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Oil Price Changes and Real Exchange Rate Movements Among Industrial Countries

Prepared by Anne K. McGuirk*

Approved by Jacques R. Artus

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Summary

The purpose of this paper is to analyze quantitatively, in a multi-country framework, the longer-run effects of the oil price increases of the 1970s on the external positions and real exchange rates of the seven major industrial countries. More specifically, the analysis focuses on the changes in countries' competitive positions in the goods market required to eliminate the deterioration or improvement in the balance of payments attributable to changes in oil prices. For this purpose, a multi-country model is used which incorporates the bilateral and third market trading relationships among the industrial countries, the oil exporting countries, and all other countries as a group. The analysis of the effects of oil price increases on real exchange rates is equally applicable to a decline in oil prices and to the general question of how a change in the price of a major commodity affects real exchange rates.

It is argued that the major effects of a change in oil prices on a country's balance of payments position in the longer run depend on the change in the country's trade balance in energy products and the increase in the country's exports to the oil exporting countries. In turn, the change in a country's real exchange rate needed to offset the effects of oil price changes on its external position depends on the size and direction of the change in its balance of payments relative to other countries and the responsiveness of its imports and exports to relative price changes.

As expected, the empirical results indicate that, under the usual ceteris paribus condition, the realignment of the real exchange rates among the major industrial countries needed to offset the longer-run effects of the oil price increases that occurred during the 1970s on countries' balance of payments positions was large. Measured in relation to the U.S. dollar, the pound sterling had to appreciate in real terms by 17 per cent and the Canadian dollar by 10 per cent. Among the net energy importers, Japan had to depreciate the most, on the order of 27 per cent. The Federal

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Republic of Germany and France had to depreciate by 10 per cent, while Italy had to depreciate by 15 per cent. In real effective terms, the needed realignment of real exchange rates corresponded to relatively small real effective depreciations for the three European countries, ranging from 3 to 7 per cent, and a real effective appreciation for the United States of 4 per cent. By contrast, the United Kingdom had to appreciate in real effective terms by 23 per cent, Canada had to appreciate by 12 per cent, and Japan had to depreciate by 28 per cent.

I. Introduction

The purpose of this paper is to isolate the contribution of the major oil price increases of the 1970s 1/ to changes in real exchange rates among the seven major industrial countries (Canada, the United States, Japan, France, the Federal Republic of Germany, Italy, and the United Kingdom) from other developments affecting real exchange rates that occurred during the 1970s and early 1980s. While the study focuses on the effects of oil price increases on real exchange rates, the analysis is equally applicable to oil price declines and to the general question of how a change in the price of a major commodity affects the overall balance of payments adjustment process among countries.

Initially, higher oil prices affect industrial countries' balance of payments positions directly through their effects on trade in energy products and indirectly through increased exports to and investment flows from the oil exporting countries. In the longer run, however, the export earnings of the oil exporting countries tend to be fully absorbed--that is, spent on goods and services from abroad. On a net basis, current investment flows from the oil exporting countries then cease and would exert no further influence on real exchange rates. The stock of foreign financial assets accumulated by the oil exporting countries during the adjustment period is sizable, but because capital tends to flow among countries so as to equalize the risk-adjusted rates of return on investment, any portfolio preferences of the oil exporting countries are counterbalanced by other capital flows among countries. Thus, the major determinants of the longer-run effects of higher oil prices on industrial countries' net balance of payments positions are the changes in

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1/ The average price of a barrel of oil exported by the oil exporting countries increased from $2.29 in 1972 to $10.49 in 1974 and from $12.83 in 1978 to $30.91 in 1980. Measured relative to the average export price of industrial countries, the real price of oil increased 406 per cent by 1980, compared with 1972. Over the same period, total real energy prices in the major industrial countries increased by varying amounts, ranging from 40 per cent for Canada and the United Kingdom to 136 per cent for the United States. In 1981 real oil prices increased by 11 per cent, but then declined by 0.8 per cent in 1982. By early 1983, the average price of a barrel of oil exported by the oil exporting countries was about $30.00 a barrel. Measured relative to the average export price of industrial countries, the price of a barrel of oil was 1 1/2-2 per cent higher in real terms than it was in 1980.

countries' trade balances in energy products and the increases in countries' exports to the oil exporting countries attributable to higher oil prices. The required change in a country's exchange rate depends on the size and direction of the net change in its external position attributable to higher oil prices relative to that of other countries. In the present paper these net balance of payments effects are first estimated for each of the major industrial countries based on certain assumptions about economic growth, real energy prices, and the trade preferences of the oil exporting countries. The Multilateral Exchange Rate Model (MERM) is then used to solve for the changes in real exchange rates that are necessary to offset the differential effects of higher oil prices on the external positions of the major industrial countries.

In Section II of this paper, the net effects of higher oil prices on countries' external positions are derived by conducting hypothetical simulations in which exchange rates are held constant. An overview of the structure of the MERM and a description of how the model is used to solve for the changes in real exchange rates among the major industrial countries that are necessary to offset the net balance of payments effects of higher oil prices are given in Section III. Conclusions follow in Section IV.

II. Assumptions and Methods Used to Estimate the Effects of Higher Oil Prices on the Balance of Payments

A number of assumptions need to be made in order to isolate the effects of higher oil prices on the overall payments balance of each of the major industrial countries. In the first place, it is necessary to choose a period of analysis that is sufficiently long to allow for lags in the adjustment of energy production and consumption in the major industrial countries to higher oil prices and also for the lagged effects on the absorptive capacity of the oil exporting countries to work their way through the economic system. In this section, projections are made of changes in the net external positions of the major industrial countries that would occur by 1985 as a result of the oil price increases of 1973-74 and 1979-80, holding other factors, including real exchange rates, constant.

The projections to 1985 probably do not extend far enough into the future to allow for complete adjustment by the industrial countries to the large changes in real energy prices that have occurred (especially those resulting from the 1979-80 oil price increases). 1/ However, it is reasonable to assume that they extend far enough to allow for complete adjustment by the oil exporting countries as a group to the higher level of their export receipts. Table 1 shows the evolution of the current

1/ For an industrial country, complete adjustment of the structure of consumption and production to the large real oil price increases that have occurred since 1972 may take as long as 20 years, considering the time required to redesign the capital stock to produce "energy efficient" durable goods. For example, Nordhaus (1980, p. 346) states that it will be 1990 before plant and equipment in the U.S. automobile industry can be completely retooled to make small cars.

Table 1. Oil Exporting Countries:
Balance of Payments on Current Account, 1973-82

(In billions of U.S. dollars)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982 1/
Exports (f.o.b.)	39.0	117.9	109.6	133.2	146.8	141.6	214.0	297.6	273.5	215.2
Oil exports	35.0	112.3	103.7	126.2	138.5	132.2	201.0	281.4	257.9	198.0
Other exports	4.0	5.6	5.9	7.1	8.3	9.4	13.2	16.2	15.6	17.2
Imports (f.o.b.)	-20.2	-35.8	-56.2	-68.1	-86.1	-101.5	-101.5	-131.0	-154.7	-156.7
Balance on merchandise trade	18.8	82.2	53.4	65.1	60.7	40.1	112.7	166.6	118.8	58.5
Net services and private transfers	-12.2	-13.9	-18.0	-24.8	-30.5	-37.9	-44.1	-52.3	-53.8	-57.5
Receipts	4.3	8.8	12.1	14.6	18.1	21.3	24.9	36.5	45.2	43.8
Payments	-16.4	-22.7	-30.1	-39.4	-48.6	-59.2	-69.0	-88.8	-99.0	-101.3
Balance on current account	6.7	68.3	35.4	40.3	30.2	2.2	68.0	114.3	65.6	1.0

Source: World Economic Outlook, 1982, and revised staff projections.

1/ Fund staff estimates.

account of the oil exporting countries from 1973 to 1982. 1/ After the 1973-74 oil price increases, the current account surplus of this group peaked in 1974 and fell to near balance by 1978. The second round of oil price increases in 1979-80 was accompanied by a similar adjustment of the current account surplus of the oil exporting countries.

The data presented in Table 1 illustrate the fact that the decline in the surplus of the oil exporting countries after each major episode of oil price increases has been quite rapid. When the oil exporting countries' surplus on energy trade is fully absorbed--spent on goods and services from abroad--the predominant factors influencing real exchange rates among industrial countries are: (1) the relative net energy position (the balance of trade in energy) of each country and (2) the effects of the additional spending by oil exporting countries on each country's exports. A deterioration in a country's net energy position due to higher oil prices will be offset, to some extent, by its share in the increased exports of goods and services to oil exporting countries, other factors being held constant. The remaining "gap" can be offset by a change in the real exchange rate that would improve the country's competitive position vis-à-vis other industrial countries.

The method used to isolate the effects of higher oil prices on the net external position of each of the major industrial countries is to project each country's external balance to 1985 based on alternative oil price assumptions, holding exchange rates and all other factors unchanged. In the first set of projections, the real price of oil is held constant at its 1972 level. In two alternative sets of projections, the changes in the real price of oil that actually took place over the two periods 1972 to 1978 and 1972 to 1980 are taken into account. The differences between the projections based on 1972 real oil prices and those based on either of the two alternative real oil price assumptions represent the changes in countries' external positions that are attributable solely to the increase in the price of oil.

It is important to note that in both the constant 1972 real oil price projections and the projections based on higher oil prices, the rates of growth of real economic activity in each industrial country are assumed to be the same. This simplifying assumption helps to isolate the direct effects of higher oil prices on the balance of payments, by abstracting from the feedback effects of oil price changes onto other variables which in turn affect the balance of payments.

Of course, the large oil price increases of 1973-74 and 1979-80 have had an effect on the rate of growth of economic activity in the industrial countries. The two most important effects are the direct effect of higher oil prices on output, and the indirect effect on output resulting from restrictive stabilization policies designed to reduce the inflationary effects of higher oil prices. The direct effect on output

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1/ The oil exporting countries are Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Oman, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.

results from the increase in the relative price of one of the factors of production, namely, energy. There is controversy in the literature about the size and duration of this effect. 1/ In general, it will depend on the share of energy in the cost of production (about 4 per cent in the United States), the substitutability of other factors of production for energy, and the scope for shifting resources to the energy producing sector and to less energy intensive sectors. In studies that have measured the direct effect of higher energy prices on output, the results indicate that this effect is not very large. For example, Pindyck (1980) 2/ estimates that if real energy prices increased at an annual rate of 5 per-cent for 30 years, assuming no net energy-capital substitution, real economic growth in the United States would be reduced by about 0.2 per-cent per year. Thus, the direct effect of higher production costs on economic growth is likely to be small, compared with the effects of the restrictive demand management policies pursued by a number of the major industrial countries following the oil price increases of 1973-74 and 1979-80. To the extent that higher energy prices have affected economic growth in the major industrial countries to a similar degree, the estimated real exchange rate changes derived below will not be very much affected.

In the analysis which follows, the change in each country's net external position attributable to higher oil prices is broken down into its two components: (1) the change in a country's net energy position (defined as the change in the balance of trade in energy products 3/) and (2) the increase in exports to the oil producing countries, which, assuming factors other than oil prices are held constant, is estimated on the basis of each country's share in exports to the oil producing countries prior to the 1973-74 oil price increases. Estimates of the effects of higher oil prices on countries' net energy positions are derived in part A of this section. In part B, these estimates are combined with the projected increases in countries' exports to the oil exporting countries to derive the change in each country's net external position attributable to higher oil prices, at unchanged real exchange rates.

A. Projection of energy balances to 1985

The framework used to estimate the effects of higher oil prices on countries' energy balances is that of the homogeneous goods model. 4/

1/ For a discussion of these issues with reference to the United States see the November/December 1980 issue of Challenge. An article by Dennison supports the no effect view, and, in an interview, Jorgensen supports the opposing view.

2/ See Pindyck (1980), p. 116.

3/ Specifically, this is defined as the change in the balance on trade in fuels as defined in Section 3 of the Standard International Trade Classification (SITC). This section includes trade in coal, petroleum and petroleum products, gas (natural and manufactured) and electric current. For the OECD countries, over 90 per cent of net energy imports consists of imports of oil and oil products.

4/ The homogeneous goods (or perfect substitutes) model is based on the assumption that foreign and domestic goods are perfectly substitutable. See Goldstein and Khan (1982, p. 10) for a characterization of this model.

In this model, imports or exports of energy products are determined residually as the difference between the domestic demand for energy and the domestic supply of energy. A country is a net importer (exporter) of energy if domestic energy demand exceeds (is less than) domestic energy supply. The projections of domestic energy demand and supply that take the oil price increases into account are based on the most recent estimates by country experts published by the International Energy Agency (IEA), 1/ where available, or on estimates derived on the basis of income and price elasticities. An examination of the pre-1973 trends in energy demand and supply provides the motivation for the methods used to derive the projections based on the 1972 real price of oil. These projections rely mainly on estimates of energy demand derived on the basis of income elasticities and real GDP growth, holding real energy prices constant at their 1972 levels, and on plausible assumptions about energy supply developments in the absence of higher real oil prices.

1. Historical trends in energy demand and supply

The projections that hold the real price of oil constant at its 1972 level are intended to answer the hypothetical question of what nominal energy balances would be by 1985 if the real price of oil had not risen sharply after 1972. For this purpose, it is useful to take a look at the trends in the demand for and supply of energy prior to the first oil price shock and the history of estimates of the effects of higher oil prices on energy demand and supply.

During the 1950s and 1960s, world oil production increased at an annual rate of 6 to 7 per cent, while the real price of oil fell gradually from the early 1950s onward, reaching its lowest level in 1970. Oil market conditions began to tighten in the early 1970s, and between 1970 and 1972 the price of Saudi Arabian crude oil rose 46 per cent, from $1.30 per barrel in 1970 to $1.90 per barrel in 1972, its highest level since 1956. At that time, however, projections of oil demand were based either on no further change in the real price of oil or on only small increases.

As a consequence of the growth of relatively cheaper oil supplies, substantial substitution away from other fuels, especially coal, took place during the 1960s. These developments were reflected in the trends in the demand for energy and, in particular, for oil in the individual industrial countries. Table 2 shows, for the major industrial countries, the elasticities of total energy consumption and oil consumption with respect to the growth of GDP for the period 1960-73. With the exception of Italy and the United Kingdom, the elasticities of total energy consumption are quite close to unity. The degree of substitution from other energy sources into oil that occurred during the 1960s in the European

1/ International Energy Agency, Energy Policies and Programmes of IEA Countries, 1981 Review, OECD (Paris, 1982).

Table 2. Elasticities of Energy Consumption and Oil Consumption with Respect to Real GDP Growth 1/
(Unadjusted for Relative Price Changes)

	Total Energy Consumption	Oil Consumption
Canada	1.02	0.98
United States	1.07	1.13
Japan	1.00	1.76
Germany, Fed. Rep. of	1.05	2.84
France	0.96	1.94
Italy	1.51	2.42
United Kingdom	0.68	2.31

Sources: Energy Policies and Programmes of IEA Countries, 1980 Review, Energy Balances of OECD Countries, (Paris, OECD) and International Financial Statistics (Washington, IMF).

1/ The average annual growth of energy consumption or oil consumption in volume terms divided by the average annual growth of real GDP.

countries and Japan is apparent from the income elasticities of oil consumption, which are nearly two to three times larger than the elasticity of total energy. 1/

The pre-1973 trends in the demand for and supply of energy possibly influenced the estimates of the response to higher oil prices made after the first oil price increases in 1973-74. The available evidence suggests that these estimates tended to underestimate the price response on the demand side and to overestimate it on the supply side. In a survey of energy projections to 1985, Brodman and Hamilton (1979) reviewed 78 studies prepared during the period 1969 through mid-1978. A study by Deagle, Mossavar-Rahman, and Huff (1981) provides an update of the Brodman-Hamilton survey through early 1980. In both these surveys, the authors tabulated the projections of energy demand and supply chronologically to see if patterns emerged in the projections over time. Selected results from the study by Deagle, Mossavar-Rahman, and Huff, which covers more recent projections, are summarized in Table 3. Part A of the table shows that there has been a steady downward revision over time in the two main factors determining energy demand, the growth of real GDP, and the elasticity of demand for energy with respect to real GDP (unadjusted for price changes). These downward revisions explain most of the differences in projections of energy demand. The downward revisions in the energy/GDP elasticities indicate that the demand response to price increases has been stronger than initially expected.

On the supply side, the historical projections displayed the opposite pattern. See Part B of Table 3. The highest supply estimates were obtained during the period immediately after the 1973-74 oil price increases, reflecting price elasticity optimism. Thereafter, supply estimates were revised downward until they fell below estimates of supply made prior to the oil price increases. The two major sources of error in the supply projections were overestimates of the supply of oil in the United States and of nuclear energy in almost all countries. Downward revisions to oil and natural gas liquid (NGL) production in the United States accounted for half of the revision to oil and NGL production in the OECD, and the expected growth of nuclear capacity did not materialize on the scale previously envisioned, owing mainly to environmental concerns and the long lead times required to install nuclear plants.

It is not surprising that the supply response has been less than initially expected. One factor contributing to the slow supply response after the 1973-1974 oil price increases was the prevalence of energy price controls, especially in the United States and Canada, some of which are still in existence. More generally, for an exhaustible resource such

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1/ The shift toward oil consumption and away from other energy sources occurred much earlier in the United States, where domestic oil supplies were plentiful, than in Europe. By 1955, coal's share in total energy consumption was around 30 per cent (compared to 75 per cent in 1915) and it declined to about 20 per cent by 1973. See Dunkerley (1980), pp. 19-21.

Table 3. Selected Energy Projections to 1985

A: Factors Affecting Energy Demand Projections to 1985 for OECD Countries 1/

Averages of Projections

	OECD Annual Rates of Growth of Real GDP 1970-1985	OECD Energy/GDP Elasticity 1970-1985 (unadjusted for price changes)
Period of Projection		
1972-1973	4.95	1.03
1974-1976	4.39	.87
1977-1978	3.75	.82
1979-1980	3.51	.71

B: Energy Supply Projections for 1985 for OECD Countries 2/

Averages of Projections

	OECD Natural Gas Production (mmbdoe)	OECD Oil and NGL Production (mmbd)	United States Oil and NGL Production (mmbd)	OECD Installed Nuclear Capacity (GWe)
Period of Projection				
1972-1973	15.2	21.0	12.1	530
1974-1976	18.3	22.5	13.0	430
1977-1978	14.3	16.9	10.6	271
1979-1980	13.6	15.0	8.9	218

1/ Source: Deagle, Mossavar-Rahman, and Huff (1981), pp. 6-7.
2/ Source: Deagle, Mossavar-Rahman, and Huff (1981), pp. 8-11.

as oil, the fields that are the easiest to find, the most productive, and the least costly to develop will be exploited first, followed by higher-cost (hence marginal) fields; that is, there are diminishing returns to exploration even at much higher real oil prices. For example, despite the fact that drilling rates increased significantly after the 1973-74 oil price increases, reflecting the behavioral response to higher prices, the increase in discovered resources slowed down. Discoveries, which had averaged about 68 billion barrels per decade for the 1950s and 1960s, fell to 35 million barrels in the 1970s. The rate of discovery of "super giant" fields was more than ten fields per decade in the 1950s and 1960s; during the 1970s only two super giant fields (both in Mexico) were discovered. Even after discovery of exploitable reserves, it takes from 8 to 12 years to bring new oil fields into production. Similarly, there are long lead times from the decision to build a nuclear plant or to exploit coal reserves and the actual production of energy on a significant scale.

In retrospect, it is safe to say that earlier projections of both the magnitude and timing of the price response of energy supply were overestimated. It now appears that the time lags between price increases and output responses are quite long. Further, since the rate of growth of actual energy supplies in the major industrial countries (with the exception of the United Kingdom) has fallen below pre-1973 historical trends, it is reasonable to expect that the deceleration in energy production would have been even greater if real energy prices had remained unchanged at their 1972 levels. These considerations underlie the assumptions employed to derive projections of energy supply based on alternative oil price assumptions. In the case of 1972 real energy prices, energy production in the major industrial countries is assumed to remain close to the levels achieved in the first half of the 1970s. For the United States and the United Kingdom allowance is made for the level of production from the Northern Slope of Alaska and the North Sea planned prior to the 1973-74 oil price increases. Estimates of the energy supply response taking into account oil price increases through 1980 rely on the projections submitted by country experts to the International Energy Agency for its 1981 review. Taking into account the long time lags on the supply side, it is assumed that most of the effects of higher oil prices on energy supply by 1985 are in response to the 1973-1974 oil price increases.

On the demand side, for the historical period 1960 to 1973, the elasticities of demand for energy with respect to the growth of GDP shown in column 1 of Table 2 reflect the growth of economic activity as well as the changes in the relative price of energy. To project energy demand under the assumption of no change in the real price of energy, estimates of the separate effects of changes in economic growth and energy prices on energy demand are necessary. These estimates are derived below based on the results of estimated equations (reported in part 2 of this subsection) which explain the demand for energy in terms of the growth of real GDP and changes in the real price of energy. For

the simulation based on 1972 constant real energy prices, the demand for energy is then projected on the basis of income elasticities and rates of growth of real GDP. These projections imply that oil exporters would have been willing and able to supply oil at the rate demanded without an increase in the real price of oil. It is most likely, however, that underlying market forces would have eventually led to an increase in oil prices. The constant real oil price assumption is, therefore, meant to serve only as an analytical device.

2. Empirical estimates of income and price elasticities of energy demand

As indicated above, estimates of the separate effects of changes in economic growth and relative energy prices on the demand for energy are needed to derive projections of energy balances based on different oil price assumptions. Charts 1 and 2, which show the demand for primary energy, the rate of growth of real GDP, and the real price of energy 1/ for each of the major industrial countries, illustrate the difficulties inherent in estimating these separte effects. Prior to 1970, the real price of energy was falling and real GDP was rising steadily in all seven countries. Both factors contributed to an increase in the demand for energy. Similarly, after the two oil price increases in 1973-74 and 1979-80, the increase in the real price of energy coincided with a decline in economic growth, and again both factors contributed to the reduced demand for energy. In econometric studies based on time series analysis, the correlation between the income and relative price variables makes it difficult to measure the separate effects of each on the demand for energy. The estimation problem is further complicated by the large and abrupt changes in real energy prices, the relatively short sample period (from the late 1950s or early 1960s to the late 1970s) on which most available estimates are based, the need to estimate long lags, and the fact that the adjustment to higher energy prices is still incomplete. Cross-section studies alleviate these problems to some degree, but not entirely since, historically, countries with relatively high income levels (the United States and Canada, for example) have tended to have low energy price levels. Further, elasticities derived from cross section studies are long-run elasticities and, therefore, give no indication of the length of the period of adjustment, or of differing propensities to consume energy when countries are not in long-run equilibrium.

The estimation problems cited above suggest that econometric estimates of income and price elasticities in energy demand equations should be interpreted with caution. What is important in the context of this study is that the relationships of the income elasticities among countries be appropriate. Table 4 shows the annual rates of growth of demand for total primary energy, real GDP, and real energy prices for the period

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1/ Indices of the price of energy for each of the industrial countries were provided by the OECD. These indices are constructed using price data for individual fuels and moving weights supplied by the International Energy Agency. Real energy prices are calculated by dividing nominal energy price indices by indices of the GDP deflator. Because energy prices are included in the GDP deflators, the indices of real energy prices used herein may understate the change in real energy prices.

Chart 1. Factors Affecting Real Energy Demand

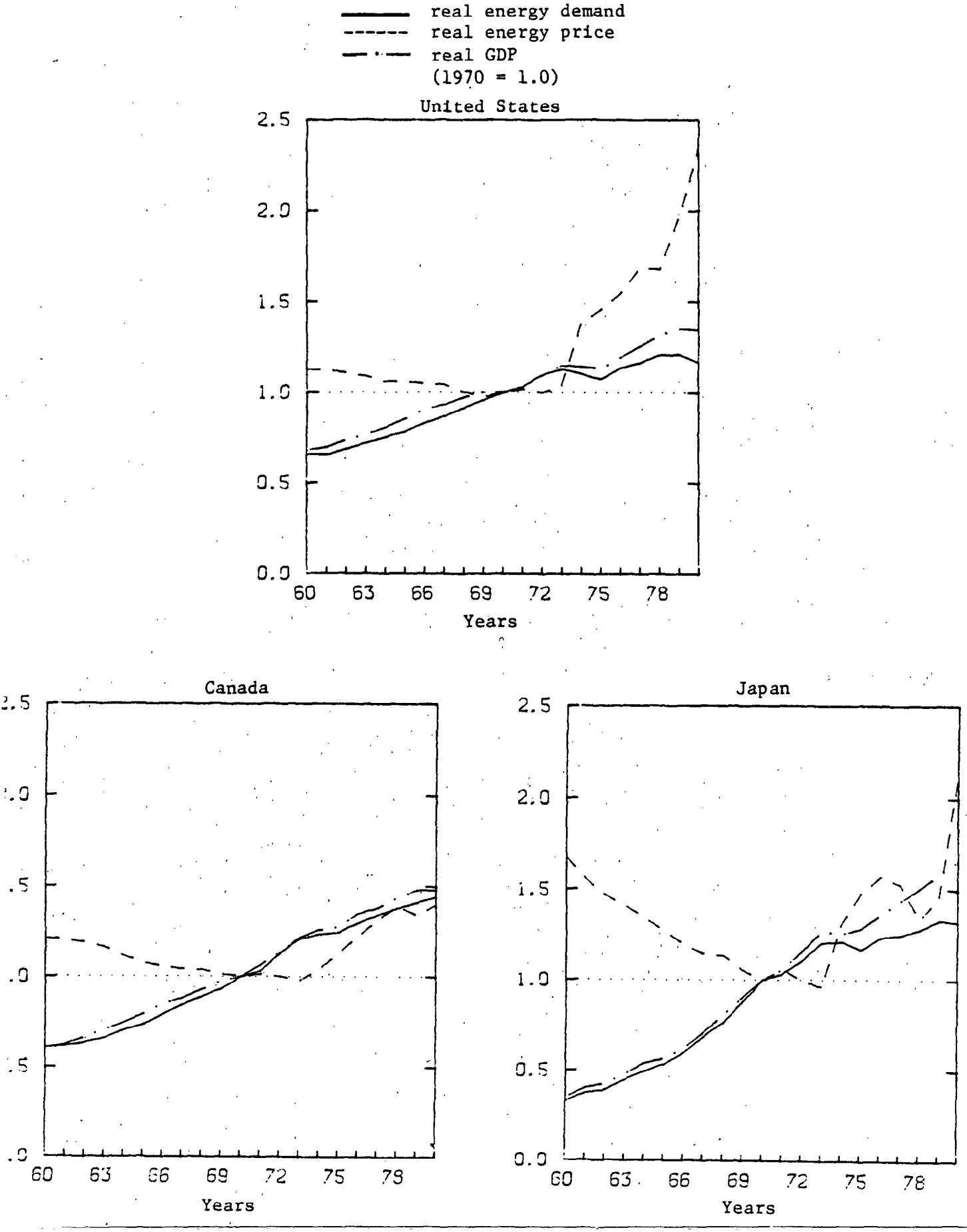

Chart 2. Factors Affecting Real Energy Demand

——— real energy demand
------ real energy price
— . — real GDP
(]970 = 1.0)

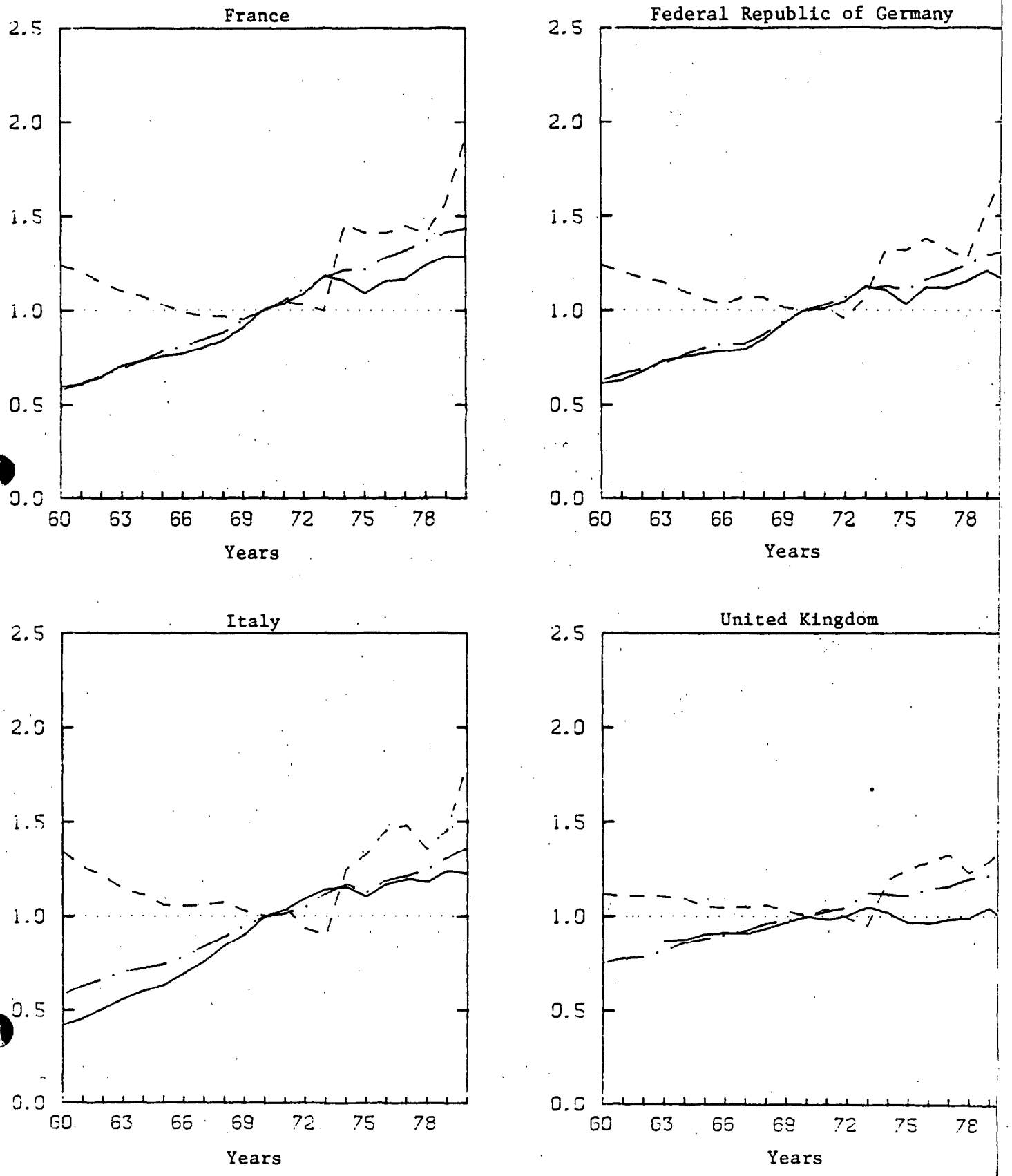

Table 4. Energy Demand, Real GDP, and the Real Price of Energy 1960 to 1972

	Annual Average Percentage Rates of Growth			
	Demand for Total Primary Energy (1)	Real GDP (2)	Real Energy Prices (3)	Energy/GDP 2/ Elasticity (4)
Canada	5.3	5.4	-1.6	0.98
United States	4.4	4.0	-1.0	1.10
Japan	10.6	10.5	-4.2	1.01
Germany, Fed. Rep. of	4.6	4.5	-2.2	1.02
France	5.2	5.6	-1.5	0.93
Italy	8.3	5.0	-3.0	1.66
United Kingdom 1/	2.3	3.4	-1.3	0.68

1/ Figures are for the period 1960 to 1973.
2/ Unadjusted for price changes.

1960 through 1972, along with the energy/GDP elasticities, unadjusted for relative price changes. Over a period of declining real energy prices, the unadjusted energy/GDP elasticities would tend to be larger than the elasticities adjusted for relative price changes. The table shows that the United States and the United Kingdom experienced the least decline in real energy prices over the period, followed by somewhat larger declines in real energy prices in Canada, France, and Germany, and substantial declines in real energy prices in Italy and Japan.

On the basis of the data shown in Table 4, it would be reasonable to expect the energy/GDP elasticities adjusted for relative price changes to be less than or equal to those shown in column 4. Since Italy and Japan experienced the largest declines in real energy prices, their adjusted elasticities may be significantly smaller than those shown in Table 4.

In terms of rank, Italy might be expected to have the highest adjusted energy/GDP elasticity, followed by the United States, Canada, Germany, France, Japan, and the United Kingdom. The econometric estimates presented in Appendix I and summarized in Table 5 generally conform to the expected results with two exceptions. First, the estimated energy/GDP elasticities for the United States and France seem to be too high; and second, the energy/GDP elasticity for France is higher than that for Canada and Germany. The higher than expected energy/GDP elasticities for the United States and France may be attributed to the relatively higher degree of correlation between real GDP and real energy prices in these two countries over the estimation period. (See column 7 of Table 5). When multicollinearity is present, the log-linear functional form used to estimate the income and price elasticities would tend to attribute more explanatory power to the variable with the greatest variability over the estimation period, real GDP in this case. The last column of Table 5 shows the energy/GDP elasticities that will be used to project energy demand. The elasticity for the United States is assumed to be slightly less than its unadjusted value while that for France is assumed to be 1, making it comparable to those of Germany and Canada. The elasticities for the remaining countries are approximately their estimated values.

3. Projections of energy balances to 1985 at constant real exchange rates

The changes in the energy balances of the major industrial countries attributable to higher oil prices are derived for two cases. In the first case, changes in real oil prices through 1978 are taken into account, while in the second case changes in the real price of oil through 1980 are taken into account. In both cases the first step is to estimate what energy balances would have been by 1985, at constant real exchange rates, based on the three alternative assumptions regarding the real price of oil: (1) 1972 real oil prices, (2) 1978 real oil prices, and (3) 1980 real oil prices.

Table 5. Estimates of Energy/GDP Elasticities 1/

	Estimation period	Real GDP	Real Price of energy 2/ (cumulative)	R^2	S.E.E.	D.W.	Correlation between real GDP and real price of energy (1960-1980)	Energy/GDP elasticity used for projections
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Canada	1966-1980	1.02 (11.7)	-0.29 (-1.9)	.99	.012	2.75	.41	1.00
United States	1966-1980	1.24 (11.6)	-0.34 (-4.8)	.97	.019	1.60	.73	1.05
Japan	1966-1980	0.91 (18.2)	-0.31 (-4.2)	.99	.017	2.08	.16	0.90
France	1966-1980	1.24 (22.7)	-0.30 (-7.4)	.99	.014	2.05	.71	1.00
Germany	1966-1980	1.03 (15.9)	-0.35 (-4.8)	.98	.017	2.70	.55	1.00
Italy	1966-1980	1.25 (19.9)	-0.46 (-6.7)	.99	.017	2.66	.46	1.25
United Kingdom 2/	1966-1980	0.60 (12.0)	-0.35 (-8.74)	.87	.016	1.87	.54	0.60

1/ Numbers in parentheses are t-statistics.

2/ The price coefficients were estimated using polynomial distributed lags of up to 6 years, except for the United Kingdom, for which a simple one-year lag was used. See Appendix I for a complete description of the estimated equations.

The rates of growth of real GDP upon which the projections of energy balances are based are the same for each oil price assumption. These growth rates are presented in Table 6. The relatively weak growth performance for the 1980-85 period reflects slower growth and/or recession during the period 1980-82, followed by a return to the average annual rates of growth that prevailed during the period 1972-78. Projections of energy balances by 1985 assuming a constant 1972 real price of oil are derived in Table 7. Energy demand by 1985 is estimated using the growth rates assumed in Table 6 and the energy/GDP elasticities shown in column 8 of Table 5.

In the constant 1972 real oil price case, energy production for most of the major industrial countries is assumed to remain close to the levels achieved in the first half of the 1970s. For the United States and the United Kingdom account is taken of the level of energy production from the Northern Slope of Alaska and the North Sea that was expected prior to the 1973-74 oil price increases. 1/ In the United States, the additional production of oil from Alaska offsets the decline in oil production in the lower 48 states, which is assumed to stabilize at its 1974 level. For the United Kingdom, the planned development of the North Sea accounts for a doubling of energy production, compared with its level in the early 1970s. To the extent that energy production would have declined significantly below the levels assumed here (because of disincentives to exploration and development), the exchange rate changes needed to offset the effects of higher real oil prices would be smaller than those estimated below.

The difference between domestic energy supply and energy demand represents the amount of net energy imports, which is shown in column 6 of Table 7 expressed in millions of tons of oil equivalent. This amount is valued at the world market price of oil since oil accounts for most of net energy imports and since the export prices of alternative fuels will tend to rise to levels equivalent to that of oil. The last column of Table 7 shows the projections of net energy imports measured in 1985 U.S. dollars, or nominal energy balances, based on the assumption of constant 1972 real oil prices.

Table 8 summarizes the projections of energy balances based on the two alternative higher oil price assumptions. The lower half of the table, part B, shows the projections of energy demand and supply by 1985 taking into account the oil price increases through 1980. These are based on the projections published in the IEA 1981 review, except in the case of France where projections provided by the Commissariat General du Plan are used. The economic growth assumptions underlying the IEA projections are higher than those shown in Table 6, and, therefore, the IEA projections of energy demand have been adjusted downward

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1/ Prior to the 1973-74 oil price increases, estimates of production from the Northern Slope of Alaska ranged from 1 1/2-2 million barrels per day (mb/d). Production for the first quarter of 1982 was 1.7 mb/d. For the United Kingdom, oil production from the North Sea was estimated to be about 100 million tons per year. See for example, OECD (1973, pp. 58-64) and Brodman and Hamilton (1979).

Table 6. Actual and Projected Rates of Growth of Real GDP/GNP

	1972-1978	1979	1980	1981	1980-1985
	(Annual average per cent change)				
Canada	4.0	2.9	0.5	3.1	2.0
United States	3.2	2.8	-0.4	1.9	2.0
Japan	4.5	5.2	4.2	2.9	3.5
France	3.4	3.3	1.1	0.4	2.5
Germany	2.5	4.0	1.8	-0.2	2.0
Italy	2.9	4.9	3.9	-0.2	2.5
United Kingdom	1.3	2.0	-2.1	-2.2	1.0

Table 7. Projections of Energy Balances to 1985 Based on Constant 1972 Real Oil Prices

	Total energy demand 1972 MTOE 1/ (1)	Per cent change real GDP 1972-85 (Annual average) (2)	Energy/GDP elasticity (3)	Total energy demand 1985 MTOE (4)	Total energy production 1985 MTOE (5)	Excess energy demand 1985 MTOE (5)-(4)=(6)	Energy balances in 1985 prices 2/ (In US$ millions) (7)
Canada	178	2.9	1.00	258	250	-8	-379
United States	1,701	2.4	1.05	2,351	1,450	-901	-42,662
Japan	312	4.2	0.90	505	50	-455	-21,544
France	168	2.9	1.00	244	50	-194	-9,186
Germany, Fed. Rep. of	248	2.4	1.00	338	120	-218	-10,322
Italy	127	3.0	1.25	205	25	-180	-8,523
United Kingdom	221	1.4	0.60	246	200	-46	-2,178

1/ Millions of tons oil equivalent.

2/ The 1972 price of oil measured in 1985 prices is $6.44 per barrel, and is defined as the 1972 price of oil, $2.29 per barrel, inflated to 1985 using the change in the export unit value for manufactures of the industrial countries. Converted to dollars per ton the price is $47.35.

based on the differences in growth rates using the assumed energy/GDP elasticities shown in column 8 of Table 5. No adjustment has been made to the IEA energy supply projections. To the extent that domestic energy supply is related to economic activity, the supply projections may be too high. However, the levels of energy supply assumed in the case of 1972 real oil prices are most likely optimistic and would tend to offset any upward bias in the unadjusted IEA supply projections.

In Table 8, the implicit price elasticities of demand shown in column 3 of part B are derived from the change in energy demand compared with the change in the real price of energy. The change in energy demand due to higher oil prices measured in real terms is the difference between energy demand based on the 1980 real price of oil and energy demand based on the 1972 real price of oil. In calculating the relevant change in real energy prices, it has been assumed that the effects on energy demand of 100 per cent of the increases in real energy prices that occurred prior to end-1978 would have occurred by 1985. The estimated distributed lag effects of changes in real energy prices on energy demand shown in Appendix I indicate that the lags for several countries, namely, the United States, the Federal Republic of Germany, and Italy are longer than five years. For these countries it has been assumed that the demand effects of only 75 per cent of the real energy price increases from 1978 to 1980 would have occurred by 1985. In the case of Canada, there was little change in the real price of energy from 1978 to 1980; however, the IEA projections take into account the Government's policy of gradually increasing the domestic price of oil to between 75 and 100 per cent of the world market price, depending on whether the oil is obtained from "old" or "new" wells. To account for the effect of this policy, it was assumed that 30 per cent of the total reduction in energy demand by 1985 for Canada (shown in part B of Table 8) results from the increase in real energy prices taking place after 1980. The implicit price elasticities of demand derived on the basis of the assumptions described above are more or less in line with the estimated price elasticities shown in Table 5, and they have been used to estimate energy demand by 1985 based on the 1978 real price of energy. These estimates are shown in part A of Table 8.

The energy supply projections in part A have been derived based on the simplifying assumption that 75 per cent of the difference in domestic energy supply based on 1980 real oil prices compared with energy supply based on the 1972 real price of oil can be attributed to the 1973-74 oil price increases. 1/ For the projections based on higher oil prices, net energy imports, measured in millions of tons of oil equivalent (column 6), are converted to nominal energy balances by multiplying net energy imports by the 1978 or 1980 real price of oil expressed in 1985 dollars. These nominal energy balances are shown in column 7 of Table 8.

1/ For Italy, which has few energy resources, domestic energy supply is assumed to be the same for both the 1978 real oil price projection and the 1980 real oil price projection.

Table 8. Projections of Energy Balances to 1985

A. Projections Based on 1978 Real Oil Prices

	Total energy demand 1972 MTOE 1/ (1)	Per cent change real energy prices 1972-78 (cumulative) (2)	Implicit price elasticity 2/ (3)	Total energy demand 1985 MTOE (4)	Total energy production 1985 MTOE (5)	Excess energy demand 1985 MTOE (5)-(4)=(6)	Energy balances in 1985 prices 3/ (In US$ millions) (7)
Canada	178	39.2	-0.16	245	270	25	3,295
United States	1,701	68.0	-0.29	2,078	1,572	-506	-66,691
Japan	312	33.7	-0.20	484	78	-406	-53,511
France	168	36.9	-0.34	224	61	-164	-21,615
Germany, Fed. Rep. of	248	33.7	-0.31	314	131	-183	-24,119
Italy	127	45.2	-0.50	176	23	-153	-20,165
United Kingdom	221	24.0	-0.45	225	228	3	395

B. Projections Based on 1980 Real Oil Prices

	Total energy demand 1972 MTOE (1)	Per cent change real energy prices 1972-80 (cumulative) (2)	Implicit price elasticity 2/ (3)	Total energy demand 1985 MTOE (4)	Total energy production 1985 MTOE (5)	Excess energy demand 1985 MTOE (5)-(4)=(6)	Energy balances in 1985 prices 4/ (In US$ millions) (7)
Canada	178	40.2	-0.16	239	276	37	9,246
United States	1,701	136.1	-0.29	1,874	1,613	-261	-65,224
Japan	312	112.5	-0.20	435	87	-348	-86,965
France	168	87.4	-0.34	197	65	-132	-32,987
Germany, Fed. Rep. of	248	84.4	-0.31	286	135	-151	-37,735
Italy	127	93.3	-0.50	152	23	-129	-32,237
United Kingdom	221	40.4	-0.45	211	237	26	6,497

1/ Millions of tons of oil equivalent.

2/ The implicit price elasticity is calculated by dividing the change in logs of energy demand due to higher energy prices (the log of column 4 part B minus the log of column 4 of Table 7) by the change in logs in real energy prices. Only 75 per cent of the effects on energy demand of the increase in real energy prices from 197[illegible] to 1980 is assumed to occur by 1985 for the United States, the Federal Republic of Germany, and Italy.

3/ The 1978 price of oil measured in 1985 prices is $17.93 per barrel, and is defined as the 1978 price of $12.83 per barrel, inflated to 1985 using the change in the export unit value for manufactures of the industrial countries. Converted to dollars per ton the price is $131.80.

4/ The 1980 price of oil was $30.92 per barrel. Inflated to 1985 using the export unit value for manufacture of industrial countries, it is $34.00 per barrel, or $249.90 per ton.

B. Projections of changes in countries' external positions attributed to higher oil prices

The differences between the nominal energy balances based on the 1978 (or 1980) real price of oil and those based on the 1972 real price of oil are estimates of the changes in countries' energy balances due to higher oil prices at unchanged real exchange rates. These calculations are shown in Table 9, columns 1, 2, and 3. The sum of column 3, the total change in industrial country energy balances attributed to higher oil prices, represents the change in export earnings of the oil exporting countries resulting from the change in the value of energy exports to the industrial countries. It is assumed that by 1985, all of the increased export earnings of the oil exporting countries will be spent on goods and services from abroad, specifically, on the imports of goods and services from the industrial countries. These projected increases in imports are allocated to the industrial countries based on the share of each country's exports to the oil exporting countries in the total imports of this group from industrial countries. These shares are derived from trade patterns that existed in 1972, 1/ (shown in parentheses next to column 4), prior to any relative price changes that may have resulted from the oil price increases. In other words, the increase in the export earnings of the oil exporting countries is distributed to the industrial countries based on the pattern of trade in 1972. The distribution to each country represents the additional amount that would have been exported to the oil exporting countries at unchanged real exchange rates.

What remain after distribution of the increased export earnings of the oil exporting countries are the estimated net effects on countries' trade balances of higher oil prices (shown in column 5). In the next section, the Multilateral Exchange Rate Model (MERM) is used to solve for the changes in real exchange rates among the industrial countries that would offset these trade balance changes, other things being equal. Table 10 details similar calculations for the projections based on 1980 real oil prices.

III. Application of the Multilateral Exchange Rate Model (MERM) to the Estimation of Real Exchange Rate Changes

The net effects of higher oil prices on countries' trade balances that remain after accounting for expected exports to the oil exporting countries need to be offset in the longer run by equal but opposite changes in countries' trade balances as a result of a real exchange rate realignment.

1/ About one third of the imports of oil exporting countries consist of services. The data on bilaterial service flows between the industrial countries and the oil exporting countries are insufficient to construct the weights necessary to allocate service flows; therefore, trade weights are used to distribute exports of goods and services to the oil exporting countries. The results will be affected to the extent that the distribution of service flows differs significantly from that of trade flows.

Table 9. Projections of the Net Effects of Higher Oil Prices on Countries' External Positions by 1985 Assuming 1978 Real Oil Prices

	Energy balances by 1978 assuming 1978 real oil price	Energy balances by 1978 assuming 1972 real oil price	Change in energy balances due to oil price increase	Offset due to exports to oil exporting countries		Change in trade balance due to oil price increase
	(Millions of U.S. dollars)					
	(1)	(2)	(1)-(2)=(3)	(4)		(3)+(4)=(5)
Canada	3,295	-379	3,674	2,221	(.0222) 1/	5,895
United States	-66,691	-42,662	-24,028	22,982	(.2297)	-1,047
Japan	-53,511	-21,544	-31,966	16,278	(.1627)	-15,688
France	-21,615	-9,186	-12,429	10,205	(.1020)	-2,224
Germany, Fed. Rep. of	-24,119	-10,322	-13,797	12,596	(.1259)	-1,201
Italy	-20,165	-8,523	-11,642	8,244	(.0824)	-3,398
United Kingdom	395	-2,178	2,573	12,616	(.1261)	15,190
Other Industrial Countries	-23,988	-11,554	-12,434	14,908	(.1490)	2,474
Total	-206,399	-106,348	-100,051	100,051		0

1/ Country's exports to the oil exporting countries as a share of total industrial country exports to the oil exporting countries.

Table 10. Projections of the Net Effects of Higher Oil Prices on Countries' External Positions by 1985 Assuming 1980 Real Oil Prices

	Energy balances by 1985 assuming 1985 real oil price	Energy balances by 1985 assuming 1972 real oil price	Change in energy balances due to oil price increase	Offset due to exports to oil exporting countries	Change in trade balance due to oil price increase
			(Millions of U.S. dollars)		
	(1)	(2)	(1)-(2)=(3)	(4)	(3)+(4)=(5)
Canada	9,246	-379	9,625	3,492 (.0222) 1/	13,117
United States	-65,224	-42,662	-22,562	36,131 (.2297)	13,569
Japan	-86,965	-21,544	-65,421	25,592 (.1627)	-39,829
France	-32,987	-9,186	-23,801	16,044 (.1020)	-7,757
Germany, Fed. Rep.	-37,735	-10,322	-27,413	19,804 (.1259)	-7,609
Italy	-32,237	-8,523	-23,714	12,961 (.0824)	-10,753
United Kingdom	6,497	-2,178	8,676	19,835 (.1261)	28,511
Other Industrial Countries	-24,239	-11,554	-12,685	23,437 (.1490)	10,751
Total	-263,644	-106,348	-157,296	157,296	0

1/ Share of country's exports in imports of oil exporting countries from industrial countries based on 1972 trade flows.

To estimate this realignment of real exchange rates requires a multicountry model that encompasses the trading relationships among countries and allows for shifts in the structure of production and demand between traded and non-traded goods. Further, at least two traded goods need to be defined--energy and non-energy. The offsetting changes in countries' trade balances result from changes in countries' competitive positions vis-à-vis each other in both bilateral and third markets and from changes in energy balances induced by exchange rate changes. Since the latter effects are relatively small, the predominant effects of the real exchange rate realignment are on non-energy transactions.

The Multilateral Exchange Rate Model (MERM) was designed for the purpose of estimating the effects of exchange rate changes on trade balances after a period of several years. If a consistent set of desired changes in countries' trade balances is known, the model can also be used to estimate the exchange rate realignment that would bring about these trade balance changes. A full description of the MERM is given in Artus and McGuirk (1981). Here, the main features of the model are summarized with emphasis on applicability to the present problem. A schematic representation of the equations of the model is provided in Appendix II for reference.

Six commodity groups are distinguished in the MERM. For each commodity, a consistent set of supply and demand equations incorporating the input-output structure of each country is specified. Based on the SITC, the commodity groups are:

(1) Agricultural commodities (SITCs 0 + 1);

(2) Raw materials (SITCs 2 + 4);

(3) Mineral fuels (SITC 3);

(4) Semi-finished manufactures (SITCs 5 + 6);

(5) Finished manufactures (SITCs 7 + 8 + 9); and

(6) Non-traded commodities (commodities and services not traded).

Each good satisfies both intermediate and final demand, the amount demanded depending on activity variables and relative prices.

The demand system distinguishes between goods and products. A product is a good produced by a particular country. For example, German-finished manufactures and Japanese-finished manufactures are the same kind of good, but two different products. The model includes 18 indus-

trial countries and two regional groups of countries. 1/ The most important relative price effects on the demand side are those pertaining to price changes among products of the same kind of good. For example, a depreciation of the exchange rate of France would reduce the price of French cars relative to foreign made cars in both the French domestic market and in foreign markets. Other factors remaining unchanged, this would increase the demand for French cars. More generally, changes in product prices shift demands for a particular good from higher price suppliers to lower price suppliers. The other important relative price effect results from the change in traded goods prices versus non-traded goods prices. Exchange rate depreciation (appreciation) raises (lowers) the prices of traded goods, shifting domestic demand toward non-traded (traded) goods, and domestic supply toward traded (non-traded) goods.

The supply of each good produced by each country is simply a function of the prices of the six goods relative to their costs of production in the market of the producing country. The feedback effects of exchange rate changes onto domestic costs and prices are fully accounted for in the model. The magnitude of these feedback effects determines the change in the real exchange rate associated with any nominal exchange rate change. Since the present analysis focuses on the effect of higher oil prices on real exchange rates, the model is solved for the real exchange rate changes that will offset the net trade balance effects of higher oil prices.

The model is closed by imposing the market equilibrium condition that the supply and demand for each product must be equal, and by constraining real GDP in each country to be constant. The latter constraint permits abstraction from price level changes among countries resulting from changes in real GDP. Since real GDP is held constant, the effect of relative price changes on the supply side is to shift resources from one sector to another, primarily between the non-traded and traded goods sectors in this application.

In the MERM, changes in real exchange rates will mainly affect competitiveness in trade in manufactures. The size of the required realignment of real exchange rates will depend to a large extent on the responsiveness of manufactures trade flows to relative price changes. Table 11 shows the aggregate import and export price elasticities used in the MERM. These elasticities pertain to an adjustment period of about three years and may underestimate the price response over the longer period considered here. Few empirical estimates of price elasticities in international trade with lags longer than three years exist; and, in those that do exist, the longer-run price responses are not out of line

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1/ The countries and groups of countries used in MERM are Australia, Austria, Belgium-Luxembourg, Canada, Denmark, Finland, France, the Federal Republic of Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, the United States, the oil exporting countries, and the rest of the world.

Table 11. Foreign Trade Price Elasticities

	Price Elasticities of Demand for Export of:					Price Elasticities of Demand for Import of:				
	Food	Crude materials	Fuels	Semi-finished manu-factures	Finished manu-factures	food	Crude materials	Fuels	Semi-finished manu-factures	Finished manu-factures
Australia	-2.0	-2.0	-2.0	-1.50	-1.75	-1.0	-0.25	-1.00	-0.75	-1.00
Austria	-2.0	-2.0	-2.0	-1.50	-1.75	-1.0	-0.10	-0.40	-0.75	-1.00
Belgium-Luxembourg	-1.0	-2.0	-2.0	-1.50	-1.75	-0.5	-0.10	-0.30	-0.75	-1.00
Canada	-2.0	-2.0	-2.0	-1.25	-1.50	-1.0	-0.25	-2.00	-1.25	-1.50
Denmark	-1.0	-2.0	-2.0	-1.50	-1.75	-1.0	-0.10	-0.30	-0.75	-1.00
Finland	-2.0	-2.0	-2.0	-1.50	-1.75	-0.5	-0.10	-0.30	-0.75	-1.00
France	-1.0	-2.0	-2.0	-1.50	-1.75	-0.5	-0.10	-0.35	-1.25	-1.50
Germany, Fed. Rep. of	-1.0	-2.0	-2.0	-1.25	-1.50	-0.5	-0.10	-0.35	-1.25	-1.50
Ireland	-1.0	-2.0	-2.0	-1.50	-1.75	-1.0	-0.10	-0.30	-0.75	-1.00
Italy	-1.0	-2.0	-2.0	-1.25	-1.50	-1.0	-0.10	-0.50	-1.00	-1.25
Japan	-2.0	-2.0	-2.0	-1.50	-1.75	-1.0	-0.10	-0.25	-1.25	-1.50
Netherlands	-1.0	-2.0	-2.0	-1.50	-1.75	-1.0	-0.10	-0.50	-0.75	-1.00
Norway	-1.0	-2.0	-1.0	-1.50	-1.75	-0.5	-0.10	-2.00	-0.75	-1.00
Spain	-2.0	-2.0	-2.0	-1.50	-1.75	-1.0	-0.10	-0.30	-0.75	-1.00
Sweden	-2.0	-2.0	-2.0	-1.50	-1.75	-0.5	-0.10	-0.30	-0.75	-1.00
Switzerland	-2.0	-2.0	-2.0	-1.00	-1.25	-0.1	-0.10	-0.30	-0.75	-1.00
United Kingdom	-1.0	-2.0	-1.0	-1.00	-1.25	-0.5	-0.10	-2.00	-1.00	-1.25
United States	-2.0	-2.0	-2.0	-1.50	-1.75	-1.0	-0.25	-0.60	-1.50	-1.75
Oil exporting countries	-2.0	-2.0	-0.1	-1.50	-1.75	-0.1	-0.10	-2.00	-0.10	-0.10
Rest of the world	-1.0	-0.5	-2.0	-1.50	-1.75	-0.5	-0.10	-0.30	-0.50	-0.50

with the elasticities shown in Table 11. 1/ To the extent that these elasticities are too small for the length of the adjustment period considered, the estimated realignment of real exchange rates will be too large. That is, the more responsive trade flows are to relative price changes, the smaller will be the exchange rate changes required to offset an external disturbance.

The final estimates of changes in trade balances due to the oil price increases since 1972, shown in column 5 of Tables 9 and 10, purport to measure the effects of higher oil prices on countries' trade balances, other things remaining the same. In particular, industrial countries' competitive positions vis-à-vis each other are held constant, as well as real interest rate differentials. Pressures on real exchange rates arise from two sources in this exercise. First, assuming countries were initially in equilibrium, the oil price increases disturb that equilibrium by the amount measured in columns 3 of Tables 9 and 10, the effect on energy balances. Second, at unchanged relative prices, the pressure on real exchange rates from the effects on energy balances is either reinforced or offset by countries' expected exports to oil exporting countries. For example, the United Kingdom experiences upward pressure on its real exchange both because of its favorable energy balance and because of its increased exports to the oil exporting countries. At unchanged relative prices, the demand for exports from the United Kingdom would be too large. Appreciation of its real exchange rate, vis-à-vis other industrial countries, changes its competitive position in both industrial markets and in markets in which the United Kingdom competes against other industrial countries for exports, namely, the markets of the oil exporting countries and the rest of the world. The changes in the real exchange rates estimated are the amounts real exchange rates would have to change in order to offset the net changes in countries external positions due to higher oil prices by increased exports or imports of goods. These estimates will be too large to the extent that service flows, which are not included in the MERM, are sensitive to real exchange rate changes.

Table 12 presents the projected net effects on countries' trade balances of higher real oil prices based on the two oil price assumptions (reproduced from Tables 9 and 10). The projections based on 1978 real oil prices (column 1) correspond roughly to the net trade balance effects attributable to the 1973-74 oil price increases, while those based on 1980 real oil prices (column 4) correspond to the combined effects of the 1973-74 and the 1970-80 oil price increases. As already noted above, the required realignment of real exchange rates among the industrial countries depends on the relative size of these net trade balance effects. For example, in both sets of projections, Japan experiences a much larger net deterioration in its trade balance than other countries. Consequently,

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1/ See Goldstein and Khan (1982) for a recent survey of income and price elasticities in foreign trade. Only one study cited therein reported price elasticities significantly higher than those used here.

Table 12. Real Exchange Rate Realignment Needed to Offset the Differential Effects of Higher Oil Prices on Countries' External Positions

	Simulations Based on 1978 Real Oil Prices			Simulations Based on 1980 Real Oil Prices		
	Changes in trade balances in 1985 due to oil price increase (1)	Changes in real exchange rates that would eliminate changes in trade balances 1/ (2)	Changes in real effective exchange rates that would eliminate changes in trade balances 2/ (3)	Changes in trade balances in 1985 due to oil price increase (4)	Changes in real exchange rates that would eliminate changes in trade balances 1/ (5)	Changes in real effective exchange rates that would eliminate changes in trade balances 2/ (6)
Canada	5,895	5	5	13,117	10	12
United States	-1,047	0	0	13,569	0	4
Japan	-15,688	-10	-11	-39,829	-27	-28
France	-2,224	0	-1	-7,757	-10	-3
Germany, Fed. Rep. of	-1,201	0	0	-7,609	-10	-3
Italy	-3,398	-2	-2	-10,753	-15	-7
United Kingdom	15,190	12	12	28,511	17	23

1/ Estimates are derived from the Multilateral Exchange Rate Model and measured vis-à-vis the U.S. dollar. They represent the change in real exchange rates (or in countries' competitive positions) that would, after a period of several years, have equal but opposite trade balance effects as those shown in columns (1) and (4). Estimates are rounded to the nearest integer.

2/ The change in the real effective exchange rate is defined as the unilateral real exchange rate change that would have the same trade balance effect as the actual set of real exchange rate changes estimated.

a relatively large depreciation by Japan is needed to offset the effects of higher oil prices on its external position, other factors remaining unchanged. Similarly, the United Kingdom requires a large real appreciation.

Estimates of the exchange rate realignment that is needed to offset the changes in countries' trade balances attributable to higher oil prices are derived from the MERM and are shown in columns 2 and 5 of Table 12. The corresponding changes in real effective exchange rates are shown in columns 3 and 6. These estimates take into account all of the bilateral and third market effects of changes in relative prices on countries' trade balances, but they hold constant other factors that may affect real exchange rates. As such, they represent the realignment of real exchange rates attributable solely to higher oil prices.

The results of the simulations based on the 1978 real price of oil indicate that Canada and the United Kingdom need relatively large real appreciations vis-à-vis the United States and that Japan needs a large depreciation. Only small changes in real exchange rates are estimated for the European countries. Canada appreciates relative to the United States and the European countries because its favorable energy position more than offsets its relatively weak initial trading position with the oil producing countries. As previously explained, the United Kingdom benefits both from its strong energy position and it's relatively large share in the imports of the oil exporting countries. By contrast, Japan has the second largest share in exports to the oil exporting countries, but the deterioration in its energy balance is much larger than that of any other country.

In the simulations based on 1978 real oil prices, the value of the U.S. dollar does not change much in relation to the currencies of France and the Federal Republic of Germany, since these countries experience modest net deteriorations in their trade balances of the same order of magnitude as that of the United States. The simulations based on 1980 real oil prices leave Canada, Japan, and the United Kingdom in about the same relative positions, but they give quite a different result for the position of the U.S. dollar. In this simulation, the net effect of higher oil prices on the U.S. trade balance is positive. This results from the fact that domestic energy supply as a portion of total energy demand is much larger in the United States than in the other oil importing countries. In these circumstances, a similar percentage increase in supply and decrease in demand results in a proportionately larger reduction in net energy imports for the United States, compared with countries for which net energy imports represent a larger share of total energy supply. Consequently, the European countries depreciate significantly vis-à-vis the United States. Italy depreciates somewhat more than France and German because it has a relatively smaller share in the increased exports to the oil exporting countries. Because the European countries depreciate by a

significant amount vis-à-vis the United States, Japan has to depreciate relatively more vis-à-vis the United States than in the 1978 real oil price simulation to to achieve the same competitive effect.

The above results are no doubt subject to a large margin of error because of the uncertainties regarding developments in energy supply and demand, the validity of the assumptions and parameters underlying the calculations, and the focus on merchandise trade. A price responsiveness of energy demand or supply greater than that assumed in the calculations presented above would tend to reduce the required change in real exchange rates needed to offset the effects of higher oil prices on countries' external positions. Larger import and export price elasticities for traded goods would also reduce the required change in real exchange rates, as would a significant price responsiveness of trade in services.

IV. Conclusions

In this paper an attempt has been made to estimate the real exchange rate changes among industrial countries needed to offset the differential effects of the oil price increases of the 1970s on countries' balance of payments positions, other things remaining the same. The emphasis has been on the change in countries' competitive positions in the goods market needed to eliminate the change in their external positions attributable to higher oil prices.

For the simulations based on the increase in real oil prices that occurred from 1972 to 1980 (about the same as from 1972 to early 1983), it was found that among the major industrial countries net energy exporters such as the United Kingdom and, to a lesser extent, Canada, needed relatively large real effective appreciations, 23 per cent and 12 per cent, respectively. Among the net energy importers, Japan required the largest real effective depreciation, on the order of 28 per cent. The European countries required real effective depreciations ranging from 3 to 7 per cent and the United States needed a 4 per cent appreciation in real effective terms.

These results show that the real exchange rate adjustments required to offset the effects of a change in the relative price of a major traded good such as oil can be quite large, depending on countries' natural endowments and trading relationships. In the case of oil, the relative price increases were very large, amounting about 400 per cent from 1972 to 1980 measured in real terms. Further, the net effects of higher oil prices on countries' external positions varied significantly across countries. If the results shown in Table 12 are normalized on the basis of the size of export flows, the estimates imply that a shock to the balance of payments equivalent to 10 per cent of exports could be offset by a real exchange rate change of about 7 per cent for Canada, France, and

Italy, 8 per cent for the Federal Republic of Germany, 9 per cent for the United States, 11 per cent for the United Kingdom, and 14 per cent for Japan.

The above results reflect, to a large extent, the composition and price responsiveness of traded goods for each country. For example, the relatively large real exchange rate change required by Japan to offset an external shock can be explained by the low aggregate import price elasticity of Japan, compared with the other countries. In 1980 about 80 per cent of Japan's imports consisted of food, raw materials, and fuels, all of which have relatively low price elasiticities. By contrast, 50-60 per cent of the imports of the other major industrial countries consisted of manufactured goods, which have relatively high price elasticities. Given the structure of trade, a deterioration in Japan's external position will be offset much more by an increase in exports than by a decline in imports. Another example is the United Kingdom, where the larger than average real exchange rate change required to offset an external disturbance is explained by the relatively low price responsiveness of exports.

Regressions Explaining Real Energy Demand 1/2/

	Canada	United States	Japan	France	Fed. Rep. of Germany	Italy	United Kingdom
Constant	-0.014	-0.020	-0.024	-0.030	0.001	0.030	-0.019
	(-0.646)	(-1.368)	(-0.835)	(-5.877)	(0.148)	(2.233)	(-4.602)
Real GDP	1.047	1.237	0.906	1.237	1.028	1.248	0.597
	(13.005)	(11.618)	(18.246)	(22.668)	(15.861)	(19.866)	(11.950)
Real price of energy							
Period t	-0.180	0.040	-0.170	-0.172	-0.089	0.039	-0.248
t-1	0.010	-0.044	-0.061	-0.136	-0.073	-0.036	-0.108
t-2	0.058	-0.070	-0.038	-0.088	-0.050	-0.064	
t-3	0.021	-0.064	-0.055	-0.036	-0.029	-0.069	
t-4	-0.045	-0.049	-0.066	0.013	-0.018	-0.072	
t-5	-0.086	-0.053	-0.027	0.051	-0.026	-0.095	
t-6	-0.044	-0.099	0.010	0.072	-0.061	-0.160	
Sum	-0.265	-0.339	-0.308	-0.295	-0.346	-0.457	-0.356
	(-1.758)	(-4.796)	(-4.160)	(-7.435)	(-4.830)	(-6.687)	(-8.740)
Mean Lag	2.580	4.219	0.152	-1.079	2.393	4.581	
	(0.421)	(1.085)	(0.053)	(-0.964)	(1.253)	(2.995)	
Dummy Variable [1960-73 = 0 1974-80 = 1]		-0.577	0.043			-0.084	
		(-0.765)	(1.124)			(-2.429)	
1st order Auto-regression Coefficient	-0.715						-0.511
	(-3.306)						(-1.964)
Adjusted R^2	0.999	0.974	0.995	0.993	0.985	0.991	0.916
SEE	0.012	0.019	0.017	0.014	0.017	0.017	0.016
D.W.	2.718	1.596	2.077	2.050	2.700	2.664	1.871

1/ Real energy demand is measured as the demand for total primary energy in real terms. The form of the estimated equation is given below. The lag distribution of the real price of energy was estimated using an unconstrained Almon polynomial lag of degree 3, except for the United Kingdom for which a simple lag was used.

$$\ln(\text{real energy demand}) = a + b \cdot \ln(\text{real GDP}) + \sum_{i=0}^{n} c_i \cdot \ln(\text{real energy price})_{t-i}$$

2/ Figures in parentheses are t statistics.

Overview of the Multilateral Exchange Rate Model

The systems of equations that make up the Multilateral Exchange Rate Model are illustrated in matrix notation with variables expressed in percentage change. For a detailed description of the specification of MERM see Artus and McGuirk (1981).

Notation

$\overset{*}{D}{}_i^k$ = per cent change in demand for good i in market k, in real terms.

$\overset{*}{O}_{ik} = \overset{*}{O}{}_i^k$ = per cent change in output of good i in country k, in real terms.

$\overset{*}{C}{}^k$ = per cent change in consumption in country k, in real terms.

$\overset{*}{G}{}^k$ = per cent change in government expenditures in country k, in real terms.

$\overset{*}{I}{}^k$ = per cent change in investment expenditures in country k, in real terms.

$[a_{in}^k]$, $[b_i^k]$, $[c_i^k]$, $[d_i^k]$ = fixed input-output coefficients representing the proportion of each good in intermediate or final demand.

$[\ _i^k]$ = income elasticity of demand for good i in market k.

$[\bar{\eta}_{i/n}^k]$ = income compensated price elasticity of demand for good i with respect to good n in market k.

$\overset{*}{D}{}_{ij}^k$ = per cent change in the demand for good i produced by country j in market k.

$[\bar{\eta}_{ij/il}^k]$ = income compensated price elasticities of demand for product ij with respect to product il in market k.

$[\alpha_{i/n}^k]$ = price elasticity of supply of good i with respect to the price of good n, in volume terms, in market k.

$\overset{*}{S}_{ij}$ = per cent change in cost of production of good i by country j.

$[SP_n^{ij}]$, $[SP_R^{ij}]$, $[SP_{TX}^{ij}]$ = fixed-input output coefficients representing the shares in production costs of material inputs or primary factors.

P_n^{*k} = per cent change in price of good n in market k in U.S. dollars.

P_{il}^{*k} = per cent change in price of good i produced by country l in market k in U.S. dollars.

T_k^* = per cent change in exchange rate of country k vis-à-vis U.S. dollar.

$PL_n^{*k} = P_n^{*k} - T_k^*$ = per cent change in price of good n in market k measured in local currency.

PL_{ij}^* = per cent change in price of good i produced by country j measured in local currency.

DN_{ij} = demand for good i produced by country j, in nominal terms.

QN_{ij} = supply of good i produced by country j, in nominal terms.

W_j^* = per cent change in wages in country j.

R_j^* = per cent change in rental price of capital in country j.

TX_j^* = per cent change in net tax payments in country j.

sc_n^j, sg_n^j, si_n^j = fixed input-output coefficients representing the share of good n in components of final demand in country j.

w_j, r_j, t_j = feedback parameters of domestic prices and costs onto the prices of the factors of production in country j.

sh_{ij} = share of good i in total output of country j.

$\overline{O}_j^*$ = real output constraint in country j, in per cent.

SYSTEM OF DEMAND EQUATIONS

I. Demand Equations for Goods

$$(1)\quad \begin{bmatrix} {}^{*k}_{D_1} \\ \cdot \\ \cdot \\ \cdot \\ {}^{*k}_{D_n} \end{bmatrix} = \underset{a^k_{in}}{\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ & & \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}} \underset{Q^k_n}{\begin{bmatrix} {}^{*}_{Q_1} \\ \cdot \\ \cdot \\ \cdot \\ {}^{*}_{Q_n} \end{bmatrix}} + \underset{b^k_i}{\begin{bmatrix} b_1 & \cdots & 0 \\ \cdot & & \\ \cdot & b_2 & \\ \cdot & & \cdot \\ 0 & & b_n \end{bmatrix}} \left[\underset{\varepsilon^k_i}{\begin{bmatrix} \varepsilon_1 \\ \\ \\ \varepsilon_n \end{bmatrix}} {}^{*k}_{C} + \underset{\bar{\eta}^k_{i/n}}{\begin{bmatrix} \eta_{1/1} & \cdots & \eta_{1/n} \\ & & \\ \eta_{n/1} & \cdots & \eta_{n/n} \end{bmatrix}} \underset{P^k_n}{\begin{bmatrix} {}^{*}_{P_1} \\ \cdot \\ \cdot \\ \cdot \\ {}^{*}_{P_n} \end{bmatrix}} \right] + \underset{c^k_i}{\begin{bmatrix} c_1 \\ \cdot \\ \cdot \\ \cdot \\ c_n \end{bmatrix}} {}^{*k}_{G} + \underset{d^k_i}{\begin{bmatrix} d_1 \\ \cdot \\ \cdot \\ \cdot \\ d_n \end{bmatrix}} {}^{*k}_{I}$$

II. Demand Equations for Products

$$(2)\quad \underset{{}^{*k}_{D_{ij}}}{\begin{bmatrix} {}^{*}_{D_{i,1}} \\ \cdot \\ \cdot \\ \cdot \\ {}^{*}_{D_{i,20}} \end{bmatrix}} = {}^{*k}_{D_i} + \underset{\bar{\eta}^k_{ij/i1}}{\begin{bmatrix} \bar{\eta}_{i,1/i,1} & \cdots & \eta_{i,1}\ /i,20 \\ & & \\ \bar{\eta}_{i,20/i,1} & \cdots & \eta_{i,20/i,20} \end{bmatrix}} \underset{{}^{*k}_{P_{i1}}}{\begin{bmatrix} {}^{*}_{P_{i,1}} \\ \cdot \\ \cdot \\ \cdot \\ {}^{*}_{P_{i,20}} \end{bmatrix}}$$

SYSTEM OF SUPPLY EQUATIONS

I. Supply Equations for Goods

$$\overset{*}{Q}_{ij} \qquad \alpha^{k}_{i/n} \qquad \overset{*}{PL}_{ij} - \overset{*}{S}_{ij}$$

$$(3)\quad \begin{bmatrix} \overset{*}{Q}_{1j} \\ \cdot \\ \cdot \\ \cdot \\ \overset{*}{Q}_{nj} \end{bmatrix} = \begin{bmatrix} \alpha_{1/1} & \cdots & \alpha_{1/n} \\ & & \\ \alpha_{n/1} & \cdots & \alpha_{n/n} \end{bmatrix} \begin{bmatrix} \overset{*}{PL}_{1j} - \overset{*}{S}_{1j} \\ \\ \overset{*}{PL}_{nj} - \overset{*}{S}_{nj} \end{bmatrix} + \overset{*}{T}_{j}$$

II. Cost Indicators

$$\overset{*}{S}_{ij} \qquad SP^{ij}_{n} \qquad \overset{*}{PL}^{j}_{n} \qquad SP^{ij}_{w} \qquad SP^{ij}_{R} \qquad SP^{ij}_{TX}$$

$$(4)\quad \begin{bmatrix} \overset{*}{S}_{1,j} \\ \cdot \\ \cdot \\ \cdot \\ \overset{*}{S}_{n,j} \end{bmatrix} = \begin{bmatrix} SP^{1j}_{1} & \cdots & SP^{1j}_{n} \\ & & \\ SP^{nj}_{1} & \cdots & SP^{nj}_{n} \end{bmatrix} \begin{bmatrix} \overset{*}{PL}^{j}_{1} \\ \cdot \\ \cdot \\ \cdot \\ \overset{*}{PL}^{j}_{n} \end{bmatrix} + \begin{bmatrix} SP^{1j}_{w} \\ \cdot \\ \cdot \\ \cdot \\ SP^{nj}_{w} \end{bmatrix} \overset{*}{W}_{j} + \begin{bmatrix} SP^{1j}_{R} \\ \cdot \\ \cdot \\ \cdot \\ SP^{nj}_{R} \end{bmatrix} \overset{*}{R}_{j} + \begin{bmatrix} SP^{1j}_{TX} \\ \cdot \\ \cdot \\ \cdot \\ SP^{nj}_{TX} \end{bmatrix} \overset{*}{TX}_{j}$$

MARKET EQUILIBRIUM

(5) $DN_{ij} = QN_{ij}$ Demand for good i produced by country j equals supply of good i produced by country j.

FEEDBACK EFFECTS

(6) $\overset{*}{COL}_j = \sum_n sc_n^j (\overset{*}{PL}_n^j)$ = per cent change in consumption deflator in country j.

(7) $\overset{*}{DDD}_j = \sum_n sg_n^j (\overset{*}{PL}_n^j)$ = per cent change in domestic demand deflator in country j.

(8) $\overset{*}{DINV}_j = \sum_n si_n^j (\overset{*}{PL}_n^j)$ = per cent change in investment deflator in country j.

(9) $\overset{*}{W}_j = w_j \cdot \overset{*}{COL}_j$ = per cent change in wages in country j.

(10) $\overset{*}{R}_j = r_j \cdot \overset{*}{DINV}_j$ = per cent change in return to capital in country j.

(11) $\overset{*}{TX}_j = t_j \cdot \overset{*}{DDD}_j$ = per cent change in indirect taxes in country j.

OUTPUT CONSTRAINT

(12) $\overset{*}{\overline{O}}_j = \sum_i sh_{ij} (\overset{*}{O}_{ij})$ The per cent change in aggregate real output of country j is constant.

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