Energy, International Trade, and Economic Growth

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A Background Study for World Development Report 1981

This paper is designed to complement the work that is now ongoing in connection with the World Bank (IBRD)'s World Development Report 1981 (hereafter abbreviated WDR IV). Results will be reported from a small-scale international trade model that is focused on issues related to energy and economic growth. The analysis is intended to provide some broad orders of magnitude as a cross-check upon detailed country-by-country projections but is not to be viewed as a substitute for these "bottom-up" analyses. Our model is compact enough so that all numerical results (and virtually all input assumptions) can fit onto a single sheet of paper. This also facilitates a rapid turnaround in response to changes in input assumptions. The numerical results here are based upon the WDR IV guidelines available in November 1980.

In the following pages, we will review the economic assumptions that underlie the model, and will then present nine alternative cases - varying the assumptions with respect to energy supplies, demands, economic growth, and capital flows. Half of these cases imply much the same price scenario as specified in the current set of WDR IV guidelines - a 3% annual real oil price increase between 1980 and 1990. It will be shown, however, that relatively small differences in supplies - and relatively small differences in the ease of demand adjustments to rising prices - can lead to 100% differences in the energy prices projected for 1990.

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Contents

Tables and Figures

Tables

Figures

Acronyms and Abbreviations

CES	Constant elasticity of substitution
EIA	U.S. Energy Information Administration
EMF	Energy Modeling Forum (Stanford University)
EPDCE	Economic Analysis and Projections Department (IBRD) Commodities and Exports Projections
IBRD	International Bank for Reconstruction and Development (World Bank)
MBD	Million barrels daily, oil equivalent
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Oil-Exporting Countries
SITC	Standard International Trade Classification
WAES	Workshop on Alternative Energy Strategies
WDR IV	World Development Report 1981

1. Introduction

Despite the volatility of energy prices, the GDP growth rates of the industrialized countries do not vary widely. Imported energy still remains a relatively small fraction of their GDP, and growth appears largely determined by the underlying assumptions with respect to the productivity of capital and labor. Even a 100% difference in energy prices leads to a difference of only 0.3% in the annual gross domestic product (GDP) growth rates of these countries between 1978 and 1990. At first glance, this appears a counter-intuitive result - and quite different from the conventional wisdom expressed in newspaper headlines and editorial pages. Our analysis does not, however, refer to short-term political and military disruptions, but to medium-term economic trends. With a decade for energy demands and trade flows to adjust to higher prices, there is room for guarded optimism that energy constraints will not be the principal determinant of the industrialized countries' growth during the 1980s.

For the oil-importing developing countries, the outlook is more problematic. During the 1970s, they succeeded in financing their oil deficits through an unprecedented inflow of capital. If there are even larger capital inflows to compensate for the likely rise in oil prices during the 1980s, the developing countries may be able to achieve the growth targets outlined in World Bank (1981; World Development Report 1981, hereafter cited as WDR IV). Without such flows, the outlook is considerably bleaker. A 100% rise in energy prices would then have a major impact upon their terms of trade, and it could reduce their GDP growth rates by as much as 1.1% per year.

2. General Background

Although the developing countries now consume a relatively small fraction of the world's energy, this fraction could grow rapidly over the coming decades. In comparison with the industrialized nations, the developing countries have high population growth rates and high income elasticities of demand for commercial energy. Moreover, if today's North-South income disparities are to be reduced, the developing countries' per capita incomes will have to grow more rapidly. Taken together, these factors imply a substantial increase in their demand for energy. For example, the Workshop in Alternative Energy Strategies (WAES) study (Wilson 1977, p. 269) projected that the developing countries' share of the world's commercial energy consumption would grow from 15% in 1972 to 25% in the year 2000. Meanwhile, the principal consumers of energy are the industrialized countries. Their imports - and OPEC's readiness to expand production - are the principal determinants of international oil prices.

In view of the price increases experienced since 1973, it is quite likely that the oil-exporting developing countries will continue to enjoy a rapid increase in GDP, and will consume ever-increasing amounts of their own energy production. The oil-importing developing countries, however, constitute a far more populous group, and their energy demand projections appear quite uncertain. With sluggish growth in traditional export markets among the industrialized nations, the oil importers are likely to encounter chronic balance-of-payments difficulties. Their prospective trade deficits cannot easily be offset by official development assistance or by private capital flows.

In qualitative terms, it is easy enough to arrive at these generalizations. But what about their quantitative effects? To what extent is energy likely to impose constraints upon economic growth? For this purpose, it appears essential to construct a computable model of international trade. One region's export prospects cannot be assessed without an understanding of the imports of non-energy products to other nations. The ease or difficulty of this adjustment process will be governed largely by the elasticities of substitution in energy and in international trade.

3. The Basic Simplifications

These are the general considerations that have led to the specific approach taken here - a three-region general equilibrium model. This is not intended for general-purpose analysis of international trade and macroeconomic fluctuations. It is not designed to deal with individual commodities outside the energy sector - hence it is inappropriate for policy issues such as comparative advantage and tariff and non-tariff barriers to trade. For these purposes, one would need far more disaggregation than that adopted here (see Ginsburgh and Waelbroeck 1975 and Whalley 1980). As in these more detailed trade analyses, we shall construct a "snap shot" view (comparative statics) for a single point of time, 1990. There will be no attempt to analyze the year-by-year details of the transition from 1978 (the data benchmark year) to 1990. This is a "surprise-free" scenario.

Aggregating the nineteen individual regions distinguished within WDR IV, we arrived at the following three-region classification of the market economies:

1. industrialized countries (region 17; the major OECD nations)
2. oil-exporting developing countries (regions 10-16; primarily OPEC + Mexico)
3. oil-importing developing countries (regions 1-9).

This model is not addressed to East-West trade issues. In effect, we assume zero net trade in energy with the centrally planned economies (regions 18, 19). This is closely consistent with other WDR IV projections.

Following in the tradition of Armington (1969), Barten (1971), Hickman, Kuroda, and Lau (1979), and Hickman and Lau (1973), non-energy tradeables are aggregated in dollar terms but distinguished by their region of origin. Energy forms are expressed in terms of their oil equivalents. Thus, there are only four internationally traded goods whose prices are to be determined: energy plus one composite non-energy export product for each of the three regions. All prices are to be viewed as c.i.f.. Because of base-year data limitations, we shall project merchandise trade flows only.

Both an optimistic and pessimistic view will be explored with respect to energy supplies. In both cases, these will be taken as exogenous data for each region in 1990. This "bean counting" approach appears more practical than attempting to estimate price-responsive supply curves. Over the next decade, the industrialized nations' domestic supplies appear far less dependent upon future prices than upon institutional and public acceptability factors; e.g., petroleum leasing policies, environmental constraints upon air quality, and neclear safety regulations. Institutional and political factors also have a major impact upon the supplies likely to be available in the developing nations.

In order to project each region's demand for energy and for non-energy imports, we employ nested constant-elasticity-of-substitution (CES) production functions. With a CES production function, there are diminishing marginal returns from imports into each region. To this extent, the model automatically allows for "absorptive capacity" constraints within the rapidly growing economies of the oil exporters (see Ezzati 1978).

Each region's future endowments of capital and labor enter into its individual production function. These endowments are estimated in accordance with the region's potential GDP growth rates under constant prices of energy and non-energy items. Each region views these international prices as a datum. To the extent that OPEC exerts monopoly power, this is already incorporated in the assumptions with respect to the quantities of energy supplied by region 2 (OPEC + Mexico).

Prices are projected so as to equilibrate 1990 supplies and demands. Given the prices of the internationally tradeable goods - and given the production functions together with each region's capital, labor, and energy resources - it is supposed that each region will choose a mix of energy and of non-energy imports so as to maximize its GDP. The maximization is subject to region-by-region constraints upon the balance of merchandise trade. The outcome of this process is termed the realized GDP. This may exceed or fall below the potential GDP - depending upon whether there is an improvement or a deterioration in the international terms of trade.

For technical details on the three-region model, see Appendix A and the dissertation of S. Kim (Stanford University, forthcoming).

4. Macroeconomic Assumptions and Energy Supplies

Potential GDP growth rates are a key input to the three-region model. These growth rates may be interpreted as an index number of capital and labor inputs - provided that the labor force is expressed in "efficiency units" to allow for productivity growth. One approximation should be noted. In effect, we are assuming that the growth of domestic capital stocks will not be significantly affected by oil price increases or by other changes in the terms of trade. For 1990, side calculations suggest that this feedback effect is minor. Over a longer time horizon, however, we would need an intertemporal model to allow properly for this savings and investment process.

For the "high GDP" cases reported here, the 1978-90 potential growth rates are identical to those being employed elsewhere in WDR IV: 3.5% for the industrialized countries, 6.4% for the oil exporters, and 5.3% for the oil-importing developing countries. In general, the realized growth rates turn out to be lower for the oil importers and higher for the exporters. This is an immediate consequence of the rise in energy prices projected between 1978 and 1990.

Two alternatives will be considered with respect to the commercial energy supplies available to the market economies in 1990: 122 and 114 million barrels daily, oil equivalent (MBD). From Table 1, note that 122 MBD is broadly consistent with the WDR IV guidelines, but that 114 MBD represents a more pessimistic asessment of the supply prospects within the developing countries. With a continuation of military and political disturbances in the Middle East, it is quite possible that there could be a 5 MBD shortfall in region 2. Similarly, there could be a 3 MBD shortfall in region 3 if energy development is not pursued aggressively there. Note that the 122 and 114 MBD

cases bracket the 116 MBD "mid-price" scenario released in October 1980 by the U.S. Energy Information Administration (EIA; 1980, p. 4). All these estimates lie well below the earlier ones made by the EIA, IBRD, and other organizations. The overthrow of the Shah of Iran - and the anti-nuclear fallout from the reactor accident at Three Mile Island, Pennsylvania - have led to drastic downward revisions since 1978.

TABLE 1. Alternative energy supply projections for three-region model, 1990 (MBD: million barrels daily oil equivalent)

Item	Region 1: Industrialized countries	Region 2: Oil-exporting developing countries	Region 3: Oil-importing developing countries	Total, regions 1-3
IBRD, EPDCE, a/ October 29, 1980	64.3	47.0	14.7	126.0
Cases 1, 3, 5, 7, 9 b/	62.3	45.0	14.7	122.0
Cases 2, 4, 6, 8: 5 MBD shortfall in region 2 and 3 MBD shortfall in region 3	62.3	40.0	11.7	114.0
1978 actual supplies	46.9	35.9	6.8	89.6

a/ Economic Analysis and Projections Department Commodities and Exports Projections.
b/ Cases are defined, and more detailed data given, in Appendix B.

5. Energy Demands - The Adjustment Problem

Energy demands depend both upon price and income elasticities. These runs have been based on the following GDP elasticities of demand for commercial energy: 1.0 in region 1; 1.3 in regions 2 and 3 for 1978, but declining thereafter. That is, at constant energy prices and other terms of

trade, each 1.0% increase in GDP will lead to an increase of 1.0% in energy demands in region 1; and an increase of 1.3% in regions 2 and 3. These GDP elasticities seem inconsistent with time series and also multi-country econometric estimates made both before and after the oil price increases of 1973 (Blitzer, Choe, and Lambertini 1979, p. 55).

But energy prices have not been constant during the past decade, and they are likely to rise still further during the 1980s. What clues on price elasticities can we gather from the post-1973 experience with higher energy prices? At the time this report went to press, satisfactory data were available only for the industrialized countries. Between 1970 and 1978, c.i.f. oil prices had tripled (in dollars of constant purchasing power). Over the same period, real GDP increased by 3.5% per year, and energy consumption increased at a 2.0% annual rate. To some extent, we have already observed a decoupling between energy consumption and economic growth.

For the industrialized countries between 1970 and 1978, the conventionally measured "income elasticity of demand for energy" was 2.0/3.5 = 0.57. But this calculation tells us little or nothing about long-term price elasticities of demand - or about the prospects for further adjustments of energy demands to higher prices. If we assume that all of the adjustments to the tripling in oil prices had already occurred by 1978, the implied long-term price elasticities are quite low. Conversely, if we assume that only 25% of the long-term adjustment had occurred by 1978, the implied long-term price elasticity of demand for primary commercial energy is 0.27 (in absolute terms). This view of adjustment - plus multi-country cross-section econometric studies - has led the Energy Modeling Forum (EMF) to specify 0.40 as the long-term price elasticity of demand for primary energy. (This 0.40 value is specified

for the EMF's reference case - and for most of the other scenarios currently being analyzed in the World Oil Study.) If this view is correct, the after-effects of the 1970-78 price increase will continue to help decouple energy consumption from GDP growth during the 1980s. Further assistance will be provided by the 1978-80 price shock - and by the cumulative impact of the real price increases projected post-1980.

For the developing countries, there have been only a handful of systematic studies of demand growth since the 1973 price rise. Some clues may be obtained from the following comparison between two time periods: 1960-70 and 1970-78. Dunkerley and Matsuba (1980) have calculated that the conventionally measured "energy/GNP [gross national product] elasticity" dropped (from 1.29 to 0.94) for the oil importers, and that it rose (from 1.04 to 1.46) for the oil exporters between the 1960s and the 1970s. The decline for the importers would be roughly consistent with the price elasticities estimated by Blitzer, Choe, and Lambertini (1979). The rise for the exporters is counter-intuitive, but it may be related to the fact that many of them held their domestic energy prices well below international levels during the 1970s. This stimulated domestic demands and also helped attract energy-intensive industries away from traditional locations.

What follows from all this? On the basis of the actual experience between 1970 and 1978, we cannot be at all certain whether energy demand adjustments will be easy or difficult. The key uncertainty appears to be the diversity in opinions on how long it takes for energy demands to respond to rising prices.

With the CES production functions employed in the three-region model, energy demand adjustments are specified quantitatively through "elasticities of

substitution." These are medium-term elasticities for 1990, and therefore lie below the long-term price elasticities of demand for primary energy. In order to achieve comparability with the current set of WDR IV energy demand projections, we have had to adopt rather low values for the 1990 elasticity of substitution between energy and other productive inputs. This will be termed a "difficult" view of the adjustment process. In contrast, when we employ the elasticities corresponding to an "easy" view, the results for the industrialized countries check quite closely with those in the EMF's reference case. It is assumed that the 1990 energy substitution elasticities will vary by region as follows:

	Difficult adjustment	Easy adjustment
Region 1: industrialized countries	.15	.20
Region 2: oil-exporting developing countries	.10	.10
Region 3: oil-importing developing countries	.10	.15

The elasticity of substitution refers to each individual region's production function. It is defined as the optimal reduction in total demand for energy relative to that of capital and labor in response to a 1% increase in the relative price of energy, total output remaining constant.

6. International Trade and Capital Flows

For each of the three regions' production functions, there is an elasticity of substitution between imports and domestic capital and labor. On the basis of the literature review cited by Whalley (1980, pp. 31-33), we have

adopted import trade elasticities of the order unity: 1.25 for the industrialized nations and 0.80 for the developing countries. Since each region's imports constitute another's exports, there is no need to specify export elasticities of demand in this model.

Side calculations suggest that the trade elasticities do not have a major impact upon energy price projections. They do, however, affect the relative prices of non-energy tradeables. In region 2, for example, case 1 implies an 83% real increase of export prices (e.g., through domestic inflation or through currency appreciation).1/ With these changes in the terms of trade, there are strong incentives to import non-energy tradeables. (Between 1978 and 1990, this generates a 14% annual increase in imports from region 3.) Moreover, these changes in the terms of trade lead to strong disincentives to export non-energy items from region 2. If the import elasticities were higher, the non-energy price adjustments might be lower, but trade volumes would still have to move in much the same direction so as to restore balance-of-payments equilibrium.

To some extent, international capital flows can cushion the impact of rising oil prices. In order to span a wide range of views, two polar extremes will be examined. Neither is designed to be altogether realistic, but together they cover a realistic range of possibilities. The optimistic view will be described as that of "compensatory capital flows." In these cases, the oil exporters (region 2) recycle 10% of their energy revenues, and the net effect of international capital markets is that this entire amount is available to finance the merchandise trade deficit of region 3. Thus, the higher oil prices rise, the greater becomes the value of these compensatory capital flows.

1/ Cases cited by number here and on following pages are defined in Appendix B.

In contrast, the pessimistic view is described as "zero trade deficits." In these cases, region 3 succeeds in borrowing just enough new capital to offset its non-merchandise current account deficit (including interest payments on past debts). With zero trade deficits, export volumes must be expanded, and there is a deterioration in ther terms of trade. Region 3's GDP growth is affected by amounts ranging up to 1.2% per year. Under the conditions associated with cases 2 and 6 (see Table 2) capital flows of $78 billion would permit a GDP gain of $167 billion in 1990.

7. Numerical Results

For "high GDP growth" in region 1, eight alternative scenarios have been calculated. These differ with respect to energy supplies, demands, and capital flows. For a summary, see Figure 1 and Table 2. Details on each case are provided in Appendix B. Merchandise trade flows are expressed in value terms (adjusted for changes in terms of trade) in Table and in volume terms in Appendix B.

According to WDR IV guidelines, the international price of oil will rise at 3% per year, net of inflation, between 1980 and 1990. This implies a 1990 price of about $45 per barrel, expressed in dollars of 1980 purchasing power. Cases 1, 4, 5 and 8 have been constructed so that they all lead to this level of oil prices. That is, real prices could increase by 3% annually during the 1980s - either with the 122 MBD level of supplies and "difficult" demand adjustments or with 114 MBD and "easy" adjustments. Note, however, that plausible changes in the input assumptions could lead to energy prices that are either much higher or lower than $45. If the "difficult" adjustment view is correct - and if 1990 energy supplies are limited to 114 MBD - there

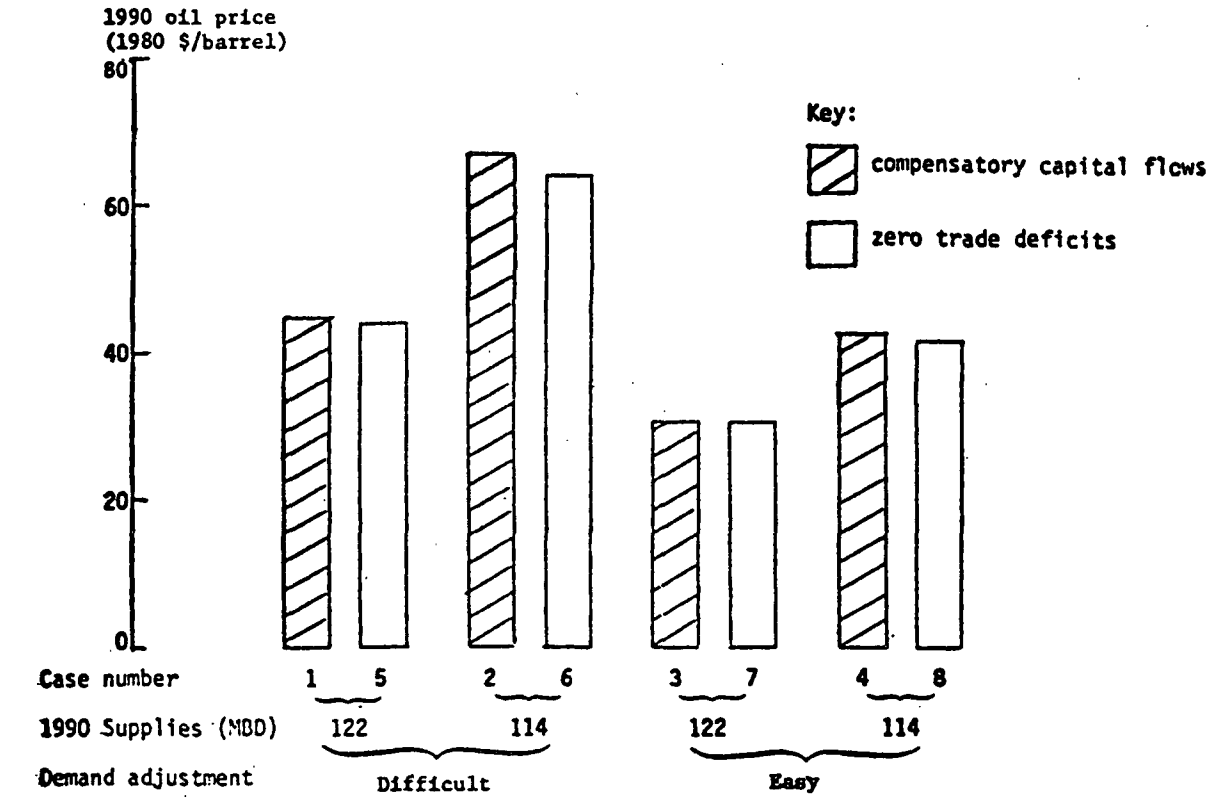
TABLE 2. Alternative projections of oil prices, GDP growth rates, and merchandise trade

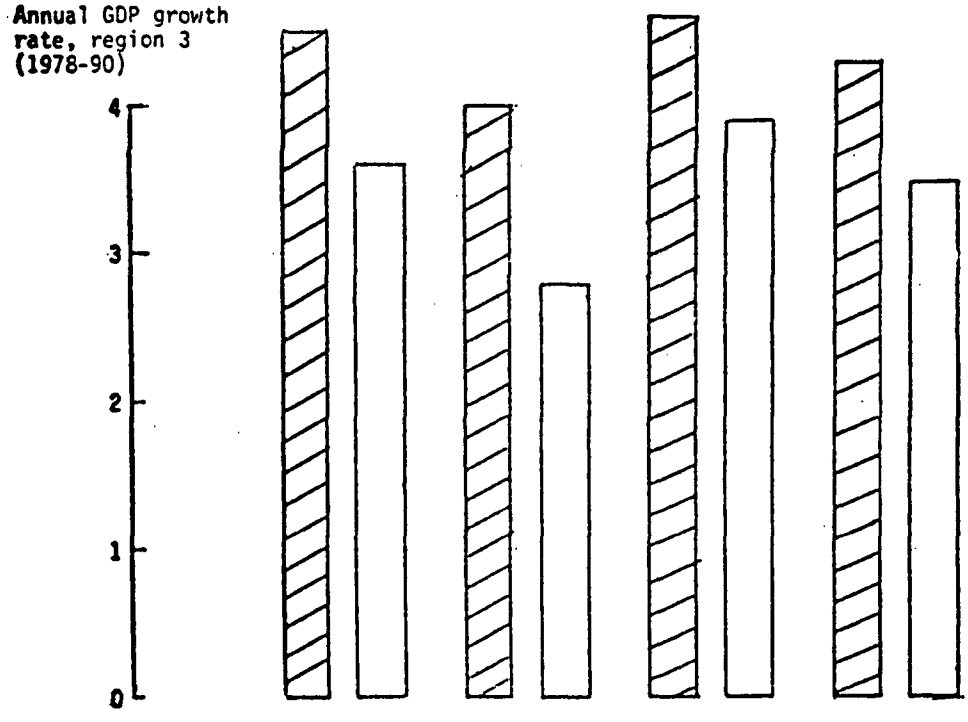
Case number	Capital flows	Adjustment of energy	Available energy supplies, regions 1-3, 1990 (MBD)	Oil price (1980 $/barrel)	Results for 1990: Realized annual GDP growth rates, 1978-90 (percent) — Region 1: Industrialized countries	Region 2: Oil exporting developing countries	Region 3: Oil importing developing countries	Value of merchandise trade, region 3, (billions of 1978 dollars, adjusted for changes in terms of trade) — Energy imports	Non-energy imports	Exports	Merchandise trade deficit
High GDP growth (region 1):											
1.	Compensatory	Difficult	122	45	3.2	7.1	4.5	73	143	156	60
2.	Compensatory	Difficult	114	67	3.0	7.4	4.0	123	106	151	78
3.	Compensatory	Easy	122	31	3.3	6.5	4.6	46	150	155	41
4.	Compensatory	Easy	114	43	3.2	6.8	4.3	79	125	153	51
5.	Zero Deficits	Difficult	122	44	3.2	7.4	3.6	51	114	165	0
6.	Zero Deficits	Difficult	114	64	3.1	7.7	2.8	86	77	163	0
7.	Zero Deficits	Easy	122	31	3.3	6.8	3.9	35	129	164	0
8.	Zero Deficits	Easy	114	42	3.3	7.0	3.5	60	102	162	0
Potential annual GDP growth at constant energy prices and other terms of trade, 1978-90					3.5	6.4	5.3				
Low GDP growth (region 1):											
9.	Zero Deficits	Difficult	116	43	2.8	7.0	3.5	46	107	153	0
1978 trade flows, region 3								16[a/]	122	95	43

a/ This $16 billion refers to net merchandise imports recorded in SITC (Standard International Trade Classification) category 3. At energy import rates of 6.3 MBD and a c.i.f. price of $13.70 per barrel, the 1978 energy import bill would have been $31.5 billion. Since these two methods of estimation are inconsistent, one must be cautious in making comparisons between our 1990 projections based on physical import rates and the 1978 statistics referring to SITC category 3.

Figure 1

Oil Prices and GDP Growth Rates, Region 3
(high GDP growth in region 1)





could be a sharp run-up. (The price of a barrel of oil rises to about $65 in cases 2 and 6.) Conversely, with "easy" demand adjustments and 122 MBD of supplies, prices could remain close to their 1980 level of $33. Note that the GDP growth rate of the oil exporters is highly correlated with the level of oil prices.

Oil prices are not significantly affected by the presence of compensatory capital flows (hatched bars in Figure 1) or by their absence (no hatching). It appears, however, that capital flows have a substantial impact upon the GDP growth rates of region 3, the oil-importing developing countries. If these flows are available to cushion the impact, a 100% rise in oil prices leads to a drop of 0.6% in their GDP growth rates. (Compare cases 2 and 3.) Without these flows, the drop is projected at 1.1%. (Compare cases 6 and 7.) In the most pessimistic scenario examined here (case 6), the GDP growth rate would be only 2.8% - barely enough to keep pace with the growth of population.

Despite the wide range of possible energy prices, the GDP growth rates of the industrialized countries do not vary widely. Imported energy still remains a relatively small fraction of the industrialized countries' GDP, and growth appears largely determined by the underlying assumptions with respect to the productivity of capital and labor. Even a 100% difference in energy prices leads to a difference of at most 0.3% in the annual GDP growth rates of these countries between 1978 and 1990. At first glance, this appears a counter-intuitive result - and quite different from the conventional wisdom expressed in newspaper headlines and editorial pages. Our analysis does not, however, refer to short-term political and military disruptions, but to medium-term economic trends. With a decade for energy demands and trade flows to adjust to higher prices, there is room for guarded optimism that energy constraints will not be the principal determinant of the industrialized countries' growth during the 1980s.

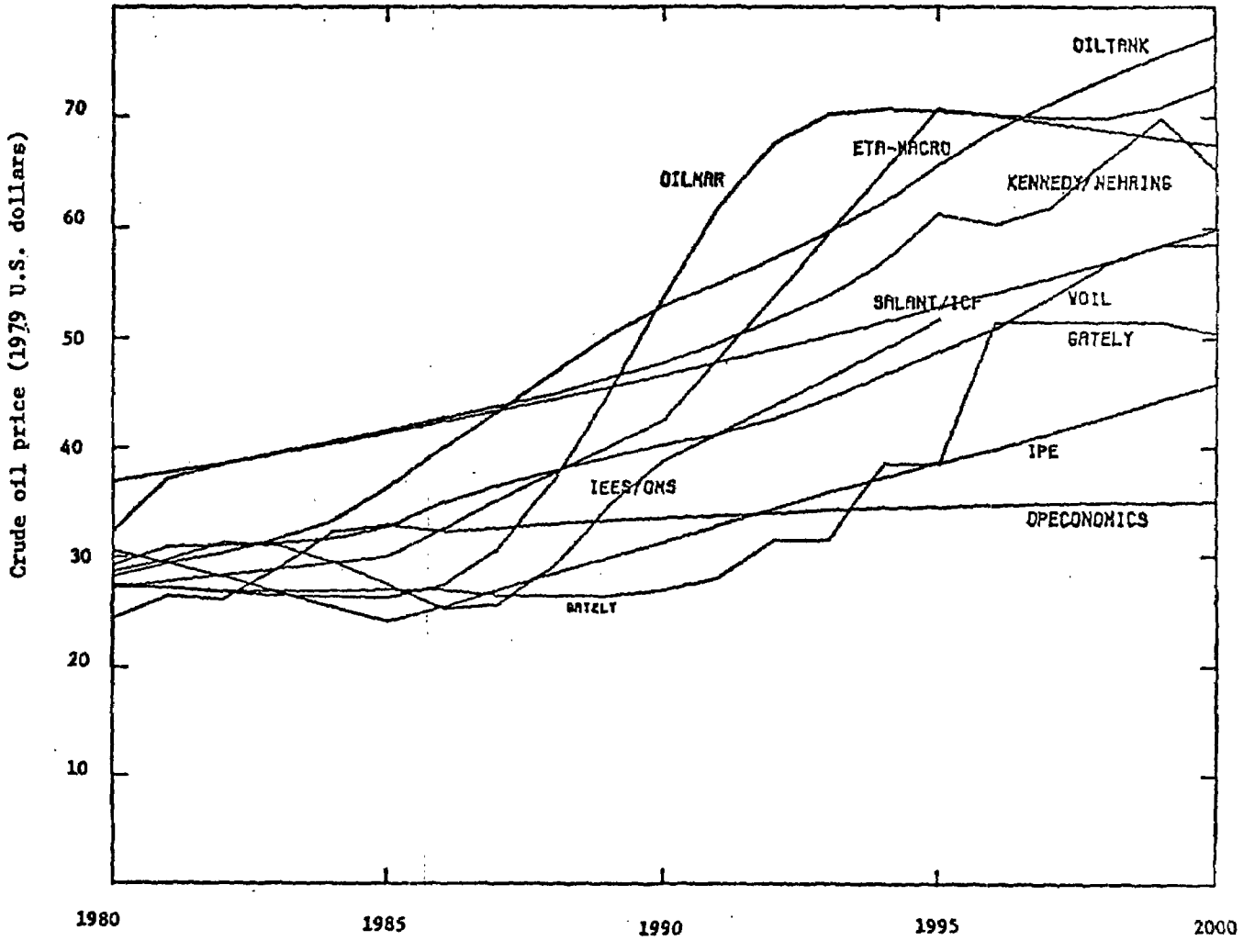
On the medium-term prospects for oil prices, some insights may be obtained from the EMF's World Oil Study. See Figure 2, and note that the WDR IV guideline value for 1990 lies in the middle of the range obtained for the EMF's reference case. There is a wide spread in the price projections from the ten different models participating in this study - even though it was intended that all would be run on similar assumptions with respect to GDP growth rates, price elasticities of demand, OPEC capacity, oil resources, etc.

ETA-MACRO was one of the models included in the EMF exercise (see Figure 2). Its 1990 price projection lies in the central cluster and cannot easily be distinguished from its neighbors. Among these models, ETA-MACRO was the only one to allow for dynamic energy-economy interactions - via the accumulation of capital and a "putty-clay" model of energy conservation. It is of particular interest, therefore, that the results of the EMF reference case check so closely with case 4 of the three-region model. Under this view of demand adjustments, it is relatively easy to decouple energy consumption from GDP growth in the industrialized countries:

	Three-region model, case 4 (114 MDB and "easy" demand adjustments	ETA-MACRO, reference for EMF World Oil Study
Annual growth rates, industrialized countries, 1978-90:		
Primary energy consumption	1.2%	1.29%
GDP	3.2%	3.05%
Ratio ("Energy/GDP elasticity")	0.38	0.42

Figure 2

Energy Modeling Forum (EMF)
world oil price projections, reference case



Despite extensive econometric reserch, there is still no general agreement whether the "easy" or the "difficult" adjustment view is more nearly correct for the industrialized countries. See the diversity of results reported in the demand elasticity study by EMF (1980). For the developing countries, there is an even wider range of debate - and only a handful of empirical studies. Surely it ought to be a high-priority research topic to study the post-1973 energy price and consumption trends in these countries and to draw whatever inferences are possible on the basis of this evidence.

8. A Postscript on "Low GDP Growth"

As of December 1980, WDR IV's "low" case had not been fully defined. It was generally understood that this would refer to a scenario in which the industrialized countries' GDP growth rate would be lowered by at least half a percentage point annually during the 1980s. This decline might be the result of high energy prices, or it might be attributed to declining growth in the labor force and productivity or to other factors. In any case, it was specified that international oil prices would continue to increase by 3% annually in real terms.

Case 9 represents an initial attempt to describe the WDR IV "low" case in terms of the three-region model. It is identical to case 5 (zero trade deficits and difficult demand adjustments) with only two exceptions: (a) region 1's potential GDP growth rate is reduced from 3.5% to 3.0% for the years 1978-90; and (b) region 2's energy production is cut back by 6 MBD to avoid the erosion of prices in the face of sluggish demand growth. (See Table 2 and Appendix B.)

Under these conditions, region 1's realized GDP growth rate drops from 3.2% (case 5) to 2.8% (case 9). Perhaps the principal surprise is that

there are no major indirect effects on region 3. Their export markets grow more slowly, but this leads to a minor decline in their GDP growth rate - from 3.6% (case 5) to 3.5% (case 9). Note however, that the indirect effects upon region 3 might be far more serious if low domestic growth were to stimulate political pressures for protectionism in the industrialized countries. This possibility has been incorporated in our "low GDP growth" case.

Appendix A. Model Formulation

The following definitions are adopted here:

Input data (excluding production function parameters)

d_j = domestic energy supplies in 1980, region j (adjusted for non-unitary GDP elasticities and capital transfers, if any)

x_{i1} = index number of capital and labor inputs in 1990, region i; can also be interpreted as potential GDP at constant 1978 prices of energy and non-energy imports

Quantity variables

y_i = realized GDP, region i (in 1978 dollars, adjusted for terms of trade

x_{ij} = non-energy products of region i imported into region j; $(i \neq j;\ i,j, = 1,2,3)$

x_{4j} = energy consumed by region j.

Price variables

π_j = price of non-energy products, region j $(j = 1,2,3)$

π_4 = price of energy.

It will be convenient to report all prices as π_j/π_1. That is, the numeraire is defined as region 1 products, 1978 dollars. For 1980 dollars, add 25%.

The nested CES production functions appear within the first three material balances below. There will be considerable debate about the magnitudes of the exponents in these CES functions. The ease or difficulty of substituting between domestic and imported non-energy inputs will be determined by the parameter α. The "elasticity of trade substitution" is defined as $1/(1 - \alpha)$. Similarly, the "elasticity of energy substitution" is $1/(1 - \beta)$.

Given the values of the exponents α and β, we employ 1978 data to estimate the a_{ij} constants that appear in the nested CES functions. (The 1978 benchmark estimates are reproduced in Appendix B.) Assuming that the inputs were optimally adjusted to the international prices prevailing in 1978,

it is straightforward to determine the a_{ij} coefficients from the first-order optimality conditions. That is, the marginal productivity of each input must be equal to its 1978 price. For details, see the dissertation of S. Kim (Stanford Universy, forthcoming). This will also describe our solution algorithm - an extension to nonlinear economies of the procedure described by Marine, Chao, and Wilson (1980).

In connections with this benchmarking, two observations should be noted: (1) To allow for the incomplete adjustment (approximately 50%) that had taken place by 1978 in response to the energy price increases of 1973-74, we assume that the 1978 "reference price" of oil was only $10 per barrel. This is the price inserted into the first-order optimality equations - not the actual 1978 price of $13.70. (2) The production function elasticities incorporate institutional and behavioral as well as technological constraints. In effect, our benchmarking procedure ignores the possibility of changes in tariff and non-tariff barriers to international trade between 1978 and 1990. Other approaches are required to investigate these barriers to adjustment.

The model is based upon four material balances for the four tradeable commodities:

GNP	+	exports of non-energy products	$\leq$	domestic production, non-energy	
				non-energy inputs	energy inputs

$$y_i + \sum_{j \neq i} x_{ij} \leq \left[\left(\sum_{j=1}^{3} a_{ij} x_{ji}^{\alpha} \right)^{\beta/\alpha} + a_{i4} x_{4i}^{\beta} \right]^{1/\beta} \qquad (i = 1,2,3)$$

where subscripts for region i are omitted on exponents α and β.

total energy consumption	$\leq$	total energy supplies
$\sum_{j=1}^{3} x_{4j}$		$\sum_{i=1}^{3} d_j$

There is also one balance-of-trade constraint for each region:

$$\begin{pmatrix}\text{value of}\\ \text{non-energy}\\ \text{exports}\end{pmatrix} \leq \begin{pmatrix}\text{value of}\\ \text{non-energy}\\ \text{imports}\end{pmatrix} + \begin{pmatrix}\text{value of energy}\\ \text{imports}\\ \text{(exports)}\end{pmatrix}$$

$$\pi_i \sum_{j\neq i} x_{ij} \geq \sum_{\substack{j\neq i,\\ j\neq 4}} \pi_j x_{ji} + \pi_4 (x_{4i} - d_i)$$

$$(i = 1,2,3).$$

As written here, the three balance-of-trade constraints imply that net capital transfers will be zero in 1990. To allow for such transfers, we have adjusted the ownership of energy supplies - transferring 10% of region 2's resources and placing them at the disposal of region 3.

To reflect 1.3 GDP elasticities of energy demand (at constant prices) in the developing countries, another adjustment is made to the domestic energy supplies, d_j. That is, 30% is added to the base-year energy supplies and demands. The identical amount is added to the 1990 domestic energy supplies. In this way, we allow for a gradual long-term decline in the GDP elasticity of demands. This 30% adjustment can also be interpreted as an allowance for non-commercial to be replaced by commercial energy.

One piece of algebra is straightforward, but is not shown explicitly: In cases 1,3,5,7 and 9, region 2's energy supplies include 3 MBD available at a domestic cost of $12 per barrel (1978 price level). These supplies are not available in the shortfall scenarios (cases 2,4,5 and 8).

One final detail: The 1978 base-year energy consumption was adjusted so that it would be identical to the supplies available within the market economies. Consumption was increased by 0.6% in each region to account for the net effect of exports from the centrally planned economies, bunkers, and other items.

Appendix B. Nine Alternative Projections

High GDP growth:

1. Compensatory capital flows; difficult demand adjustments; 122 MBD
2. " "; "; 114 MBD
3. " "; "; 122 MBD
4. " "; "; 114 MBD
5. Xero trade deficits ; difficult demand adjustments ; 122 MBD
6. " "; "; 114 MBD
7. " ; easy demand adjustments ; 122 MBD
8. " "; "; 114 MBD

Low GDP growth:

9. Zero trade deficits ; difficult demand adjustments ; 114 MBD

Note: In the following tabulations, DCS = developing countries.

CASE 1

HIGH GDP GROWTH
COMPENSATING CAPITAL FLOWS
DIFFICULT ADJUSTMENT OF ENERGY DEMANDS
122 MBD ENERGY SUPPLIES IN 1990

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY TRADE	1990 ELASTICITY ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized	1990	8075.	8382.		314.6	140.3	86.8	62.3	1.25	0.15
Countries	Annual Growth	3.2%	3.5%		11.5%	1.3%	1.7%	2.4%		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting	1990	1045.	962.	5.2		1.4	15.0	45.0	0.80	0.10
DCS	Annual Growth	7.1%	6.4%	-3.9%		-3.5%	8.2%	1.9%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting	1990	1390.	1522.	166.2	48.2		20.2	14.7	0.80	0.10
DCS	Annual Growth	4.5%	5.3%	5.7%	13.9%		3.7%	6.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	10510.	10866.	171.4	362.8	141.8	122.0	122.0		
	Annual Growth	3.7%	4.0%	5.2%	11.8	1.2	2.6%	2.6%		
1990 Equilibrium Prices				1.000	1.833(A)	0.727(A)		45.39(B)		

NOTES:
(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES.

ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

CASE 2

HIGH GDP GROWTH
COMPENSATING CAPITAL FLOWS
DIFFICULT ADJUSTMENT OF ENERGY DEMANDS
114 MBD ENERGY SUPPLIES IN 1990

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY TRADE	1990 ELASTICITY ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized Countries	1990	7940.	8382.		375.1	103.6	80.7	62.3	1.25	0.15
	Annual Growth	3.0%	3.5%		13.1%	-1.2%	1.1%	2.4%		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting DCS	1990	1082.	962.	3.6		1.0	15.2	40.0	0.80	0.10
	Annual Growth	7.4%	6.4%	-6.7%		-6.4%	8.4%	0.9%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting DCS	1990	1310.	1522.	153.3	58.0		18.0	11.7	0.80	0.10
	Annual Growth	4.0%	5.3%	5.0%	15.7%		2.7%	4.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	10332.	10866.	157.0	433.1	104.6	114.0	114.0		
	Annual Growth	3.5%	4.0%	4.4%	13.4%	-1.3%	2.0%	2.0%		
1990 Equilibrium Prices				1.000	2.238(A)	0.716(A)	67.00(B)			

NOTES:
(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES.

ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

CASE 3

HIGH GDP GROWTH
COMPENSATING CAPITAL FLOWS
EASY ADJUSTMENT OF ENERGY DEMANDS
122 MBD ENERGY SUPPLIES IN 1990

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY	
									TRADE	ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized Countries	1990	8211.	8382.		230.2	147.9	88.2	62.3	1.25	0.20
	Annual Growth	3.3%	3.5%		8.6%	1.7%	1.9%	2.4%		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting DCS	1990	976.	962.	8.2		2.0	14.0	45.0	0.80	0.10
	Annual Growth	6.5%	6.4%	-0.2%		-0.9%	7.6%	1.9%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting DCS	1990	1399.	1522.	188.3	36.5		19.7	14.7	0.80	0.15
	Annual Growth	4.6%	5.3%	6.8%	11.3%		3.5%	6.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	10585.	10866.	196.6	266.7	149.9	122.0	122.0		
	Annual Growth	3.7%	4.0%	6.4%	8.9%	1.7%	2.6%	2.6%		
1990 Equilibrium Prices				1.000	1.337(A)	0.691(A)		31.29(B)		

NOTES:
(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES.

ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

CASE 4

HIGH GDP GROWTH
COMPENSATING CAPITAL FLOWS
EASY ADJUSTMENT OF ENERGY DEMANDS
114 MBD ENERGY SUPPLIES IN 1990

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY	
									TRADE	ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized Countries	1990	8130.	8382.		260.7	122.7	81.9	62.3	1.25	0.20
	Annual Growth	3.2%	3.5%		9.7%	0.2%	1.2%	2.4		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting DCS	1990	1002.	962.	6.5		1.6	14.1	40.0	0.80	0.10
	Annual Growth	6.8%	6.4%	-2.2%		-2.7%	7.7%	0.9%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting DCS	1990	1354.	1522.	181.2	41.6		17.9	11.7	0.80	0.15
	Annual Growth	4.3%	5.3%	6.5%	12.5%		2.6%	4.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	10487.	10866.	187.6	302.3	124.3	114.0	114.0		
	Annual Growth	3.6%	4.0%	6.0%	10.1%	0.1%	2.0%	2.0%		
1990 Equilibrium Prices				1.000	1.547(A)	0.688(A)		43.37(B)		

NOTES:
(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES.

ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

CASE 5

HIGH GDP GROWTH
ZERO TRADE DEFICITS
DIFFICULT ADJUSTMENT OF ENERGY DEMANDS
122 MBD ENERGY SUPPLIES IN 1990

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY TRADE	1990 ELASTICITY ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized Countries	1990	8108.	8382.		351.8	112.0	87.6	62.3	1.25	0.15
	Annual Growth	3.2%	3.5%		12.5%	-0.6%	1.8%	2.4		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting DCS	1990	1075.	962.	4.7		2.0	15.7	45.0	0.80	0.10
	Annual Growth	7.4%	6.4%	-4.7%		-6.1%	8.6%	1.9%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting DCS	1990	1253.	1522.	214.6	62.4		18.7	14.7	0.80	0.10
	Annual Growth	3.6%	5.3%	8.0%	16.4%		3.0%	6.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	10436.	10866.	219.3	414.2	113.1	122.0	122.0		
	Annual Growth	3.6%	4.0%	7.4%	13.0%	-0.7%	2.6%	2.6%		
1990 Equilibrium Prices				1.000	2.022(A)	0.598(A)		44.10(B)		

NOTES:
(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES. ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

CASE 6

HIGH GDP GROWTH
ZERO TRADE DEFICITS
DIFFICULT ADJUSTMENT OF ENERGY DEMANDS
114 MBD ENERGY SUPPLIES

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY TRADE	1990 ELASTICITY ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized	1990	7980.	8382.		417.1	75.1	81.8	62.3	1.25	0.15
Countries	Annual Growth	3.1%	3.5%		14.1%	-3.9%	1.2%	2.4		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting	1990	1111.	962.	3.4		0.7	15.9	40.0	0.80	0.10
DCS	Annual Growth	7.7%	6.4%	-7.4%		-9.4%	8.8%	0.9%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting	1990	1143.	1522.	204.2	76.3		16.3	11.7	0.80	0.10
DCS	Annual Growth	2.8%	5.3%	7.6%	18.4%		1.8%	4.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	10234.	10866.	207.6	493.4	75.7	114.0	114.0		
	Annual Growth	3.4%	4.0%	6.9%	14.7%	-3.9%	2.0%	2.0%		
1990 Equilibrium Prices				1.000	2.434(A)	0.580(A)	64.11(B)			

NOTES:

(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES.

ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

CASE 7

HIGH GDP GROWTH
ZERO TRADE DEFICITS
EASY ADJUSTMENT OF ENERGY DEMANDS
122 MBD ENERGY SUPPLIES

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY TRADE	1990 ELASTICITY ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized	1990	8232.	8382.		259.0	126.9	88.8	62.3	1.25	0.15
Countries	Annual Growth	3.3%	3.5%		9.7%	0.4%	1.9%	2.4		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting	1990	1006.	962.	7.3		1.5	14.7	45.0	0.80	0.10
DCS	Annual Growth	6.8%	6.4%	-1.2%		-3.0%	8.0%	1.9%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting	1990	1300.	1522.	226.8	46.1		18.5	14.7	0.80	0.15
DCS	Annual Growth	3.9%	5.3%	8.5%	13.5%		2.9%	6.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	10538.	10866.	234.1	305.1	128.4	122.0	122.0		
	Annual Growth	3.7%	4.0%	7.9%	10.2%	0.4%	2.6%	2.6%		
1990 Equilibrium Prices				1.000	1.470(A)	0.600(A)	30.90(B)			

NOTES:

(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES.

ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

CASE 8

HIGH GDP GROWTH
ZERO TRADE DEFICITS
EASY ADJUSTMENT OF ENERGY DEMANDS
114 MBD ENERGY SUPPLIES

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY TRADE	1990 ELASTICITY ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized	1990	8156.	8382.		292.9	99.7	88.6	62.3	1.25	0.20
Countries	Annual Growth	3.3%	3.5%		10.8%	-1.6%	1.3%	2.4		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting	1990	1033.	962.	5.8		1.2	14.8	40.0	0.80	0.10
DCS	Annual Growth	7.0%	6.4%	-3.0%		-5.0%	8.1%	0.9%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting	1990	1236.	1522.	224.4	53.4		16.6	11.7	0.80	0.15
DCS	Annual Growth	3.5%	5.3%	8.4%	14.9%		2.0%	4.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	14248.	10866.	230.2	346.3	100.9	114.0	114.0		
	Annual Growth	3.7%	4.0%	7.8%	11.3%	-1.6%	2.0%	2.0%		
1990 Equilibrium Prices				1.000	1.703(A)	0.583(A)		42.42(B)		

NOTES:
(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES.

ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

CASE 9

HIGH GDP GROWTH
ZERO TRADE DEFICITS
DIFFICULT ADJUSTMENT OF ENERGY DEMANDS
116 MBD ENERGY SUPPLIES

(UNIT FOR GDP AND EXPORTS: BILLIONS OF 1978 U.S. DOLLARS)
(UNIT FOR ENERGY: MILLION BARRELS DAILY: OIL EQUIVALANT)

		REAL-IZED	POTEN-TIAL	EXPORTS TO REGION 1, NON-ENERGY	EXPORTS TO REGION 2, NON-ENERGY	EXPORTS TO REGION 3, NON-ENERGY	ENERGY CONSUMP-TION	DOMESTIC ENERGY PRODUCTION AVAILABLE	1990 ELASTICITY TRADE	1990 ELASTICITY ENERGY
Region 1	1978	5547.	5547.	----	85.4	120.4	70.7	46.9		
Industri-alized	1990	7708.	7909.		288.4	105.6	83.0	62.3	1.25	0.15
Countries	Annual Growth	2.8%	3.0%		10.7%	-1.1%	1.3%	2.4		
Region 2	1978	457.	457.	8.4	----	2.2	5.8	35.9		
Oil Ex-porting	1990	1030.	962.	5.5		1.1	14.7	39.0	0.80	0.10
DCS	Annual Growth	7.0%	6.4%	-3.5%		-5.6%	8.0%	0.7%		
Region 3	1978	819.	819.	85.1	10.1	----	13.1	6.8		
Oil Im-porting	1990	1241.	1522.	217.1	53.5		18.3	14.7	0.80	0.10
DCS	Annual Growth	3.5%	5.3%	8.1%	14.9%		2.8%	6.6%		
Total	1978	6823.	6823.	93.5	95.5	122.6	89.6	89.6		
Regions, 1-3	1990	9979	10393.	222.5	341.9	106.7	116.0	116.0		
	Annual Growth	3.2%	3.6%	7.5%	11.2%	-1.1%	2.2%	2.2%		
1990 Equilibrium Prices				1.000	1.682(A)	0.567(A)		43.30(B)		

NOTES:

(A) TERMS OF TRADE INDICES. RATIOS TO 1978 DOLLARS FOR REGION 1.

(B) ENERGY PRICES EXPRESSED IN 1980 $/BARREL; COMPARE WITH THE 1978 ACTUAL PRICE OF $13.7 AND THE 1978 "REFERENCE PRICE" OF $10/BARREL EMPLOYED FOR BENCHMARKING PURPOSES.

ENERGY-GDP ELASTICITIES OF 1.3 AT CONSTANT PRICES IN REGIONS 2 AND 3. DECLINING AFTER 1978.

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