APPENDIX C. HOW OIL PRICE INCREASES AFFECT REAL GNP AND REAL DISPOSABLE INCOME

HOW OIL PRICE INCREASES AFFECT POTENTIAL REAL GNP

Potential real GNP depends upon the availability of nationally owned labor, capital, and natural resources. A rise in the price of imported oil can affect potential real GNP only by affecting one or more of these factors; it cannot, by itself, directly alter GNP.

As Chapter III discusses in greater detail, an oil price rise could increase potential GNP if it made it profitable to produce more oil or oil substitutes from the existing set of resources. The rise in the oil price may also, however, make some existing capital and labor resources unprofitable to employ at their current prices. If the real prices of these factors do not fall enough, then excess capacity and unemployment will rise. Potential output under these circumstances will fall. Potential output can also fall, though not by as much, even if real wages and rents on capital adjust fully.

This appendix considers none of these effects, but rather concentrates on the effects of an oil price rise on real GNP through its effect on aggregate demand. That exercise permits focusing on the policy actions that policymakers in oil-importing countries may take in order to counter the unemployment effects, rather than on the question of how they may undo the effects of the oil price rise itself, a question considered in Chapter VII.

Under these assumptions, real GNP is related to the productive factors capital (K), labor (L), and land (T) through the production function

$$Y = y(K,L,T) \qquad (1)$$

Assuming that technology and the economically usable quantities of the factors of production do not change, an oil price rise does not change potential output.

HOW OIL PRICE INCREASES AFFECT ACTUAL REAL GNP

Oil price increases reduce real GNP in oil-importing countries by reducing consumers' real disposable income. Because their demand is inelastic, consumers do not switch away from oil consumption; instead, they reduce their consumption of other goods, including imported and domestically produced non-oil goods and services. The drop in domestic consumption is not offset by a rise in exports, on net, because OPEC runs a trade surplus. Either monetary policy or fiscal policy could offset the depressing effect of the rise in the oil price, but policymakers typically will not take completely offsetting measures because they fear aggravating the inflationary effects of the OPEC price rise.

Treating real consumption (C) as a function of disposable income (Y_d); investment (I) and government expenditure (G) as exogenous; exports (X) as a function of foreign disposable income (Y_d^*) and of relative non-oil export prices (P_G relative to dollar foreign export prices, $\$P_g$); real non-oil imports (M_{no}) as a function of disposable income and the relative price of foreign non-oil products (P_{no}); and real oil imports as a function of disposable income and the price of oil relative to the price of domestically produced goods (P_o/P_G), then real GNP (Y) is

$$(2) \qquad Y = \overset{+}{C}(Y_d) + \overset{+}{I} + \overset{+}{G} + X(\overset{+}{Y_d^*}, \overset{-}{P_G/P_g}) - M_{no}(\overset{-}{Y_d}, \overset{-}{P_G/P_g}) - M_o(\overset{-}{Y_d}, \overset{+}{P_o/P_G})$$

The sign of the effect of each variable on GNP, when GNP is less than potential, is shown above the expression. An increase in disposable income operates on real consumption to raise domestic demand and real GNP; but it also raises imports of foreign goods and oil, thereby reducing U.S. GNP. In stable economic systems, however, a rise in disposable income will, on net, increase real GNP.

Increases in investment, government expenditure, and exports raise home demand for domestically produced goods and, thereby, real GNP. U.S. exports will rise with increases in foreign real disposable income. A rise in U.S. prices (P_G) relative to foreign prices (P_g), however, that is not offset by a depreciation of the dollar exchange rate (a rise in "r," where r = \$/foreign currency) will tend to reduce U.S. exports.

Similarly, a rise in foreign prices (P_g) relative to U.S. prices (P_G) that is not offset by dollar appreciation (a fall in "r") will reduce U.S. imports and raise GNP. A rise in the real oil price (P_o/P_G) will reduce oil imports, by itself increasing real GNP. The change in real GNP is

$$(3) \qquad dY = c'dY_d + dI + dG + x_Y dY_d^* + x_P dP - m_Y dY_d - m_P dP - m_{o,Y} dY_d - m_{o,P} dP_o$$

The Y and P subscripts indicate the partial derivative of the expression with respect to the income or price variable within the expression, whatever the precise definition of that income or price variable.

Several assumptions simplify the analysis. To investigate the size of the decline in GNP when monetary and government expenditure policies are unaltered, set "dI" and "dG" equal to zero. To focus on the interaction of income effects between one oil-importing country and the oil-exporting countries, assume that governments of other non-oil-exporting countries stabilize real disposable income and that the short-term responsiveness of oil and non-oil imports and exports to price is zero. These simplifying assumptions permit writing

$$(4) \qquad dY = c'dY_d + x_Y dY_d^* - m_Y dY_d - m_{o,Y} dY_d$$

or

$$(5) \qquad dY = (c' - m_Y - m_{o,Y})dY_d + x_Y dY_d^*$$

In order to solve expression (5), the next two sections derive expressions for dY_d, dY_d^*, and x_Y.

The Effect of an Oil Price Increase on Real Disposable Income

To obtain real disposable income, the national income accounts deflate nominal disposable income by the personal consumption expenditures (PCE) deflator. To obtain real GNP, they deflate nominal GNP by the GNP deflator (P_G). Real taxes may be computed by deflating nominal taxes with either the GNP deflator or the personal consumption expenditures deflator; it is convenient here to use the personal consumption expenditures deflator.

(6) $$Y_d = \frac{YP_G - TP_C}{P_C} = Y\left[\frac{P_G}{P_C}\right] - T$$

The GNP and PCE deflators are represented with geometric indexes, as in expressions (1) and (11) from Appendix A. Substituting these in (6) yields

(7) $$Yd = Y\left[\frac{P_o}{P_{no}}\right]^{A-B} - T$$

The change in disposable income then becomes

(8) $$dY_d = \frac{P_G}{P_C}\,[Y(A - B)(\dot{P}_o - \dot{P}_{no}) + dY] - dT$$

If any given percentage rise in the oil price leads to a K percent rise in non-oil prices, and if the GNP deflator and the PCE deflator are each equal to one in the base period, then disposable income becomes

(9) $$dY_d = Y(A - B)(1-K)\dot{P}_o + dY - dT$$

The Effect of an Oil Price Increase on Foreign Real Disposable Income

The change in foreign real disposable income largely determines the rise in exports that might offset the drop in domestic demand. Other oil-importing countries, by assumption, take measures, discussed below, to maintain real GNP and disposable income. This section discusses the rise in oil-exporting countries' real disposable income.

The rise in oil-exporting countries' real disposable income can be developed in this simple model in several ways. While for several countries the rise in oil export revenues operates directly on imports through government expenditures on imported products, this section assumes that governments of oil-exporting countries distribute the proceeds of the rise in oil revenues to their citizens through reductions in taxes or increases in transfer payments. That permits developing the rise in oil-exporting countries' disposable income symmetrically with the fall in oil-importing countries' disposable income. Further detail on oil-exporting countries' government expenditures is not germane to the problem treated here.

For simplicity, real disposable income of oil-exporting countries is treated as the total value of oil produced deflated by the price of imported goods. The price of goods imported by oil-exporting countries is assumed here to be P_G, the U.S. GNP deflator. A more elaborate deflator would weight both the U.S. GNP and non-U.S. GNP deflators (P_G and P_g of Appendix A), but deflating with the U.S. price index alone does capture the spirit of the problem without the algebraic complexity that would accompany a finer rendition. Real disposable income for the OPEC countries is, then,

$$Y_d^* = \frac{P_o X_o}{P_G} \tag{10}$$

Assume again that oil and GNP are defined in units such that their prices equal one in the base period. Assume, further, that the quantity of oil exports does not change because of the price rise. In part, this is consistent with the earlier assumption that the short-term responsiveness of oil demand to price change is zero. But here this assumption also involves ignoring the depressing effect of an oil price increase on OPEC oil exports through its effect in reducing the oil-importing countries' disposable income and real GNP. These secondary effects are also ignored for simplicity. The change in OPEC real disposable income under these assumptions will be

$$dY_d^* = X_o(1-A)(1-K)\dot{P}_o \tag{11}$$

An Expression for the U.S. Marginal Propensity to Export to OPEC

To show the direction of trade simply, commas used in the subscripts of export and import numbers separate the sending country from the recipient country; so, for example, U.S. exports to OPEC are denoted as "$X_{US,O}$". A blank entry indicates all regions, so that world exports to OPEC are "$X_{,O}$"; these would be the same as total OPEC imports, "$M_{,O}$".

If, by assumption, the U.S. share in world exports to OPEC does not change, then the marginal propensity of the United States to export to OPEC, equivalently the marginal propensity of OPEC to import from the United States, $m_{US,O}$, given an overall OPEC marginal propensity to import of m*, will be

$$(12) \qquad x_Y = m_{US,O} = m^*\left[\frac{X_{US,O}}{M_{,O}}\right]$$

The Change in U.S. Exports to OPEC

Under these assumptions, expressions (11) and (12) define the change in total U.S. exports to OPEC:

$$(13) \qquad x_Y dY_d^* = m^*\left[\frac{X_{US,O}}{M_{,O}}\right] X_{O,}[(1-A)(1-K)]\dot{P}_O$$

The Effect of an Oil Price Increase on Real GNP and Real Disposable Income

Substituting expressions (9) and (13) in expression (5) permits estimating the effect on GNP of an oil price rise:

$$(14) \qquad dY = (c' - m_Y - m_{O,Y})[Y(A-B)(1-K)\dot{P}_O + dY - dT]$$

$$+ m^* X_{US,O} \frac{X_{O,}}{M_{,O}} (1-A)(1-K)\dot{P}_O$$

Note in expression (14) that the effect of an oil price rise on GNP can be completely offset by the tax cut (dT) that makes dY equal zero. This section, however, concerns the effect on GNP of an oil price rise that is not offset, so the argument proceeds holding dT equal to zero. Expressing the result in terms of the percentage change in GNP implies

$$(15) \qquad \dot{Y} = \frac{(1-K)}{V}\left[(A-B)V' + m^{*}\frac{X_{US,O}}{Y}\frac{X_{O}}{M_{O}}(1-A)\right]\dot{P}_{O}$$

$$V = 1 - c' + m_{Y} + m_{O,Y} \quad \text{and} \quad V' = c' - m_{Y} - m_{O,Y}$$

Several features should be noted about this expression. First, if passthrough is complete (K = 1), then real GNP does not change: a 100 percent passthrough implies no change in the relative oil price, neutralizing the real effects of the price rise. Second, if the share of oil in GNP (A) is the same as the share of oil in consumption (B), then the only effect on the economy of an oil price rise follows from its effect on exports to OPEC. Third, symmetrically, if OPEC's marginal propensity to import is zero, or if U.S. exports to OPEC are small relative to GNP, then the entire effect of an OPEC price rise occurs through the relative shares of energy in production (A) and consumption (B), not in the trade with OPEC.

Numerically, the second term in expression (15) is probably not very important. OPEC's marginal propensity to import out of nominal exports is about 0.7 and the ratio of its nominal exports to nominal imports is about 1.5; their product is about one, so the second term amounts to the ratio of exports to OPEC relative to GNP. 1/ OPEC imports from the OECD countries in 1979 amounted to about $63 billion, 2/ while OECD GNP amounted to about $6.8 trillion, 3/ so the size of this ratio will be about 1 percent. The balance of this section sets this term equal to zero.

Consider now a foreign country with passthrough of oil prices into non-oil prices of "k," with weight "a" of oil in GNP (y),

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1/ Chapter IV, Table 7, p. 29.

2/ OECD Economic Outlook (July 1980), p. 136.

3/ OECD, Main Economic Indicators (June 1980), p. 169.

and a weight "b" of oil in total consumption (c). Then the percentage change in U.S. GNP relative to the percentage change in foreign GNP will be

(16)
$$\frac{\dot{Y}}{\dot{y}} = \frac{\frac{V'}{V}(1-K)(A-B)\dot{P}o}{\frac{v'}{v}(1-k)(a-b)\dot{P}o}$$

It is difficult to evaluate expression (16). Everyone would concede, of course, that differences in passthrough (K versus k), differences in the underlying structure of the economies (V and v versus V' and v'), and different oil price control programs ($\dot{P}_O$ versus $\dot{p}_O$) will lead to different effects on GNP.

These differences, however, can be held constant in order to show how GNP would vary when only production and consumption patterns of oil differ. To do that, assume $\dot{P}_O = \dot{p}_O$, K = k, V = v, and V' = v', so that the relative changes in GNP produced by differences in patterns of energy production and consumption are

(17)
$$\frac{\dot{Y}}{\dot{y}} = \frac{(A-B)}{(a-b)}$$

Table C-1 derives values for expression (17) to determine the relative sizes of the percentage declines in GNP that oil price increases produce among major industrial countries and country blocs. Estimate 2 indicates that oil price increases, when not offset by other policies, produce larger declines in foreign GNP than in U.S. GNP; estimate 1 indicates that GNP in OECD/Europe would fall by marginally less than in the United States. Either result is consistent, however, with the argument made below that nominal GNP and disposable income will rise more in the United States than in major foreign countries (Appendix E); it is that finding that underlies the result that oil price increases first raise U.S. interest rates and appreciate the dollar. Because of the great simplicity of the model used, and the assumption of identical economic structures across countries, the actual percentage differences in impact are probably unreliable; it is,

TABLE C-1. ESTIMATED PERCENTAGE DECLINE IN GNP FROM AN OPEC OIL PRICE INCREASE (U.S. = 100)

	United States	OECD	OECD/ Europe	Japan	Germany	United Kingdom
Weight of Energy Output in GDP (Divided by Energy Price, (A or a)/P_o) a/	0.76	0.48	0.27	0.06	0.23	0.64
Weight of Energy Consumption in Total Consumption (Divided by Energy Price, (B or b)/P_o), Estimate 1 b/	1.48	1.20	0.98	1.03	0.91	1.46
Weight of Energy Consumption in Total Consumption (Divided by Energy Price, (B or b)/P_o), Estimate 2 c/	0.96	0.74	0.59	0.50	0.51	0.87
Percentage Decline in GDP, Estimate 1 (U.S. = 100) d/	100	101	98	135	95	115
Percentage Decline in GDP, Estimate 2 (U.S. = 100) e/	100	134	161	226	144	117

a/ Energy production data, in million tons oil-equivalent, divided by Gross Domestic Product (GDP) in current dollars and current exchange rates (Table 1). The weight of energy production in total output, "A", would be (quantity of home energy production times price, "P_o") divided by nominal GDP. Without specifying the energy price, line 1 shows the weight, "A" (or "a" outside the United States) divided by the energy price, "P_o".

b/ Total real energy requirement divided by total nominal domestic consumption (C), or (B or b)/P_o. Total energy requirement taken from OECD, Energy Balances of OECD Countries, 1975/1977 (Paris, 1979). This estimate of B (or b) assumes that all energy is used to produce consumption goods.

c/ Total energy requirement divided by total private domestic consumption, or (B or b)/P_o. This estimate assumes that the proportion of the total energy requirement used to produce consumption goods is the same as the proportion of total consumption to total output.

d/ Estimates the size of expression (17), using the first estimate of B.

e/ Estimates the size of expression (17), using the second estimate of B.

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however, the direction and ranking of the impacts that is of concern here.

Relation of Previous Results to Oil-Importing Country/Oil-Exporting Country Status. Expression (17) is consistent with the finding that any oil-importing country will face a drop in real domestic demand and GNP when no offsetting domestic policy action is taken. To see this, note that a net oil-importing country must have oil production (Q_o^P) less than oil consumption (Q_o^c). If that same oil-importing country has positive savings so that consumption (C) is less than GNP (Y), then

(18) $$\frac{Q_o^P}{Y} < \frac{Q_o^c}{C} \quad \text{or} \quad A < B$$

Being an oil-exporting country, however, is insufficient in this framework to guarantee that an oil price rise will increase domestic demand. The boundary condition for a rise in aggregate demand and real GNP is

(19) $$\dot{Y} \gtrless 0 \text{ for } A \gtrless B \text{ or } \frac{Q_o^P}{Y} \gtrless \frac{Q_o^c}{C}$$

For GNP to rise, therefore, an oil-exporting country must have production in excess of domestic consumption in the same proportion as total GNP exceeds total consumption:

(20) $$\frac{Q_o^P}{Q_o^c} \gtrless \frac{Y}{C}$$

Therefore, for a country that imports oil and has positive savings ($A < B$, $A - B < 0$), real GNP will fall when the oil price rises (expression 17). For any given tax rate, real disposable income must also fall (expression 9).

APPENDIX D. DECOMPOSING THE PERCENTAGE CHANGE IN OIL IMPORTS INTO ITS COMPONENTS

THE DEMAND AND SUPPLY COMPONENTS OF AN IMPORT CHANGE

Assuming, for simplicity, that domestically produced and imported energy are homogeneous products, then imports (M) are the difference between domestic demand (D) and domestic supply (S):

(1) $$M = D - S$$

Representing the percentage change with a dot, the change in imports is the weighted sum of the percentage change in demand and supply:

(2) $$\dot{M} = \dot{D}\left[\frac{D}{M}\right] - \dot{S}\left[\frac{S}{M}\right], \; M > 0$$

Expression (2) shows the derivation of columns 2 and 5 in Table 8. The bracketed terms (D/M and S/M) are the weights referred to in the text.

FURTHER DECOMPOSITION OF THE COMPONENTS OF THE CHANGE IN ENERGY DEMAND AND SUPPLY

Treating the demand for oil as a function of domestic income (Y) and of price and non-price factors (a), and the domestic supply of oil and gas (S_o) and of domestic substitutes for oil and gas (S_{no}) as predetermined, imports may be written as

(3) $$M = D(Y,a) - S_o - S_{no}$$

Differentiating totally produces

(4) $$dM = D_Y dY + D_a da - dS_o - dS_{no}$$

The first term in expression (4) can be written as the elasticity of energy demand with respect to income [E(D.wrt.Y)]:

$$(5) \qquad D_Y dY = E(D.wrt.Y)D\dot{Y}$$

Substituting (5) into (4), dividing through by imports (M), and denoting percentage change with a dot, results in

$$(6) \qquad \dot{M} = E(D.wrt.Y)\left[\frac{D}{M}\right]\dot{Y} + E(D.wrt.a)\left[\frac{a}{M}\right]\dot{a} - \left[\frac{S_o}{M}\right]\dot{S}_o - \left[\frac{S_{no}}{M}\right]\dot{S}_{no}$$

The first term in expression (6) gives the percentage change in total import demand attributable to the change in domestic income. Given the income elasticity of demand for energy (a value of 1.0 is assumed here), the numerical value of the first term may be calculated. The sum of the first and second terms is the total effect of demand change shown in the first term of expression (2). Since the sum of the first two terms of expression (6) is the actual change in demand, the estimated value of the first term in (6) (income factors determining demand) determines the estimate of the size of the second term (non-income factors).

The third term in expression (6) shows the percentage change in total imports attributable to changes in the domestic supply of gas and oil. Its numerical value, as well as the numerical value of the fourth term, the supply of non-oil energy, can be derived from data shown in the sources indicated in the notes to Table 8.

The items in the memorandum columns of Table 8 are derived as follows. From the first two terms of expression (4), substituting (5), the change in demand becomes

$$(7) \qquad dD = D_Y dY + D_a da = E(D.wrt.Y)DY + D_a da$$

Substituting, as before, the elasticity of demand for oil for the first term in the expression, the percentage change in total demand can be written as

$$(8) \qquad \dot{D} = E(D.wrt.Y)\dot{Y} + D_a\left[\frac{a}{D}\right]\dot{a}$$

Again, assuming that the elasticity of domestic energy demand with respect to GDP is 1.0 permits determining the effect of GDP changes on total demand. Subtracting that effect from the total percentage change in demand gives the estimate of changes in demand attributable to non-income factors.

APPENDIX E. EFFECT OF OIL PRICE INCREASES ON NOMINAL GNP AND NOMINAL DISPOSABLE INCOME IN THE UNITED STATES AND IN OTHER INDUSTRIAL COUNTRIES

NOMINAL GNP

Writing nominal GNP [NOM(Y)] as the product of real GNP (Y) and the GNP deflator (P_G), the percentage change in nominal GNP is

(1) $$\dot{NOM}(Y) = \dot{Y} + \dot{P}_G$$

Appendix C showed that an oil price rise not offset by government policies would reduce real GNP in any oil-importing country. But such a price rise would reduce U.S. GNP (Y) less than GNP (y) in other major industrial oil-importing countries, so

(2) $$\dot{Y} > \dot{y}$$

Appendix A showed that the U.S. GNP deflator would rise more than GNP deflators in other industrial countries, or

(3) $$\dot{P}_G > \dot{P}_g$$

Substituting (2) and (3) in expression (1) shows that nominal U.S. GNP [NOM(Y)] will fall less or rise more than nominal foreign GNP [nom(y)]:

(4) $$\dot{P}_G + \dot{Y} > \dot{P}_g + \dot{y}, \text{ or } \dot{NOM}(Y) > \dot{nom}(y)$$

NOMINAL DISPOSABLE INCOME

Writing disposable income (Y_d) as GNP (Y) less net taxes and transfer payments (T), and holding net taxes and transfers unchanged, deflating disposable income with the PCE deflator, the percentage change in nominal disposable income is

(5) $$\dot{NOM}(Y_d) = \dot{Y}\left[\frac{Y}{Y_d}\right] + \dot{P}_c$$

In 1978 the ratio Y/Y_d was 1.45 for the United States, 1.39 for Japan, and 1.35 for the average of Germany, Italy, and the United Kingdom. 1/

Given this and expression (2), then

(6) $$\dot{Y}\left[\frac{Y}{Y_d}\right] > \dot{y}\left[\frac{y}{y_d}\right]$$

Appendix A showed that

(7) $$\dot{P}_c > \dot{p}_c$$

Thus the sum of (6) and (7) indicates that nominal U.S. disposable income falls by less or rises by more than nominal disposable income in other major oil-importing countries:

(8) $$\dot{NOM}(Y_d) > \dot{nom}(y_d)$$

1/ Disposable income figures taken from OECD Economic Outlook (July 1980), p. 131; GNP data taken from OECD, Main Economic Indicators (August 1980), pp. 17-18.

APPENDIX F. ESTABLISHING PLAUSIBLE RANGES FOR ESTIMATES OF THE DEMAND FOR SAUDI ARABIAN OIL

Even a relatively pessimistic outlook on the world oil market, such as the August 1979 study by the Central Intelligence Agency, "The World Oil Market in the Years Ahead," 1/ may still be consistent with the possibility of a substantial drop in the demand for Saudi oil and a substantial drop in the OPEC oil price. The CIA report concluded that prices would rise because, at then-current prices, an oil supply gap of 3.2 to 7.7 million barrels per day would develop by 1982; that finding was not based on the anticipation of the supply interruptions that occurred as a result of the Iranian revolution or the Iran-Iraq war.

This appendix examines the CIA report because it is unusually complete and permits one to derive the estimates needed to show that some of the possible outcomes in the world oil market of the 1980s differ substantially from what many might consider the most likely single outcome. Understanding the full range of possible outcomes is crucial to evaluating different policy options.

DERIVING THE CIA POINT ESTIMATES

Table F-1 reproduces the essential CIA findings. Total energy demand by the OECD countries was expected to rise from 75.2 million barrels of oil-equivalent per day in 1978 to between 82.5 and 87 million barrels in 1982 (line 1). The CIA's low-demand estimate assumed a 3 percent annual GNP growth rate and a 1 percent annual fall in demand as a result of "conservation"; the high-demand estimate assumed a 4 percent annual GNP growth rate and a 0.5 percent annual fall in demand from conservation.

The CIA forecast that OECD energy supply would rise from 49.2 million barrels of oil-equivalent per day to 56.2 million barrels per day in both the high- and low-demand cases (line 2). These

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1/ U.S. Central Intelligence Agency, National Foreign Assessment Center, The World Oil Market in the Years Ahead (August 1979).

TABLE F-1. THE IMPLIED CIA FORECAST OF 1982 DEMAND FOR SAUDI ARABIAN OIL (In millions of barrels per day of oil-equivalent)

	1978	1982 Low Demand	1982 High Demand
Demand for Imported OPEC Oil			
1. OECD energy demand a/	75.2	82.5	87.0
2. OECD domestic energy supply b/	49.2	56.2	56.2
3. OECD demand for oil imports c/	25.7	26.3	30.8
4. Non-OECD demand for imported oil d/	2.5	4.2	4.2
5. Total demand for imported OPEC oil e/	28.2	30.5	35.0
Supply of Imported OPEC Oil			
6. Total OPEC oil exports f/	28.2	27.3	27.3
7. Non-Saudi OPEC supply g/	20.1	18.8	18.8
The "Gap"			
8. Demand for Saudi Arabian oil h/	8.1	11.7	16.2
9. Saudi Arabian desired exports g/	8.1	8.5	8.5
10. "Gap" i/	0.0	3.2	7.7

SOURCE: Derived from data presented in Central Intelligence Agency, National Foreign Assessment Center, The World Oil Market in the Years Ahead (August 1979). References in the footnotes to this table refer to this source as "CIA."

a/ Data for 1978 taken from Table 8, representing total amount supplied to the OECD countries plus stock drawdown. High and low forecast for 1982 taken from CIA, Table 10, p. 12. Low forecast assumes 1 percent annual conservation and 3 percent annual GNP growth; high forecast assumes 5 percent annual conservation and 4 percent annual GNP growth.

b/ CIA, Table 6, p. 7.

c/ The entry for 1978 is taken from CIA, Table 8, p. 8. The entries for 1982 are derived by subtracting OECD domestic supply (line 2) from OECD domestic demand (line 1).

d/ The sum of net imports of non-OPEC less developed countries, other developed countries, and communist countries; taken from CIA, Table 7, p. 8.

e/ The sum of lines 3 and 4.

f/ CIA, Table 5, p. 5.

g/ Derived from CIA, Table 5, p. 5.

h/ Total non-OPEC demand for imported oil (line 5) less non-Saudi OPEC oil exports (line 7).

i/ Demand for Saudi oil (line 8) less Saudi desired output (line 9).

projections imply a 1982 oil import demand of 26.3 to 30.8 million barrels per day (line 3), compared with 25.7 million barrels in 1978. It projected that non-OPEC countries outside the OECD would import 4.2 million barrels per day in 1982, rising from 2.5 million barrels per day in 1978 (line 4). Total demand for oil from OPEC would rise, therefore, from 28.2 million barrels per day in 1978 to between 30.5 and 35.0 million barrels in 1982 (line 5).

In meeting this demand, the CIA projected that non-Saudi Arabia OPEC members would be willing to supply 18.8 million barrels per day in 1982, compared with 20.1 million barrels per day in 1978 (line 7). Therefore, the demand for Saudi oil would rise from 8.1 million barrels per day in 1978 to between 11.7 and 16.2 million barrels per day in 1982 (line 8). But the CIA posited that the Saudis would be willing to supply only 8.5 million barrels per day (line 9). Therefore, at a constant oil price, a gap would develop of 3.2 to 7.7 million barrels per day (line 10). To close this gap, the oil price would have to rise.

WHAT IS THE RANGE AROUND THE CIA POINT ESTIMATE?

The foregoing represents the CIA's best (1979) guess about the oil shortfall in 1982. Each element of that estimate, however, is subject to some error, and the combined effect of the uncertainty is sufficiently large to permit a very wide range of possible values for the residual demand for Saudi Arabian oil. Table F-2 follows the lines of Table F-1, but marks off a plausible range of possible outcomes around the CIA mean estimate. As line 8 shows, one possible outcome is a substantial fall in demand for Saudi oil.

Table F-2 derives one set of ranges of high and low forecasts of demand for Saudi Arabian oil exports. The left column combines the low-demand growth forecast with the high-supply growth forecast to produce a low estimate of the demand for Saudi exports in 1982. The right column reverses this procedure: it combines the highest estimate of the demand for Saudi oil exports with the lowest estimate of non-Saudi supply. In each case, measures of "plausibility" are based on findings within the CIA study; these are discussed further below and in the notes to Table F-2.

Line 1 of Table F-2 shows an estimated range of demand for OPEC oil based on the CIA's own reported standard error of estimate of 1.2 percent. Line 1a reports an alternative estimate of

TABLE F-2. ESTIMATED RANGE OF VALUES FOR THE CIA FORECAST OF 1982 DEMAND FOR SAUDI ARABIAN OIL

	Extreme Low Demand High Supply	Extreme High Demand Low Supply
Demand for Imported OPEC Oil		
1. Range of OECD demand within standard error of 1.2 percent a/	81.5	88.0
1a. Alternative estimate of OECD demand b/	77.8	87.3
2. Range of OECD domestic supply within range of U.S. oil production c/	62.3	51.9
3. OECD oil import demand d/	16.8	35.4
4. Non-OECD oil import demand e/	4.2	4.2
5. Total demand for imported OPEC oil f/	21.0	39.6
Supply of Imported OPEC Oil		
6. Total OPEC oil exports g/	21.0	25.9
7. Range of non-Saudi OPEC oil exports c/	20.8	17.4
The "Gap"		
8. Demand for Saudi Arabian oil exports h/	0.2	22.2
9. Saudi Arabian desired oil exports i/	8.5	8.5
10. "Gap" j/	0.0	13.7

SOURCE: Derived from data in U.S. Central Intelligence Agency, National Foreign Assessment Center, The World Oil Market in the Years Ahead (August 1979). References in the footnotes to this table refer to this source as "CIA."

a/ The ranges of the demand forecast use the standard error of 1.2 percent shown in the CIA report, Table F-8, p. 61. It applies that standard error to the "high"- and "low"-demand outcomes in Table F-1, line 1.

b/ Over the four years between 1973 and 1977, OECD real GNP rose by 8.4 percent (CIA, p. 60), while OECD energy consumption rose by 3.2 percent (CIA, p. 61). For each 1 percent rise in OECD GNP, therefore, energy demand rose by 0.38 percent; the change in demand also reflects, of course, the rise in the oil price. The same calculation for the 1975-1977 period, using data from the same sources, shows that each 1 percent rise in GNP was accompanied by a rise in energy demand of 0.86 percent.

The CIA's low-growth scenario assumes that OECD income grows at 3 percent per year in 1979-1982. Actual growth in 1978 was 3.9 percent (OECD, Main Economic Indicators (December 1980), p. 169), so total GNP growth in

(continued)

1979-1982 would be $(1.039)(1.03)^4 = 1.169$. Actual 1977 energy demand was 74.3 million barrels per day (CIA, Table F-9, p. 61), so if energy demand responded to income and past price changes as it did in 1973-1977, a rise in income of 16.9 percent would produce an increase in energy demand of (16.9)(0.38), or 6.4 percent, thereby increasing energy demand to 77.8 million barrels per day (which is entered as the low forecast). On the other hand, the higher rate of income growth in the high-demand scenario amounts to $(1.039)(1.03)(1.04)^3$, or 20.4 percent over the period (CIA, Table 10 and footnote c, p. 12). With the larger response of energy demand to a GNP rise of 0.86, energy demand would rise by 17.5 percent, to 87.3 million barrels per day.

c/ The CIA sets the range of oil production in the United States at 8.5 to 10.2 million barrels per day in the early 1980s (CIA, pp. 18-19), and adopts 9.2 million barrels per day as the point estimate for the United States (CIA, Table 6, p. 7). In percentage terms, that range lies between -7.6 percent and 10.9 percent of the CIA's most probable forecast. While this is admittedly limited evidence, there is no obvious reason to believe that non-U.S. production prospects should be any more certain than U.S. production prospects or that non-oil production prospects should be more certain than oil production prospects. The same range of uncertainty, therefore, is used for OECD domestic energy supply (line 2) and for non-Saudi OPEC oil supply (line 7).

d/ Line 1a minus line 2.

e/ See Table F-1, line 4. The CIA does not supply total energy demand and supply figures for non-OPEC less developed countries, other developed countries, and communist countries. The point estimates used here, therefore, underestimate the actual variance of those estimates. Mexico alone, by CIA estimates, has the capacity to produce between 2.5 and 3.0 million barrels per day between 1982 and 1985, with "higher rates . . . technically feasible" (CIA, p. 28). An error of 0.5 million barrels per day would, by itself, represent more than 10 percent of the value of the entry for non-OPEC oil demand; similar ranges in estimates for other countries would further increase the interval.

f/ Sum of lines 3 and 4.

g/ Equals total demand (line 5) or the sum of non-Saudi output (line 7) and Saudi output (line 9), whichever is smaller.

h/ Equals zero or total demand for imported OPEC oil (line 5) less non-Saudi OPEC oil exports (line 7), whichever is larger.

i/ CIA, Table 5, p. 5.

j/ Demand for Saudi exports (line 8) less desired supply of Saudi oil exports (line 9) or zero, whichever is greater.

demand growth based on the evolution of energy demand and GNP growth shown in the CIA study. (See Table F-2, note b/, for further discussion.)

Line 2 uses the CIA's own interval of error around its forecast of U.S. oil production to estimate the range of possible OECD domestic energy supply projections. This procedure assumes, reasonably, that expectations about non-oil energy production should be at least as uncertain as those about oil production, and that expectations about non-U.S. production should be at least as uncertain as those about U.S. production (see Table F-2, note c/).

The estimates of OECD demand from line 1a and of OECD supply from line 2 imply a range of OECD demand for imported oil of 16.8 to 35.4 million barrels per day (line 3).

For non-OECD oil import demand, the table gives the CIA point estimate of 4.2 million barrels per day (line 4), but only because the CIA report did not contain data on total energy demand and supply for the non-OPEC less developed countries, the non-OECD developed countries, and the communist bloc. Had such data been presented, the same technique as before could have been employed to mark off an estimated range for non-OECD oil import demand.

Combined OECD and non-OECD demand for OPEC oil exports appears in line 5, ranging from 21.0 to 39.6 million barrels per day.

To determine the Saudi share of the market, the table first estimates non-Saudi production (line 7). It makes this estimate by using the same range of uncertainty for non-Saudi OPEC members as the CIA applies to U.S. oil production. The range of non-Saudi output so derived is 17.4 to 20.8 million barrels per day. For the higher rate of output, in combination with the low total demand estimate, the demand for Saudi oil would fall to 0.2 million barrels per day. Under such circumstances, the Saudis would try to restore their share of the market by establishing prorating agreements among OPEC members. Should these agreements fail, as they typically do, the Saudis would be forced to cut prices to regain their share of the market. (Should the opposite conjunction of demand and supply outcomes occur, of course, a substantial rise in prices would be required to close the gap.)

Each line of the table suggests policies that ultimately reduce the demand for Saudi Arabian oil and increase the pressure for OPEC price reductions. An energy policy that aims only at increasing domestic supply or reducing domestic demand, focusing on only one component of lines (1a) and (2), misses many potentially important energy strategies.