case of a quota it is independent of Q.

20. The interested reader should consult Kemp and Ohyama's elegant mathematical model and compare it to the above model.

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WHO PAID FOR THE INCREASE OF

ENERGY PRICES?

by

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NOTICE

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The 1973-74 increase in oil prices has been argued to change the pre-1973 pattern of "economic order" in the world. In economics (contrary to politics) we are reluctant to use the term revolution (even the Industrial revolution was spread over more than a century and nowadays would probably be termed "technological change".) Yet, the hypothesis that the price hike of oil has shifted many economies away from their previous course is important for testing given future acts by the oil cartel. The pre-crisis decade was signified by granting political independence to many countries, most of which are still in the less developed countries category in spite of the massive economic aid granted to them. These countries constitute only a small fraction of the world oil market (less than 9 percent in 1972).[1/] Also oil consumption per capita in these countries is the lowest in the world (partly because of climatic effects). Yet either directly or through the international trade, the economies of these countries are still affected by the increase of oil prices.

In this study we ask the explicit question who paid more for the increase of energy prices - the developed or the underdeveloped countries? When talking about payments we do not refer explicitly to expenditures on energy. We have in mind the alternative costs in terms of social welfare. We consider six variables from which costs can be inferred. They are: GNP growth rate or GNP per capita growth rate; unemployment; capital formation; deficit in the balance of trade; inflation rate; and changes of exchange rate. These six indicators (consequences) of the increased energy prices are obviously not independent. Furthermore, given possible tradeoffs among them (e.g., the

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1/ U.N. World Energy Supplies, Table 1. The per capita consumption in the LDC's was 363 kilograms of coal while in the developed countries 6239 kilograms, i.e., about 17 times more.

traditional Philips Curve), they might be manifested to a different extent in different countries, depending, presumably, upon the country's specific marginal rates of substitution in terms of social welfare.

In order to assess the impact of the increased energy prices on the macro variables of the developing countries one should know the structure of the economy and the response parameters of the various sectors to energy prices. While the latter are partly available for developed countries, none are available for the developing ones. On the top of this, the share of non-commercial energy is well above that in the developed countries. Also any assessment is sceptical for predictive purposes due to the relatively faster changing structure of the developing economies (urban-rural, transportation means, employment behavior).

The low figures for per capita consumption of energy might imply that in the residential sector most of the energy consumed is close to the base necessity. In industry, given the relative lower price of labor, energy utilized is again close to the minimum required. Thus, the flexibility downward does not exist and would take place only when forced by major declines in per capita income or by a steep increase in relative prices. Hence, the absorption of the increase in the price of energy is mainly not by changing the quantity of energy, but mainly by other macro economic variables. Since the impacts of the price increases are also indirect through external forces (reduced demand for their raw materials vs. higher prices they have to pay for imported goods), the balance of payment is a major indicator for these effects. Furthermore if borrowing is an effective constraint, energy import quota or heavy duties on oil imports would have to be employed. The effect of either of them on the macroeconomic variables is obvious. (See the work by Hudson and Jorgenson [1978]).

The plan of the study is as follows: The effect of an increase in the price of a major imported input on each of the six economic variables is traced out. Then the performance of each of the six variables in the 1962-1972 period is related to the level of economic development. The same is done for the 1972-76 period. The differences in performances between the two time periods are assigned to the increase of energy prices. The main statistical tool employed in the analysis is a correlation analysis between variables.

Production-Growth Model

For simplicity sake, we concentrate only on energy as a distinctive input in addition to the two domestic inputs, labor and capital (disregarding raw materials which may also be imported). To allow for a rather flexible but close to reality production function, we assume that gross output of the economy, Q, is produced according to the following (in the short run) relation among inputs 1/

$$Q_t = \min[Ae^{rt}(\delta_L((\sum_\tau 1 - U_{L,t-\tau})L_\tau)^{-\rho} + \delta_K(\sum_\tau(1 - U_{K,t-\tau})I_\tau)^{-\rho}))^{-1/\rho}, \beta(t)E_t]$$

where L, I and E denote labor, investments and energy, t and τ stand for time, which also represents technological progress. The latter is either disembodied with parameters δ and $\beta(t)$ or, embodied in labor and capital (L_τ, I_τ). Labor and capital are substitutes. The elasticity of substitution between them is $\sigma = {}^1/1 + \rho$, i.e. constant but not necessarily unity (dated back to Arrow et al (1961)). Labor and capital together account for most of the value added of the economy. Energy is used in a fixed proportion with value

1/ This specific formulation is used since it serves as a hypothesis in a current study (Fishelson (1978)).

added. Energy, E, is obtained from two sources, which are perfect substitutes, a domestic source, E_d, and a foreign source, E_f. The returns to the domestic source accounting wise are part of the recorded value added of the economy, usually defined as GNP.

Hence,

$$GNP = Q - E_f \cdot P_E/P$$

where $\frac{P_E}{P}$ is the price of energy in terms of the domestic product.

$U_{L,t-\tau}$ and $U_{K,t-\tau}$ are the unemployment rates of labor and capital of vintage τ. U_L is known as unemployment rate while $(1 - U_K)$ is the capital utilization rate. When $U_L = U_K = 0$ for all τ the economy is at its maximum potential GNP. The production function also implies that regardless of how large $\beta(t)$ is (its inverse is the output-effective energy, ratio), some positive quantity of energy, E_t, has still to be used. A decline of E_t everything else constant, if not compensated for by an increase of $\beta(t)$ (energy saving technological change), would also cause Q_t to decline.

Because of the infinitely elastic supply of oil in the past, energy could not have been the limiting factor to economic growth. The growth rate was determined by the growth of labor and capital and the rate of technological progress. This growth rate would equal the growth rate of employed energy if there would not have been technological progress in energy utilization. (The production function was assumed to be of fixed proportions at a given point in time, but of varying proportions over time). For example, in the U.S. in the 1929-66 period, GNP grew at an annual rate of 3.29 percent, labor at a rate of 1.15 percent, capital at a rate of 2.20 percent, and their joint labor-capital productivity at a 1.89 percent rate.[1/]

1/ Kendrick, J.W., Postwar Productivity Trends in the United States, 1948-1969, Columbia University Press for MBER, 1973, Table A-17.

With no productivity change in energy utilization, energy would have had to increase by 3.29 percent. It grew, however, at a rate of 2.35 percent, implying technological progress in its usage of 0.94 percent.1/ Note that the technical progress in energy was only one half of that of the capital-labor complex, thus its physical quantity grew at a higher rate than either labor or capital. Hence, the increased energy/labor and energy/capital ratios.

The Macro Economic Model

In this note we do not attempt to develop a complete macroeconomic model. We sign out of a macroeconomic model the elements that are relevant to the questions asked. These relations are:

a) The economy production function
b) Labor market relations
c) Capital services market relations
d) Energy market relations
e) Output market relations
f) a GNP identity
g) a total energy identity
h) an exchange rate relation
i) a domestic price level relation

The model is restricted to the real part of the economy although the quantity of money explicitly appears in the domestic price equation.

The model contains four explicit markets. The first is of output. Supply is determined by technology and input prices. Demand is determined by domestic

1/ Internal Calculations. Energy consumption in 1929 was 24.6 10^{15} Btu and in 1966 56.6 10^{15}Btu.

GNP, domestic price level and foreign demand. The labor market (a market for each vintage of labor) consists of a downward sloping demand which is the marginal product of labor and an
upward sloping supply which might become infinitely elastic at current nominal wages. The upward sloping part depends upon nominal wages and prices. If one believes in money illusion, then the elasticity with respect to nominal wages (positive) acceeds that of the absolute value to the elasticity of prices (negative). The capital market as that of labor is for capital services, i.e. it is not explicitly a market for investment, although the latter can be directly implied from it.

The energy market consists of an aggregate supply curve which is infinitely elastic at the international price. The demand for energy is downward sloping, since (as that for labor and capital) it is the marginal product. Yet, at the short run, for given amounts of labor and capital employed, the demand for energy is inelastic due to the fixed proportion production function.

The four markets are presented diagramatically (formally in the Appendix with the other equations of the macroeconomic system).1/

The Effects of Increasing Energy Prices

To trace out the effects of the exogeneous increase of the price of imported energy on an economy, we go through the diagrams that describe the four markets.2/ The first effect was obviously in the energy market. The horizontal line P_E shifted upward. Although the quantity of imported energy did not change immediately

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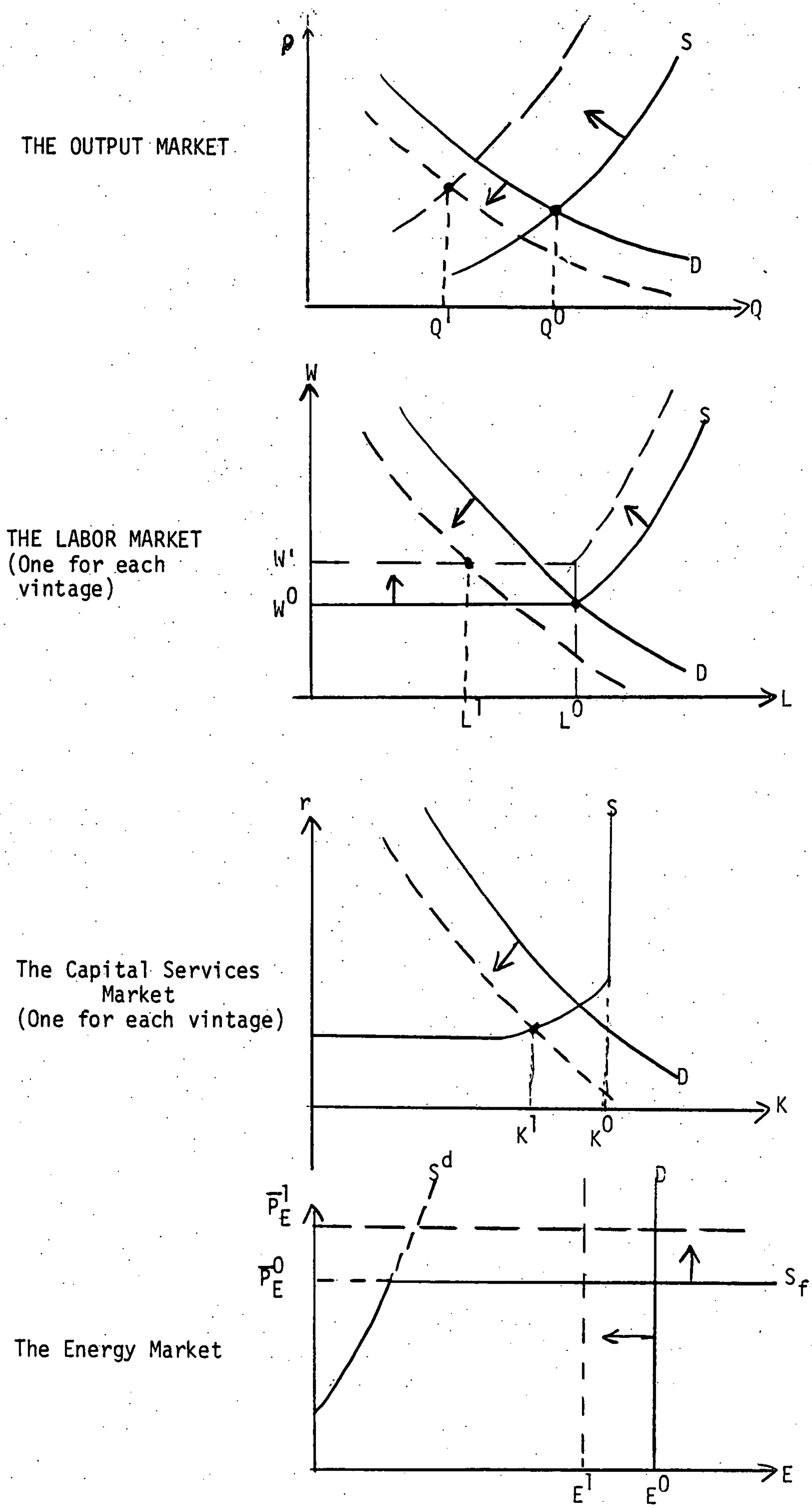
1/ At this stage of the study we do not estimate the parameters of the system.

2/ An alternative procedure is to derive the reduced form equations of the macro economic system and to predict from them the effects of energy prices.



THE FOUR MARKETS

(unless the demand is not infinitely inelastic), the drain of payments for oil out of the system increased while only part of it returned in the form of demand for produced goods. In the output market, the supply, S_Q, immediately shifted upward due to the increased price of an input while, D_Q, falls due to the lower domestic and insufficient growth (or decline) of foreign demands. Equilibrium output obviously declined while the effect on domestic prices is a priori undetermined depending upon the relative shifts of the demand and the supply. (We know, however, that prices did increase).

The decline in desired output leads to a decline in the inputs employed. In the labor market, labor supply, S_L, moved upward due to the domestic price increase while demand, D_L moved downward. With W^o as a lower bound to any equilibrium nominal wage rate, the result is higher nominal wages and unemployment. In the capital market, the supply curve of capital services is almost horizontal up to full utilization of the existing stock, and then becomes vertical. Here, due to the shift of demand, D_K, downward, while S_K is fixed (short run), capital utilization declines (it is measured from the vertical line K^o) thus discouraging new investments (unless they are with higher $\beta(t)$-energy saving). The circle closes when the demand for energy shifts leftward from E^o. Furthermore, domestic energy substitutes somewhat for imported energy.

To summarize the results, we find that due to the increase of energy prices the real GNP declined, unemployment increased, demand for new investment declined (indirectly since the utilization rate of existing capital declined), and the domestic price level increased. It is also expected that the deficit in the current account increased. What happened to the exchange rate is not obvious given that it is the ratio between price levels in two countries (the purchasing power parity theory)but may also be a function of the relative deficits in the balance of payments (the monetary approach to the balance of payments).

The description above is a comparative statistics analysis of an increase of the price of an imported input. The dynamics of the effect, the path of the movement towards the new equilibrium also involves the time dimension and its effects on the economy (population growth, technological progress). Thus, in one country the new (dynamic) equilibrium may be reached within a short period of time while in another country the process of adjustments may persist for a longer period. The factors that affect the length of the adjustment period are the "natural rate" of economic growth, the rates of technological progress and the mix from the energy intensity point of view of the products produced, consumed and traded internationally. The more energy intensive is the mix of each, the slower ceteris paribus will the adjustment process be. However, the energy intensive economies might also have relatively higher rates of technological progress, or, employ technologies with larger elasticities of substitution between energy and other inputs, thus making the adjustment process less costly and shorter in time.

In the following we examine the reaction of the various economies to the 1973-74 increase in energy prices. We do not imply that a new steady state equilibrium was already reached by 1976, the last year for which most of the data are available. Yet, we suggest accepting the results up to that year as indicators to the direction of the final comparative statics.

Empirical Observations

As noted above, we relate the relative changes in the macro-economic variables affected by energy prices to the absolute level of GNP per capita.[1] We examine each of the welfare variables independently. One would, however, like to analyze the behavior of the whole list of the macro economic variables in the pre-1973 period and in the post-1973 period simultaneously, checking for structural changes in the system and specifically identifying the impact of the exogeneous shock - the increase of the price of oil. This task calls for a detailed and fully specified macro model which, at this stage, is beyond the scope of the current research.

The data sources are OECD publications, United Nations publications, and the International Monetary Fund Publications. Those of the OECD, while containing the most detailed data, are limited to OECD members, only some of which can be considered an underdeveloped country (the lowest income per capita in 1972 was in Turkey $435.) Thus, for countries with per capita income in the below-$500 per annum, other statistical sources are explored. Needless to say, for these countries the information is not complete. The missing data overwhelm the existing data the further into the past one goes. Qualitywise, we expect it to deteriorate the further into the past we dig, but no judgement can be passed. This led us to divide the analysis into that related to OECD countries and to one related to developing countries.

The OECD sample consists of 20 countries (the excluded ones being Australia, New Zealand, Luxemberg and Iceland). The results are presented in Table 1 in the form of correlations between the macro-economic variable and the variable which characterizes the countries as to the level of development-GNP per capita. The GNP per capita data are as of 1970.

1/ The social welfare function we have in mind is (obviously more variables can be added): W = F (GNP per capita, GNP total and per capita growth rate, capital formation, unemployment, inflation rate, deficit in the balance of payment, exchange rate). The first three variables have a positive effect of welfare while those listed from unemployment have a negative effect on social welfare.

The results in terms of consequences of the increased oil prices are clearly in favor of the high per capita GNP. In the 1972-76 period the increase of the consumer price index was more strongly negatively linked to the GNP per capita than in the 1967-72 period, while the growth rate of per capita GNP which in the pre 1973 period was negatively correlated with the level of GNP, in the post 1973 period the negativity almost disappeared.

The depreciation rate of the domestic currency against the U.S. dollar was also at a relatively lower rate for high GNP per capita countries. On the other hand the negative correlation between GNP per capita and unemployment rate that was observed previously has weakened. The variable which was not affected was capital formation which remained mildly correlated with per capita GNP as before.

Table 2 contains correlations which link the economic performance variables with energy utilization. It turns out that the stronger was the dependence upon oil (percent of oil in total energy required) the lower was the growth rate of GNP per capita, and the larger was the inflation rate. The correlations are small for capital formation, unemployment and exchange rate depreciation.

The results for growth rates of "total energy required" and electricity generated support each other as do the positive relations with the growth rates of GNP per capita in the pre and post 1973 periods. Of special interest are the consistently high correlations of the growth rate of capital formation and the growth of total energy and electricity requirements. Unemployment and exchange rates are actually unaffected by the growth of energy requirement.

Hence, the estimated correlations establish once again the positive linkage between GNP and energy usage (see Darmstadter (1978)) except that we show it for rates of growth (they do it for absolute levels). It turns out that economies with high per capita GNP are more capable of minimizing diverse effects of exogeneous interferences in the markets at which they purchase inputs (and if generalizing in the form of a hypothesis also in markets at which they sell their output). These conclusions indicate that the less developed countries are the ones that suffered relatively more from the increase in oil prices given that the relations found for GNP per capita at the above $500 can be extrapolated to lower levels.

Due to data deficiencies we present only one check for the relationship between growth rates of energy used and the growth rates of GNP in the LDC's. We assume that if it exhibits the same pattern as that for developed countries the other relations (not tested explicitly for the LDC's, but only for OECD) are also the same, i.e. the conclusions reached above hold for countries in the below $500 GNP per capita.

The Developing Countries

The data for the developing countries are available for shorter time spans than those for the OECD countries. Furthermore, since most of the LDC's are located in geographical areas which do not require space heat, and air conditioning is a major luxury, the per capita energy consumption is likely to stay at low levels, even when GNP per capita increases. Other characteristics that cause inaccuracy in the data and might bias the estimated pattern of growth over time is the relatively large rural farm population which continuously migrates into urban areas. The data on energy consumed is for the more modern sources (oil, gas, coal and electricity) while other sources (wood) are more likely to be used in the rural farm areas.

Similar problematics are relevant also for the GNP data. The growth of the modern sector simultaneously with the decay of the traditional farm sector is likely to show a positive gain even if the real net gain in terms of national product is nil (the traditional sector is hardly accounted for). These reasons lead us to a more general analysis. Table 3 contains data on total consumption of energy and of GNP in 1972 and 1976 in 20 developing countries. In order to avoid standardization of GNP(given in domestic currency) by the official exchange rate (which is less representative of the true purchasing power parity, the less developed the country is) we tabulate rates of growth of energy consumption and total GNP. The correlation coefficient is positive:0.38 which, although not significant, points in the expected direction.

Conclusions

In this study we provide new evidence for the argument that the countries who carry the main burden of the increased energy prices are the less developed ones. We did not investigate the reasons for it nor the paths through which the burden channels into the economy. Studies on production functions do suggest that the main avenue through which input prices affect the national economy is the possibility of substitution between other factors of production and energy. When the elasticity of substitution is small either output declines as the price of the input increases (ceteris paribus with regard to all other prices), implying the increase of unemployment and the decline in capital formation or, even with no change in output the price of output would necessarily increase leading to an inflationary process.

In the real world the outcome is a mix of the two possibilities. As shown in the data all countries experienced both inflation and unemployment to a larger extent in the 1972-76 period than in previous years. We relate it to the increased energy prices. This is somewhat an exaggeration given that other exogeneous disturbances also were present (such as weather effects). To find the net effect of the increased energy prices on the macro-economic variables each country specific macroeconomic model has to be estimated.

TABLE 1

CORRELATION OF MACRO VARIABLES WITH GNP PER CAPITA, 20 OECD COUNTRIES

Variable		Correlation
Consumer price index growth rate 1962-1967		-.55
Consumer price index growth rate 1967-1972		-.52
Consumer price index growth rate 1972-1976		-.86
Gross Fixed Capital Formation Growth Rate	1962-67	-.46
	1967-72	-.46
	1972-76	-.48
GNP per capita growth rate	1952-67	-.36
	1967-72	-.52
	1972-76	-.08
Unemployment rate (average)	1962-67	-.40
	1967-72	-.36
	1972-76	-.28
Exchange rate growth rate*	1967-67	-.24
	1967-72	-.46
	1972-76	-.58

* The depreciation of the domestic currency against the U.S. dollar

TABLE 2

CORRELATION COEFFICIENTS BETWEEN ENERGY CONSUMPTION VARIABLES AND ECONOMIC PERFORMANCE VARIABLES 1972 and 1976, 20 OECD COUNTRIES

	(1)	(2)	(3)	(4)	(5)
% Oil in Total energy required 1972	-.36	.39	-.17	-.02	.13
Same for 1976	-.40	.44	-.16	.17	.23
Total energy required, growth rate, 1967-72*	.74	-.14	.55	.07	-.14
Same for 1972-76	.40	.35	.43	-.03	.09
Electricity Generated, Growth Rate, 1967-72*	.13	.44	.39	.18	.25
Same for 1972-76	.61	.30	.52	-.04	.19

(1) GNP per capita growth rate 1972-76.

(2) Consumer price index growth rate 1972-76.

(3) Gross fixed capital formation growth rate 1972-76.

(4) Unemployment rate (average) 1972-76.

(5) Exchange rate growth rate 1972-76.

* The correlation is with the variables (1)-(5) in the 1967-72 period.

TABLE 3

LESS DEVELOPED COUNTRIES, GNP ENERGY CONSUMPTION AND GROWTH RATES - 1972-1976*

			Energy Consumption		
		GNP	Growth Rate	Energy	Growth Rate
Ghana	1972	5441		1.447	
	1975	6044	3.52	1.619	2.85
Liberia	1972	807.2		.698	
	1975	855.0	1.95	.717	.74
Zambia	1972	105.8		2.312	
	1976	134.6	6.28	2.814	5.03
Argentine	1972	1235		43.045	
	1976	1309	1.47	46.404	1.89
Chile	1972	46472		11.827	
	1976	43996	-1.36	10.323	-3.34
Paraguay	1972	155.3		.345	
	1976	204.8	7.16	.515	10.53
Peru	1972	473.1		8.655	
	1976	571.7	4.85	10.366	4.54
Uruguay	1972	7634		2.941	
	1976	8491	2.70	2.964	.20
Costa Rica					
	1972	14478		.903	
	1976	17528	4.90	1.016	2.99
El Salvador					
	1972	3914		.771	
	1976	4757	5.00	1.073	8.61
Guatemala	1972	3.148		1.282	
	1976	3.924	5.66	1.607	5.81
Honduras	1972	1998		.657	
	1976	2265	3.19	.748	3.30

TABLE 3 (Cont'd)

		GNP	Growth Rate	Energy	Growth Rate
Nicaragua	1972	9204		.787	
	1976	12513	7.98	1.068	7.93
Cyprus	1972	394.4		1.116	
	1976	266.2	-12.30	.959	-3.72
Jordan	1972	254.0		.838	
	1976	364.0	9.41	1.464	14.97
India	1972	629.7		108.62	
	1975	720.6	4.60	132.92	5.18
Korea	1972	6705		26.67	
	1976	10663	12.19	36.58	8.22
Pakistan	1972	98.03		11.37	
	1976	117.71	4.68	13.11	3.62
Phillipines	1972	92.63		11.18	
	1976	122.07	7.14	14.38	6.49
Thailand	1972	239.7		10.18	
	1976	320.6	7.55	13.22	6.73

* GNP is in units of domestic currency in 1970 prices. Energy is in millions of tons of coal.

Sources: GNP International Monetary Fund, Financial Statistics.

Energy - U.N. World Energy Supplies.

APPENDIX

THE ECONOMETRIC MACRO-ECONOMIC MODEL

1) Output Production Function (Domestic Supply)

$$Q = \mathrm{Min}[\alpha(t)(Ae^{\lambda t}(\delta_K((1-U_L)L)^{-\rho} + \delta_K((1-U_K)K^{-\rho}))^{-1/\rho}, \beta(t)E]$$

2. Labor Market-demand (for each vintage of labor)

$$L^d = L^d(W,P)$$

3) Labor Market-Supply (for each vintage of labor)

$$L^S = \begin{cases} L(W,P) & W \geq W^o \\ 0, & W < W^o \end{cases}$$

4) Capital Services Market Demand (for each vintage of capital)

$$C^d = C^d(r,P,W)$$

5) Capital Services Market-Supply (for each vintage of capital)

$$C^S = \gamma K$$

6) Stock of capital (for each vintage of capital)

$$K_{t+1} = (1-d)K_t + I_t$$

7) Investment (potentially for each vintage but with meaning only for the last one).

$$I = I(r,P,\Pi)$$

8) Demand for Energy

$$E^d = Q/\beta(t) + E(\text{Consumption})$$

$$E(\text{Consumption}) = E(GNP,P,P_E)$$

9) Supply of Energy (imports > 0).

$E_d^S = f(P_E)$ domestic sources

$P_E = \overline{P}_E$ foreign supply

$$E = E_d^S + E_f^S$$

10) Demand for the output

$$Q^d = Q(GNP,\ P/P^* GNP^*) = Q^d_d + Q^d_f$$

11) Gross National Product

$$GNP = Q - \overline{P}_E/P \ .\ E^S_f$$

12) Exchange Rate

$$R = R(P/P^*,\ DF)$$

13) Deficit in the Balance of Trade

$$DF = P_E \ .\ E_F - Q^d_f$$

14) Domestic Price Level

$$P = P(W, r, P_E)$$

NOTATIONS

$$\sum_\tau (1-U_{L_\tau})L_\tau = \sum_\tau (L^S_\tau - L^d_\tau) = (1 - U_L)L$$

where τ denotes vintage of labor

$$\sum_\tau (1 - U_{K\tau})K_\tau = \sum_\tau (\gamma_\tau K_\tau - \sum C^d_\tau) = (1 - U_K)K$$

where τ denotes vintage of capital.

W - nominal wage rate

P - domestic price level

P* foreign price level

r - rental cost of capital

I - gross investment

d - capital depreciation rate

E^S_f foreign supply of energy

Q^d_F - foreign demand for domestic products

Q^d_d - domestic demand for domestic products

$\overline{P}_E$ - foreign price of oil

Π - expectations for inflation

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