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OIL AND THE DOLLAR

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ABSTRACT

This paper develops a simple theoretical model of the effect of an oil price increase on exchange rates. The model shows that the direction of this effect depends on a comparison of the direct balance of payments burden of the higher oil price with the indirect balance of payments benefits of OPEC spending and investment. In the short run, what matters is whether the U.S. share of world oil imports is more or less than its share of OPEC asset holdings; in the long run, whether its share of oil imports is more or less than its share of OPEC imports. Casual empiricism suggests that the initial effect and the long run effect will run in opposite directions: an oil price increase will initially lead to dollar appreciation, but eventually leads to dollar depreciation.

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Probably the two most watched prices in the last decade have been the value of the dollar and the price of oil. A natural question is how they are related: how does an increase in the price of oil affect the dollar's exchange rate? This paper sets out a model which can be used to analyze this question.

There are several reasons besides its practical importance why this is an interesting subject for study. First, the interaction between oil prices and exchange rates is inherently a problem of multilateral economic relations, since we are concerned with the dollar rate against other industrial countries' currencies rather than against OPEC currencies. Even a minimal model in this area must involve at least three countries, in contrast to the one- and two-country models prevalent in the literature on exchange rates.

Second, the problem of analyzing an oil price increase is one in which some commonly used simplifications made in much recent analysis can be shown to be misleading. Recent papers by Findlay and Rodriguez (1977), Buiter (1978), and Obstfeld (1980) have treated an increase in oil prices as an increase in a single country's import bill, invoking "small country" considerations in neglecting the consideration of the effects of the oil price increase on other countries or of how OPEC disposes of its income. In this paper we will see that such neglect is never justified, regardless of the size of the country concerned.

Finally, the case of an oil price increase offers an interesting example of possible conflict between an asset market and a goods market view of the exchange rate. Suppose that one were, in practice, to attempt to assess the effects of an oil price increase on the dollar.

One approach would be to focus on "real" factors: how does U.S. oil import dependence compare with that of other countries? How much of its increased income will OPEC spend on U.S. goods? Another approach would be to look at financial factors: how will OPEC invest its surplus? As I will argue later, these approaches can easily yield conflicting answers, and in the case of the dollar appear to conflict in fact. The model developed in the paper suggests a reconciliation: in the short run, before OPEC spending has risen to absorb its higher income, the financial question is the right one, while in the long run, when OPEC is spending its income, the real questions become appropriate.

The model developed here is a dynamic partial-equilibrium portfolio model based in large part on Kouri (1981). The structure of this model is set out in Section 1, and its dynamic behavior is analyzed in Section 2. Section 3 contains the analysis of the effects of an oil price increase. Finally, Section 4 contains an examination of the ways in which the analysis would be modified if certain complications assumed away in earlier sections are let back in.

1. Assumptions of the Model

Consider a world consisting of three countries: America, Germany, and OPEC. America and Germany sell manufactured goods to OPEC and each other; OPEC has a single export, oil, the price of which is assumed exogenously fixed in dollars.[1]

Germany's trade balance with respect to the U.S., measured in dollars, will be assumed to depend on the exchange rate:

$$T = T(V) \tag{1}$$

where V is the mark price of the dollar. In writing this partial equilibrium relationship we are implicitly taking industrial countries' real incomes and price levels as given.

Oil imports will be assumed to be exogenously fixed in volume terms,

$$O_A = \bar{O}_A \tag{2}$$

$$O_G = \bar{O}_G$$

Thus we assume away--until Section 4 below--the complications introduced by the possibility that countries will be differentially successful in reducing oil consumption.

OPEC import behavior involves spending a share γ of its expenditure on German products, $1 - \gamma$ on American products, where γ in general depends on the dollar-mark exchange rate:

$$X_G = \gamma(V)X \tag{3}$$

$$X_A = [1 - \gamma(V)]X$$

where X_G, X_A are OPEC dollar expenditures on German and U.S. goods, and X is total OPEC dollar expenditure.

What determines OPEC expenditure? The crucial aspect of actual OPEC spending behavior that we will want to capture in this paper is the lag in the adjustment of OPEC imports to export earnings. I will assume that OPEC dollar spending adjusts gradually to the level of dollar export earnings:

$$\dot{X} = \lambda(P_O\bar{O} - X) \tag{4}$$

where $\bar{O} = \bar{O}_G + \bar{O}_A$ is total oil exports.[2]

Notice that there is an asymmetry in the treatment of OPEC imports and the imports of America and Germany. Industrial country imports are assumed to depend only on prices, whereas OPEC's imports are allowed to depend directly on income. The basic reason for assuming this is, of course that the lag of OPEC spending behind income is central to our story, while income changes in the industrial countries are not. One can, however, offer an empirical justification. The redistribution of world income caused by oil price changes involves much larger percentage changes in OPEC real income than in the income of, say, the OECD countries, for the simple reason that oil imports constitute only a few percent of OECD GNP but most of OPEC's GNP. Thus in considering the impact of an oil price increase it may not be too unreasonable to take income changes into account in analyzing OPEC's behavior, while ignoring them in industrial countries.

Let us turn next to the asset markets. There will be assumed to be only two assets, dollars and marks, each held by all three countries. Following Kouri (1981), we will assume that America holds a fixed dollar value of marks in its portfolio, and that Germany holds a fixed mark value of dollars in its portfolio:[3]

$$M_A/V = H_A \tag{5}$$

$$D_G V = H_G$$

where M_A is American mark holdings, and H_A and H_G are constant terms.

OPEC will be assumed to allocate its wealth between dollars and marks. Let W_O be OPEC wealth measured in dollars, i.e.,

$$W_O \equiv D_O + M_O/V \tag{6}$$

where D_O and M_O are OPEC dollar and mark holdings. Then we will assume that a fraction α of this wealth is held in marks, $1 - \alpha$ in dollars:

$$M_O/V = \alpha W_O \tag{7}$$

$$D_O = (1 - \alpha) W_O \tag{8}$$

We have now specified a complete dynamic model. The next step is to analyze its behavior, before applying it to the central question of the paper.

2. Dynamic Behavior

To understand the model's dynamic behavior, it is useful to begin by deriving several balance of payments measures. First, let us derive the German current account measured in dollars. This is German net exports to America, plus exports to OPEC, less oil imports:

$$B_G = T(V) + \gamma\,(V)X - P_o\,\overline{O}_G \tag{9}$$

Similarly, the American current account may be written

$$B_A = -T(V) + [1-\gamma\,(V)]\,X - P_o\,\overline{O}_A \tag{10}$$

We will assume that the appropriate Marshall-Lerner conditions hold, i.e.,

$\partial B_G/\partial V > 0$ and $\partial B_A/\partial V < 0$.

OPEC's current account is simply the difference between exports and imports:

$$B_O = P_O\,\overline{O} - X \tag{11}$$

The equation for the rate of change in OPEC's wealth, however, must also take into account capital gains and losses on its German currency holdings; thus we have

$$\dot{W}_O = B_O - \alpha\,W_O\,(\dot{V}/V) \tag{12}$$

Next we can write down capital account balances. For continuous exchange rate changes, we can derive a net flow of capital into Germany which equals purchases of marks by America and OPEC, less purchases of dollars by Germany:

$$K_G = \dot{M}_A/V + \dot{M}_O/V - \dot{D}_G \tag{13}$$

$$= (M_A/V)\ (\dot{V}/V) + (M_O/V)\ (\dot{V}/V)$$

$$+ D_G\ (\dot{V}/V) + \alpha\ \dot{W}_O$$

$$= [M_A/V + \alpha\ (1-\alpha)\ W_O + D_G]\ (\dot{V}/V) + \alpha\ B_O$$

Now consider the condition of overall balance of payments equilibrium for Germany (we could equivalently use a condition of equilibrium for America). We must have $B_G + K_G = 0$; that is,

$$[M_A/V + \alpha\ (1-\alpha)\ W_O + D_G]\ (\dot{V}/V) \tag{14}$$

$$+ \alpha\ B_O + B_G = 0$$

or $$\dot{V}/V = \frac{-[B_G + \alpha\ B_O]}{M_A/V + \alpha\ (1-\alpha)\ W_O + D_G}$$

This is a variant of the "acceleration equation" derived by Kouri. In Kouri's two-country model, the rate of change of the exchange rate depended on the ratio of the current account to gross international investment. Here we have to extend the equation owing to the presence of a third country, but the principle remains the same. In the special case where OPEC holds no marks, i.e., $\alpha = 0$, (14) reduces to Kouri's acceleration equation where the rate of change of the exchange rate depends only on the German current account,

$$\dot{V}/V = \frac{-B_G}{M_A/V + D_G} \tag{14^{1}}$$

Similarly, if OPEC holds no dollars, i.e., $\alpha = 1$, the rate of change of the exchange rate depends only on America's current account:

$$\dot{V}/V = \frac{B_A}{M_A/V + D_G} \tag{14^{11}}$$

Except in these special cases, however, there is no one-for-one relationship between a country's current account and its exchange rate. Figure 1

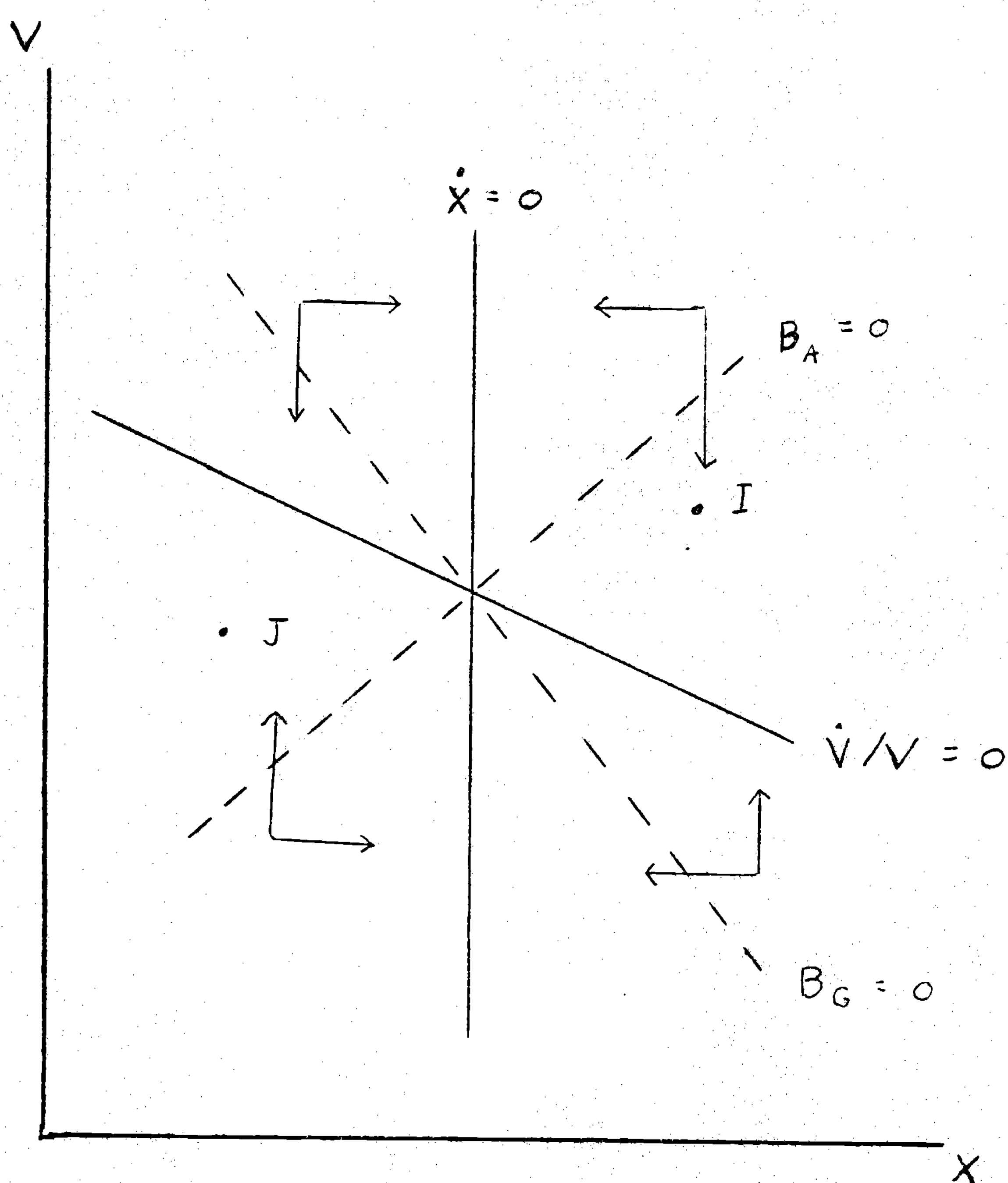

Fig. 1

illustrates the dynamic system defined by equations (4) and (14). OPEC expenditure adjusts towards its income, and this behavior is indicated by the vertical schedul $\dot{X} = 0$. For reference I also indicate those combinations of X and V for which the current account of each industrial country is in balance. An increase in OPEC expenditure improves each country's current account, and to restore balance, this must be offset by an appreciation of the dollar in the case of America, a depreciation in the case of Germany. The slopes of these schedules can be derived from (9) and (10):

$$\left.\frac{dV}{dX}\right|_{B_A=0} = \frac{1-\gamma}{\frac{\partial T}{\partial V} + X\frac{\partial \gamma}{\partial V}} \tag{15}$$

$$\left.\frac{dV}{dX}\right|_{B_G=0} = \frac{-\gamma}{\frac{\partial T}{\partial V} + X\frac{\partial \gamma}{\partial V}}$$

Finally, we have the combinations of X and V for which the exchange rate is stationary, $\dot{V}/V = 0$. In the figure, this is shown as downward sloping, but in fact it can be slope either way. From (14), the slope is

$$\left.\frac{dV}{dX}\right|_{\dot{V}/V = 0} = \frac{\alpha-\gamma}{\frac{\partial T}{\partial V} + X\frac{\partial \alpha}{\partial V}} \tag{16}$$

Whether the schedule slopes up or down depends on whether α - the share of marks in OPEC's portfolio - is greater or less than γ, the share of German goods in OPEC imports. Clearly, also, the slope of $\dot{V}/V = 0$ lies between those of the current-account balance schedules (15). If OPEC holds only dollars, $\alpha = 0$ and the schedule coincides with $B_G = 0$; if OPEC holds only marks, $\alpha = 1$ and the schedule coincides with $B_A = 0$.

The intuition behind these results is straightforward. Suppose OPEC expenditure were to rise from its long-run level. This would have two direct effects on Germany's balance of payments. First, it would improve the current account, because part of the expenditure would fall on German goods. On the other hand, it would worsen the German capital account, because

OPEC would now be running a current account deficit which it would in part finance by liquidating its holdings of marks. Only if OPEC holds no marks can this second effect be neglected.

As long as OPEC holds both currencies, neither country's current account provides an accurate guide to the direction of movement of the exchange rate. At point I in the figure, America is running a current account surplus, yet the dollar is depreciating; at J America is running a deficit, yet the dollar is appreciating. Nor does the bilateral trade balance between America and Germany provide a guide, since given this balance each country's overall balance still depends on OPEC expenditure.

Finally, note that assuming that either Germany or America is "small" does not remove these ambiguities. Suppose we wanted to assume that Germany is "small", and wanted to argue that this would allow us to focus solely on the German current account. Consider the slope of $\dot{V}/V = 0$ relative to that of $B_G = 0$; only if these converge can we use the German current account alone. But the relative slope is $1 - \alpha/\gamma$. If Germany is small, both α and γ will be small numbers, but their ratio need not be. The only justification for an exclusive focus on an individual country's current account is the assumption that it is "smaller" in OPEC's asset holdings than in its import bill.

3. Effects of an Oil Price Increase

The effects of an oil price increase on the exchange rate depend primarily on three parameters: α, the share of marks in OPEC's portfolio; γ, the share of German goods in OPEC's imports; and $\sigma = O_G/\overline{O}$, the German share in world oil imports. The short run impact depends whether α is greater or less than σ; the long run impact depends on whether γ is more or less than σ.

The intuition behind this is simple. Since OPEC spending lags behind income, an oil price increase initially increases industrial country import bills without a corresponding increase in exports. While American and German current accounts are thus worsened, however, there is an improvement in capital accounts as OPEC invests its trade surplus in dollars and marks. Whether the net effect is favorable or unfavorable for the dollar depends on whether OPEC invests in dollars more or less than America's share of the industrial world's current account deficit.

Over time, however, OPEC's spending rises to match its income, and reduces the rate at which it acquires foreign assets. Thus the balance of payments effects of higher oil prices depend to a diminishing extent on OPEC's asset preferences, and increasingly upon its preferences for goods. In the long run, OPEC ceases investing abroad, and only a comparison of import and export shares matters.

Formally, we can determine the impact effect of an oil price increase by differentiating (14) with respect to P_O:

$$\frac{d(\dot{V}/V)}{d\,P_O} = \frac{\overline{O}\ (\sigma - \alpha)}{M_A/V + \alpha\ (1-\alpha)\ W_O + D_G} \tag{17}$$

The long run effect can be determined by setting $X = P_O\overline{O}$ and requiring that $B_O = B_A = 0$, which implies

$$\frac{dV}{dP_O} = \frac{\overline{O}\ \ (\sigma - \gamma)}{\frac{\partial T}{\partial V} + X\,\frac{\partial \gamma}{\partial V}} \tag{18}$$

Interestingly, the initial movement of the exchange rate and its long run change may be in different directions. If $\gamma > \sigma > \alpha$, for instance - that is, speaking loosely, if OPEC prefers American investments and German products - the dollar will appreciate in the short run yet depreciate in the long run. The process is illustrated in Figure 2. Initially, long run

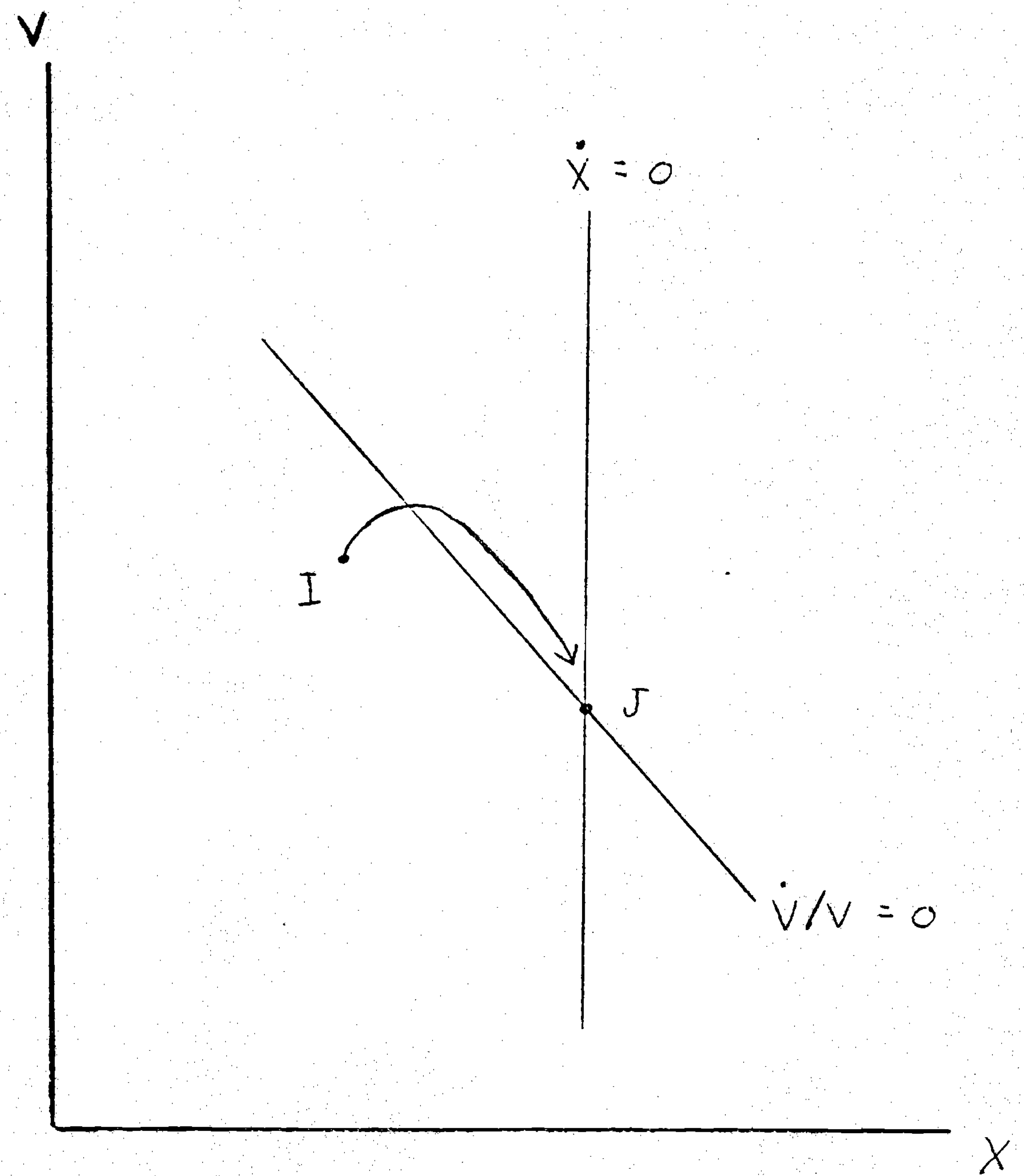

Fig. 2

equilibrium is at I. An increase in the price of oil shifts $\dot{V}/V = 0$ upward and $\dot{X} = 0$ right, sothat the new equilibrium is at J. By referring back to Figure 1, we can see that America remains in current account deficit throughout this process, whereas Germany, after initially running a deficit, may later move into surplus; but the mark will appreciate whether or not this happens, and will begin appreciating before Germany's trade moves into balance if it does.

What makes this case interesting is that it seems to bear some resemblance to the facts. If we view "Germany" as the OECD except for the U.S., the relationship $\gamma > \sigma > \alpha$ appears to hold. The U.S. share of OECD oil imports is comparable to its share of OECD GNP, while its share of OPEC imports is comparable to its much smaller share of OECD exports. Except for the complicating factors to be discussed in the final section of the paper, this suggests that an oil price increase ought to lead first to dollar appreciation, and later to an even greater dollar depreciation.

4. Some Complications

The model presented in this paper contains enough structure so that qualitative behavior depends on only a handful of easily quantifiable parameters. In this section I will somewhat mar this simplicity by showing that two other factors can matter. The first of these is the effect of oil prices on oil consumption; the second of these is the effect of market anticipation of exchange rate changes.

Suppose that instead of being exogenously fixed, oil imports depend on the price of oil in domestic currency. We would then have to rewrite (2) as

$$O_A = O_A(P_O) \qquad (19)$$

$$O_G = O_G(P_O \cdot V)$$

where $O_A(\ )$ and $O_G(\ )$ are demand curves which may have different elasticities, although in both cases we may safely assume the elasticity to be less than one. The introduction of demand elasticity will modify both the short-run and long-run effects of increasing P_O, since Germany's share of the the marginal burden of an oil price increase will no longer equal its share of current oil imports. The appropriate share variable now becomes

$$\tilde{\sigma} = \frac{O_G \cdot (1 - \varepsilon_G)}{O_G(1 - \varepsilon_G) + O_A(1 - \varepsilon_A)}$$

where ε_G, ε_A are the price elasticities of oil demand in Germany and America--numbers much less accessible to casual, or even careful, empiricism than O_A and O_G.

A more difficult analytical problem is posed by market expectations of exchange rate changes. I have been assuming that OPEC holds a fixed share α of its wealth in marks; that America holds a fixed dollar value of marks; and that Germany holds a fixed mark value of dollars. Realistically, all of these should depend on the expected rate of dollar appreciation:

$$\alpha = \alpha(\pi) \tag{20}$$

$$H_A = H_A(\pi)$$

$$H_G = H_G(\pi)$$

where $\pi = E\ [\dot{V}/V]$.

The effect of introducing these expectations, particularly if we adopt the popular hypothesis of "rational" expectations, is to blur the distinction between short run and long run. As many authors have emphasized, long-run factors, even if they have no effect on the current distribution of asset holdings, can still have an immediate effect on the exchange rate through their effect on expectations. Thus the real factors can dominate the financial ones even from the start.

A complete analysis of the effect of speculation is a difficult task, since it involves three differential equations and hence defies graphical analysis. A heuristic approach, however, suggests the kind of results which ought to emerge. Suppose we distinguish between the "non-speculative" value of the dollar--the value it would have if investors expected its value to remain unchanged--and its actual value. If expectations were static, the "non-speculative" and actual exchange rates would always coincide. What we showed in Section 3 was that if $\gamma > \sigma > \alpha$, the path of the rate would then look like the solid line in Figure 3. Now suppose that expectations are rational. This will change the actual path of V; it will also change the path of the "non-speculative" exchange rate, because both trade balances and capital gains will be different from what they would have been under static expectations.

If these effects are not too strong, the qualitative features of the "non-speculative" rate's path will not change: it will first rise, then fall.

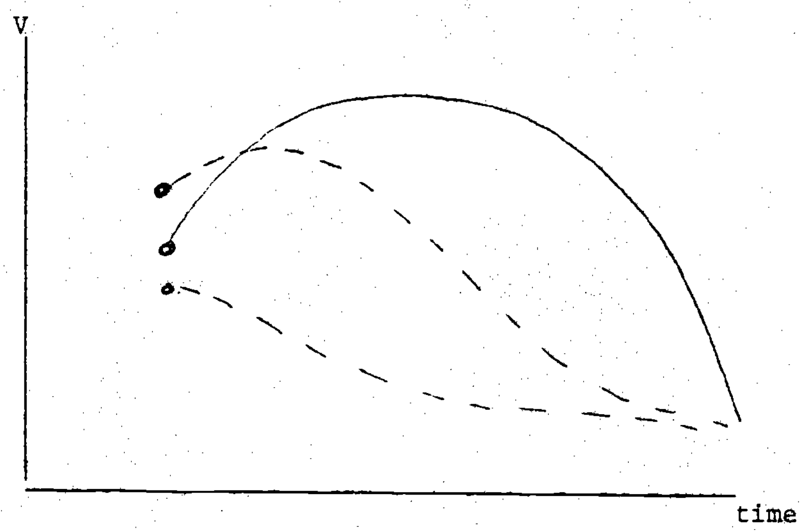

Figure 3

If this is the case--and I have assumed it, not proved it--then the actual path of the exchange rate can be analyzed using the "non-speculative" path as a reference. For V will lie above its non-speculative value if $\dot{V}/V$ is positive, below it if $\dot{V}/V$ is negative.

The possibilities are indicated by the broken lines in Figure 3. Either V is initially expected to rise or it is expected to fall. In the first case there must be an initial jump in the value of the dollar and continuing appreciation for a time before $\dot{V}/V$ turns negative and the dollar falls below its non-speculative value (this must happen while the non-speculative rate is still rising). In the second case there is an initial discrete devaluation of the dollar, followed by continuing gradual depreciation. Thus in this case the long-run fundamental considerations of current account balance dominate even in the short run. This case is presumably more likely, the faster the adjustment of OPEC spending and the more sensitive portfolio holdings are to expected exchange rate changes.

In this paper I have developed a simple model which allows us to consider some of the channels through which changes in the price of oil affect exchange rates. Although the model is necessarily a highly oversimplified representation of reality, it does bring out two basic considerations. First, the effect of the price of oil depends on whether the burden to a country's balance of payments created by higher oil imports is greater or less than the improvement due to OPEC imports and investment. Second, the relative importance of OPEC investment preferences falls over time so that in the long run it is OPEC's import preferences which matter.

NOTES

[1] Alternatively, we might suppose that OPEC attempts to fix the real price of oil by pegging the price to a basket of dollars and marks. This would not alter the qualitative results.

[2] Strictly speaking, it might be more reasonable to assume that real as opposed to dollar spending adjusts with a lag. Again the qualitative results, though more difficult to derive, remain unchanged.

[3] This amounts to assuming that each country has a zero marginal propensity to hold wealth in the other's currency. As Kouri and deMacedo (1978) have shown, what is crucial for explaining the effect of current accounts or exchange rates is the "wealth transfer effect": each country has a marginal propensity to hold wealth in its own currency which is larger than that of foreigners. The assumption made here can be viewed as a shorthand way of capturing this effect, one which will be a reasonable approximation if foreign assets are a small fraction of each country's portfolio.

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