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REAL EXCHANGE RATE ADJUSTMENT AND THE WELFARE EFFECTS OF OIL PRICE DECONTROL

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ABSTRACT

Conventional analysis of the welfare effects of U.S. oil price regulation in the 1970's focuses on the deadweight losses in the oil market. This paper argues that such analysis substantially understates the benefits from decontrolling prices, because decontrol will lead to an improvement in the U.S. terms of trade with respect to other oil importing countries. A simple model of the relationship between oil decontrol and the terms of trade is developed, and the impact is calculated for plausible parameter values. The results suggest that the terms of trade benefits are several times larger than the benefits as conventionally measured.

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Introduction

What are the benefits from decontrolling U.S. oil prices? Essentially, decontrol is a way of reducing oil imports by increasing domestic supply and reducing domestic demand. Reduced imports, in turn, release resources for other uses: if the U.S. spends less on oil imports, it can export less or import more of other goods. The standard analysis of oil price decontrol argues that the social cost of imported oil, in terms of additional exports or foregone imports of other goods, can be measured by the world price -- or perhaps by the world price plus a premium reflecting the political costs of dependence. Decontrol, by bringing the prices faced by producers and consumers closer to this true social cost, leads to a better allocation of resources.

The purpose of this paper is to argue that the world price of oil does not measure the social cost of oil imports to the U.S. -- even though it may be the right measure if we consider the interests of the oil-importing countries as a whole. The reason for this lies in the process by which a reduction in oil imports releases resources for other uses. Only a fraction of these resources will be released through a direct, compensating reduction in U.S. exports to OPEC. For the most part, the gains from U.S. decontrol will take the form of reduced exports to and increased imports from other oil-importing countries. To effect these changes in trade flows, the dollar will have to appreciate in real terms. But this appreciation, by improving America's terms of trade, provides a secondary benefit from decontrol.

The thesis of this paper, then, is that the benefits of oil price decontrol come primarily via a real appreciation of the dollar; and that because the U.S. has substantial monopoly power in world trade, these benefits are much larger than a simple consideration of the value of oil imports saved would indicate. This argument is presented in four parts. Section 1 presents the standard analysis of oil price controls, then discusses its problems. Section 2 develops a model which captures the essential role of real exchange rate adjustment. Section 3 then carries out a computation of the gains from decontrol using plausible parameter values. Finally, Section 4 discusses some of the international implications of this analysis.

1. The Conventional Analysis of Decontrol

The conventional analysis of the U.S. oil price control system -- as presented, for example, by Arrow and Kalt (1979) -- is based on a partial equilibrium model of the oil market. A simplified version of such a model is illustrated in Figure 1. In the figure, SS is the domestic

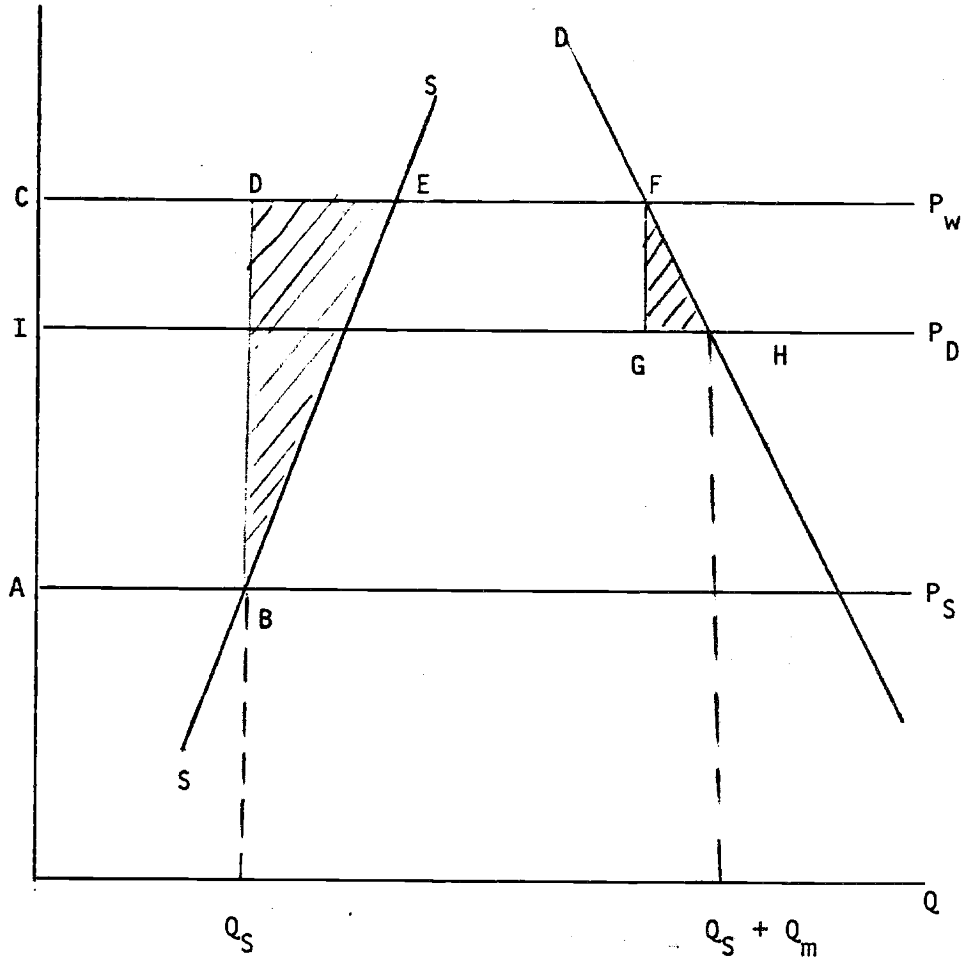

Figure 1

supply curve for oil, DD the domestic demand. P_W is the world price, P_D the price charged to consumers, P_S the controlled producer price. Under the entitlements system, the prices of domestic oil supply Q_S and imports Q_m were averaged, so that

$$P_D = P_S \cdot \frac{Q_S}{Q_S + Q_m} + P_W \cdot \frac{Q_m}{Q_S + Q_m}$$

Decontrolling oil prices means allowing both P_S and P_D to rise to the import price P_W. Using conventional producer and consumer surplus measures, the overall benefit is the sum of the deadweight production gain, measured by the shaded triangle BDE, and the deadweight consumption gain, measured by FHG. The political economy of controls also appears clearly, since the aggregate net benefits are the sum of a producer gain ACEB and a consumer loss CFHI.

The important thing to notice about this diagram is that it does not directly show how these net benefits are realized. The costs of decontrol are the extra resources devoted to oil production, and the reduced use of oil, both of which can be read directly from the diagram. The benefits, however, are measured only by the reduction in oil imports, which is not a good in itself. We value a reduction in oil imports only because it allows the U.S. to export less or to import more of something else.

There is one case in which the route by which reductions in oil imports release resources for other uses would be direct. Suppose that every dollar reduction in U.S. imports from OPEC were to be matched by an equal reduction in OPEC purchases from the U.S. -- i.e., suppose OPEC had a marginal propensity to spend on U.S. goods of one. Then reduced oil imports would translate directly into a reduction in resources used to produce goods and services for OPEC.

In reality, however, OPEC's marginal propensity to spend on U.S. exports -- even in the long run, when OPEC spending and income are equal -- will be much less than one. Most of the reduction in OPEC's income will be reflected in reduced imports from other countries, rather than from the U.S. This means that the U.S. will realize most of its benefits not through a reduction in resources devoted to supplying OPEC with goods and services, but in exporting less to and importing more from other oil importing countries.

The mechanism through which this will be accomplished is through real exchange rate adjustment. Reduced U.S. oil imports will mean an initial U.S. balance of payments surplus, leading to dollar appreciation. As the dollar rises, U.S. exports will fall and U.S. non-oil imports will rise, the process continuing until balance of payments equilibrium is restored. The principal channel through which oil decontrol benefits the economy is through the exchange rate.

Will the "welfare triangles" in Figure 1 still give an appropriate measure of these benefits? The answer is no. As the dollar appreciates, the U.S. will experience an improvement in its terms of trade with respect to other oil importers. This is a secondary benefit which is not reflected in the world price of oil.

2. A Theoretical Model

In this section I present a model which takes account of the crucial role of the real exchange rate in realizing the benefits of oil price decontrol. Although I make a number of simplifying assumptions, the model is difficult to treat analytically except in special cases. Thus in the next section some plausible parameter values are assigned and the model is solved numerically.

The basic structure of the model follows my own earlier work (Krugman 1981) in adopting a compromise between partial and general equilibrium analysis. I divide the world into three regions: two oil-importing regions and OPEC. The two importing regions are treated in partial equilibrium fashion: their imports from OPEC and from each other depend only on nominal prices in domestic currency (so that I neglect possible changes in output and price levels). OPEC, however, is treated differently. The effect of changes in the quantity of oil imported on OPEC's income, and the effects of changing OPEC income on OPEC's imports, are explicitly taken into account. In effect, an "elasticities" approach is used for oil importers but an "absorption" approach for OPEC. This asymmetrical treatment can be defended as a resonable approximation to a situation in which OPEC's marginal propensity to import other countries' goods is much higher than their marginal propensity to import oil. And the hybrid partial-general model is much simpler than a full general-equilibrium treatment.[1/]

The equations of the model fall into four blocks: the equations determining oil prices, outputs, and imports; the equations describing OPEC behavior; the equations of international exchange;and a set of equations measuring welfare impacts. Since we do not know much about functional forms, linearity is assumed wherever possible to simplify the computations in Section 3.

A. The oil market.

The world price of oil is assumed to be set by OPEC, with oil elastically supplied at that price. It is assumed that OPEC partially indexes the price to the exchange rate between the dollar and other currencies:

$$P_w = \overline{P}_w + \beta_w [E - \overline{E}] \quad \text{(OPEC pricing)} \tag{1}$$

where E is the dollar price of non-US currency and β_w is a coefficient of indexation.

Inside the U.S., pricing depends on the regime: the price received by suppliers is exogenously fixed under controls, equal to the world price after decontrol:

$$P_S = \overline{P}_S \quad \text{(controls)} \tag{2}$$

$$P_S = P_w \quad \text{(decontrol)} \tag{2'}$$

Consumer prices are a weighted average of domestic and import prices under controls, equal to world prices after decontrol:

$$P_D = P_S \cdot (Q_S/Q_D) + P_w (Q_m/Q_D) \quad \text{(controls)} \tag{3}$$

$$P_D = P_w \quad \text{(decontrol)} \tag{3'}$$

The U.S. demand for oil is decreasing in the dollar price; the supply is increasing in the price; imports are the difference between supply and demand:

$$Q_D = \overline{Q}_S - \beta_D (P_D - \overline{P}_D) \quad \text{(oil demand)} \tag{4}$$

$$Q_S = \overline{Q}_S + \beta_S (P_S - \overline{P}_S) \quad \text{(oil supply)} \tag{5}$$

$$Q_m = Q_D - Q_S \quad \text{(oil imports)} \tag{6}$$

Finally, foreign imports depend negatively on the <u>foreign</u> currency price of oil:

$$Q_m^* = \overline{Q}_m^* - \beta_m^* [P_w/E - \overline{P_w/E}] \quad \text{(foreign oil imports)} \tag{7}$$

B. OPEC behavior.

OPEC's income comes from sales of oil to the two oil importers:

$$Y = P_w [Q_m + Q_m^*] \quad \text{(OPEC income)} \tag{8}$$

I assume that OPEC always spends a share α of that income on U.S. goods:

$$X_0 = \alpha Y \quad \text{(OPEC imports from US)} \tag{9}$$

C. Trade and the exchange rate.

The U.S. is assumed to have a perfectly elastic supply of exports at a fixed price in domestic currency. The demand for these exports from the other oil importer depends on their price in foreign currency and hence positively on the exchange rate:

$$X = \overline{X} + \beta_X [E-\overline{E}] \tag{10}$$

Similarly, non-oil imports are available at a fixed price in foreign currency, so that the domestic currency price and demand depend negatively on the exchange rate:

$$I = \overline{I} - \beta_I [E-\overline{E}] \tag{11}$$

Finally, we come to balance of payments equilibrium. This is a static model. I have elsewhere developed a model in which it is clear that a change in energy policy will set in motion a dynamic process of payments imbalances and exchange rate changes. In the long run, the result is a restoration of current account balance. Here I will suppress the dynamic complications and assume that the exchange rate immediately adjusts to maintain trade balance:

$$X + X_0 - EI - P_w Q_m = 0 \tag{12}$$

D. Welfare.

The welfare gains from decontrol can be measured in either of two equivalent ways. The first, which is more fundamental, is to measure the gains as the sum of the utility gained from increased consumption of non-oil imports and the utility lost from oil imports foregone, less the cost of resources used to produce oil and exports:

$$U = E\,[I - \overline{I}] + \tfrac{1}{2}\,[E-\overline{E}]\,[I-\overline{I}] \tag{13}$$
$$+ \overline{P}_D\,[Q_D - \overline{Q}_D] + \tfrac{1}{2}\,[P_D - \overline{P}_D]\,[Q_D - \overline{Q}_D]$$
$$- \overline{P}_S\,[Q_S - \overline{Q}_S] - \tfrac{1}{2}\,[P_S - \overline{P}_S]\,[Q_S - \overline{Q}_S] - (X-\overline{X}) - (X_0-\overline{X}_0)$$

(aggregate change in welfare)

Alternatively -- and equivalently -- we can measure the change in welfare by the changes in consumers' surplus in the import and oil markets, and producers' surplus in the oil market:

$$U_D = -\overline{Q}_D\,(P_D - \overline{P}_D) + \tfrac{1}{2}\,\beta_D\,(P_D - \overline{P}_D)^2 \tag{14}$$
$$-\overline{I}\,(E-\overline{E}) + \tfrac{1}{2}\beta_I\,(E-\overline{E})^2$$

(change in consumer surplus)

$$U_S = \overline{Q}_S(P_S-\overline{P}_S) + \tfrac{1}{2}\beta_S\,(P_S-\overline{P}_S)^2 \tag{15}$$

(change in producer surplus)

It is tedious to prove but true that $U = U_D + U_S$; i.e., these are in fact equivalent ways of computing the welfare effects of decontrol. Equation (13) is useful as a way of partitioning the welfare effects by their source; (14) and (15) let us apportion them by their recipients.

We are now prepared to work through the consequences of oil price decontrol.

3. Computing the Effects of Decontrol.

A. An overview.

The effects of decontrol can be decomposed into two parts: the direct effects holding the exchange rate fixed, and the indirect effects resulting from the induced exchange rate change. Before calculating these effects, it is useful to talk them through.

Holding E constant, the behavior of the oil sector is exactly that illustrated by Figure 1, above. Domestic supply rises, domestic demand falls, hence imports of oil fall. A reduction in U.S. oil imports means a reduction in OPEC income, and this in turn will mean a fall in OPEC's demand for U.S. exports.

Unless all of the fall in OPEC spending falls on U.S. goods, however -- $\alpha = 1$ in equation (9) -- the story will not stop here. Instead, since $P_w Q_m$ will fall more than X_0, an incipient balance of payments surplus will develop, requiring an appreciation of the dollar. This will then produce a whole second round of effects. The dollar price of oil will fall (slightly); U.S. exports to the other oil importer will fall, U.S. non-oil imports rise.

The welfare consequences will depend on both the initital set of effects and the second round. The partial equilibrium analysis of Figure 1 will give the right results only if there is no second round. By inspecting (14) and (15), one can see that if the exchange rate does not change, the effects will reduce to consumer and producer surplus in the oil market. But the exchange rate can remain unchanged in only two circumstances. Either OPEC must spend any marginal change in income entirely on U.S. goods ($\alpha = 1$); or U.S. goods must be perfect substitutes for foreign goods ($\beta_X + \beta_I = \infty$). Since neither of these seems reasonable, it is necessary to go through a full-scale computation.

B. Assumed parameters.

Tables I and II present the numbers that will be used in calculating the impact of oil decontrol. In Table I are the constant terms from the model; the model is normalized so that at an exchange rate of one, these constant terms are also the equilibrium values in the presence of price controls on oil. The numbers are chosen so as roughly to reproduce the situation in 1978, with the U.S. importing half its consumption. Several unrealistic features should, however, be noted. First, the complexities of the price regulations on U.S. oil production are ignored: all oil is assumed to be sold at the average price. Second, the entitlements system is assumed to work as planned; thus I ignore the apparent fact that perhaps half of the rents from controls went to middlemen, not consumers. Third, the effects of small-refiner bias are ignored. Finally, the initial position is one of balanced trade, with the actual OPEC surplus and oil importer deficits eliminated by a proportional scaling-up of OPEC's imports.

Table II presents the assumed parameter values. These are all slopes, but the final column shows the implied elasticity in the neighborhood of the initial equilibrium. I have attempted to choose reasonable values based on a variety of empirical estimates.

Clearly, the numbers used here are far from being the best that careful research could produce. Thus the results should be regarded as illustrative rather than as a definitive estimate of the benefits and costs of decontrol.

C. Partial equilibrium results

For comparison purposes, it is useful to have an estimate the welfare effects of decontrol ignoring the exchange rate adjustment. That is, we can use the equations describing the U.S. oil market to compute a conventional, partial equilibrium set of results. These results are reported in Table III. Oil imports are calculated to fall by about one

Table I: Equilibrium with Controls

Variable	Description	Value
$\overline{P}_w$	World oil price in dollars	14.5
$\overline{P}_S$	Controlled price of US oil	9.0
$\overline{P}_D$	Price to US consumers	11.75
$\overline{Q}_S$	US oil production	3.0
$\overline{Q}_D$	US oil consumption	6.0
$\overline{Q}^*_m$	Non-US oil imports	7.0
$\overline{X}$	US non-OPEC exports	151
$\overline{I}$	US non-oil imports	136.5
$\overline{E}$	Exchange rate	1.0
$\overline{X}_0$	US exports to OPEC	29

Table II: Parameter values

Parameter	Description	Value	Implied elasticity
β_W	Indexation of OPEC price to exchange rate	7.25	0.5
β_S	Oil supply response	.067	0.2
β_D	Oil demand response	.235	0.5
β_m^*	Foreign oil import response	.241	0.5
β_X	Export price response	302	2.0
β_I	Non-oil import price response	136.5	1.0
α	OPEC marginal propensity to import US products	0.2	1.0

Table III: Partial equilibrium computation of decontrol effects

Increase in oil supply		.3625
Reduction in oil demand		.64625
Gain in producer surplus		17.51
Loss in consumer surplus		15.61
Net gain		1.90
of which:		
Production gain	1.01	
Consumption gain	0.89	

billion barrels, producing a net gain of 1.9 billion dollars. It is noticeable that this net gain is quite small compared with the redistribution of income from consumers to producers. (We should keep in mind, however, that the actual redistribution has in practice been much smaller, since consumers actually received only part of the benefits of controlled prices, and since much of the increase in producer surplus is taxed away).

This partial equilibrium estimate is, however, seriously misleading in its measurement of the net gain. As we will see, a computation which takes the international implications into account suggests much larger gains.

C. A full computation

To solve for the full effects of decontrol, we need to solve the whole system (1)-(15). The results of this computation are given in Tables IV and V. Table IV shows values of the key variables. According to this calculation, decontrol produces a 3.6 percent appreciation of the dollar.

The dollar appreciation produces some important effects. There is a slight fall in the dollar price of oil, meaning slightly less supply and more demand than in the partial equilibrium estimate. Because the _foreign_ currency price of oil has increased, there is a slight fall in rest-of-world oil imports. More importantly, there is a substantial fall in exports, primarily because of the exchange rate appreciation but to a limited extent because of reduced OPEC income. There is also a rise

Table IV: Equilibrium after decontrol

Variable	Value	Change
P_w	14.24	-.26
Q_S	3.35	+.35
Q_D	5.42	-.58
Q_m	2.06	-.94
Q_m^*	6.93	-.07
X	140.1	-10.9
X_0	25.6	-3.4
I	140.1	+3.6
E	.964	-.036

Table V: Welfare Effects of Decontrol

Change in producer surplus	16.6
Change in consumer surplus: oil	-14.2
non-oil imports	5.0
Equals: net gain	7.5
of which	
Reduced exports to OPEC	3.4
Reduced consumption of oil	-7.6
Increased resources used for oil production	-4.1
Reduced exports to oil importers	10.9
Increased non-oil imports	4.9

in non-oil imports. The important point to notice is that the changes in trade flows which offset the fall in oil imports occur mostly in reduced exports to and imports from the other oil importer.

The most striking effect of the exchange rate change, however, is the way it modifies our estimates of the welfare effects of decontrol. Table V reports these effects. There is a net gain of 7.5 billion dollars. This compares with 1.9 billion dollars if we ignore the exchange rate effect. Partial equilibrium estimates understate U.S. gains by nearly 75 percent.

The sources of the extra gains are the slight fall in the price of oil and, more importantly, the reduced price of non-oil imports. Note also that all of the extra gains accrue to consumers, so that there is a reduction in the distributional impact of decontrol (although consumers still lose heavily).

The lower part of Table V accounts for the gains in terms of resources released and used as a result of decontrol. Here we note that the direct effects of decontrol are costs: less use of oil, and more resources devoted to its production. The benefits come indirectly: fewer goods and services must be provided to OPEC, and more can be imported from and less exported to other oil importers.

No doubt these numbers can be questioned in a number of ways. The main point, though, is unlikely to change: the gains from decontrol are realized primarily through a change in the terms of trade, and these gains are substantially larger than a partial equilibrium calculation would have suggested.

It must be noticed, however, that the extra gains come in the form of a redistribution from other oil importers to the U.S., rather than at OPEC's expense. For the past seven years, U.S. oil policy has been hamstrung by questions of the internal distribution of income; what this analysis does is to suggest that some of the concern has been misplaced, and that we ought instead to worry more about the international distributional effects of U.S. policy.

Notes

1/ The combination of partial equilibrium analysis of individual markets with an exchange rate adjustment to insure trade balance is standard in the applied analysis of protection: see Corden (1975). The formal restrictions on technology and consumer preferences necessary for a rigorous justification have been discussed by Samuelson (1971).

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