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Intermediate Inputs and International Trade: An Analysis of the Real and Monetary Aspects of an Oil Price Shock

By

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ABSTRACT

This paper analyses the real and monetary effects of an increase in the price of a traded intermediate input. On the production side, the model differs from other work on the subject in that our economy produces the intermediate input and also traded and non-traded final goods. On the asset side, titles representing ownership of the specific factor which is used in the production of the intermediate input, are explicitly introduced into portfolios. The analysis mainly focuses on the effects of an increase in the price of the intermediate input on the distribution of income, relative prices, production levels, the balance of trade and the level of, as well as the rates of change in, nominal prices and the exchange rate.

Introduction

The succession of increases in the price of oil relative to that of other traded goods over the last decade, has had a drastic effect on both oil importing and oil exporting countries. In the theoretical literature,[1] most of the attention has been focused on the question relating to the proper use of macro policy instruments in order to minimize the short-run unemployment and/or inflation effects that are associated with an oil price shock. With the exception of Rodriguez (1977), and more recently Bruno and Sachs (1979), these models assume that no oil production takes place in the country under analysis, hence all of the intermediate input is imported. The number of countries producing significant quantities of oil has been increasing over the last few years, while at the same time the effects of OPEC price changes have differed substantially from country to country. This indicates a need for a model that can track the developments in an economy following an oil price increase regardless of the level of oil production or whether the country is an importer or an exporter of oil.

The present paper complements the work of Rodriguez (1977) and Bruno and Sachs (1979) by developing such a model and focusing on the distinction between the real and monetary effects of an oil price change. On the real side, the analysis is based on the Heckscher-Ohlin approach, extended to include a third sector that produces the intermediate input. The monetary side of the model draws on the portfolio-balance approach to the problem of exchange rate determination. All of the markets are assumed to be continuously in equilibrium, thus the emphasis is not on unemployment effects, but instead on the effects of an oil price increase on relative prices, distribution of income, production changes, the balance of trade and the level of, as well as the rates of change in, nominal prices and the exchange rate.

Section I develops the production structure of the model which consists of three sectors. One sector produces the traded intermediate input and the other two produce traded and non-traded consumption goods. In the sector that produces the intermediate input, land, rich in resources, is combined with a bundle of other non-traded primary factors, referred to as labor, in the process of producing oil. Oil can be traded at world prices in exchange for a traded consumption good and/or it can be used as an input, along with labor, in the production of traded and non-traded consumption goods.[2]

Assuming that oil and labor are the only two inputs used in the production of final goods, we show that the relative price of traded in terms of non-traded consumption goods, or what is often called the real exchange rate, is solely determined by production technology in the two sectors and the world price of oil in terms of traded consumption goods. Using this relationship between technology, the price of oil, and the real exchange rate, we analyse the effect of an increase in the price of oil in terms of traded consumption goods on production activity in the three sectors, trade in oil, relative prices, rewards to the non-traded factors of production and real income.

We observe that by trading in the world market a final product for a factor of production, in effect the country is able to exchange one factor of production for another. The terms of trade in factors is determined by the technology of production in the sector producing the traded consumption good and the relative price of oil in terms of that same good. Throughout this section it is assumed that trade is continuously balanced and that income is equal to absorption.

In Section II we analyse the asset side of the model and the influence of asset accumulation on demand for consumption goods. Residents are assumed to hold domestic currency, titles representing ownership of oil producing land, and either positive or negative quantities of a traded interest bearing asset which is denominated in terms of foreign currency.[3] Aggregate demand, consisting of demand for traded and non-traded consumption goods, is an increasing function of real income and the real stock of assets. Changes in the relative price of oil will affect aggregate demand through both of these channels, and in general, result in a change in income relative to absorption. This in turn is reflected in the trade account and changes in asset stocks that move the economy along the adjustment path to the steady state.

Along this path, we find a direct relationship between the magnitude and direction of a country's trade in oil, and the effect of an oil price increase on its balance of trade and the exchange rate. Furthermore, as the economy adjusts to the oil price shock, it will experience a rate of inflation and currency depreciation which is greater or less than the rate of growth in its money supply, depending on whether the oil price increase has created a deficit or a surplus in its balance of trade. Our dynamic analysis is based on the assumption that asset holders have perfect foresight and that changes in OPEC pricing policy are unanticipated. At the end of this section we briefly discuss the effects of monetary and fiscal policy. Finally, Section III states some conclusions and suggestions for further research.

I. The Three-Sector Production Structure

In the "Input Tier", oil, R, is produced according to a linear homogeneous production function, by using a given amount of oil rich land, $\bar{L}$, and variable amounts of a homogeneous bundle of non-traded primary factors, N. We shall refer to N as labor, for short. Using the subscripts, r, t, and q, to indicate that the subscripted variable pertains to sectors R, T and Q, respectively, we can write the production function for oil in its intensive form as

$$(1) \quad R = N_r h(\ell_r), \qquad \text{where } \ell_r = \bar{L}/N_r$$

As usual, we assume that the production functions in all three sectors are characterized by positive but diminishing marginal physical products of each factor, and that increased utilization of one factor raises the marginal product of the other.

In the "Output Tier", both traded, T, and non-traded consumption good, Q, are produced under constant returns to scale by using oil, R, and labor, N. The two production relationships can be written in their intensive forms as

$$(2) \quad T = R_t f(n_t), \qquad \text{where } n_t = N_t/R_t$$

$$(3) \quad Q = R_q g(n_q), \qquad \text{where } n_q = N_q/R_q.$$

Labor is fully employed and its supply is fixed at $\bar{N}$, thus

$$(4) \quad N_r + N_t + N_q = \bar{N},$$

while the supply of oil to the economy is not predetermined. Assuming that our economy has no monopoly power in trade, T can be exchanged for R in the world market at fixed terms of trade. The exogenously given relative price of oil in terms of T is denoted by ρ. Net exports of oil, $\tilde{R}$, which may be $\gtrless 0$, are defined as

$$\tilde{R} = R - R_t - R_q.$$

Although the model allows for $R \geq 0$, we assume that at least some of both T and Q is produced domestically, hence $R_t > 0$ and $R_q > 0$. Assuming also that labor is perfectly mobile among the three sectors, that oil can be costlessly allocated between the two consumption goods sectors, and that competition prevails in all markets, factor rewards are determined as follows:

$$(5) \quad f'(n_t) = w$$

$$(6) \quad g'(n_q) = we$$

$$(7) \quad \rho[h(\ell_r) - \ell_r h'(\ell_r)] = w$$

$$(8) \quad f(n_t) - n_t f'(n_t) = \rho$$

$$(9) \quad g(n_t) - n_q g'(n_q) = \rho e$$

where e is the relative price of T in terms of Q, and w is the real wage in terms of T. Equations (5) - (7) state that for each of the sectors, T, Q, and R, respectively, the marginal productivity of labor, evaluated in terms of T, must be equal to w. Similarly, equations (8) and (9) state that oil will be used in the production of T and Q up to the point where the value of the marginal product of oil is equal to its price.

Equations (5) - (9) can be used to solve for w, e, n_t, n_q, and ℓ_r as a function of ρ. Having solved for ℓ_r, and given $\bar{L}$, we can find the level of employment in the input tier, $N_r = \bar{L}/\ell_r$, and thus also the level of oil output, R. Since $\overline{N}$ is given, the total labor supply available to the output tier is $\overline{N} - N_r$, while domestic oil output is R. We thus have the dimensions of an Edgeworth Box for the output tier under autarky. With trade, as we shall see, the dimensions of that box, or the amount of oil available to the output tier, will in general be altered. The dimensions will change in such a way that output of non-traded goods is equal to the demand for them, while the output of T exceeds domestic demand for T by an amount equal to net exports, $\tilde{T}$, which may be positive or negative.

Let us now proceed to solve for some of the relationships that arise from our model. From equations (5) and (6), we have $w = f'(n_t)$ and $e = g'(n_q)/f'(n_t)$. Using these two equations in (7) and (9), we can write (7) - (9) as

(7') $\rho[h(\ell_r) - \ell_r h'(\ell_r)] = f'(n_t)$

(8) $f(n_t) - n_t f'(n_t) = \rho$

(9') $f'(n_t)[g(n_q) - n_q g'(n_q)] = \rho g'(n_q)$

Differentiating this system of equations and writing it in matrix form, we have

$$\begin{bmatrix} \rho\ell_r h''(\ell_r) & f''(n_t) & 0 \\ 0 & -n_t f''(n_t) & 0 \\ 0 & f''(n_t)e\rho & -g''(n_q)[wn_q + \rho] \end{bmatrix} \begin{bmatrix} d\ell_r \\ dn_t \\ dn_q \end{bmatrix} = \begin{bmatrix} (w/\rho)d\rho \\ d\rho \\ wed\rho \end{bmatrix}$$

Solving the system, we obtain

$$(10) \quad \frac{d\ell_r}{d\rho} = \frac{1}{\Theta_R^T n_t \rho \ell_r h''(\ell_r)} < 0$$

$$(11) \quad \frac{dn_t}{d\rho} = \frac{-1}{n_t f''(n_t)} > 0$$

$$(12) \quad \frac{dn_q}{d\rho} = \frac{-e\Theta_R^Q}{n_t g''(n_q)\Theta_R^T} > 0$$

where Θ_X^Y denotes the distributive share of factor X in industry Y. Our results show that an increase in the price of oil in terms of traded goods increases the labor intensity of all three sectors. This would be the expected outcome if the relative price of oil in terms of labor, ρ/w, were to rise along with ρ. One can easily see that that is the case by looking at the Lerner diagram in Figure 1. The TT isoquant represents unit output of the traded consumption good. It's value in terms of R is initially equal to $1/\rho°$. An increase in ρ to ρ', will reduce the value of a unit of T in terms of R to $1/\rho'$. If production is to continue in that sector, w must necessarily fall. It follows that ρ/w increases proportionately more than ρ. Differentiating equation (5) and using (11), we can solve explicitly for the proportionate change in w, $\hat{w}$, as a function of technology in the T sector and the proportionate change in the price of oil, $\hat{\rho}$.

$$(13) \quad \hat{w} = -\hat{\rho}\left(\frac{\Theta_R^T}{\Theta_N^T}\right), \quad \text{or} \quad \frac{dw}{d\rho} = \frac{-1}{n_t}$$

The relative price of T in terms of Q, or what we have called the real

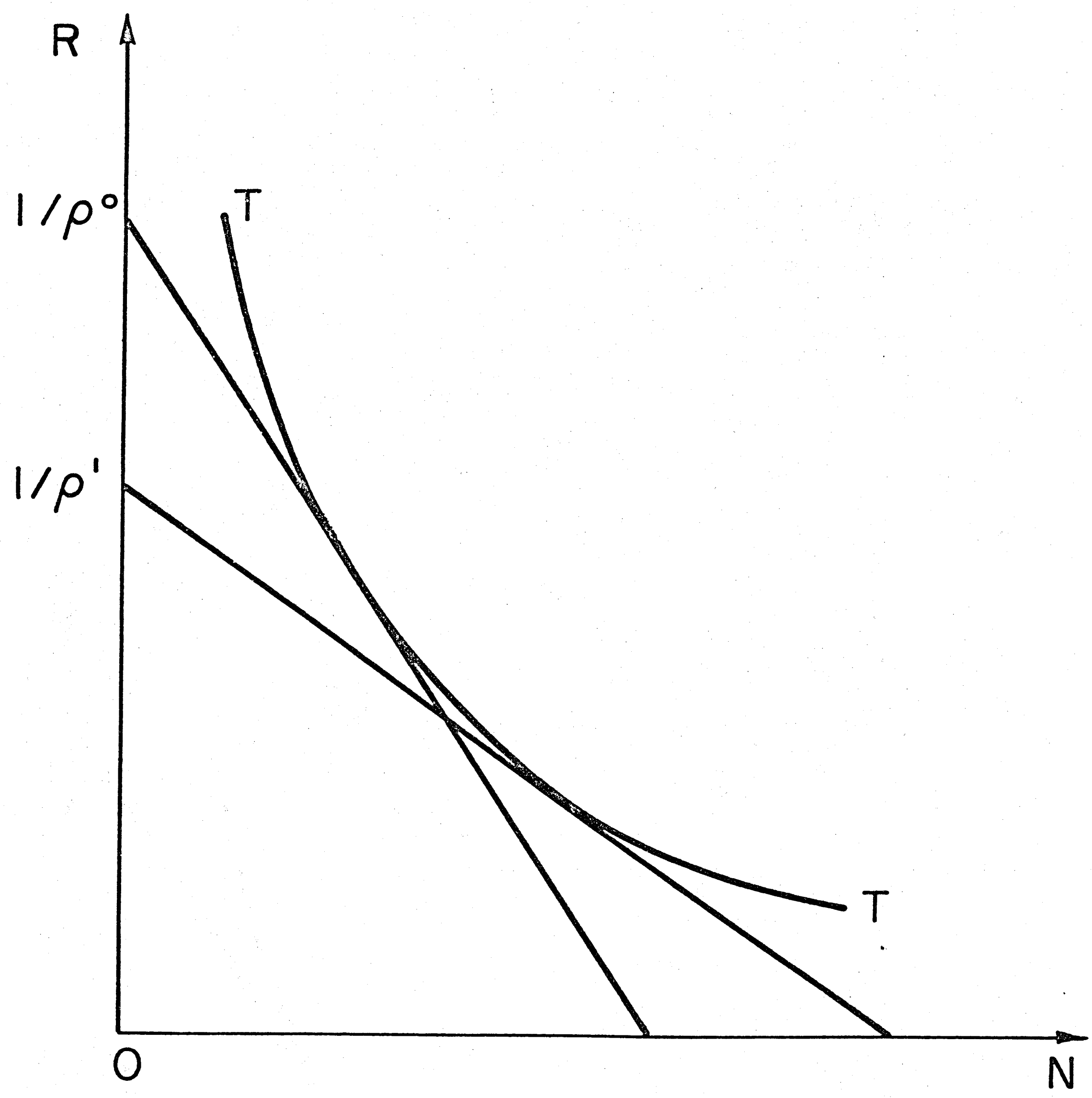

FIGURE 1

exchange rate, e, is determined solely by the technology in the output tier and ρ. Given the relationship between $\hat{w}$ and $\hat{\rho}$ in equation (13), and assuming away the possibility of factor intensity reversals in the output tier, we can use the familiar Stolper-Samuelson relationship between factor prices and product prices to solve for $\hat{e}$ as a function of $\hat{\rho}$ and the technology of production in the output tier.

$$(14)\quad \hat{e} = (\hat{w} - \hat{\rho})(\Theta_N^T - \Theta_N^Q) = \hat{\rho}\left[\frac{\Theta_N^Q - \Theta_N^T}{\Theta_N^T}\right]$$

As one would expect, the increase in the price of oil in terms of labor will result in an increase in the relative price of the final good which uses oil more intensively.

Having described the relationships between ρ and factor intensities in the three sectors, as well as the relative factor and commodity prices, we can proceed to solve for the levels of output of R, T and Q, the direction and volume of trade, and the effects on production and trade following an increase in ρ. In Figure 2, the length of the horizontal line segment OQ represents the fixed endowment of labor, $\bar{N}$. Given also the fixed endowment of land, $\bar{L}$, we can represent the production function pertaining to the input tier (equation (1)) by the curve OR_{max}. The maximum level of oil output is QR_{max}, but the actual level of production will be less than that since some labor is also allocated to the output tier. For any given value of ρ, in particular $\rho°$, we have seen that the system of equations (5) - (9) determines the unique real wage in terms of oil, $w°/\rho°$. Employment in the input tier is at an equilibrium level only if the marginal physical product of labor is equal to $w°/\rho°$. In Figure 2, this occurs at the point

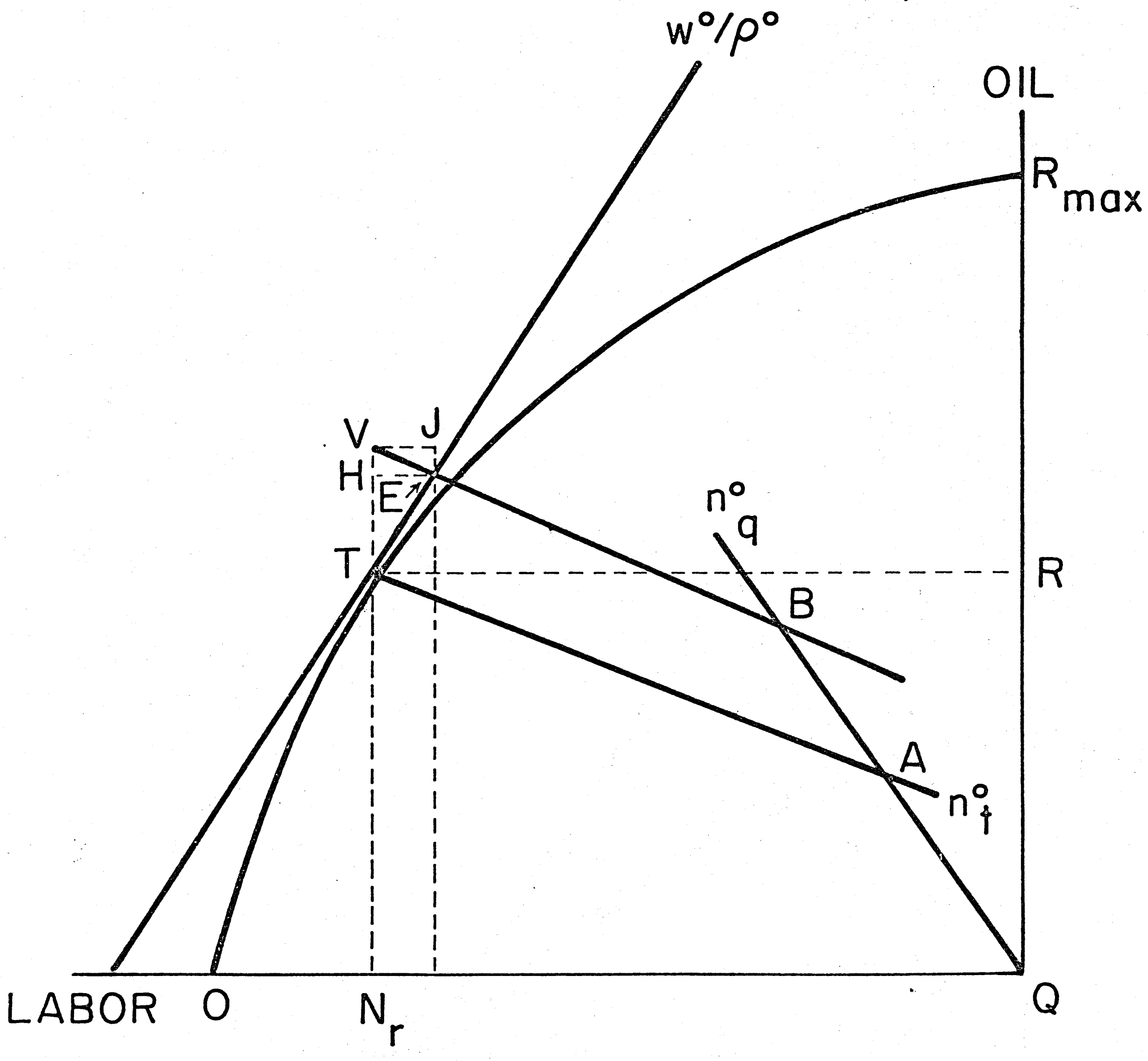

FIGURE 2

of tangency between the $w°/\rho°$ line and the oil production function, OR_{max}. The levels of oil production and employment in the input tier are QR and ON_r, respectively. The endowment of labor and oil that the output tier can operate with is given by the dimensions of the Edgeworth Box, $TRQN_r$. Using point T as the origin for the T sector and Q as the origin for the Q sector, we can project the n_t° and n_q° expansion paths from the respective points of origin. The slopes of these expansion paths $(-1/n_t^\circ$ and $-1/n_q^\circ)$, as we have seen above, are determined by ρ and the state of technology in the output tier. The expansion rays have a superscript "∘" indicating that they correspond to the relative price of oil $\rho°$. In the unlikely case such that the country neither exports nor imports oil $(\tilde{R} = 0)$, the allocation of resources within the output tier would be given by point A.[4] Production and consumption of T and Q are then given by the segments TA and QA, respectively.

Suppose that while continuing to maintain equality between income and expenditure, residents of our country decide to buy more units of Q. This can be represented by a longer segment, BQ, for example. With competitive markets and perfectly mobile factors, production will adjust to meet this change in demand. Since Q is oil intensive relative to T, in this particular case, we know that by the Rybczynski theorem, the necessary production changes can take place only if the output tier's endowment of oil increases relative to its labor endowment. Given the possibility of trading T for R, this is in effect accomplished. In Figure 2, the country can obtain TV of oil in exchange for a quantity of traded consumption good given by VE. In order to produce VE of traded consumption good, it is necessary to use VJ of labor and VH of oil. The net effect on the endowment of labor and oil that can be used by the output tier in order to produce goods *for the home market*, can therefore be summarized by a movement up along $w°/\rho°$ from point T to point E. The distance TV represents the quantity of oil imported, $-\tilde{R}$, and that same distance also measures the oil value of exports of T, $\tilde{T}/\rho°$.

If Q were instead the labor intensive consumption good, a shift in demand toward Q and away from T would result in a pattern of trade that is the reverse of the one described above. In order to produce more of the now labor intensive Q, the country would have to export R in exchange for T and thus move the "effective endowment" point down along $w°/\rho°$. *By trading one final product for one factor of production, in effect the country can trade one factor of production for another.* The terms of trade between the two *factors*, $w°/\rho°$, is determined by ρ and the technology of the sector producing the traded final product.

The model can be easily applied to countries with any ratio of $\bar{L}$ to $\bar{N}$ by varying the shape of the QR_{max} schedule. The special case of $\bar{L} = 0$, which is commonly used in models that analyse the effects of an oil price increase, can be represented in Figure 2 by drawing the $w°/\rho°$ line through point 0. That point corresponds to the autarky endowment of the output tier and emphasizes the vital need to trade that characterizes countries which lack resources that are used in production of intermediate inputs.

An increase in the price of oil in terms of T from $\rho°$ to ρ', results in a proportionately greater decline in w/ρ. This is shown in Figure 3 as a rotation of w/ρ line from $w°/\rho°$ to w'/ρ'. For countries that have some oil producing land, this results in a higher level of employment in the oil sector, N_r', and a correspondingly higher rate of oil production, R'. For a country

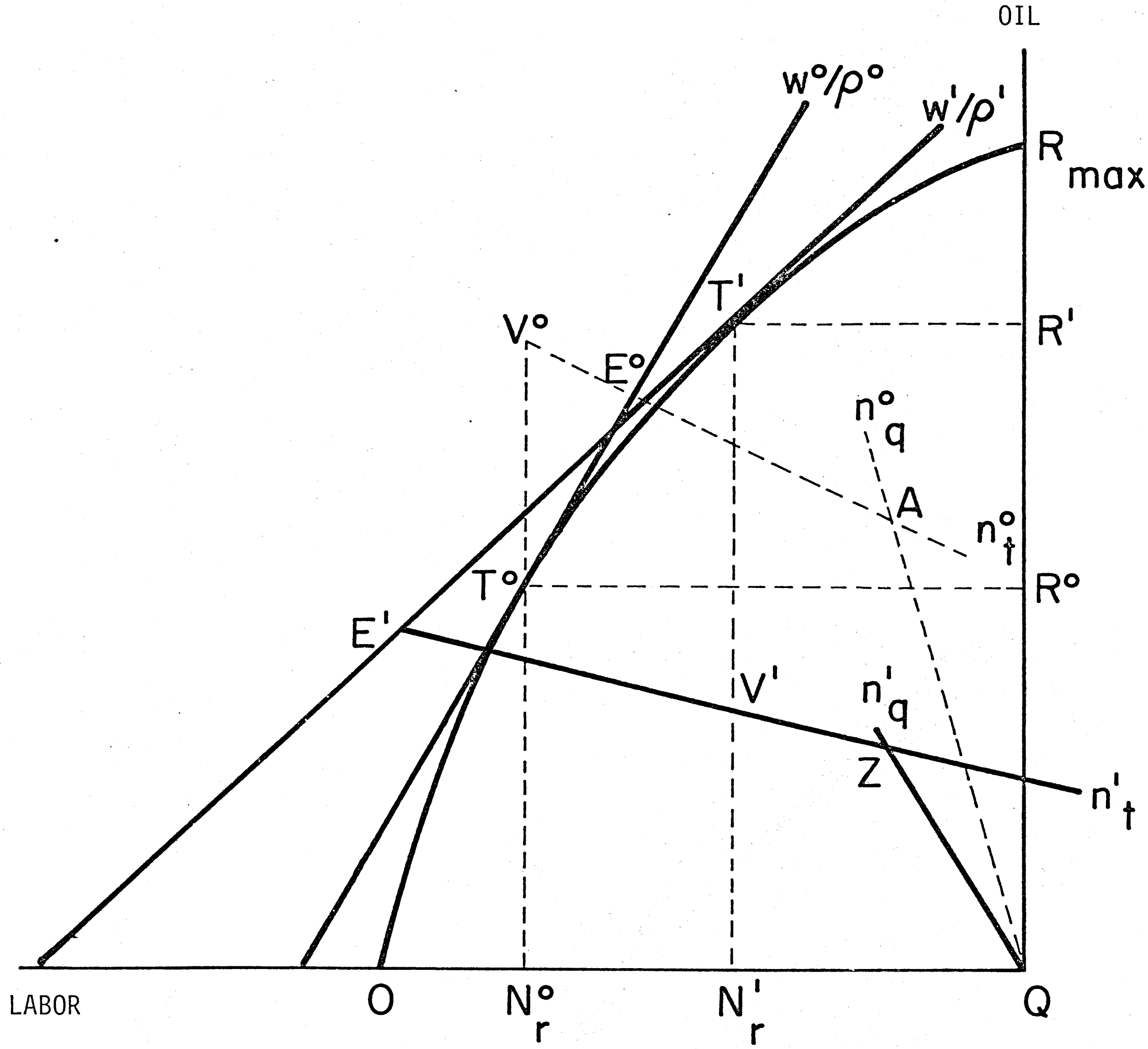

FIGURE 3

that has none of the oil producing land, $N_r = R = 0$, so its oil production is not affected, but the terms at which it can trade its "effective endowment" move against labor and in favor of oil in a proportion that is the same for every country, provided that the technology of production in the T sector is identical throughout the world.

The economy depicted in Figure 3 was initially importing $T^\circ V^\circ$ of oil in exchange for $V^\circ E^\circ$ of traded consumption goods, resulting in an "effective endowment" at point E°. This endowment was then used to produce for the home market $E^\circ A$ of traded and AQ of the non-traded consumption good. With an increase in ρ, both sectors in the output tier become more labor intensive. This is described by expansion paths n_t' and n_q' which are flatter than the initial n_t° and n_q°.

An increase in ρ will change the relative price of T in terms of Q according to equation (14). In this particular example T is labor intensive, implying that e will fall. This will have an effect on the allocation of domestic consumption expenditures between T and Q. Furthermore, the increase in ρ will also change real incomes of these same consumers. Assuming that titles to land are not traded internationally, real income in terms of traded and non-traded consumption goods, Y_T and Y_Q, respectively, can be defined as

(15) $Y_T = w\bar{N} + \rho h'(\ell_r)\bar{L}$, and

(16) $Y_Q = eY_T$

Since the oil production function is linear homogeneous, $\rho h'(\ell_r)\bar{L} = \rho R - N_r w$, and we can write Y_T as

$$Y_T = (\bar{N} - N_r)w + \rho R.$$

Differentiating this expression with respect to ρ, noting that $dR = (w/\rho)dN_r$, and using the relationship between w and ρ given in equation (13), we obtain

$$(17) \quad \frac{dY_T}{d\rho} = \frac{N_r - \bar{N}}{n_t} + R$$

Keeping in mind the definitions of $\bar{N}$, $\tilde{R}$ and n_q, we can rewrite (17) as

$$(17') \quad \frac{dY_T}{d\rho} = \tilde{R} + R_q \left[1 - \frac{n_q}{n_t} \right],$$

or we can write this relationship in terms of proportionate changes as

$$(18) \quad \frac{\hat{Y}_T}{\hat{\rho}} = \frac{\rho\tilde{R}}{Y_T} + \frac{\rho R_q}{Y_T} \left[1 - \frac{n_q}{n_t} \right].$$

By differentiating equation (16) and using equation (14), we can express the proportionate change in real income, measured now in terms of non-traded consumption goods, as

$$(19) \quad \frac{\hat{Y}_Q}{\hat{\rho}} = \frac{\rho\tilde{R}}{Y_T} + \frac{\rho R_q}{Y_T} \left[1 - \frac{n_q}{n_t} \right] + \left[\frac{\Theta_N^Q - \Theta_N^T}{\Theta_N^T} \right]$$

The proper measure of the proportionate change in real income, however, is a weighted average of $\hat{Y}_T$ and $\hat{Y}_Q$, with weights being equal to the expenditure shares of the two consumption goods. Denoting the fraction of income spent on Q by α, and on T by $(1 - \alpha)$, we can write the proportionate change in real income, $\hat{Y}$, relative to $\hat{\rho}$, as

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$$(20) \quad \frac{\hat{Y}}{\hat{\rho}} = \frac{\alpha \hat{Y}_Q}{\hat{\rho}} + \frac{(1 - \alpha)\hat{Y}_T}{\hat{\rho}}$$

Substituting equations (18) and (19) into (20) and rearranging terms, we obtain

$$(20') \quad \frac{\hat{Y}}{\hat{\rho}} = \frac{\rho \tilde{R}}{Y_T} + \frac{\rho R_q}{Y_T}\left[1 - \frac{n_q}{n_t}\right] + \alpha\left[\frac{\Theta_N^Q}{\Theta_N^T}\right] - \alpha$$

The sum of the last three terms is equal to zero,[5] therefore $\hat{Y}/\hat{\rho} = \rho\tilde{R}/Y_T$, confirming our intuition that a country's real income is affected as a result of a change in ρ only to the extent that it exports or imports oil.

An increase in ρ will therefore generate both income and substitution effects on the demand side of the model. For now, let us assume that these forces move the equilibrium point from A to Z in Figure 3. Production and consumption of Q is given by the distance ZQ, while production and consumption of T is represented by line segments V'Z and E'Z, respectively. The excess of consumption of T, relative to production, is imported in exchange for T'V' of oil exports.

In general, the effect of an increase in the relative price of oil on the production side of the model, is to raise employment and the rate of production in the oil sector and reduce the oil intensity of production and the level of activity in the output tier. Volume of oil exports (imports) will tend to rise (fall), or as in the case depicted in Figure 3, an oil importer may become an oil exporter.

We are now ready to introduce the asset markets and analyse the demand side of the model.

II. Portfolio Balance, the Exchange Rate and the Balance of Trade

Non-human wealth of our residents consists of domestic currency, M, homogeneous shares which represent ownership titles to the nation's oil producing land, D (the outstanding number of these shares is equal to $\bar{L}$), and net holdings of an internationally traded, foreign-currency denominated, short-term security, F. Domestic currency and land titles are assumed not to be traded internationally. Total holdings of assets by domestic residents, evaluated in terms of domestic currency, A, can be written as

$$(21)\quad A = M + SD + EF,$$

where S and E are domestic currency prices of one share of land and one unit of foreign currency, respectively.

Assuming that asset holders view F and D as perfect substitutes, the yields on these two securities will be equalized. Denoting the exogenously given world rate of interest by i^*, and defining units of T such that their foreign-currency price is equal to unity, in an efficient market

$$(22)\quad i^* = \frac{h'(\ell_r)\rho E}{S} + \sigma - \varepsilon,$$

where σ and ε are the expected rates of change in S and E, respectively. Under the commonly used rational expectations assumption, these expected rates of price change are equal to the actual. Noting that $h'(\ell_r)$ is determined by technology and ρ, both of which we assume are not expected to change over time, any path of asset prices characterized by $\sigma - \varepsilon \neq 0$ is explosive. Rational speculators will not choose an adjustment path along which S/E falls to zero or rises to infinity because the "fundamentals" don't justify it. This implies that along any stable path, $\sigma - \varepsilon = 0$. We can now use equation (22) to solve for S.

$$(23) \quad S = \frac{h'(\ell_r)\rho E}{i^*}$$

Using (23), A can be written as

$$(21') \quad A = M + E\left(F + \frac{h'(\ell_r)\rho D}{i^*}\right)$$

We assume that λ, defined as the desired ratio of money to income yielding assets in the portfolios of domestic residents, is a function of the opportunity cost of holding domestic currency, $\varepsilon + i^*$, and the level of real income, Y.

$$(24) \quad \frac{M}{E\left(F + \frac{h'(\ell_r)\rho D}{i^*}\right)} = \lambda(\varepsilon + i^*, Y), \text{ with } \lambda_1 < 0 \text{ and } \lambda_2 > 0.$$

By rearranging terms, we can write (24) as

$$(25) \quad E = \frac{M}{\lambda(\varepsilon + i^*, Y)\left(F + \frac{h'(\ell_r)\rho D}{i^*}\right)}$$

which gives us the nominal exchange rate as a function of M, ε, F, and ρ. The remaining variables that affect E in equation (25) are held constant in our model. By differentiating this equation with respect to M, ε, F, and ρ, we obtain

(26) $$\frac{\partial E}{\partial M} = \frac{E}{M} > 0$$

(27) $$\frac{\partial E}{\partial \varepsilon} = \eta_{\varepsilon} E > 0$$

(28) $$\frac{\partial E}{\partial F} = \frac{-E^2}{FE + SD} < 0$$

(29) $$\frac{\partial E}{\partial \rho} = \frac{-E\eta_y \tilde{R}}{Y_T} - \frac{\frac{E^2}{i^*}\left(R + \frac{N_r}{n_t}\right)}{EF + SD} \gtrless 0$$

where $\eta_{\varepsilon} \equiv -\lambda_1/\lambda(\cdot) > 0$ is the "elasticity" of demand for money with respect to the opportunity cost of holding it, and $\eta_y \equiv \frac{\lambda_2 Y}{\lambda(\cdot)} > 0$ is the income elasticity of demand for money.

Intuitively, these results may be explained as follows. An increase in the money supply results in currency depreciation as unwanted balances are brought to the foreign exchange market where asset holders attempt to exchange them for income yielding foreign securities. An increase in the expected rate of depreciation leads to the same chain of events. Accumulation of F, on the other hand, increases the size of domestic portfolios and, by way of a scale effect, raises the demand for money. Domestic currency appreciates as residents attempt to exchange through the foreign exchange market part of their newly acquired F for M. Finally, an increase in ρ affects the nominal exchange rate through two distinct channels. As was shown in Section I, real income rises or falls with ρ, depending on whether the country is an oil exporter or importer. The change in income in turn affects the demand for money and the exchange rate in an already familiar way, thus an oil exporting (importing) country should expect to see its currency appreciate (depreciate) through this particular channel. The first term on the right hand side of (29) captures this effect. On the other hand, an increase in ρ is also associated with a rise in the value of the marginal product of oil producing land. This brings about a jump in the price of D. The capital gains raise the value of asset holdings and the demand for money along with it. The second term on the right hand side of (29) corresponds to this effect. In summary, an increase in ρ affects the exchange rate by influencing the demand for money through changes in real income and portfolio scale. The first effect may be positive or negative, depending on whether a country exports or imports oil, while the second effect is always non-negative. Note, however, that equation (29) is a partial derivative. In evaluating the total effect of an increase in ρ on the exchange rate, we must also consider the relationship between ρ and ε in the short run, and ρ and F in the long run. Nonetheless, it is clear that the nominal exchange rate is a *monetary* variable which is influenced by the *real* phenomena only to the extent that the demand for money is affected.

In Section I, we analysed the factors that determine the real exchange rate. In this section we did the same for the nominal. One can examine the effect of an increase in ρ on the nominal price of Q, P_q, by remembering that $P_q = E/e$. Looking at equations (14) and (29), we see that the sign of $\partial P_q/\partial\rho$ depends on a number of factors. We may note briefly, however, that $\partial P_q/\partial\rho$ is definitely positive if Q is oil intensive relative to T and oil imports of the country are sufficiently large so that an increase in ρ results in an exchange rate depreciation. Similarly, $\partial P_q/\partial\rho$ is definitely negative if T is oil intensive relative to Q and the country exports oil. These, of course, are not the necessary conditions.

We proceed by introducing the demand side of the consumption goods market and the balance of trade.

Real consumption expenditures, C, are assumed to be an increasing function of real income, Y, and real assets, A/P, where P is the consumer price index.

$$(30)\quad C = C(Y, A/P) \text{ with } 0 < C_1 < 1, \text{ and } C_2 > 0$$

Using a Cobb-Douglas form of the price index, we define P as

$$(31)\quad P = P_q^{\alpha}E^{1-\alpha}$$

Remembering the definition of the real exchange rate, we can write P as

$$(31')\quad P = E/e^{\alpha}$$

Making use of equations (21'), (24) and (31'), real assets can be defined as,

$$(32)\quad \frac{A}{P} = \frac{e^{\alpha}}{i^*}[1 + \lambda(\varepsilon + i^*, Y)][Fi^* + h'(\ell_r)\rho D]$$

Real expenditure on the non-traded consumption good, C_q, is a fraction $\alpha(e)$ of total expenditure, where $\alpha'(e) > 0$.

$$(33)\quad C_q = \alpha(e)C(Y, \frac{e^{\alpha}}{i^*}[1 + \lambda(\varepsilon + i^*, Y)][Fi^* + h'(\ell_r)\rho D])$$

Similarly, real expenditure on T, C_t, is a fraction $1 - \alpha(e)$ of total real spending.

$$(34)\quad C_t = [1 - \alpha(e)]\, C(Y, \frac{e^{\alpha}}{i^*}[1 + \lambda(\varepsilon + i^*, Y)]\,[Fi^* + h'(\ell_r)\rho D])$$

In Section I, we *assumed* that a particular consumption point is selected. Equation (33) formally determines the demand for Q as well as the "demand determined" output of Q.[6] Equation (34) specifies the demand for traded consumption goods, which in general will not be equal to the level of production, T. In Section I, under the assumption that income is always equal to expenditure, exports (imports) of traded consumption goods were always equal in value to imports (exports) of oil. In the present section we are concerned with the adjustment process, and although income is equal to expenditure in steady state, this need not be the case in the short run. As assets are changing, income will differ from expenditure, the difference of course being the balance of trade. Under a perfectly flexible exchange rate, the foreign-currency value of the trade surplus is equal to the rate of foreign asset accumulation, $\dot{F} = dF/dt$.

$$(35)\quad \dot{F} = \tilde{T} + \rho\tilde{R} = \frac{P[Y - C(Y, A/P)]}{E}$$

Note, however, that $PY/E = Y_T$ and $(P/E)C(Y, A/P) = C(Y_T, A/E)$, so we can write $\dot{F}$ as

$$(35')\quad \dot{F} = Y_T - C\left(Y_T, [1 + \lambda(\varepsilon + i^*, Y)]\left(F + \frac{h'(\ell_r)\rho D}{i^*}\right)\right)$$

For any given ρ, $\dot{F}$ is a function of only F and ε. We can write this relationship in reduced form as

(35") $\dot{F} = \phi(F, \varepsilon; \rho)$,

with partial derivatives of $\phi(\cdot)$ evaluated in a neighborhood of the steady state given by

$$(36) \quad \frac{\partial \phi}{\partial F} = -C_2[1 + \lambda(\cdot)] < 0$$

$$(37) \quad \frac{\partial \phi}{\partial \varepsilon} = -C_2\lambda_1 \left(F + \frac{SD}{E}\right) > 0$$

$$(38) \quad \frac{\partial \phi}{\partial \rho} = (1 - C_1) \left[\tilde{R} + R_q \left(1 - \frac{n_q}{n_t}\right)\right] - \frac{C_2\lambda_2 \tilde{R}(EF + SD)}{P}$$

$$-C_2[1 + \lambda(\cdot)] \left[\frac{R + N_r/n_t}{i^*}\right] \gtrless 0$$

Equations (36) - (38) can be explained as follows. An increase in F will reduce $\dot{F}$ since it increases the stock of assets and raises expenditure relative to income. In contrast, an increase in the expected rate of depreciation lowers the demand for money and, through currency depreciation, the real money supply. The wealth effect reduces expenditure relative to income and raises the rate of foreign asset accumulation.

A change in ρ, however, has an ambiguous effect on $\dot{F}$. First we recall that the effect of a change in ρ on real income, measured in terms of traded consumption goods, is given by equation (17'). Intuitively, that relation states that real income, evaluated in terms of T, will rise (fall) if the value of resources that are *not* used in the T sector (i.e., $\rho\tilde{R} + \rho R_q + wN_q$) increases (decreases) as a result of an increase in ρ. If $\tilde{R} > 0$ and Q is oil intensive relative to T, Y_T unambiguously rises as both the value of oil exports and of resources used in the Q sector increases along with ρ. Similarly, if $\tilde{R} < 0$ and T is oil intensive relative to Q, Y_T will unambiguously fall. In the two remaining cases (i.e., $\tilde{R} > 0$ with $n_q > n_t$ and $\tilde{R} < 0$ with $n_t > n_q$) the sign of $dY_T/d\rho$ is ambiguous. In general, with the marginal propensity to consume between 0 and 1, an increase in ρ will tend to improve or worsen the balance of trade through this particular channel, depending on whether $dY_T/d\rho$ is greater or less than zero. This effect is captured by the first term on the right hand side of equation (38).

We also know that an increase in ρ will change real income in terms of a bundle of traded and non-traded consumption goods in the direction that depends on the sign of $\tilde{R}$ (i.e., $dY/d\rho = \tilde{R}Y/Y_T$). The change in real income in turn affects the demand for money, and through a change in the exchange rate, the real money supply and the real stock of assets. This has an effect on absorption and the balance of trade, as indicated by the second term on the right hand side of (38). Finally, the third term represents the effect on expenditure of an increase in the value of assets as the price of land titles jumps to a higher level along with ρ. The trade balance will deteriorate as expenditures rise, hence this term is negative (or at most zero, as is the case when $D = 0$).

We observe that both the sign and the absolute value of $\partial\phi/\partial\rho$ is related to the country's net exports of oil, $\tilde{R}$. More specifically,

$$\frac{\partial(\partial\phi/\partial\rho)}{\partial\tilde{R}} = 1 - C_1 - \frac{C_2\lambda_2(EF + SD)}{P} = \frac{C_2}{YP}\left(A - \eta_y M\right) > 0,$$

for a reasonable value of η_y, such as unity, and positive net holdings of non-monetary assets. In other words, the effect of an increase in ρ on a country's overall balance of trade is related directly to its balance of trade in oil. We may also solve for the critical value of net oil exports, $\tilde{R}_c$, such that $\partial\phi/\partial\rho = 0$.

$$\tilde{R}_c = \left[\frac{A}{A - \eta_y M}\right]\left[\frac{C_2}{1 - C_1}[1 + \lambda(\cdot)]\left(\frac{R + N_r/n_t}{i^*}\right) - R_q + \frac{N_q}{n_t}\right] \gtrless 0$$

Assuming again that net holdings of non-monetary assets are positive and that $\eta_y = 1$, the term in the first brackets is positive. It follows that $\tilde{R}_c$ has the same sign as the expression in the second brackets, thus

$$\tilde{R}_c \gtrless 0 \quad \text{as} \quad \frac{C_2[1 + \lambda(\cdot)]}{i^*}\left(R + \frac{N_r}{n_t}\right) \gtrless (1 - C_1)\left(R_q - \frac{N_q}{n_t}\right).$$

Intuitively, $\tilde{R}_c > 0$ (< 0) only if following an increase in ρ, the increase in expenditure generated by the jump in the price of land titles is greater (less) than the change in saving that results from a change in the value of resources used in the production of Q. If Q is labor intensive relative to T, $R_q - N_q/n_t < 0$ and $\tilde{R}_c$ is unambiguously positive. In other words, if the non-traded consumption good is labor intensive relative to the traded, it is necessary that a country be an oil exporter if it is to experience an improvement in its balance of trade following an increase in the price of oil. In that particular case the effect of an increase in ρ on both land prices and the value of resources used in Q will contribute toward a trade deficit. Only a positive $\tilde{R}$ can keep the trade balance from deteriorating. If Q is oil intensive relative to T, the two effects work in opposite directions, and we would need to know more about the values of the parameters involved in the above inequality if we are to determine whether $\tilde{R}_c \gtrless 0$ for a particular country.

In conclusion, an increase in the price of oil has an effect on an economy's real income and also on the value of assets held by its residents. It follows that if changes in asset stocks have an effect on absorption, it is not sufficient to look only at a country's oil trade in order to determine the effect of an increase in the price of oil on its overall balance of trade. Nonetheless, for any economy, there is a critical value of net oil exports, $\tilde{R}_c$ (which may be $\gtrless 0$) such that if actual net exports of oil exceed (fall short of) that level, the balance of trade will improve (deteriorate) following an increase in ρ.

We complete the dynamic system by focusing our attention on the market for assets.

Differentiating the asset market equilibrium condition (24), we find that along any adjustment path

$$(39) \quad \dot{\varepsilon} = \frac{\lambda(\varepsilon + i^*, Y)}{\lambda_1} \left[\mu - \varepsilon - \frac{\phi(F, \varepsilon; \rho)}{F + \frac{h'(\ell_r)\rho D}{i^*}} \right]$$

where $\dot{\varepsilon} = d\varepsilon/dt$ and $\mu = (1/M)(dM/dt)$. We can write equation (39) in reduced form as

$$(39') \quad \dot{\varepsilon} = \psi(F, \varepsilon; \rho, \mu)$$

with the following partial derivatives, again evaluated in a neighborhood of the steady state.

$$(40) \quad \frac{\partial\psi}{\partial F} = \frac{-C_2[1 + \lambda(\cdot)]}{\eta_\varepsilon\left(F + \frac{SD}{E}\right)} < 0$$

$$(41) \quad \frac{\partial\psi}{\partial\varepsilon} = \lambda(\cdot)C_2 + \frac{1}{\eta_\varepsilon} > 0$$

$$(42) \quad \frac{\partial\psi}{\partial\rho} = \frac{\partial\phi/\partial\rho}{\eta_\varepsilon\left(F + \frac{SD}{E}\right)} \gtrless 0$$

$$(43) \quad \frac{\partial\psi}{\partial\mu} = -\frac{1}{\eta_\varepsilon} < 0$$

The dynamics of adjustment within our model are described by the system of differential equations (35") and (39'). This system is depicted in Figure 4. The $\dot{F} = 0$ schedule, along which trade is balanced, is positively sloped and the directions of arrows pointing east and west correspond to the signs of partial derivatives given by equations (36) and (37). The schedule along which the exchange rate appreciates or depreciates at a constant rate is $\dot{\varepsilon} = 0$, and arrows pointing north and south correspond to the signs of the partial derivatives given by equations (40) and (41). Both $\dot{\varepsilon} = 0$ and $\dot{F} = 0$ schedules are positively

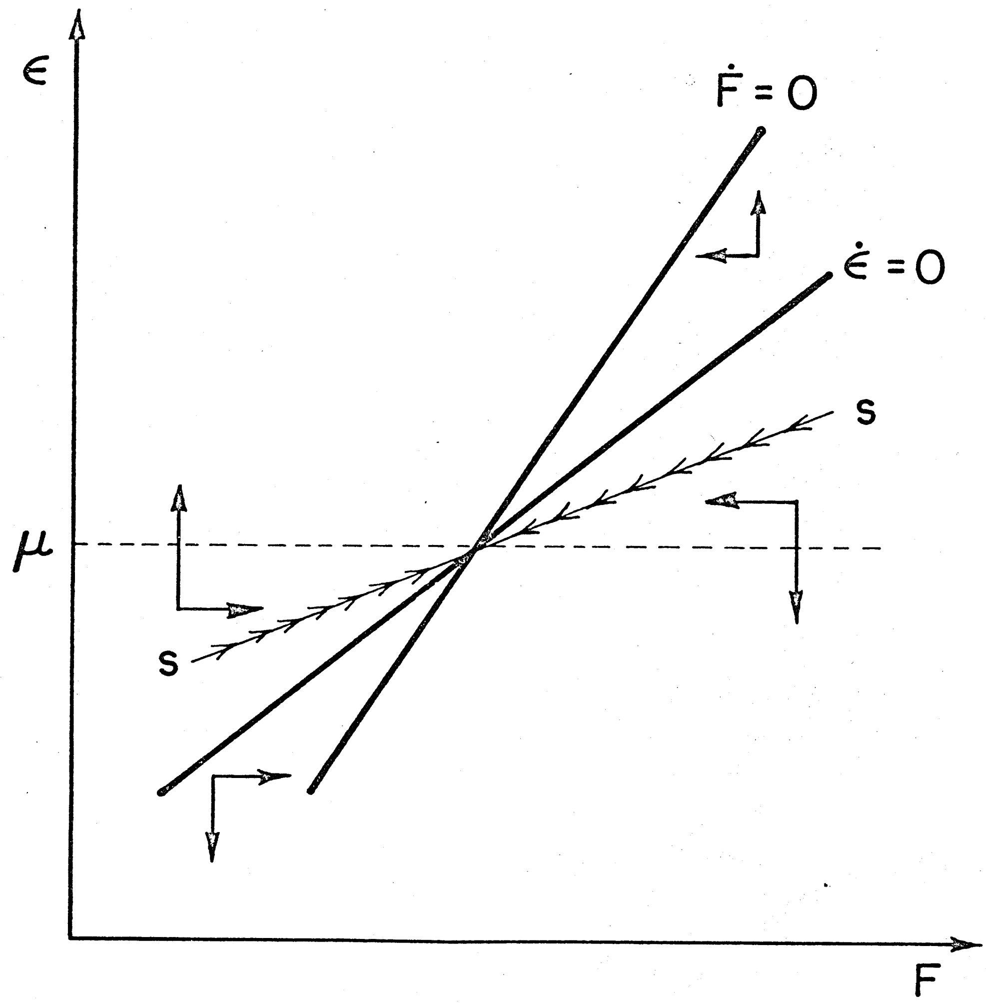

FIGURE 4

sloped, however, it could be easily shown that $\dot{F} = 0$ is steeper. In fact

$$\left.\frac{d\varepsilon}{dF}\right|_{\dot{\varepsilon} = 0} = \frac{C_2}{C_2 - (1/\lambda_1)} \left(\left.\frac{d\varepsilon}{dF}\right|_{\dot{F} = 0} \right) \text{ where } 0 < \frac{C_2}{C_2 - (1/\lambda_1)} < 1 .$$

The characteristic roots of our dynamic system have opposite signs indicating that there is a unique stable branch of the saddle path, denoted by ss in Figure 4, which the economy with perfect foresight is assumed to follow on its way to the steady state.

By looking at the ratio of equations (42) to (40) and (36) to (38), we readily observe that an increase in ρ will shift both $\dot{\varepsilon} = 0$ and $\dot{F} = 0$ schedules by the same horizontally measured distance, leaving the steady-state rate of currency depreciation unchanged and equal to μ. The shift will be to the left if an increase in ρ results in a deterioration in the trade account ($\partial\phi/\partial\rho < 0$), and to the right if $\partial\phi/\partial\rho > 0$. In Figure 4, one can imagine these shifts taking place and immediately see that ε jumps to a rate in excess of μ for deficit countries, while the opposite is true for surplus countries. In other words, whether a country experiences rates of inflation and currency depreciation in excess of, or below the rate of monetary expansion, depends on whether the country has a deficit or a surplus in its balance of trade. For portfolios to remain in balance while deficit (surplus) countries decumulate (accumulate) traded securities, it is necessary that the real money supply also decline (increase). Once long-run asset decumulation (accumulation) goals have been reached, ε will have fallen (risen) to equality with μ.

In our discussion following equation (38) we analysed the factors that influence the sign of $\partial\phi/\partial\rho$ and concluded that it depends on the sign and magnitude of $\tilde{R}$ relative to $\tilde{R}_c$. In particular, the larger is the absolute value of the difference between $\tilde{R}$ and $\tilde{R}_c$, the greater will be the absolute value of $\partial\phi/\partial\rho$ and the horizontal shift of $\dot{\varepsilon} = 0$ and $\dot{F} = 0$ schedules. This implies that there is a direct relationship between the magnitude and direction of a country's oil trade and the impact effect of an oil price increase on its overall balance of trade, as well as the difference between ε and μ.

As we already indicated, the long-run effects of an increase in ρ on F and ε are given by

$$\frac{dF}{d\rho} = \frac{(\partial\phi/\partial\rho)}{C_2[1 + \lambda(\cdot)]} \gtrless 0 \quad \text{as} \quad \frac{\partial\phi}{\partial\rho} \gtrless 0$$

$$\frac{d\varepsilon}{d\rho} = 0$$

The impact effect on the *level* of the exchange rate can be analysed by looking at equation (25) and its partial derivatives (27) and (29). The exchange rate will appreciate or depreciate depending on whether the impact effect of an increase in ρ results in a rise or a decline in the demand for money. The increase in ρ affects the demand for money in three distinct ways. First, the value of land titles will rise and tend to pull up the demand for money through the portfolio scale effect. Secondly, oil exporters (importers) experience a rise (decline) in real income, which in turn will tend to raise (lower) the demand for money. Finally, depending on whether the country experiences a trade surplus or a deficit as a result of an oil price increase, ε will either jump to a level below or above μ, as was pointed out above. In the former case the cost of holding money declines, while in the latter it increases. This results in an increase in the demand for money in surplus countries and a decline in those with a deficit. In conclusion, the less dependent an economy is on imported oil, the stronger will its currency be at the instant a higher oil price is announced. Furthermore, the relative currency strength will tend to persist along the adjustment path.

Production effects of an oil price increase have been analysed in Section I. Allowing the balance of trade to differ from zero, as in the present section, requires that the discussion in Section I be slightly modified. As the economy moves along the adjustment path, expenditures rise or fall relative to income depending on whether the country is accumulating or decumulating assets. Consequently, demand for Q and also its production will rise along the adjustment path for surplus countries, and decline for countries with a deficit. At the same time, the corresponding adjustments in production of T and trade in oil also take place. One thing to remember, however, is that relative commodity and factor prices, factor intensities, and real income, do not change along the adjustment path. The impact effect on those variables is identical to the long-run effect.

It is also useful to analyse the effects of a change in the rate of monetary expansion on the steady-state stock of traded securities and rate of currency depreciation.

$$\frac{dF}{d\mu} = \frac{-\lambda_1 \left[F + \dfrac{h'(\ell_r)\rho D}{i^*} \right]}{1 + \lambda(\cdot)} > 0$$

$$\frac{d\varepsilon}{d\mu} = 1$$

This result is typical of the portfolio-balance approach.[7] An increase in the rate of monetary expansion and the cost of holding domestic currency that is associated with it, leads to an immediate portfolio readjustment and currency depreciation. The resulting fall in the real value of assets sets the economy on a path of asset accumulation and trade balance surpluses until the real stock of assets that was held before the disturbance is restored.

In Figure 5 an increase in the rate of monetary expansion from μ° to μ' will shift the $\dot{\varepsilon} = 0$ schedule up to $(\dot{\varepsilon} = 0)'$, leaving the $\dot{F} = 0$ schedule unaffected. With the stock of foreign securities at F°, the economy jumps to a higher rate of currency depreciation (at point J) in order to reach the stable branch of the saddle path. At the same time the *level* of the exchange rate also jumps, as indicated by equation (27). Along the adjustment path $\mu > \varepsilon = \hat{P}_q = \hat{P}$, and $\dot{F} > 0$, thus the stocks of both real balances and foreign securities increases. Finally, at point K the long-run equilibrium stock of real assets is attained, expenditure is once again equal to income, trade is balance, and the economy has reached the steady state.

On the production side of the model, the increase in μ will initially reduce the output level of the non-traded consumption good as domestic expenditures on both T and Q fall with a drop in the real stock of assets. Output of T, on the other hand, will rise in spite of a decline in demand. The difference between output and consumption of T is $\tilde{T}(\gtrless 0)$, which is exchanged in the world market for oil and foreign securities. Whether net exports of oil rise or fall following a jump in μ will depend on whether Q is oil or labor intensive relative to T. As the economy moves along the saddle path from J to K, production in the output tier, as well as trade in R and T, all move back to their predisturbance levels. It follows that changes in the rate of monetary expansion have short-run effects on the production side of the model, while in the long run they don't.

We reach similar conclusions for fiscal policy. An increase in aggregate demand, as a result of an increase in tax-financed government spending, would shift both $\dot{\varepsilon} = 0$ and $\dot{F} = 0$ schedules to the left by the same horizontally measured distance. The nominal exchange rate, as well as its own rate of change, would instantaneously jump to a higher level. This is followed by a succession of trade balance deficits, which over time, through their effect on the stock of assets, reduce the level of absorption to equality with income.

Along the adjustment path, production levels would be altered in the output tier in a way which depends on what the government is purchasing. Assuming that government's spending pattern does not differ from that of the consumers, fiscal policy will have no effect on the production side of the model in the long run. Even in the short run, relative commodity prices, factor rewards, real income and production techniques are not affected by fiscal action. On the asset side, however, the scale of portfolios will be trimmed down as a result of the instantaneous exchange rate and price level jump and trade deficits that follow.[8]

Clearly, there is not much room for macro policy measures in a full-employment model, but even in this context fiscal policy can play some role. In particular, the effect of an oil price increase on the balance of trade and the rate of exchange rate depreciation can be completely neutralized by an appropriate dose of fiscal expansion or contraction. If this type of insulation is desired, fiscal policy parameters should be set at levels that maintain bal-

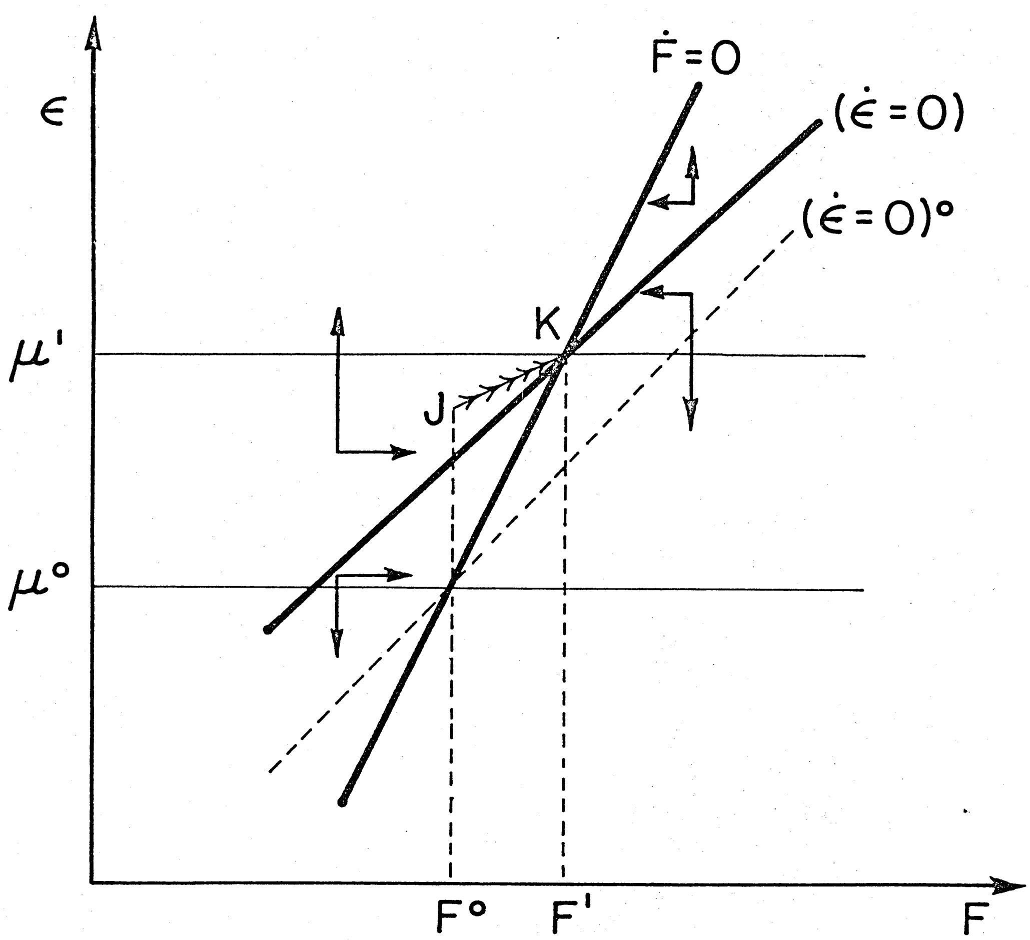

FIGURE 5

anced trade. This requires fiscal expansion in surplus countries and contraction in those with a deficit. In other words, the government would have to use fiscal policy in a way that forces the economy to cut (increase) domestic absorption by the same amount that real income falls (rises) as a result of an increase in ρ. Such "cold turkey" policies cannot be desirable, or else what is the purpose of asset accumulation.

III. Conclusions

This paper has attempted to illustrate and clarify certain effects of an increase in the relative price of a traded intermediate input. By developing a three sector production structure we were able to show that the relative price of oil and traded consumption goods in terms of non-traded consumption goods depends only on technology and the price of oil in terms of traded consumption goods. Efforts to "cheapen" the imported input by using macroeconomic policy measures that affect the nominal exchange rate are bound to fail even in the short-run if all markets are competitive. Furthermore, the real wage, measured in terms of either consumption good, must fall as a result of an oil price increase. It was also shown that the income lost by workers is gained by owners of oil producing land and that real income of the economy as a whole will change only to the extent that it imports or exports oil. The loss (gain) in real income is due to a decline (rise) in the reward to a country's relatively abundant factor.[9]

In Section II we analysed the effect of an oil price increase on the behavior of the exchange rate and the balance of trade. The emphasis was on the role of changes in real income and asset values that are associated with an oil price shock. It was shown that the conditions that guarantee currency appreciation are not identical to those for an improvement in the balance of trade. Nevertheless, the stronger is a country's position in oil trade, the stronger will be its currency and the balance of trade following an oil price increase. Interestingly enough, our analysis of the balance of trade contains no mention of the elasticity of substitution between the two consumption goods. While that parameter helps to determine the *volume* of trade, it has little to do with the *balance* of trade. We should note, however, that the greater is the elasticity of substitution in consumption, the better will be the position that the country finds itself in the next time oil prices jump.

In keeping the analysis as simple as possible, we neglected several important issues. One of them is the problem associated with imperfect mobility of resources from one sector to another. We also ignored possible differences between the consumption functions of workers and land owners. To the extent that such differences exist, our conclusions concerning the effect of an oil price increase on the balance of trade in the short run and the stock of assets in the long run, would have to be slightly modified.

The model could also be extended to recognize the fact that extracting oil from a given plot of land is a process that gradually comes to an end. This phenomena can be accounted for by introducing a relationship between the intensity with which land is used in production of oil and the rate at which its productivity declines. This exercise would not be very interesting, however, unless we also endogenize the relative price of oil in terms of traded goods, and for that it would be useful to have at least a two country model. We could then also raise questions concerning the optimal rate of oil production.

Trade in land titles is another interesting extension of the model. In some countries a significant fraction of such land titles (or more realistically, they may be called shares in oil companies), are in the portfolios of foreign residents. Under those circumstances, one would have to introduce explicitly the service account. We would then observe that by acquiring a sufficiently large stock of foreign land titles a country that produces no oil can experience exchange rate and balance of trade behavior following an oil price increase that is similar to that of oil exporters. This again emphasizes the point raised in Section I that it is through changes in factor rewards that an oil price increase affects the economy's real income. Ownership of factors rather than their physical presence will therefore determine the magnitude and the direction of change in the value of a country's currency and its balance of trade following an increase in the price of oil.

FOOTNOTES

1. See, for example Schmid (1976), Findlay and Rodriguez (1977), Rodriguez (1977), Buiter (1978), Bruno and Sachs (1979), Findlay (1979), Obstfeld (1979), Scarth (1979) and Schmid (1980).

2. A similar two tier production model, with one tier producing the intermediate inputs and the other final goods, has been developed by Sanyal and Jones (1979). One shortcoming of their model, however, is that it does not allow for trade of final products in exchange for inputs, but merely exchange of one intermediate input for another.

3. We ignore the service account in order to keep the points that this paper emphasizes as clear as possible. One can easily introduce the service account into this model, but it would not change our main conclusions.

4. Point A should not be associated in one's mind with the special case in which a country is *not permitted* to trade oil. Under those conditions, ρ becomes an endogenous variable which can be determined by the production structure and, of course, the demand functions for the two consumption goods.

5. In obtaining this result, we made use of the following: $\Theta_N^Q/\Theta_N^T = \rho R_q n_q/\Theta_R^T Y_T \alpha n_t$, $\alpha = Q/eY_T = (N_q w + R_q \rho)/Y_T$, $\Theta_N^T = 1 - \Theta_R^T$, $\Theta_N^T/n_t\Theta_R^T = w/\rho$ and $n_q = N_q/R_q$.

6. Note, however, that $C_q = P_q Q/P = Qe^{\alpha-1}$.

7. See, e.g., Kouri (1976), Calvo and Rodriguez (1977) and Rodriguez (1977).

8. A similar conclusion is reached by Rodriguez (1977).

9. It was pointed out by Laursen and Metzler (1950), p. 290, that "... an improvement in a country's terms of trade is equivalent, economically, to an increase in the productivity of some of the factors of production..." More specifically, it is equivalent to an increase in productivity of a factor that a country has in abundance relative to the rest of the world.

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