MACROECONOMIC IMPACTS OF ENERGY SHOCKS:

A SUMMARY OF THE KEY RESULTS

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WORKING GROUP REPORT

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EMF 7 STUDY

MACROECONOMIC IMPACTS OF ENERGY SHOCKS

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Macroeconomic Impacts of Energy Shocks: A Summary of the Key Results

EMF 7 Working Group Report

1 Overview

1.1 Motivation

A significant part of the poor economic performance of oil importing countries during the 1970s arose from the two oil price shocks and from the policies implemented in response to the turmoil in the oil markets. More recently, slack world oil market conditions have caused an oil price reduction in 1983 and a price collapse in 1986, promising potential gains to oil-importing countries. While surplus conditions continue to dominate the oil market today, political instability in the major oil-producing regions could represent a long-term threat to world economic growth under tighter world oil market conditions.

The study of how oil price volatility affects U.S. economic performance has considerable significance for many of today's decisions. How have reduced oil prices affected the economic recovery? Are the effects of a price decline simply the reverse of the consequences of a price rise? If oil supplies are threatened again when energy markets are tighter, what can be said about the economic consequences? Which policies appear promising for helping the economy to adjust to such shocks?

Through a comparison of existing models of the U.S. economy, the seventh Energy Modeling Forum working group evaluated the range of short- to medium-term effects of sudden increases and decreases in the price of imported oil. The study focused on inflation, unemployment, and economic growth during the four years immediately following a hypothetical future energy price change. During this period, the economy's adjustment may still be unfolding and not yet complete, resulting in greater unemployment of people, equipment, and facilities in the case of oil price increases.

1.2 The Models

The study included virtually all of the widely used models of the aggregate U.S. economy. Over the last dozen years or so, there has been a rapid increase in the use of these models in many government agencies and corporations for economic forecasting and policy analysis. These models were initially developed for explaining fluctuations in economic activity over the business cycle and they focus on the determination of prices, expenditures, and income in the national economy. During the 1970s, they were extensively revised and expanded to incorporate important energy variables in order to study the consequences of oil shocks. However, they have retained their focus on the aggregate economy rather than on the energy markets and do not represent interfuel substitution possibilities in as much detail as do energy models.

1.3 The Scenarios

The participating models simulated both energy shock and policy scenarios that were designed by the working group. The reference scenario was developed in 1982 for comparing hypothetical oil shocks and was not intended as an actual forecast of the recovery during 1983-86. It is characterized by high unemployment that falls over time.

The group considered four different energy shocks: two oil price increases of different magnitudes, an oil price reduction, and an increase in domestic energy prices. Each energy shock was assumed to be a one-time change in the energy price that was maintained permanently through the four years. No discretionary policy offsets to either the output or inflation responses were allowed in these shock cases.

In other scenarios some policies were changed one at a time to counteract the GNP losses from an oil price increase. These policies included: a temporary expansion in the growth rate of the money supply, a permanent reduction in income tax rates, a permanent increase in the investment tax credit for equipment, and a permanent cut in the payroll taxes paid by employers for social security and other programs. In addition, a stylized oil stockpile release was considered that reduces both the price and quantity of oil imports. The policy scenarios have independent interest apart from the question of countering an oil shock, since the same actions could be applied in other situations of depressed activity.

1.4 Economic Losses of a Shock

The group considered the model results as being representative of the general impacts of a shock rather than precise numerical losses. The models indicate that severe disruptions to the U.S. economy would result from a long-lasting $18 per barrel increase in the price of imported oil. The estimated losses in total output and purchasing power over the four-year period range from about $250 billion to $750 billion in 1983 dollars, with an average loss of $452 billion. The average estimate represents almost $2000 per person spread over the four years and about 3.2 percent of the cumulative baseline GNP for this period. These results emphasize that avoiding or mitigating energy shocks can be very beneficial to the U.S. economy.

Our estimates indicate that for an economy with a high unemployment rate prior to an oil shock, the impacts are proportional to the size of the shock, at least for oil price increases of $18 per barrel or less. Thus, for every dollar per barrel increase in the world oil price, estimated annual losses would amount to over $25 billion, or more than $100 per person.

About 70 percent of these total losses are declines in real output (adjusted for inflation) as measured by the Gross National Product (GNP). In all but two U.S. models, most of this decline in real output can be attributed to temporary declines in aggregate demand that push the economy well below its level of full employment. At the same time, the higher cost of energy reduces the full-employment level of real output. In most models, however, the latter plays only a secondary role, particularly during the first two years of the shock.

The remaining 30 percent of total losses do not appear as reductions in real GNP as measured by national income accounting. These additional losses represent the decline in purchasing power occurring because oil import prices rise more rapidly than do domestic U.S. prices during an international oil shock. As a result, more U.S. exports are required for importing each barrel of oil, leaving fewer domestic goods for internal use.

There are mixed views on how rapidly the economy would recover from the losses that are associated with reductions in total demand. Virtually all models show real GNP declining through the second year, with the losses ranging from 2.0 to 3.5 percent by that second year. In half of the U.S. models, real output subsequently begins to recover in the third year. The remaining models, including several that are used by many government agencies and corporations, do not show such a recovery within the four years examined in the study, although most working group members expect that the recovery would be well under way by that time.

The effect on unemployment generally mirrors the losses in real output described above. With real output declining by about 3 percent during the second year, the unemployment rate increases by about 1.2 percentage points. The smaller effect on unemployment reflects a cyclical response in which firms initially reduce their output without releasing an equivalent number of employees, so that workers produce less per hour or work fewer hours in a week. The economic downturn will also discourage some workers, causing them to leave the labor force and thereby dampening the impact on measured unemployment.

There have been frequent discussions of the role of energy prices in inflation. Some believe that the inflation of the 1970s was largely caused by the OPEC price increases and other exogenous factors. The same view would hold that significant relief from inflation has resulted from the recent oil price reductions. Our results indicate that a once-for-all oil price shock induces only a short-lived burst of inflation. The prices of goods and services purchased in the United States rise an additional two percent during the first year and one percent during the second year as a result of an $18 per barrel increase in the oil price. However, inflation due to the shock does not last; it moderates over time and becomes negligible by the fourth year, although the price level remains permanently higher. A one-time increase in the price of imported oil can not permanently alter the underlying inflation rate as long as economic policy, particularly the growth rate of the money supply, is not changed.

1.5 Alternative Energy Shocks

We also asked whether the estimated impacts can be generalized to energy shocks we didn't explicitly consider. There has been recent interest in the effects of oil price reductions on the U.S. economic recovery. Some argue that the economy can only benefit from an oil price reduction, while others think that it would reveal financial constraints and lead to adjustment costs that would be harmful to the economy.

The model results suggest that when the economy is experiencing significant unemployment, the economic gains from a modest oil price reduction of $7 per barrel or less are equal but opposite to the losses induced by an oil price increase of comparable size. While this finding appears applicable for the price decline experienced in 1983, the group thought it inappropriate to extend this conclusion to larger oil price declines with different baseline economic trends, as happened with the oil price collapse of 1986. The model results suggest that a price decline of $7 per barrel would reduce real GNP by about 1.2 percent after two years and would reduce the inflation rate by about 0.4 percentage points in each of the first two years. Thus, the models show unambiguously that a modest oil price reduction will be a net benefit to the overall economy. Oil price increases during the last decade contributed to the stagflationary conditions of greater short-term inflation and lower economic output; conversely, a modest oil price reduction in today's economy should ease short-term inflationary pressures and aid an economic recovery.

World oil price reductions represent an unqualified gain for the aggregate U.S. economy. But, sudden price changes—either increases or decreases—will create adjustment problems for many firms and individuals. These are not represented in the models, which focus instead on the aggregate relationships of economic activity. Moreover, for large reductions in the world oil price, it is possible that a crisis in the international financial system could develop and impinge upon all economies by depressing world economic trade. While these caveats are important to note, they do not obviate our conclusions that moderate oil price reductions are beneficial for the U.S. economy.

Another issue concerns whether there are important differences between internal and external energy shocks. Does it matter that we are importing the energy whose price is increasing? These models do not incorporate the gains from an improved allocation of resources that would accompany the deregulation of individual energy markets. For this reason, our domestic shock scenario should be considered not as a deregulation of domestic energy markets, but rather more like a domestic tax increase with offsetting income transfers that leave the distribution of income unchanged.

When standardized for the change in energy price in our models, the domestic and international shocks produce approximately the same GNP losses. These losses result primarily from the direct and induced changes in the domestic price level. How much energy we are *importing* appears to be relatively unimportant for the GNP impacts estimated by the models, although how much energy we are *consuming* may be important. In designing policies for mitigating the adverse impacts of energy shocks on real GNP, programs simply to increase energy supply would appear to be less important than those directed toward offsetting direct increases in energy prices or toward directly augmenting aggregate demand in response to the shock.

Although a domestic and international energy shock induce similar losses in real GNP, international shocks will cause greater total economic losses than will domestic shocks. A price rise for imported energy will reduce the purchasing power of domestic income but a price increase for domestic energy will not. Thus, reductions in energy imports will help reduce the total economic losses from an international oil shock by mitigating the decline in purchasing power, even though the GNP losses are virtually independent of the level of imports (for the level of consumption held constant).

1.6 Energy Security Policies

Energy security policies are oriented toward reducing sudden oil price increases and the quantity of imported oil. Examples of such policies include a release from the Strategic Petroleum Reserve (SPR) and an imposition of a disruption tariff on imported oil. Both policies would decrease the transfer of wealth to foreign oil producers, thus reducing their claims on total U.S. domestic output of goods and services.

However, these two policies would have sharply different consequences for total U.S. output as measured by real GNP. The oil stockpile release would lower the oil price to U.S. consumers, producing gains in total output as measured by real GNP. For every $1 per barrel reduction in the world oil price, our average results indicate that the SPR release would augment real GNP by $3.2 billion in 1983 dollars or about 0.1 percent during the first year. In addition, the international purchasing power of domestic income would increase.

Although a disruption tariff was not specifically analyzed in this study, such a tariff levied during a disruption would raise U.S. prices while lowering the oil price received by foreign oil producers. Real GNP would be adversely affected by any policy that raised oil prices to U.S. consumers and industry during a disruption. The reduced oil import levels would reduce the purchasing power losses but would have a relatively minor effect on the declines in real GNP. The net effects of this policy would contrast sharply with those of the stockpile release. The disruption tariff would produce losses in total output (real GNP) that counter the gains in international purchasing power. In many cases, these output losses will be the more important effect.

Any policy that changes the price of oil during a disruption should be evaluated for its effect on both total output (real GNP) and purchasing power. In these cases, estimated GNP results from macroeconomic models should be supplemented with separate estimates of the changes in purchasing power.

1.7 Economic Policy Responses

Government can implement policies that attempt to either accommodate the oil shock to offset the loss in GNP or restrict the economy to fight inflation. In this study the group considered policies for mitigating the GNP losses resulting from an $18 per barrel increase in the price of imported oil.

The discretionary policies considered in this study mitigate but do not completely offset the GNP losses. The working group did not consider larger policy responses. Thus we could not examine whether larger policies could eliminate these GNP losses.

Moreover, some policies also raise the aggregate price level for goods and services. The temporary expansion in the money supply reveals the greatest increase in the aggregate price level for goods and services, while the income tax reduction and the investment tax credit increase also indicate some upward pressure on prices. In contrast, supply-oriented policies directly reduce the production costs in the economy, providing price relief while augmenting real output. From this perspective, they appear to be more appropriate policy responses to oil shocks, although other concerns may prevent their implementation. These policies include a reduction in payroll taxes paid by employers and a stylized oil stockpile release to reduce oil prices directly.

It should be emphasized that the tradeoff between prices and unemployment is only one criterion for evaluating policy responses to an oil disruption. Other important considerations include the effect on the federal deficit and the speed and ease with which the policy can be implemented during a disruption. Finally, the policies have different distributional impacts on individuals and businesses.

Oil prices were not changed from their shock levels in these policy cases because most of the models do not evaluate the effects of higher GNP and oil demand on oil prices. The importance of this effect will depend upon whether all oil-importing countries are adopting the expansive policy as well as the responses of oil producers and consumers to changes in price and income. To the extent that these factors cause significant further oil price increases, the GNP gains from a policy would be less than estimated in this study.

Differences among models appear more striking in representing the effects of various policies than in simulating the energy shocks. While they generally agree on the direction of the response, the models differ on which policy produces the largest impact on inflation and real GNP. Some show strong price and output responses to the income tax reduction case but weak responses when the money supply is expanded. Others show the reverse set of responses. These variations reflect less consensus among professional macroeconomists on the economy's response to different monetary and fiscal policies than in its response to oil price shocks. The full report includes a chapter that relates assumptions about key model parameters and structures to their observed responses to the various policy initiatives. That information should help policymakers use these models more effectively for evaluating macroeconomic policies as well as for studying oil shocks.

1.8 Use of Models

The impacts estimated by the models are based upon model structures incorporating historical responses to past shocks, but using assumptions about macroeconomic policies and conditions representative of today's economy. Although the world has undergone considerable change over the last decade, it is unclear whether the simulations are too optimistic or pessimistic about the impacts of future oil shocks. Future disruptions might have less damaging effects than past ones because energy systems today are generally more flexible and capable of substituting alternative fuels in sectors other than transportation. On the other hand, the consequences could be more severe because the international financial system is more fragile today and because many easy conservation options have already been exploited.

Since these national models focus on the U.S. economy, most do not project world oil market conditions or economic activity in major U.S trading partners. In order to use these models to simulate the impacts of an oil disruption, standardized assumptions have been used to represent the oil market disruption and its repercussions on the world economy. The oil market disruption has been represented as a permanent increase in the price of imported oil. This assumption appears appropriate when a reduction in oil supplies leads to rapidly rising oil prices, as was the case in previous oil shocks. Moreover, most of the models are designed to be driven by such price changes.

These models are most useful for evaluating aggregate economic consequences and corrective macroeconomic policies on a quarterly basis. They will not be appropriate for analyzing: the detailed distribution of impacts by region and industry, intricate interfuel substitution possibilities within the energy sector, or very short-term emergency energy actions whose impacts are important on a weekly or monthly basis.

Although the models have been used in the past for evaluating the effects of decontrolling oil and natural gas prices, the working group decided not to study natural gas deregulation. We concluded that the evaluation of such a policy would depend upon assumptions about critical issues not incorporated by the models. For similar reasons, the working group also decided not to use these models to study the imposition of price controls as a policy response to oil price shocks.

2 Study Design

2.1 Previous Oil Shocks

The macroeconomic effect of oil price volatility is likely to continue to be an important global concern. World economic growth declined sharply, unemployment became widespread, and inflationary pressures mounted during the 1970s, subsequent to the oil price shocks of 1973 and 1979-80. More recent oil price drops in the 1980s may have created economic conditions more favorable to economic growth.

The importance of this issue can be easily seen by the U.S. stagflationary experience reviewed in Table 1, which shows economic growth, inflation, and unemployment during four distinct phases of this decade. Economic growth was considerably depressed and inflation more severe during 1973-1975 and again in 1979-80 than in the other periods.

A number of factors contributed to the fluctuations in economic growth and inflation over this period. Economic activity was particularly brisk in 1971-73 because the economy was recovering from the 1969-70 recession. Price controls were artificially restricting the increase in measured price inflation, even though inflationary pressures were mounting due to expansive monetary and fiscal policy. By 1973, these pressures were becoming visible, while the economy was being shocked by increases in prices for food and imported nonoil materials as well as for petroleum. Economic growth slowed dramatically during the severe recession of 1973-75; the growth rate in real Gross National Product (GNP) declined from 3.6 percent for the previous four-year period to -0.9 percent for this two-year period. As a result, the real GNP level was 7 to 8 percent lower by 1975 than would have been the case

Table 1: Economic Growth, Inflation, and Unemployment During 1969-80

	1969-73	1973-75	1975-78	1978-80
Real GNP Growth Rate (%)	3.6	-0.9	5.3	1.2
Inflation Rates (%)				
GNP Deflator	5.1	9.1	6.1	9.0
Consumer Price Index				
All Items	4.9	10.1	6.6	12.4
Excluding food and energy	4.4	8.8	6.7	11.1
Excluding food, energy and housing	4.0	8.2	6.3	8.2
Unemployment Rate (%)[a]	4.9	8.5	6.1	7.1

Source: *Economic Report of the President*, 1983.
[a]End of period.

if it had increased by 2.5 to 3 percent per year during these years. Inflation as measured by the GNP deflator increased from about 5 to 9 percent per year during this same period.

Past studies of this 1973-75 period assign a significant part of this poor economic performance to the first oil price shock during the last quarter of 1973. Previous simulation studies by some of the macroeconomic models participating in this study suggest that the 1975 GNP level was reduced by about 3 to 5.5 percent by the oil shock alone.[1] These same models attributed about 2 percent of the incremental inflation to this shock as well. According to these estimates, the economy's performance would have been significantly improved if the first oil shock could have been avoided.

Rising inflation rates and slower economic growth rates again characterized the period during and after the second oil price shock. Once again, the oil shock was accompanied by other factors that complicate a simple interpretation of the figures for the period. The growth rate of real output in 1975-78 was far higher than its long-term trend, reflecting the economy's

[1]Dohner derives this conclusion after reviewing simulation studies performed with the MPS, Michigan, DRI, Mork, and Fair models. See Dohner, R.S., "Energy Prices, Economic Activity, and Inflation: A survey of Issues and Results." In *Energy Prices, Inflation, and Economic Activity*, edited by K.A. Mork. Cambridge, Mass: Ballinger, 1981.

rebound from the 1973-75 experience. Moreover, inflation was increasing throughout this period, reaching 7.4 percent (as measured by the GNP deflator) by 1978. Finally, major shifts in U.S. macroeconomic policy and the substantial appreciation of the U.S. dollar complicate the interpretation of the period after 1980. Accounting for some of these other factors, two studies of the second OPEC oil price shock again suggest that the oil shock did considerable damage to the U.S. economy. It was estimated that the level of real GNP would have been about 2 to 4 percent higher and prices 1 to 3 percent lower by the second year of the second oil price shock if it had not happened.[2]

2.2 Focus of the Study

In this study U.S. macroeconomic models were used to estimate the impacts of hypothetical future oil price shocks. Through a comparison of these results, the working group focused on identifying the principal mechanisms by which energy price increases are transmitted through the rest of the economy. We also examined the macroeconomic responses of several discretionary policies for mitigating the losses due to a shock. The economic impacts of energy shocks and accommodating economic policies were evaluated primarily in terms of changes in real output, the aggregate price level for goods and services, and unemployment over a four-year horizon. The interest in studying the policy responses to oil price changes as well as the effects of the oil shocks themselves led us to focus more on price increases than decreases, although our results appear to be relevant for modest oil price reductions as well.

As in other EMF studies, the group pursued two broad goals. First, we sought to understand the models themselves by identifying important commonalities as well as structural differences. The second objective was to use the models to probe important policy issues that are often debated with regard to oil price shocks and appropriate policy responses.

[2]The lower estimates for the second OPEC shock are from simulations with the DRI model reported by O. Eckstein, "Shock Inflation, Core Inflation, and Energy Disturbances in the DRI Model," in *Energy Prices, Inflation, and Economic Activity*, edited by K.A. Mork. Cambridge, Mass: Ballinger, 1981. The higher ones are reported for the Mork model by Mork and Hall, "Energy Prices and the U.S. Economy in 1979-1981," *The Energy Journal* (April 1980), 41-53.

2.3 The Models

The study included virtually all of the widely used U.S. models. The use of a large number of models allowed us to explore issues from a wide diversity of intellectual orientations. Although we focused on the United States, the methodological issues raised by this comparison have relevance to other economies as well. In addition, to provide some international perspective, the study included a Canadian energy-economy model and two models incorporating the international linkages between major countries.

An oil price shock would reverberate throughout the world economy as well as the world oil market. Thus, U.S. macroeconomic linkages should be imbedded within other relationships defining world oil market dynamics and international economic conditions. A framework that encompasses the key relationships is depicted in Figure 1. Here linkages are shown that integrate the world oil market, the U.S. economy, and the foreign economies. Unfortunately, there are few models that treat this issue so comprehensively. Nevertheless, insights can be derived by examining different aspects of this picture. For example, the sixth Energy Modeling Forum study focused on ten prominent world oil models to derive implications about the world oil market dynamics, but did not carefully examine impacts on U.S. macroeconomic activity.

Several of the models used in this study integrate the U.S. macroeconomic linkages with either the world oil market or foreign macroeconomic activity. However, for the most part, U.S. macroeconomic models generally treat these other blocks as exogenous to the system. Therefore, relatively simple assumptions must be made about shocks to world oil prices and about the responses of prices and activity levels of foreign economies trading with the United States. Perhaps complicated assumptions about these external interactions would improve the realism, but they would also make the results more difficult to interpret.

In order to facilitate the presentation of results, the 14 models have been divided into two groups as shown in Table 2. Most in the first group are large systems that produce quarterly forecasts of the U.S. economy. These models were developed specifically to forecast key price, income, and expenditure variables over a 3-5 year horizon under different macroeconomic policy assumptions. They include the three large commercial forecasting models—Chase, Data Resources, and Wharton—that are used extensively by many companies and government agencies. Other models in this group are: the Bureau of Economic Analysis Quarterly Econometric Model, the

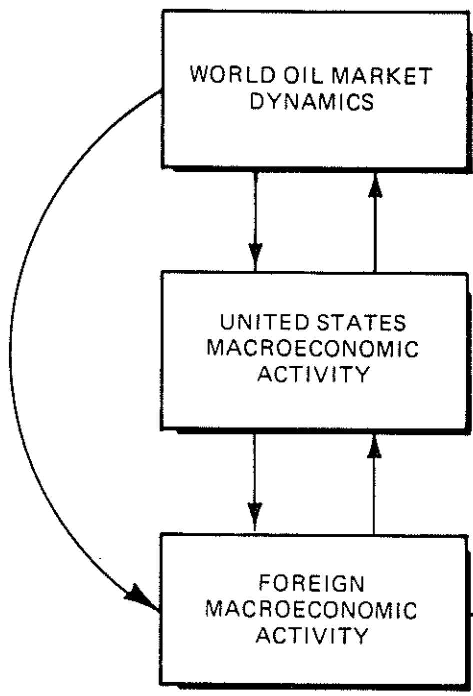


Figure 1: Important Linkages in International Oil Shock Analysis

new annual version of the University of Michigan model (a smaller annual version of the larger quarterly model), and the version of MPS (MIT-Penn-SSRC) maintained at the University of Pennsylvania. In addition, the LINK system may be included here because it uses the Wharton model as its U.S. component. Thus, the Wharton and LINK results refer to essentially the same U.S. model, differing only in the way that foreign linkages and feedbacks are specified in the linked and unlinked versions.

A second group includes smaller models representing many diverse perspectives. Hickman-Coen is an annual growth model used primarily to examine intermediate and longer-term macroeconomic policies and growth trends. An avowedly monetarist system is the St. Louis Federal Reserve Bank model, which is represented by a reduced-form version specifically developed for energy shock studies. Claremont is a small reduced-form model incorporating rational expectations and monetarist principles. It was one of several used to evaluate economic conditions and budget considerations during the first year of the Reagan Administration.

Table 2: Features of Participating Models

Model	Stochastic Equations	Parameter Estimation Period	Data Frequency Q	Data Frequency A	Endogenous Oil Import Price	Endogenous Oil Import Quantity	Linkages with US Economy
Group 1							
BEA Quarterly Econometric	150	1959-1979	X				
Chase Quarterly Macroeconomic	250	1958-1980	X			X	
Data Resources Quarterly	424	1960-1980	X			X	
LINK	3000[a]	1955-1980	X		X	X	International
Michigan Annual Econometric	64	1954-1979		X			
MPS (MIT-PENN -SSRC)	130	1946-1980	X			X	
Wharton Quarterly	432	1955-1980	X			X	
Group 2							
Claremont Economics Institute Domestic	10	1970-1980	X				
FRB Multi-Country (MCM)	500[b]	1960-1975[c]	X			X	International
Hickman-Coen Annual Growth[d]	60	1949-1979		X			
Hubbard-Fry	80	1960-1980	X		X	X	Oil
MACE (Macro Energy)	23[e]	1955-1980		X		X	Canadian Energy[f]
Mork Energy-Macroeconomic	15[g]	[g]		X	X	X	Oil
St. Louis (FRB) Reduced-Form	3	1955-1981	X				

[a]Total for 32 countries.
[b]100 for each of five countries (Canada, Germany, Japan, U.K., and U.S.).
[c]Oil and exchange rate equations are estimated through 1980.
[d]Long-run as well as short-run policy analysis and forecasting.
[e]Macroeconomic sector only.
[f]Canadian model with extensive energy market detail.
[g]Parameters are judgmental rather than estimated.

The Hubbard-Fry and Mork models emphasize the two-way interaction between oil markets and economic growth, explicitly representing a world oil market as well as U.S. macroeconomic linkages. In addition to incorporating oil market dynamics, the Mork model was developed in a rational expectations framework with short-run rigidities in the labor and capital markets.

International perspectives have been incorporated in several ways. Both Project LINK, maintained at the University of Pennsylvania, and the Federal Reserve Board's Multi-Country Model (MCM) incorporate the trading relationships between the United States and other oil-importing countries. Thus, they can be used to trace the international mechanisms through which an oil price shock is transmitted. While both models are quite large, the MCM model has been placed in the second group because its U.S. component is smaller than most of those in the first group. And finally, the Canadian MACE model has been included to provide a perspective from a small open economy, heavily dependent upon foreign trade.

Of the 14 models, only four were originally developed specifically to evaluate energy price shocks: Hubbard-Fry, MACE, Mork, and the reduced-form St. Louis version.[3] The others are used primarily for macroeconomic forecasting and policy analysis but have been expanded to incorporate the key linkages with the energy sector.

Many of the larger macroeconomic models are routinely updated using recent data and revised to incorporate improved specification of the principal relationships. The evolving nature of these models implies that their responses to oil shocks, and especially to macroeconomic policies, may be different today than when the model participated in the EMF study. However, the general spectrum of policy responses is probably much the same as reported herein.

2.4 Use of the Models

The EMF simulations were not developed to evaluate impacts of past oil shocks. The impacts of hypothetical future oil price shocks were estimated under a set of common assumptions not chosen to duplicate actual U.S. policy during previous shocks. For example, GNP losses during the prior oil shocks were exacerbated by a restrictive monetary policy directed at stabiliz-

[3]The St. Louis model was initially developed for macroeconomic forecasting and policy analysis. The reduced-form version compared in this study extends the original model to incorporate energy price changes.

ing prices, while our scenarios include neutral or accommodating monetary policy. Moreover, the underlying economic conditions prevailing at the time of a shock can significantly influence the magnitude of the responses. The current study reflects economic conditions of the early 1980s rather than the 1970s. The upward pressure on prices may not be as great in our simulations as occurred in the 1970s because unemployment is more pervasive now than during the previous shocks.

Although policies and macroeconomic conditions may vary from history, the impacts estimated in this study are based upon model structures incorporating historical responses to past shocks. Modelers were instructed not to substitute additional assumptions to reflect their judgments about how future oil shocks could affect the economy differently from past ones. They were also requested to report any special adjustments they used in the shock and policy scenarios. Since few were reported, these simulations can be considered as unmanaged, reflecting outputs of the models themselves. The reported impacts could differ from those that would have been estimated if the simulations had incorporated the modelers' judgment about factors not represented in the formal structure of the model or in the scenario designs.

The working group speculated about whether there was a clear bias toward overstating or understating the impacts of the shock by using these models as they now stood. Some changes between the 1970s and now are probably incorporated into the models. For example, the economic losses of oil price shocks can be expected to be lower because oil consumption is now smaller relative to GNP, but these losses could be higher because total energy expenditures increased relative to GNP during the 1970s.

Other factors are more problematical. For example, people might not expect the initial oil price increase to persist because oil market conditions are softer today than during previous shocks. Even though the oil price shock was implemented as a long-term increase (50 and 20 percent above the control level), wage negotiators and other decisionmakers might in fact assume that such a shock would not persist, at least at its initial level. Moreover, many consider the energy system to be more flexible today than in past years. The existence of dual fuel-burning capacity and other possibilities for substituting quickly for oil can reduce oil consumption and thus can dampen the adverse impacts of an oil shock.

While such considerations suggest that the simulations overestimate the economic losses, others could operate in the opposing direction. For example, many easy conservation options have already been exploited, thus making oil use reductions potentially more difficult. In addition, the international financial system is more fragile than during the previous decade. The debt problems of oil-importing less-developed countries could greatly exacerbate the world repercussions of an oil shock in the future. For these reasons, no consensus developed within the group on whether the EMF simulations were too optimistic or pessimistic about the impacts of future oil shocks.

2.5 Scenarios

The participating models simulated the energy price shock and policy scenarios briefly described in Table 3. Appendix 1A discusses these scenarios in greater detail.

Each energy shock was assumed to result in a one-time change in the energy price that was maintained through the four-year horizon of the study. The four energy shocks included two world oil price increases, an oil price reduction, and a domestic energy price increase. No discretionary policy offsets to either the output or inflation responses were allowed in these energy shock cases.

In additional scenarios some policies were changed one at a time to counteract the GNP losses from the 50 percent increase in the world oil price. These policies included a temporary expansion in the growth rate of the money supply and the following permanent changes implemented separately: a reduction in income tax rates, a cut in the payroll taxes paid by employers (including contributions to social security), and an increase in the investment tax credit for equipment. A "stylized" oil stockpile release that reduced both oil prices and import levels was also considered.

3 Impacts of an Oil Shock

The U.S. economy would suffer large losses in total production of goods and services and in the purchasing power of its income if the world oil price were to rise suddenly by $18 per barrel.[4] The first column of Table 4 reveals that the projected losses, when added over four years, range from $246 to $747 billion (B) in 1983 dollars. The average loss for the models is $452 B, or about $2,000 per U.S. resident. Moreover, even in the smallest estimate, the losses appear significant. These results emphasize that the economy would gain considerably if such oil shocks could be avoided or mitigated.

[4]The 50 percent shock was applied to a hypothetical reference oil price of $36 per barrel in 1983.

Table 3: Specifications of Scenarios: Change from Control Solution

Scenario	Oil (Gas) Price and Oil Imports	Economic Policy: Monetary	Economic Policy: Fiscal
shock			
50 percent oil price increase	Imported oil nominal price raised by 50%, 1983-1986	None	None
20 percent oil price reduction	Imported oil nominal price reduced by 20%, 1983-1986	None	None
Natural gas price increase	Wellhead natural gas price raised by 80%, 1983-1986	None	None
20 percent oil price increase	Imported oil nominal price raised by 20%, 1983-1986	None	None
policy			
Monetary accommodation	Imported oil nominal price raised by 50%, 1983-1986	M1 supply growth rate increased by 1983: 3% 1984: 1 1/2% 1985-86: 0%	None
Income tax reduction	Imported oil nominal price raised by 50%, 1983-1986	None	Personal income tax rate reduced by 10%, 1983-1986
Investment tax credit increase	Imported oil nominal price raised by 50%, 1983-1986	None	Credit increased by 13 percentage points, 1983-1986
Payroll tax reduction	Imported oil nominal price raised by 50%, 1983-1986	None	Employer's share reduced by 2.1 percentage points, 1983-1986
Oil stockpile release	Nominal imported oil price raised by 47.5%, 1983-1986; oil imports reduced by 0.5 MMBD, 1983-1986	None	None

Table 4: Four-Year Cumulative Losses Due to a 50 Percent Oil Shock (1983 $B)

Model	Total Losses	Real GNP Losses[a] Actual	Potential	Cyclical	Terms-of-Trade Losses[b]
Bureau of Economic Analysis (BEA)	569.8	457.3	132.0	325.3	112.5
Chase	470.3	300.5			169.8
Data Resources	398.8	298.1	92.7	205.4	100.7
LINK	554.9	379.1			175.8
Michigan		408.2			
MPS	487.5	341.9			145.6
Wharton	574.1	434.1			140.0
Claremont		325.9	304.1	21.8	
FRB Multi-Country	290.5	149.9			140.6
Hickman-Coen	246.0	216.6	41.3	175.3	29.4
Hubbard-Fry	287.5	142.1			145.4
Mork	747.1	608.7			138.5
St. Louis		252.7	383.2	N.C.[c]	
Average[d]	452.4	328.0	N.C.	N.C.	124.7

[a]Reported by modelers. Cyclical losses have been derived as actual minus potential GNP losses to show the increase in excess productive capacity.

[b]Calculated from reported changes in oil import prices, export prices, and levels of real exports and oil imports. See Appendix 1B.

[c]Actual and potential GNP are separate projections that are not linked to each other, as discussed by Tatom. Thus, the residual cannot meaningfully be considered as cyclical GNP losses.

[d]Excludes LINK. Means are reported so that components will sum to total losses; the use of medians does not fundamentally alter the conclusions.

N.C.—Not calculated because either the concept was not meaningful for a particular model or fewer than half the models reported data from which a mean could be calculated.

About 70 percent of these total losses would represent reductions in aggregate production, as measured by declines in real GNP shown in column 2 of the same table. These losses primarily reflect increased unemployment of people and equipment rather than a shrinkage in the economy's production at full employment. The increased unemployment results from sharp declines in total spending or aggregate demand for U.S. production.

The remaining 30 percent of total economic losses represents the decline in the purchasing power of U.S. national income. Reported in the last column of Table 4, these terms-of-trade losses are not incorporated in the estimated GNP losses but are based upon the changes in imported oil prices and U.S. export prices reported by the models.[5] When the price of imported oil rises relative to other prices in the economy, the United States must produce more exports to buy a barrel of imported oil. With full employment of U.S. workers and equipment, production would be diverted away from goods for internal use in order to purchase oil imports. The country is poorer because it must produce more goods for foreigners and fewer goods for its own use. This shift in claims on U.S. production would exist even if the level of U.S. output (or real GNP) were left unchanged by the shock.

3.1 Permanent Losses

The reduction in purchasing power will persist as long as the price of imported oil remains high relative to prices of goods and services that the United States produces for exports. In addition, a lasting increase in the price of oil will also permanently reduce the economy's potential output—the level of production attainable when all workers, equipment, and facilities are fully and efficiently employed.[6] This reduction occurs because these other inputs become less productive when energy use is reduced in response to higher prices. Moreover, since an energy shock raises the price of capital

[5] The terms-of-trade losses are calculated as the change in the real imported oil price times the average quantity of oil imports in the shock and control scenarios, minus the change in the real price of U.S. exports times the level of exports. For example, oil prices rise by $18 per barrel in the 50 percent oil shock case. U.S. oil imports average 5 million barrels per day or 1.8 billion barrels per year in these simulations. Thus, the terms-of-trade losses amount to about $33 billion, minus the gains realized for U.S. exports. This calculation is discussed more fully in Appendix 1B.

[6] This definition of potential output excludes reductions in the capital stock attributable to temporary declines in aggregate demand and investment. These effects may be incorporated by the potential output variable reported by some of the models.

relative to the wage rate, potential output will be reduced further through a slower rate of capital formation.[7]

Estimates of the declines in potential GNP are available for only five U.S. models (Table 4, column 3). Except for Claremont and St. Louis, the potential output losses in column 3 for the U.S. models are small relative to the total GNP losses. The dominant losses appear to be the "cyclical" ones (in the fourth column) where actual output is reduced more than potential output, resulting in declining capacity utilization. Since the other models have structures more similar to these three than to the Claremont and St. Louis models, this conclusion would be broadly applicable to them as well.

The dominant role of potential output losses in Claremont and St. Louis does not appear to affect the magnitudes of the actual GNP losses relative to other models. In column 2 of Table 4, the actual GNP losses for these models are not significantly different from the losses for the other models.

Figure 2 contrasts the proportional impacts on potential output in the Claremont and St. Louis models with those in the remaining models.[8] Claremont and St. Louis reveal sharp first-year declines, with little or no further reductions in subsequent years. In contrast, the other four models represent potential output as falling gradually below the control path as the growth in the capital stock is retarded. The effects in these models, particularly for the United States, are substantially smaller than in the first two models above. As a result, capacity utilization in Figure 3 falls considerably more in these models than in the Claremont and St. Louis models.

3.2 Short-Run Macroeconomic Effects

This emergence of excess productive capacity, coupled with higher prices throughout the economy, confronts policymakers with a pernicious set of

[7]Even if its price does not rise relative to wages, the demand for capital could be reduced by the declining use of energy. This situation occurs when energy and capital are cooperating or complementary inputs that are more likely to be used in combination with each other rather than as substitutes. However, except for the Canadian Mace model, the participating models reporting potential output represent energy and capital as substitute rather than complementary inputs.

[8]The impacts on potential output will depend upon whether energy prices or quantities enter the production function and whether the latter represents aggregate output or value added. The relevance of these specification issues for the models that report this variable are discussed in Hickman, B.G., "Macroeconomic Effects of Energy Shocks and Policy Responses: A Structural Comparison of Fourteen Models," in *Macroeconomic Impacts of Energy Shocks*, edited by B.G. Hickman, H.G. Huntington, and J.L. Sweeney, Amsterdam: North-Holland, 1987 (Chapter 2).

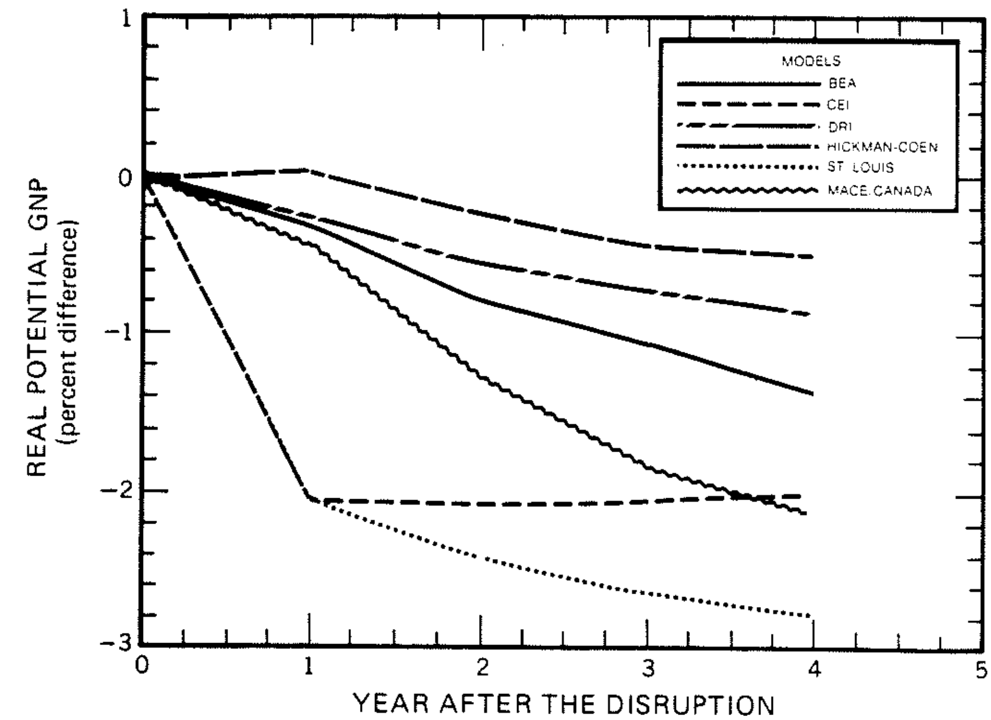


Figure 2: Impact of a 50 Percent Oil Price Increase on Potential Real GNP

stagflationary conditions. Table 5 summarizes these impacts with the median[9] result estimated by the models. By the second year, real output has fallen 2.9 percent, the unemployment rate has increased by 1.2 percentage points, and the aggregate price level for goods and services has risen 2.0 percent.

Some recovery in real output and moderation in the price effects are evident in these results for later years. However, the rates of inflation and economic growth are essentially unchanged by the fourth year, although the output path remains lower and the price level is higher.

The reduction in real GNP can be further disaggregated into effects on consumption, investment, government purchases, and net exports. The decline in consumption is proportional to the reduction in real GNP, while investment falls by more than twice as much in the second year. Due to the

[9]Half of the model results lie above and half fall below the median result. Medians give less weight to extreme values, although this is not a severe problem in most cases. However, we have used means when we have disaggregated an effect into its components, e.g., Table 4, in order that the components sum to the total impact.

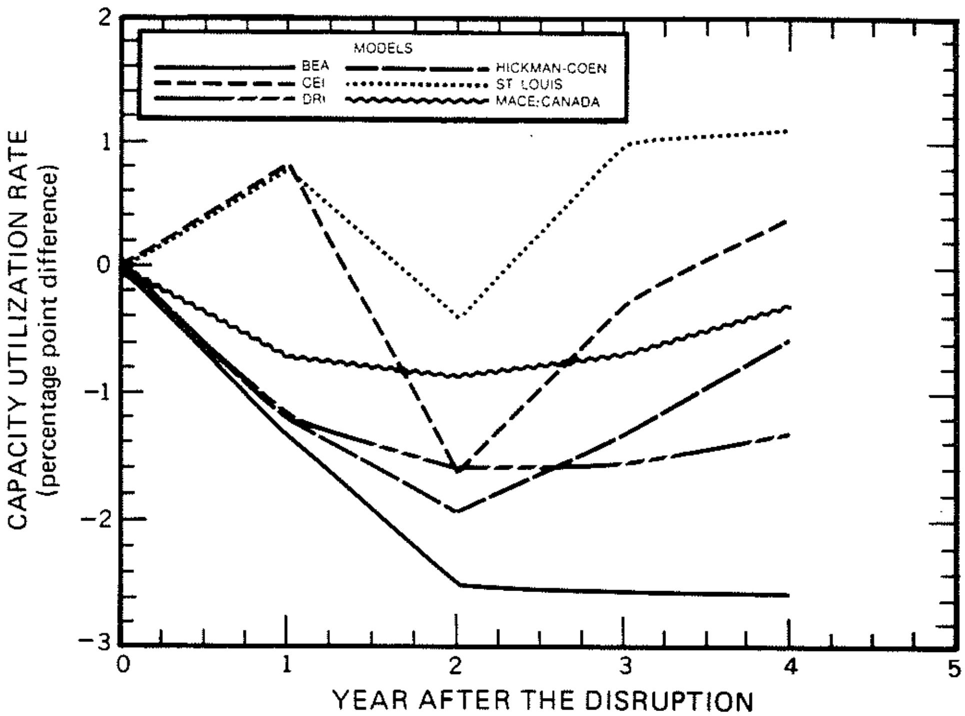


Figure 3: Impact of a 50 Percent Oil Price Increase on the Capacity Utilization Rate

standardized assumptions in the scenarios, federal government purchases remain unchanged in real terms, although some models show state government purchases falling. On net, total government purchases either are not changed or fall by proportionally less than the other major expenditure categories. Countering the declines in these three components is the response in the foreign trade sector. Due to the drop in petroleum imports, total imports decline proportionally more than exports, causing net exports to increase.

The oil price shock causes federal deficits to worsen because higher prices and lower output raise expenditures more than the tax base. The deficit increases on average by almost $1 B for every $1 increase in the oil price during the first few years. Additionally, the current trade account initially deteriorates because import prices rise more than export prices. However, this effect does not last, reflecting the response of import demand to higher prices.

Table 5: Key Impacts of a 50 Percent Oil Shock

	Median Result[a] for Year:			
	1	2	3	4
Real Output:				
Constant-Dollar GNP[b]				
Percentage Deviation	-1.42	-2.90	-2.54	-2.07
	(0.47)	(0.57)	(0.83)	(0.84)
Price Level:				
Implicit GNP Deflator				
Percentage Deviation	1.13	2.02	2.25	2.01
	(0.65)	(0.80)	(0.76)	(1.18)
Unemployment Rate				
Absolute Deviation	0.56	1.21	1.04	0.88
	(0.16)	(0.29)	(0.41)	(0.54)

[a]For U.S. models excluding LINK. Semi-interquartile range is reported in parentheses and is calculated as 1/2 times the difference between the third and first quartiles.

[b]GNP adjusted for inflation.

Each of these effects is discussed more thoroughly in the following sections summarizing the impacts of an oil price shock.

3.3 Inflation

The world economy experienced both debilitating oil shocks and rampant inflation during the 1970s. Some believe that this inflation has been mainly caused by oil price increases and other factors outside the control of U.S. policy. The same view holds that significant inflationary relief resulted from exogenous events like the recent oil price reductions.

Our results indicate that an oil price shock would produce an immediate short-run burst of inflation. However, these price effects would be considerably dampened by the third and fourth years, as long as the government does not adopt a stimulative monetary policy. For a sustained 50 percent increase in the oil price, the prices of goods and services purchased in the

United States would rise by about 2 percent in the first year and by another 1 percent in the following year. While these impacts are significant, they suggest that the inflation rates experienced during the 1970s were only partially attributable to past oil shocks.

Immediately after an oil price increase, substitution away from energy is limited and the prices of other inputs do not fall. Moreover, spillover effects on wages and the prices of materials and other intermediate goods operate in conjunction with higher energy prices to raise unit costs. As a result, firms increase the prices of final goods and services.

The aggregate price level for goods and services, as measured by the implicit price deflator for GNP in Figure 4, is raised in the early years in all models, but these effects begin to level off by the third year in many of them. The upward pressure on prices of goods and services begins to subside over time as growing unemployment and excess productive capacity dampen wage increases and other variable production costs for firms. Several models—Chase, MPS, Hickman-Coen, and Michigan—show the price effects becoming smaller by the fourth year or earlier.

A one-time energy price shock increases the aggregate price level for goods and services in all models. However, it does not alter the underlying inflation rate, the rate at which the price level is changing over time, as long as discretionary economic policy does not become more expansive. By the second year, the difference between the two price paths has stopped growing in most models, implying that the inflation *rate* has begun to return to the rate prevailing without an oil shock. This conclusion is represented more directly in Figure 5, which shows the incremental effect of the oil shock on the inflation rate in terms of percentage points. By the third year, the incremental inflation rate subsides considerably in all models and appears to become negligible. This conclusion applies only for a once-for-all increase in the price of oil without changes in discretionary economic policies, such as the growth rate of the money supply. Thus, the underlying inflation rate could be altered if the U.S. government responded to an oil shock with some of the policies considered in the policy scenarios.

Inflation can be measured by several different indicators. The implicit GNP deflator represents the ratio of nominal GNP to real GNP measured in 1972 dollars. It has an important limitation in that the GNP deflator measures the prices of final goods and services *produced* in the United States rather than of those *purchased* in the United States. It does not directly in-

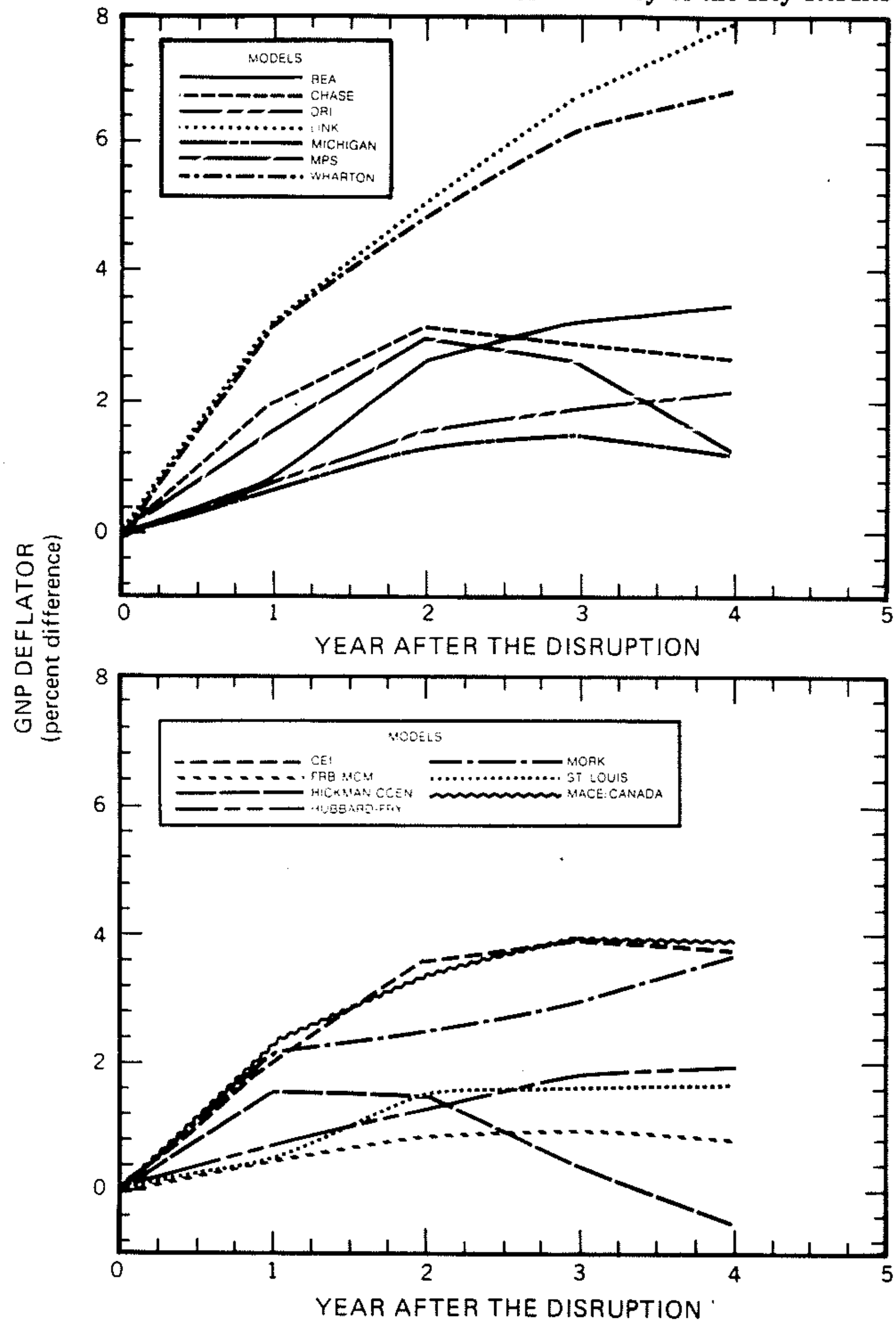


Figure 4: Impact of a 50 Percent Oil Price Increase on the Aggregate Price Level for Goods and Services

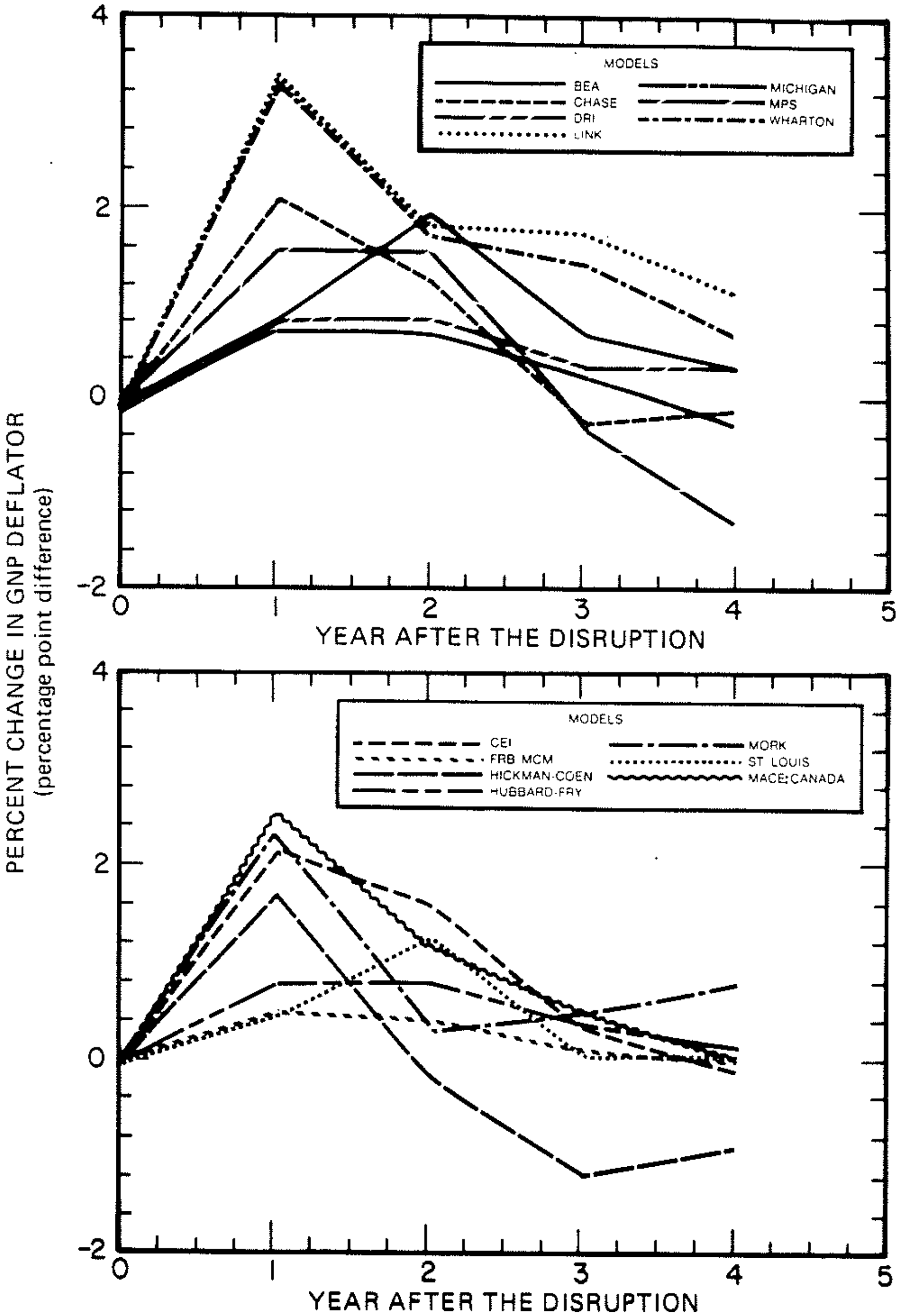


Figure 5: Impact of a 50 Percent Oil Price Increase on the Inflation Rate

clude the price of oil imports and hence will understate the inflation induced by an oil shock.[10]

Other measures overcome this problem by measuring prices of goods consumed in the United States, including imports. In contrast to the implicit GNP price deflator, these measures directly include changes in the price of imported oil. They include the price deflators for gross domestic purchases and personal consumption expenditures and the consumer price index. The last measure represents the costs of goods and services purchased by consumers in some particular base period; the importance of each item to the overall index does not change. The first two indices allow changes in the mix of items. The deflator for personal consumption expenditures measures the price of goods and services purchased by households. The deflator for gross domestic purchases incorporates the prices of goods and services purchased for investment and for the government as well as for consumption.

The inflation effects in the previous figures were measured by the GNP deflator because it is the one price index reported by all models. As shown in Table 6, the principal difference between the various inflation measures occurs in the first year of the shock when the inflation rate for the GNP deflator is substantially smaller. After the first year, however, the different indices display similar inflation effects, because the price effects are predominately indirect results of the previous rise in the price of imported oil. Nevertheless, the absolute level of the GNP deflator remains permanently lower than the other indices. This differential result occurs because the imported oil cost increases are excluded from the GNP deflator but are directly included in the three other measures.

[10]The implicit GNP deflator is calculated as:

$$PY = \frac{[PC * C + PI * I + PG * G + PX * X - PM * M]}{[C + I + G + X - M]}$$

where C, I, G, X, and M are respectively real purchases of goods and services for consumption, investment, government, exports, and imports, and PC, PI, PG, PX, and PM are the corresponding price deflators. Import prices enter negatively in order to exclude the value added by foreign producers from the national product. Assuming no escalation of import price increases through the domestic price structure to augment domestic value added, an increase in import prices will leave the GNP deflator initially unaffected despite the induced increases in the deflators for domestic expenditures and exports. In actuality, domestic markups will tend to be maintained in the face of higher import prices and domestic wages and prices may spiral in response to an import price increase, so that the implicit GNP deflator will rise. Nevertheless, by the arithmetic of its construction, the implicit GNP deflator will tend to understate the initial rise in domestic prices of final goods from import price shocks.

Table 6: Comparison of Inflation Measures for a 50 Percent Oil Shock

	Median Percentage Point Difference in Year:			
	1	2	3	4
Deflator for				
Gross National Product	1.18	1.00	0.23	-0.07
Gross Domestic Purchases[a]	1.72	0.65	0.17	-0.15
Personal Consumption Expenditures[b]	2.00	1.07	0.17	0.10
Consumer Price Index[c]	2.68	1.08	0.12	0.12

For U.S. models excluding LINK.
[a]Could not be calculated for Claremont, Mork and St. Louis.
[b]Not reported by FRB Multi-Country, Mork and St. Louis.
[c]Not reported by Claremont, Hickman-Coen, Hubbard-Fry, Michigan, MPS, and St. Louis.

As a result, the inflation effects shown in Figures 4 and 5 will be similar to those based upon other price measures, except that the median inflation rate during the first year could be 0.5 percentage points higher if the deflator for gross domestic purchases were used or 0.8 percentage points higher if the deflator for personal consumption expenditures were used.[11] From Table 6, we conclude that inflation from the consumer's perspective would increase by about 2 percent during the first year and by an additional 1 percent in the second year.

[11]The difference in the first-year inflation rates between the GNP deflator and other price indices is related to the terms-of-trade loss discussed in footnote 5. When the prices of purchased goods rise more than those of produced goods: (1) domestic purchasing power falls, and (2) the GNP deflator will understate the inflation measured by the other price indices. The annual wealth transfer to foreign oil producers averages about $33 billion or 1 percent of real GNP. Since gains from higher U.S. export prices will partially offset this loss, the difference between measured inflation rates should be somewhat less than 1 percentage points during the period that oil prices are rising.

3.4 Real Output

The rising aggregate price level for goods and services contributes importantly to the decline in U.S. output, as measured by real GNP.[12] With the growth rate of money supply unchanged (as specified in the EMF shock cases), a rising price level will reduce the supply of real money balances. In most models, this reduction in real money supply initially raises interest rates and discourages investment and interest-sensitive components of consumer expenditures such as automobile and other durable purchases. Real disposable income and consumption are also depressed because wages and dividends fail to respond promptly to price increases. In addition, real consumption will decline in some models as rising prices lower the real value of household assets or wealth. And finally, the higher price level will also reduce in real terms those public purchases of goods and services that are not increased with inflation. All these initial effects will induce further declines in income, and hence in consumption and investment, causing the economy to contract further.

In addition, the demand for U.S. goods and services is likely to be reduced by factors other than a rising aggregate price level. First, an international oil price hike has been likened to a tax on U.S. consumers with the proceeds being allocated abroad to foreign oil producers. The spending patterns of foreigners cannot be expected to favor the purchase of U.S. goods and services to the same extent that spending by domestic residents would. Domestic income will be further eroded by rising prices for non-oil imports but will be augmented by rising export prices induced by the shock.

Second, an international oil price shock will lower the GNP of the other oil-importing countries as well. The resulting decline in world trade will reduce the real demand for all exports, including those from the United States. This effect appears to be the dominant one on U.S. exports, although U.S. goods could gain a competitive edge in international markets if U.S. prices rose less rapidly than foreign prices.

In addition, government policies and programs in place could shift total spending in either direction during a shock. Before income tax rates were indexed in 1985, "bracket creep" reduced spending during an oil shock. Operating in the opposite direction to stabilize output would be those federal transfer payments that are automatically linked, with a lag, to unemploy-

[12] The transmission mechanisms in Claremont, Mork, and St. Louis are fundamentally different from that described here. See Hickman, op. cit., and the individual model chapters for their approaches to representing oil price shocks.

ment. Later in the report, we discuss the effects of the discretionary use of monetary and fiscal tax policies, which can either raise or lower aggregate demand.

Efforts were made in this study to standardize across models for the export response and the use of discretionary policy that might shift the aggregate demand curve. Thus, these factors should not be important in explaining differences between model results for the shock scenarios.

The model results in Figure 6 show real GNP declining through the second year. Moreover, there appears to be relatively close agreement on the magnitude of the estimated loss from 11 models, which report GNP losses for the second year to range from 2.0 to 3.5 percent. These reductions in real output are predominately temporary, as emphasized in the discussion of Table 4. Hence, some recovery in real GNP would be expected eventually. Half of the U.S. models show real output beginning to recover partially from the second year losses. This recovery is facilitated by a reversal in the aggregate price level in the Hickman-Coen, Michigan, and MPS models but not in the Claremont, Mork, and St. Louis models.

The remaining models, including several that are used by many government agencies and corporations, do not show a recovery within four years. These models—BEA, Chase, Data Resources, Wharton-LINK, Hubbard-Fry, FRB Multi-Country, and the Canadian MACE model—show the losses to be persistent through the four years although they are generally not growing after the second year. Ultimately, these models would likely show a recovery to a lower level of GNP loss sometime after the fourth year.

As a result, the effect on the GNP growth rate is temporary, even for models showing persistent GNP losses, as long as there are no additional energy shocks or shifts in economic policy. Figure 7 shows the GNP growth rate declining with the oil shocks before reverting back toward the underlying rate. These trends do not measure the longer-term effects on the growth rate of the economy's productivity capacity (at full employment), which must be evaluated by considering potential rather than actual real GNP.

3.5 Unemployment

As real GNP falls below its full-employment level, unemployment increases. Firms initially reduce their output without releasing an equivalent number of employees so that workers produce less per hour or work fewer hours in a week. The economic downturn also causes some workers to leave the labor force (the discouraged worker effect). With labor demand less sensitive to

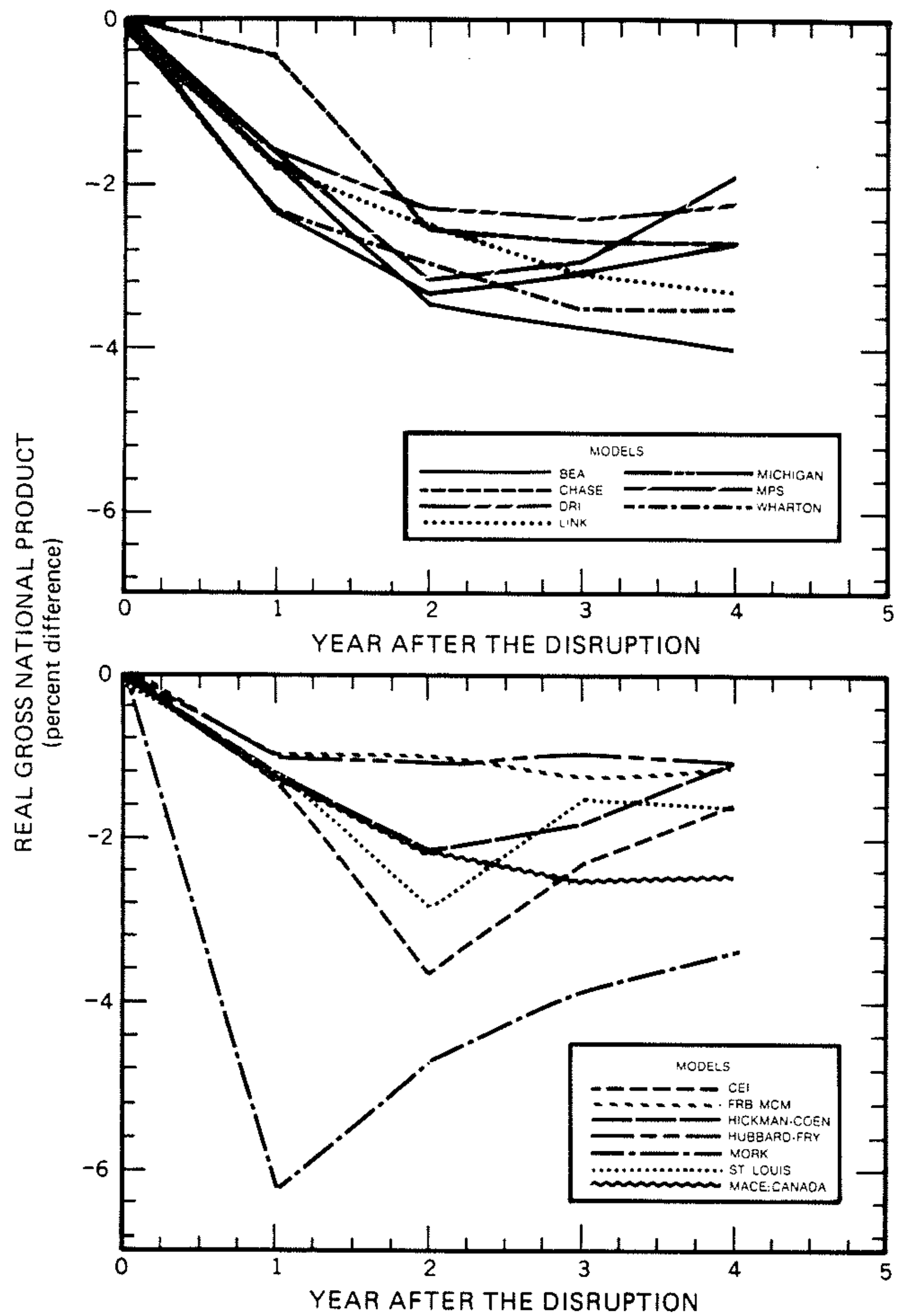


Figure 6: Impact of a 50 Percent Oil Price Increase on Real GNP

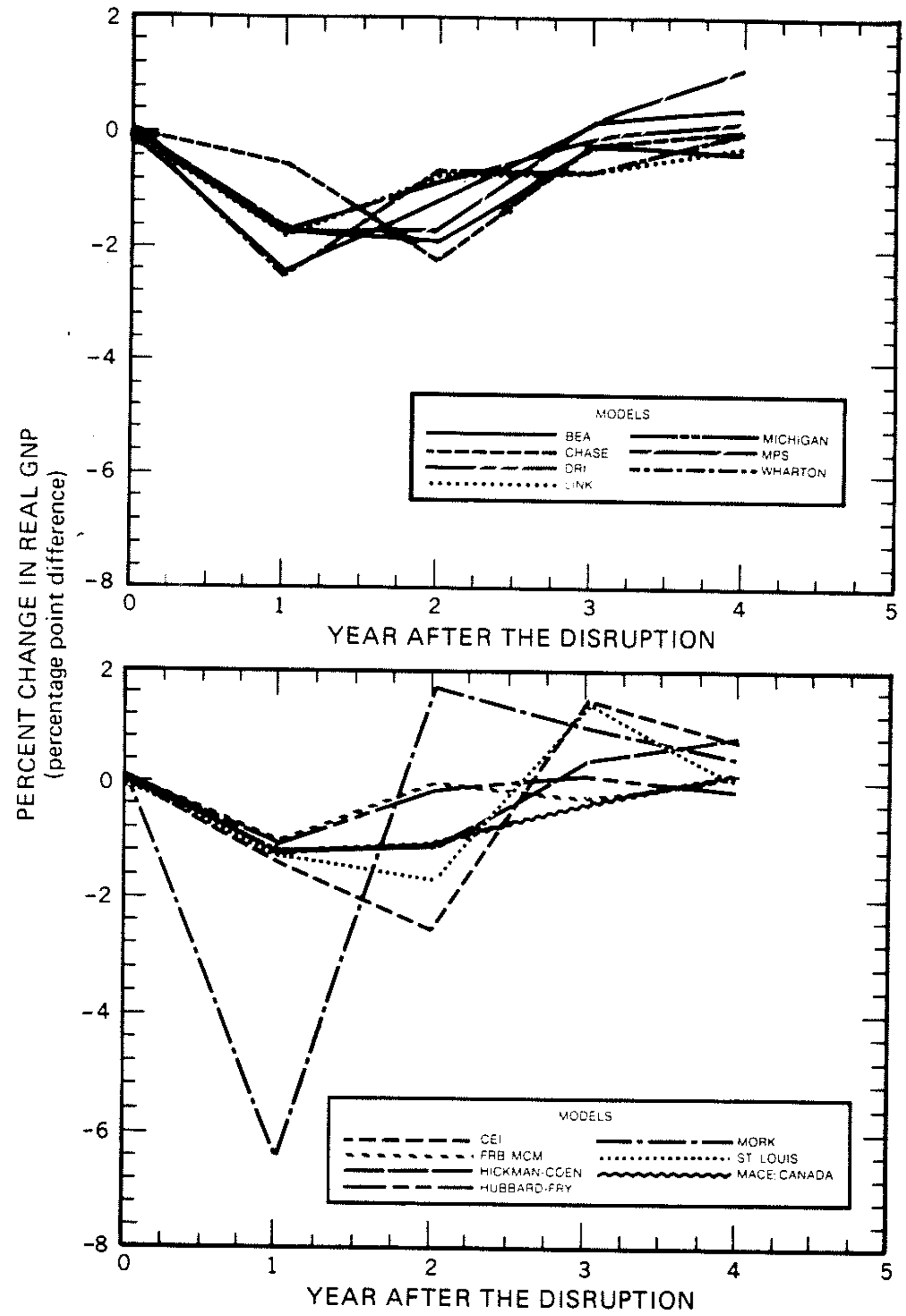


Figure 7: Impact of a 50 Percent Oil Price Increase on the Economic Growth Rate

output fluctuations and the labor force reduced, measured unemployment rises more moderately than GNP declines.

These trends are reflected in our estimates of the changes in the unemployment rate, which mirror the actual GNP losses in Figure 6. As represented in Figure 8, unemployment rises as GNP falls in all models and subsequently turns down in those models in which GNP recovers. In proportional terms, the unemployment rate changes less than actual GNP, reflecting the cyclical response of firms and workers described above.

3.6 Federal Deficit

Growing federal deficits have become a paramount concern of policymakers and the financial community in recent years. There have also been proposals for "recycling" government revenues through rebates in order to offset fiscal "drag" due to an oil shock.

The concerns about fiscal drag appear misplaced, according to the average impacts on the federal budget shown in Table 7. Federal government expenditures rise more than receipts during the oil shock, resulting in larger federal deficits of about $15B (in current dollars) during each of the last three years. Half of the models show deficits increasing by $20B or more. Thus, income tax rebate programs should not be justified on the basis of fiscal "drag", although they may still be useful for stabilizing output and employment or for redistributing income to offset the impact of rising energy prices on households. The first issue is evaluated later in the discussion of macroeconomic policies.

Federal expenditures increase through several mechanisms associated with higher prices and increased unemployment. Some federal government purchases of goods and services will increase as they are adjusted for inflation. Transfer payments will rise as unemployment increases. In addition, to the extent that these payments are indexed to inflation, they will rise further. Finally, if interest rates also rise, greater payments will be required to service the national debt.

Meanwhile, federal government receipts will depend upon the tax base. The base will expand with higher prices but contract with lower real output. The first effect historically has been the dominant of the two, although it may not continue to be. Legislated indexation of individual income tax brackets, scheduled for 1985, will stop inflation from moving individuals into higher tax brackets, and will thereby reduce revenue increases due to higher oil prices. Although federal receipts from the oil windfall profit tax

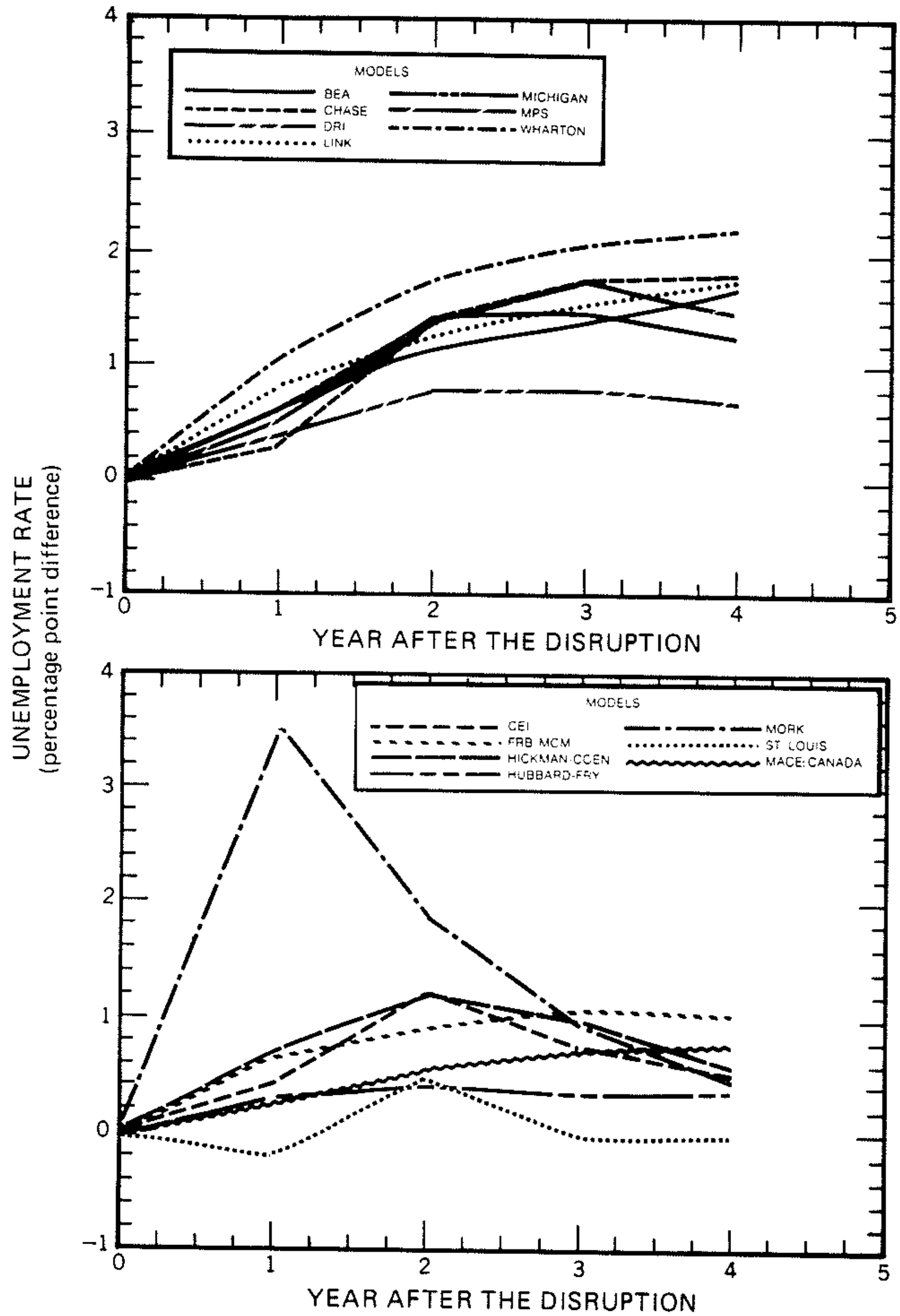


Figure 8: Impact of a 50 Percent Oil Price Increase on the Unemployment Rate

Table 7: Effect of a 50 Percent Oil Shock on Federal Receipts, Expenditures, and Deficit

	Average Change[a] in Level (Current $B) for Year:			
	1	2	3	4
Receipts	11.5	4.5	6.7	9.7
Expenditures	13.4	19.6	21.8	24.2
Deficit	1.9	15.1	15.1	14.5

[a]Results are averages for all U.S. models that report the effects on the federal deficit. Thus, the change in the deficit in this table will equal the difference between the changes in expenditures and the deficit. Excluded U.S. models include FRB Multi-Country, Mork, and St. Louis. LINK results have also not been included because the U.S. submodel in that system is Wharton.

would also increase, this effect is likely to be small relative to changes in the other, larger tax sources.

In summary, oil price increases tend to raise the federal deficit while price decreases reduce the deficit. Each $1 change in oil price changes the deficit by almost $1 B for the first few years after the price change.

3.7 Consumption and Investment

Critical to the long-run future of the U.S. economy is the amount of output allocated to investment in plants and equipment for augmenting future output. Our results indicate that an oil shock will reduce investment proportionally more than consumption during the four years, reducing the share of GNP to be used for expanding the capital stock. Future output levels would thus be lessened.

All models except Claremont and St. Louis disaggregate total aggregate demand into four components: personal consumption expenditures for goods and services, investment for replacing or augmenting the existing capital stock, federal and state and local government purchases, and real net exports (exports minus imports). The estimated GNP losses from the 50 percent oil shock are concentrated in consumption and investment as highlighted by the average model results reported in Table 8.

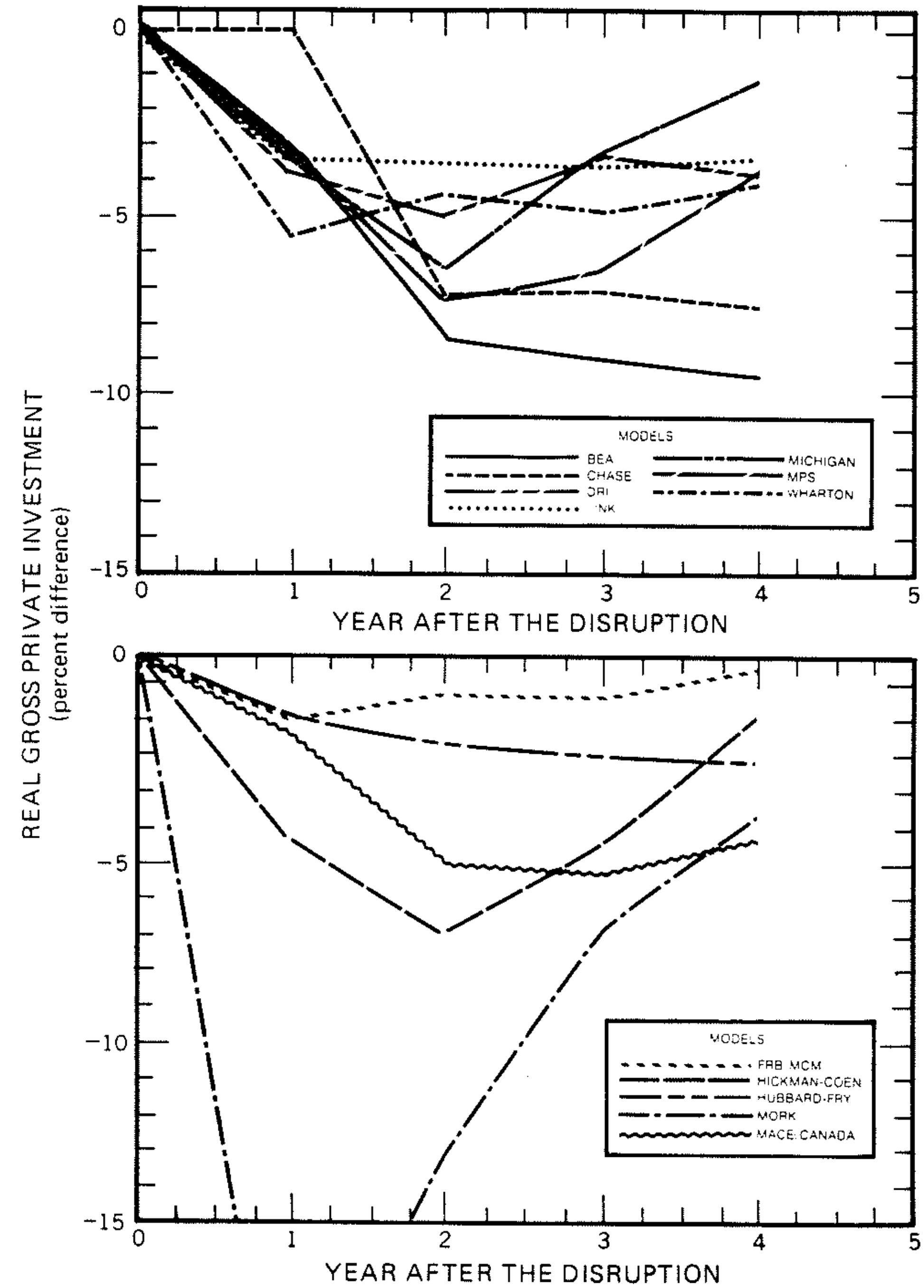
Table 8: Average Impact of a 50 Percent Oil Shock on GNP Components

GNP Component[b]	1983 Level (1972 $B)	1972 $B Change in Year[a] 1	2	3	4	% Change in Year 1	2	3	4
Gross National Product	1534.8	-22.5	-39.2	-41.1	-38.6	-1.5	-2.4	-2.5	-2.3
Consumption	1011.4	-15.6	-26.1	-29.0	-29.1	-1.6	-2.5	-2.8	-2.7
Investment	218.4	- 6.2	-13.1	-12.4	-10.2	-2.8	-5.5	-5.0	-3.8
Government	293.3	- 1.4	- 2.4	- 2.9	- 3.1	-0.5	-0.8	-0.9	-1.0
Net Exports	11.7	0.7	2.4	3.2	3.8	N.A.	N.A	N.A.	N.A.
Exports	138.9	- 1.7	- 3.0	- 3.0	- 2.6	-1.1	-1.8	-1.7	-1.4
Imports	127.2	- 2.4	- 5.4	- 6.2	- 6.4	-2.0	-4.2	-4.6	-4.5

[a]By convention, real GNP results are reported in constant 1972 dollars. Total GNP can be converted to 1983 dollars by multiplying by 2.16. Each GNP component, however, has a different price deflator for making this conversion.
[b]Results are averages for all U.S. models that report complete disaggregation of GNP. Thus, changes in real GNP (in billions of dollars) will equal the sum of changes in its components in this table. Excluded U.S. models include Claremont, Mork, and St. Louis. LINK results have also not been included because the U.S. submodel in that system is Wharton.
N.A.—Not applicable.

The biggest dollar losses occur in personal consumption, which in percentage terms declines at a rate comparable to that for real GNP. Personal consumption declines primarily because real disposable income falls, as wages rise more slowly than consumer prices and employment falls. Some purchases of durable consumption goods such as automobiles are curtailed further if interest rates rise with the shock.

In proportional terms, the oil shock has a particularly severe impact on investment, particularly on nonresidential investment by business in plant and equipment. Investment is particularly sensitive to fluctuations in aggregate output and may be discouraged further by higher interest rates and higher prices of capital goods relative to the wage rate. The percentage decline in investment is approximately twice that in GNP for most of the models. By the second year, total investment is about 4-10 percent lower than otherwise in many models, as shown in Figure 9.



Note: Investment declines by 25 percent in first year in Mork.

Figure 9: Impact of a 50 Percent Oil Price Increase on Investment

3.8 Government Purchases

The response of government purchases of goods and services to an oil shock will depend upon administrative and legislative decisions in federal, state, and local governments. In the EMF study, nominal federal purchases were assumed to increase with inflation to maintain their levels in real terms.[13] State and local purchases were determined within the individual models based upon historical experience. In the few models where this response was not explicitly represented, modelers were instructed to keep state and local purchases constant in nominal dollars.

The response of total real government purchases to the oil shock varies across models, as shown in Figure 10. Since federal purchases were effectively standardized across scenarios by all models, this result reflects differences in the response of state and local purchases to the oil shock. Total public purchases decline sharply by up to 2 percent (in real terms) for some models (in particular, BEA , FRB Multi-Country, and Chase) and little or not at all for other models (Wharton-LINK, Mork, Hubbard-Fry, and Hickman-Coen). Larger declines in real state and local purchases in the first set of models contribute to a greater GNP loss than would be the case otherwise.

3.9 International Linkages

An international oil shock will affect the foreign demand for U.S. output by increasing prices and reducing activity in other oil-importing countries. Most U.S. models have not been designed to determine these international repercussions. In the EMF study, the responses of foreign prices and economic activity were standardized for all models on the basis of a special Project LINK simulation. Although all models used the same foreign price and output responses, they can reveal different impacts on the volume of exported goods and services depending upon how these foreign economic variables influence the demand for U.S. exports.

The volume of U.S. exports falls less than the volume of U.S. imports in the EMF oil shock scenarios, thus increasing net exports. The resultant increase in the demand for goods and services mitigates slightly the GNP losses originating in consumption and investment. The decline in the quantity of petroleum imports, responding to both higher oil prices and lower economic activity, primarily accounts for this result. A contributing but less important factor is that exports also fall less than nonpetroleum imports in

[13] Over 70 percent of federal government purchases are related to national defense.

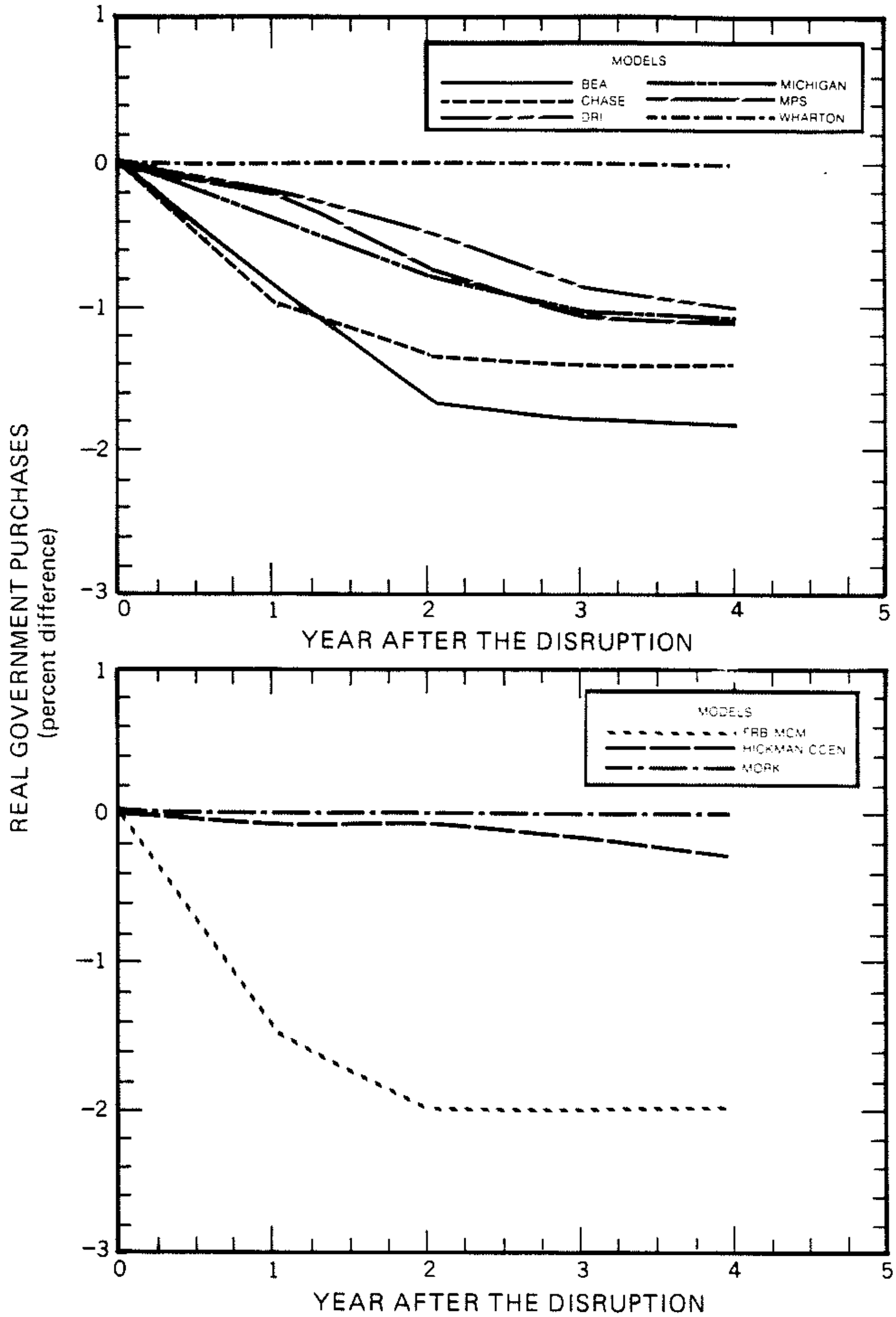


Figure 10: Impact of a 50 Percent Oil Price Increase on Government Purchases

our simulations, due in part to the smaller decline in OECD activity than in U.S. activity.[14] The Project LINK simulation for standardizing the foreign economic repercussions assumed foreign economic policy to be more expansive than U.S. policy during the oil shock, although the precise non-U.S. responses are subject to some uncertainty.

Fluctuations in exchange rates, a particularly complicated aspect of oil shocks, can be important in determining the relative costs of U.S. foreign goods. Most national models do not treat this issue. Thus, exchange rates were kept fixed during the shock in the EMF simulations.

Experiments with the two linked modeling systems, Project LINK and the Federal Reserve Multi-Country Model, indicate that the GNP losses would have been larger than reported here if foreign exchange rates had been allowed to be flexible rather than fixed.[15] In these linked simulations the value of the dollar rises relative to other currencies, primarily because the wealth of oil producers is held initially in dollars. Appreciation of U.S. currency raises the costs of U.S. exports relative to imports, thereby increasing real imports and reducing real exports. This effect causes the GNP losses to be more severe than when exchange rates are fixed. However, this effect is mitigated somewhat as an appreciating dollar reduces the prices of nonoil imports and, hence, the price level for all goods and services, thereby stimulating real GNP.

Given the focus on national U.S. models, this study could not probe the robustness of these international effects to the same extent that other impacts of the shock have been examined. Other estimates of these effects on foreign prices and activity and on exchange rates could change the estimates of the GNP loss experienced by the United States. The effects would be more important for an economy more dependent upon foreign trade than the United States. Further research on these international effects of an oil shock appears to be warranted.

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[14] Appendix 1B shows that the decline in U.S. nonpetroleum imports does not appear more severe than the reduction in exports, once allowance is made for the different foreign and domestic GNP effects.

[15] While both models revealed a larger GNP loss with flexible than with fixed exchange rates, the magnitude of the effect varied. Since these estimates are based upon only two models, we were unable to determine the relative importance of this effect from the EMF simulations.

3.10 U.S. Trade Balance

The current trade balance for the United States measures the excess of exports over imports in current dollars. As such, it reflects changes in the prices as well as quantities of imports and exports. The current trade balance initially declines after an oil shock, as shown in Figure 11. This worsening of the trade deficit occurs because prices of imports (including oil) rise quickly relative to export prices, while quantities of imports and exports adjust more slowly. Thereafter, in subsequent years, this deterioration becomes less severe or is reversed because export quantities fall less than import quantities.

An oil price increase does not necessarily lead to a long-term reduction in the current trade balance. As early as the fourth year after the oil shock, a roughly equal number of models showed the following effects: increases of up to $20 billion, decreases of up to $20 billion, and no change.

4 Alternative Energy Shocks

We cannot expect future oil price shocks of precisely 50 percent, as was assumed in the preceding discussion. Future energy price changes could be of a different form and magnitude: (a) oil prices could change by more or less than 50 percent, (b) oil prices could fall, (c) the spillover effects on other energy prices could be greater or less, (d) the source of the shock could be a domestic fuel price, e.g., through a tax. In this section we show that the price and output responses to the 50 percent scenario can be generalized remarkably well to other energy price shocks.

4.1 Size of the Shock

Our model results indicate that when there is considerable unemployment, a sudden price reduction would have virtually equal but opposite impacts of a sharp price increase of comparable size. Similarly, impacts of a price increase less than 50 percent would be proportionately smaller than the impacts previously discussed.

The top half of Figure 12 plots the percentage losses in real GNP after two years against the percentage changes in the imported oil price for all three oil shocks. The three points for a single model are connected with a line. Although there are differences across models, the GNP gains or losses for a particular model are virtually proportional to the change in the

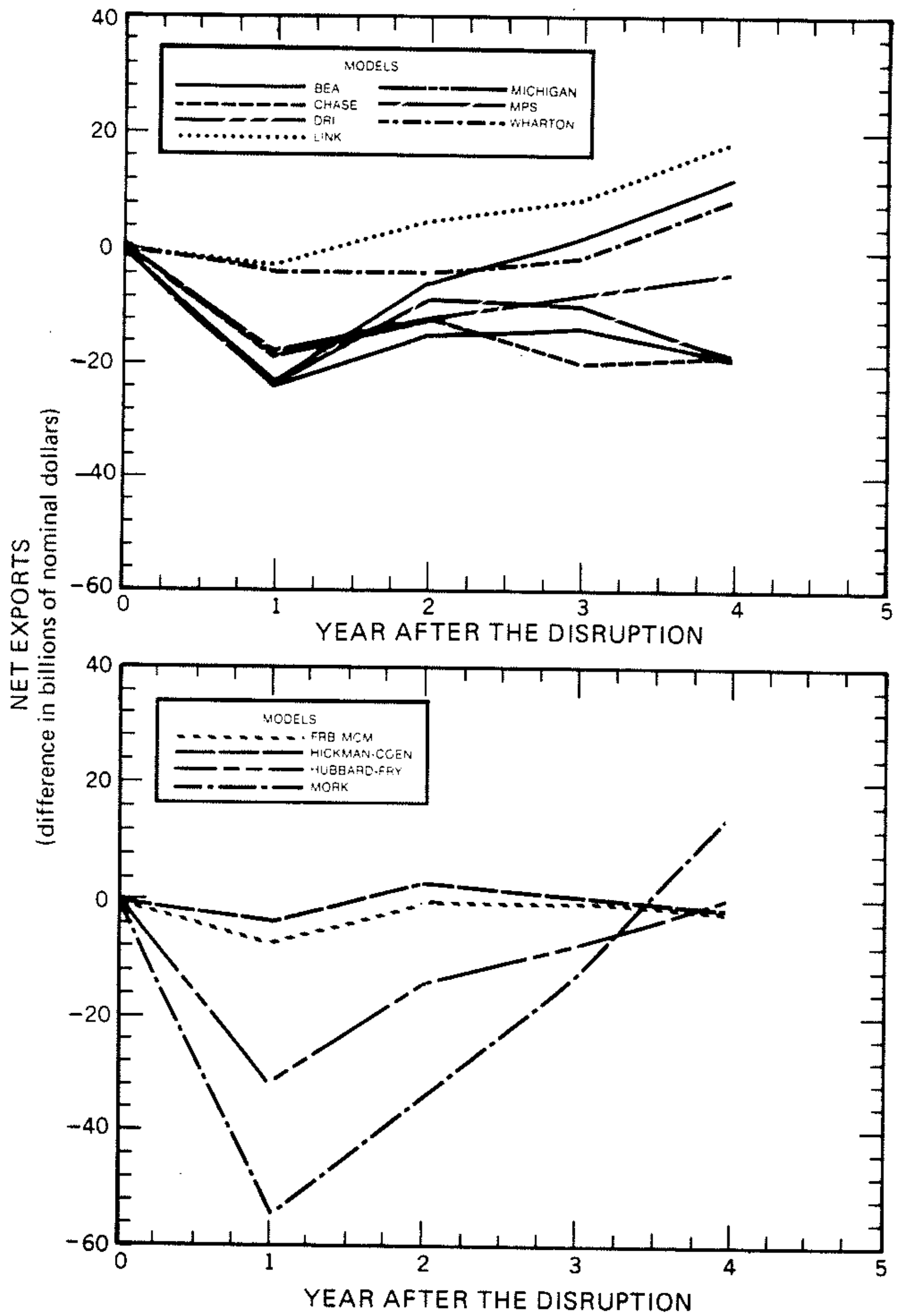


Figure 11: Impact of a 50 Percent Oil Price Increase on the Current Trade Balance

imported oil price. Moreover, this same proportional relationship extends to the effects of oil price decreases as well. The GNP gains from an oil price drop in Figure 12 are symmetrical with the losses from an oil price increase.[16]

These results indicate that the impacts of the 50 percent oil price increase can be generalized to any size oil price increase or decrease, at least within the range considered here, when the economy is well below full employment. One could estimate impacts of larger or smaller disruptions by scaling the estimated impacts to be proportional to the size of the oil price change. Based upon the median impacts shown in Table 5, real GNP will be changed by 0.8 percent and the GNP deflator by 0.6 percent after the second year for every $5 per barrel change in the world oil price. The size of these impacts, as well as the general conclusions about proportionality and symmetry, may not apply to an economy that operates much more closely to full employment.

The bottom half of Figure 12 shows a similar relationship between the imported oil price and the implicit GNP price deflator. The price effects for the U.S. models also appear both symmetrical and proportional to the size of the price shock.

4.2 An Oil Price Reduction

For an economy with considerable unemployment and excess capacity, the impacts on economic activity are proportional to the change in oil prices, whether the latter increase or decrease. The models assume that oil price increases and decreases are passed through similarly to the prices of final products.

These results imply that if past oil price increases have harmed the economy, lower oil prices should provide net economic benefits. The major impacts of the 20 percent reduction in oil prices, about $7 per barrel, are summarized by median values in Table 9. By the second year, the oil price reduction raises GNP by 1.2 percent, decreases the GNP deflator level by 0.8 percent, and lowers the unemployment rate by 0.5 percentage points. However, as with the oil price increase, this one-time reduction in oil prices does not appreciably change the underlying inflation rate or rate of real GNP growth, if discretionary economic policy is not changed.

[16] These symmetrical results are underscored by the fact that most lines in Figure 12 are straight and pass through the origin, the point of no change in both the oil price and GNP. An asymmetric response would be indicated if the straight line connecting the 20 percent increase and decrease cases did not pass through the origin in Figure 12.

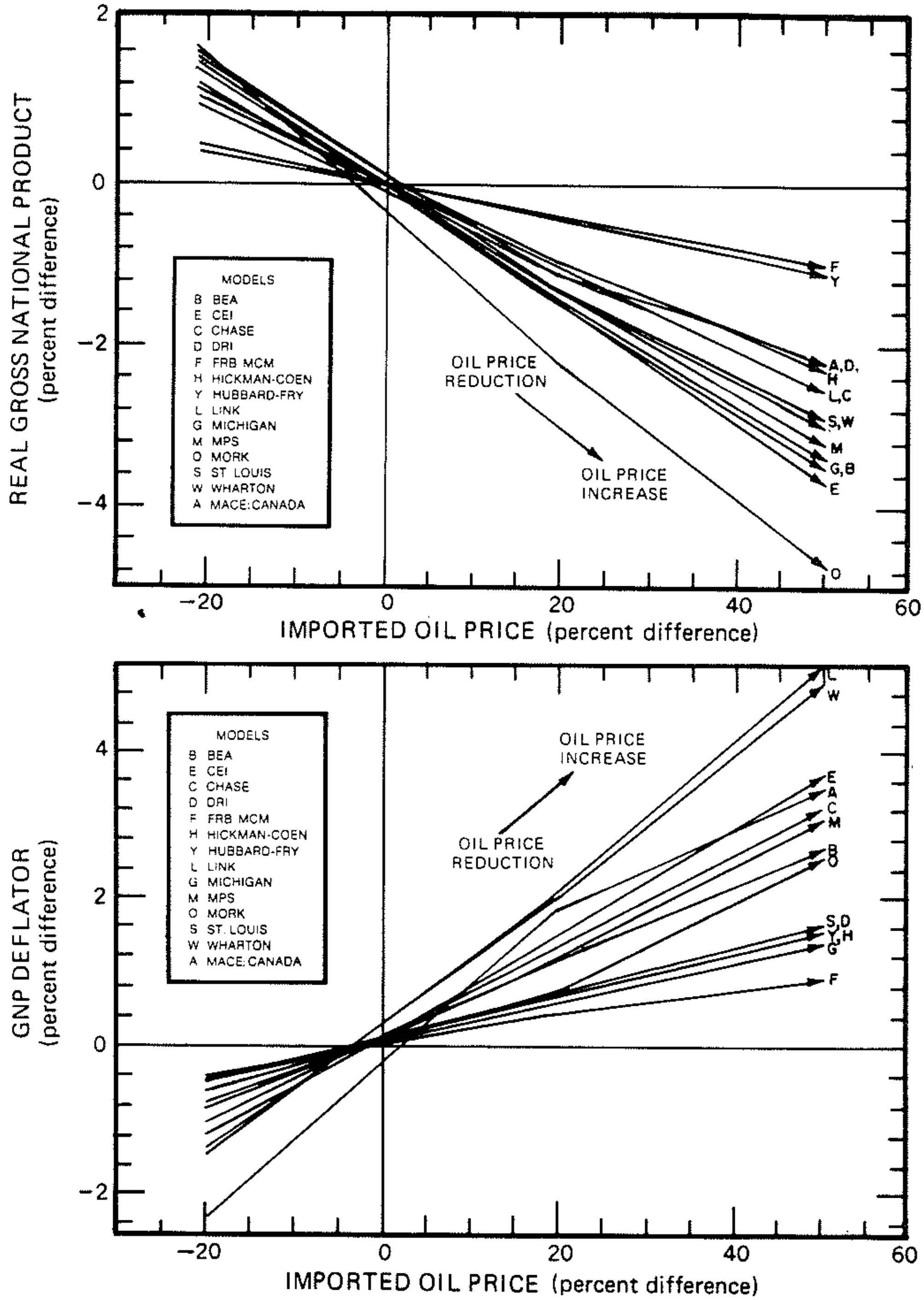


Figure 12: Second-Year Impacts of Different Oil Price Shocks

Table 9: Key Impacts of a 20 Percent Oil Price Reduction

	Median Result[a] for Year:			
	1	2	3	4
Real Output:				
GNP (1972$)				
Percentage Deviation	0.54	1.18	1.13	0.99
	(0.21)	(0.23)	(0.26)	(0.26)
Price Level:				
Implicit GNP Deflator				
Percentage Deviation	-0.42	-0.80	-0.89	-0.89
	(0.20)	(0.29)	(0.28)	(0.42)
Unemployment Rate				
Absolute Deviation	-0.20	-0.51	-0.46	-0.44
	(0.09)	(0.12)	(0.17)	(0.16)

[a]For U.S. models excluding LINK. Semi-interquartile range is reported in parentheses and is calculated as 1/2 times the difference between the third and first quartiles.

When adjusted for the size of the oil price change, many of the more detailed results are equal but opposite to the ones discussed in the context of the 50 percent oil shock. Although these details are not discussed here, the impacts on the federal deficit and the current trade account deserve some attention, because an oil price reduction of $5 per barrel (compared to the $7 per barrel drop simulated in this study) did occur early in 1983 and other drops are to be expected.

The federal deficit improves as a result of the lower oil price in all but two U.S. models (Hubbard-Fry and LINK). As Table 10 shows, the federal deficit declines by almost $10 B by the second year after the oil price reduction. This decline occurs primarily because federal spending is reduced both by a decrease in prices and by the smaller interest and unemployment compensation payments in an improving economy. There is a slight offsetting tendency for tax receipts to decline, reflecting primarily a lower price for

Table 10: Effect of a 20 Percent Oil Price Reduction on the Federal Budget and Current Trade Balance (Nominal $B)

	Median Change[a] for Year:			
	1	2	3	4
Federal Budget				
Receipts	-3.8 (4.5)	-1.0 (2.9)	-1.6 (4.6)	-3.3 (5.0)
Expenditures	-4.8 (1.9)	-7.3 (3.6)	-9.1 (3.9)	-11.6 (4.1)
Deficit	-0.7 (3.9)	-9.5 (4.4)	-9.7 (4.7)	-8.3 (5.9)
Current Trade Balance	10.2 (7.9)	6.2 (5.8)	6.3 (4.9)	4.4 (5.3)

[a]For U.S. models excluding LINK. Semi-interquartile range is reported in parentheses and is calculated as 1/2 times the difference between the third and first quartiles.

goods and services and secondarily reduced revenues from the oil windfall profit tax.

The oil price reduction causes the U.S. current trade account to improve because import prices (including oil) fall more than do export prices. However, a lower oil price and an expanding U.S. economy contribute to a more vigorous growth in the volume of petroleum and nonpetroleum imports, which dampens or eliminates the improvement in the current trade account by the fourth year.

The higher real output and lower prices for goods and services represent an unqualified gain for the U.S. economy. But sudden price changes, whether rising or falling, will create adjustment problems for some firms and individuals. These considerations are not represented in the models, which focus instead on the aggregate relationships of economic activity. Past investments in new and expensive sources of domestic energy and in highly energy-efficient plant and equipment will not be as profitable with a lower oil price. Those who made such investments over the last few years may see their relative competitive position within the economy deteriorate to some extent. More generally, sudden changes in prices will require that resources be allocated to different sectors in order to be more efficiently employed. Uncertainty and institutional constraints may limit these shifts, causing the oil price change to be costly to some sectors. However, overall, the opportunities for expanded economic activity should dominate these potential bottlenecks. In the aggregate, drops in oil price should enhance recovery in the U.S. economy.

This assessment would change if lower oil prices caused a crisis in the international financial system. For a 20 percent reduction in oil prices, the working group does not consider this event to be likely. The increased borrowing needs of oil-producing countries would be offset by the reduced need to finance oil imports in other countries. However, some analysts believe that larger price drops occurring very rapidly could lead to serious balance-of-payments problems for oil exporters that would jolt the world financial system, curtailing economic growth in many countries dependent upon international borrowing. Similar fears have been expressed for oil importers in the case of an oil price increase. If these international financial problems developed, they could have important consequences, even for economies like the U.S. that were not directly limited by international borrowing. Since our study included predominately national models of the U.S. economy, the working group could not probe this issue to determine whether and at what point this might become a problem.

4.3 Source of the Shock

Does it matter if the energy resource whose price is rising is imported or produced domestically? During recent oil shocks, countries that were energy self-sufficient or net energy exporters did experience macroeconomic adjustment costs as did oil-importing countries. For example, both the United Kingdom and Norway became important energy exporters during the 1970s. While the real economic growth rate between 1979 and 1980 slowed from 3.2 to 1.0 percent in the seven major OECD countries, it declined from 2.0 to -2.6 percent in the United Kingdom. The more modest decline for Norway, from 5.1 to 4.3 percent, was comparable to the experiences of the smaller European countries, where economic growth fell from

2.7 to 2.3 percent.[17] Thus, even allowing for important differences in policies and economic structures among countries, these trends appear to underscore the common macroeconomic dilemma faced by energy importers as well as producers.

From a policy perspective, if a domestic and external energy shock have similar impacts, programs that reduce the nation's dependence upon oil imports, but leave constant the quantity of oil consumed, would not be effective in mitigating the macroeconomic adjustment costs. However, these actions would still be effective in reducing the losses in purchasing power.

This question stimulated the working group's decision to include as one scenario a domestic energy shock, in which the wellhead price of domestic natural gas rose 80 percent during the first year and remained permanently higher through the four years. This domestic shock is financially comparable to a 20 percent increase in the world oil price, because wellhead expenditures on natural gas were only 25 percent as large as expenditures for crude oil (imported as well as domestic) in the baseline conditions used in the study.

The study design was developed at a time when regulated natural gas prices were below the price that would make gas competitive with oil. Under such circumstances, an increase in domestic natural gas prices could have different macroeconomic effects than would an international oil price increase. Since these effects operate in different directions, we cannot easily assess the net impact.

First, rising natural gas prices could lead to more efficient resource allocation by encouraging increased natural gas supplies and by shifting gas consumption from low-valued to high-valued uses. The gas price shock considered by the working group explicitly assumed away any such effects and hence should not be interpreted as a natural gas deregulation scenario.

Second, in an international oil price shock, higher energy expenditures flow to foreign and domestic energy producers as well as to the federal government through the oil windfall profit tax. By assumption, in the natural gas scenario there is initially no income loss either to foreigners or the government. This difference means that aggregate demand, and hence real GNP, will fall less with a domestic shock if domestic recipients of this income tend to spend more than foreign producers or the government on U.S. goods and services.

And third, a higher international oil price will raise both foreign and domestic prices of goods and services, while an internal natural gas shock

[17] Growth rates are those reported in OECD, *Economic Outlook*, July, 1984, Paris.

will initially raise U.S. prices relative to foreign ones. This difference tends to reduce the demand for U.S. goods and services after an internal shock, thereby further depressing the economy.

The 1984 real GNP losses of the oil price (20 percent) and gas price cases, relative to the control path, are compared in Figure 13. The origin, or control solution value, appears at the lower left corner of the figure. The percentage decline in real GNP per 10 percent increase in the wholesale price of fuel and power is shown for the gas shock on the vertical axis and for the oil shock on the horizontal one.[18] A 45-degree line marks those points where the two shocks produce comparable impacts. A model appearing above that line would be indicating a larger real GNP loss for a gas shock than for a comparable-sized oil shock; conversely, one below the line would represent a smaller real GNP loss for a gas shock.

Figure 13 shows that the two shocks are reasonably comparable, once the impacts have been standardized for the change in energy prices. This result appears to be particularly strong for Data Resources, Hickman-Coen, St. Louis, and Wharton. The two U.S. models developed specifically for energy shock analyses (Hubbard-Fry and Mork) show some tendency for the losses to be lower for a standardized gas shock. Chase and MPS show a tendency in the opposite direction, although none of these variations from the 45-degree line appears pronounced.

Only Michigan shows a large difference between the scenarios. The negligible impact on real GNP revealed in the Michigan gas shock scenario reflects a particularly strong investment response to natural gas price increases. That investment response counters the decline in GNP due to the shock itself. This projected investment response appears much stronger for natural gas than for oil, even though the United States produces large amounts of each. This response would presumably be absent if the domestic shock in this model had been represented purely as a tax with no additional stimulus to domestic energy production.

[18] The wholesale price of fuel and power is a composite index of the price of crude oil and the wholesale prices of petroleum refined products, coal, natural gas, and electric utilities. It is the basic aggregate energy price in many macroeconomic models and is used here to ensure a more precise standardization across the two scenarios than can be obtained simply by assuming that the gas and the 20 percent oil price increases were comparable shocks. Wharton uses a value-added series for electric utilities that they believe moves closely with the producer price index for fuel and power. Hubbard-Fry, Mork, and Michigan use an aggregate price for primary energy, which excludes electricity. BEA simulated the gas case but did not report an aggregate energy price for standardizing the two shocks. Thus, their results are not plotted in Figure 13, nor are the Mace results for the Canadian economy.

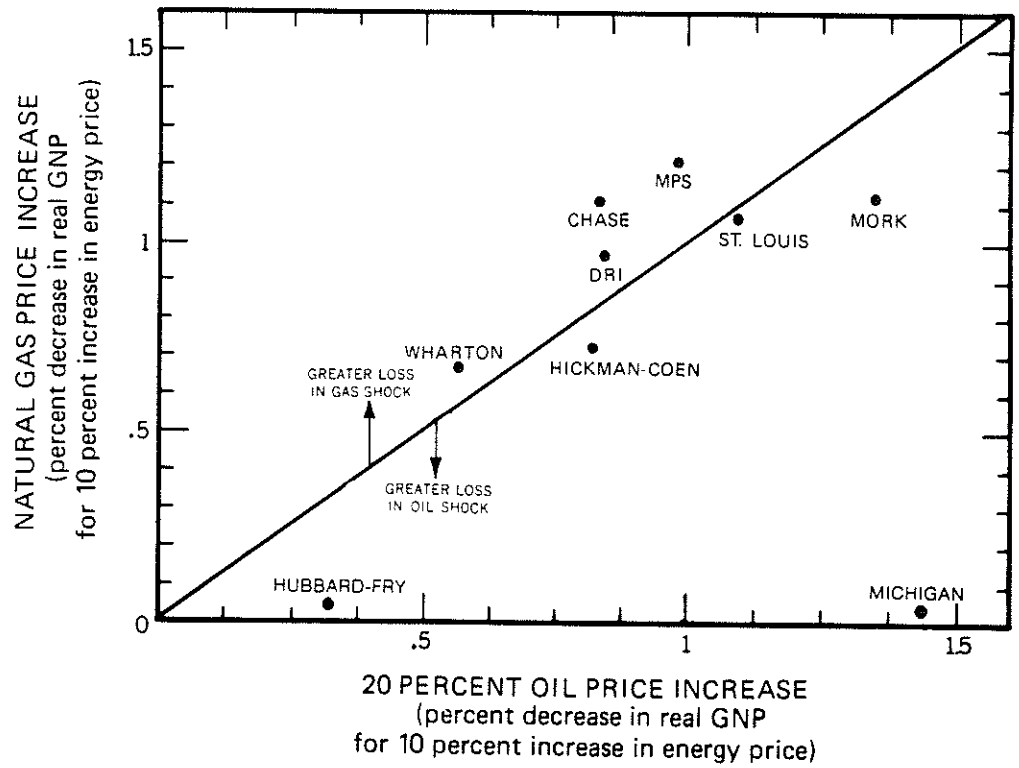


Figure 13: Second-Year Impacts of Oil and Gas Price Shocks on Real GNP

Virtually all the models imply that the domestic and international energy shocks have similar GNP impacts: the losses will be determined primarily by the relative importance of energy consumption in the economy, the change in energy prices, and its induced effects on other prices. It is relatively unimportant in these models whether the energy is being imported or produced domestically. Total U.S. output is not appreciably different whether income is transferred abroad or remains within the country.

Even though the real GNP impacts may be similar, the international shock will produce larger total economic losses because the higher price for imported oil also reduces domestic purchasing power. If these purchasing power (terms-of-trade) losses are added to the GNP losses, all models would show greater total losses for the oil shock.

5 Macroeconomic Policies for Reducing the Impacts of an Energy Shock

5.1 The Policies

Since an oil shock raises prices and reduces real output, macroeconomic policies could be designed to stabilize either prices or output. The working group examined several such policies for reducing the seriousness of GNP losses occurring in response to the 50 percent oil price shock.

These policy results are useful for evaluating the effectiveness of economic policies, not just for offsetting an energy shock but also for countering depressed activity resulting from factors unrelated to oil shocks. Additionally, as shown in the model comparison chapter, the results provide important structural information about the models.

In accommodating real GNP, policies can operate either by raising aggregate demand for goods and services or by increasing aggregate supply, or by both. The aggregate demand instruments can be used to replace some of the lost spending induced by a shock but cannot reverse the permanent losses in potential output and purchasing power.

Under this category, the group considered an increase of the nation's money supply (M1) by 3 percent above the control path in the first year and by another 1.5 percent in the second year. Thereafter, money supply was assumed to grow at the same rate as in the control case although its level remained permanently higher. A second case assumed that marginal income tax rates were permanently reduced by 10 percent across all income groups.

The group considered several policies which augmented both aggregate supply and aggregate demand. One such policy would be a permanent increase in the investment tax credit for producers' durable equipment. The group examined an increase from the current 9 percent to 22 percent. Such a large change would lower the net cost of capital and hence would stimulate investment. Since this policy would encourage capital formation, it is more appropriately considered as a long-run strategy for augmenting aggregate supply. However, within the short time horizon of this study, an increase in the investment tax credit operates principally as an aggregate demand stimulus by increasing investment expenditures. But secondarily, even in the short run, potential output increases because the credit motivates a gradual increase in capital per worker.

A fourth policy scenario assumed a permanent reduction in the employers' payroll tax rate by 2.1 percentage points, from a 1983 level of 6.75

percent. Such a policy would stimulate output and employment through lowering unit labor costs and prices. Thus, it would augment aggregate supply in the short run as well as the long run. Moreover, since such a tax cut would reduce revenues collected by the government, it would also operate to restore some spending lost during the shock and would thus also stimulate demand.

These two policies represent very large—perhaps unrealistically large—changes in tax rates. Their magnitudes were chosen so that the initial impact on federal revenues (prior to any behavioral response to changes in aggregate output or price) would be approximately $30 billion in current dollars, the same initial impact as the income tax reduction scenario.[19]

In addition to these policies for managing the economy, the group also considered an energy policy that lowered both the price and level of oil imports. The results and interpretation of this policy scenario, the oil stockpile release case, are evaluated more fully in a separate section on energy policy issues. It is briefly considered in our initial evaluation of policy impacts in order to provide a broader perspective for understanding policy options for coping with energy shocks.

The median price and output responses to the policies are highlighted initially but other policy criteria are also discussed. It should be emphasized that these median estimates are but one summary measure of a set of model results, which differ from each other in several important respects. Most notably, the relative effectiveness of different policies in reducing unemployment or price inflation will differ from one model to another. For this reason, these model differences are explained for each policy scenario in a later section. This discussion of macroeconomic policies concludes with several caveats with respect to the implementation of the policy scenarios in this study.

5.2 Impact on Prices and Output

Even the aggressive discretionary policies assumed in our scenarios mitigate but do not completely offset the GNP losses. Figure 14, which shows the median result for each scenario, demonstrates that GNP declines in each case as a result of the oil price increase.

As shown in the bottom half of that figure, these policies have different effects on the aggregate price level for goods and services. Two policies directly reduce the production costs in the economy, providing price relief

[19] There was no comparable way to standardize the monetary policy case.

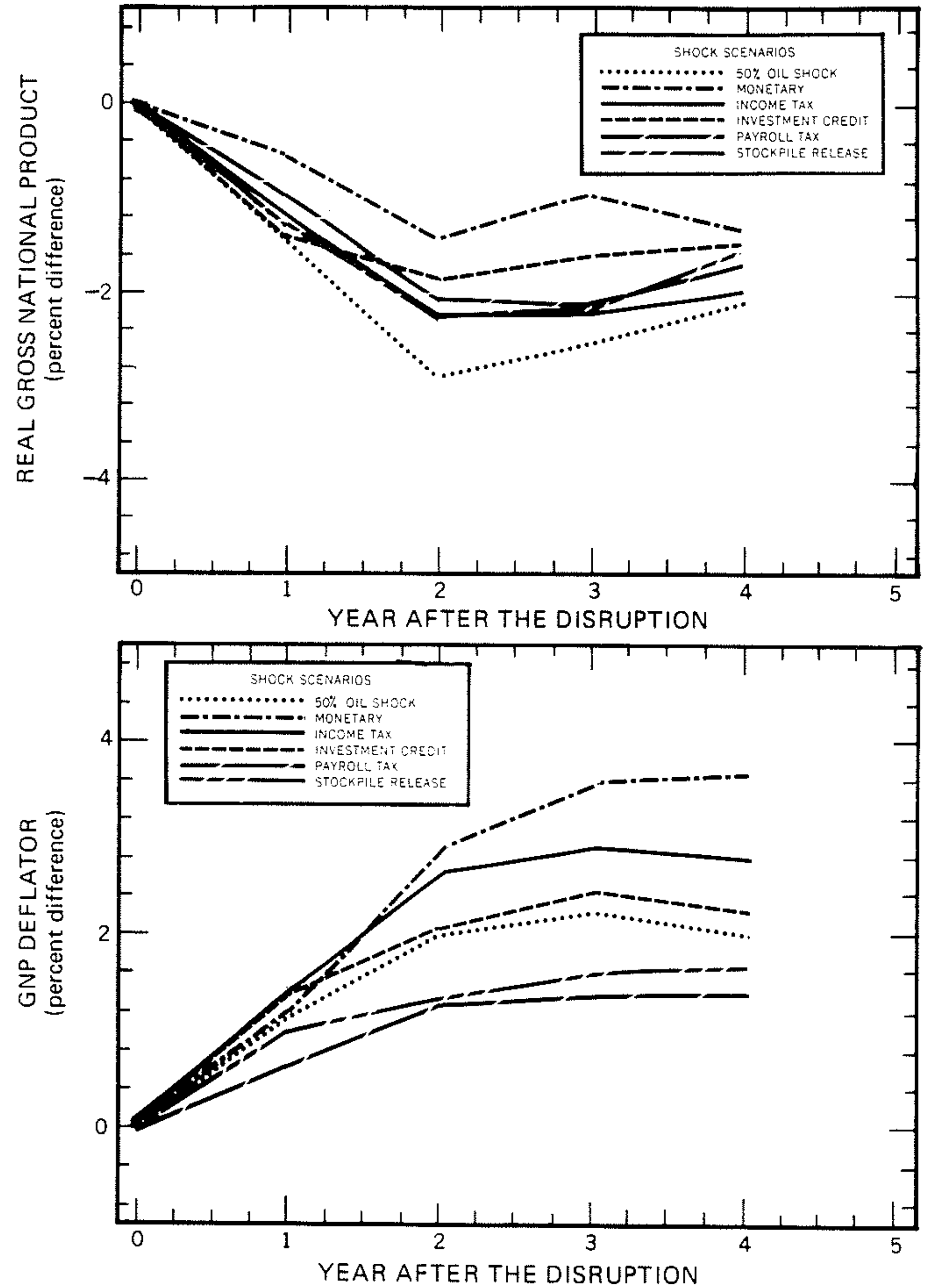


Figure 14: Median Impacts of Policy Responses

while augmenting real output. These policies include the reduction in payroll taxes paid by employers, which lowers wages and hence unit labor costs, and the stylized oil stockpile release, which reduces oil import prices directly. Other policies exacerbate the price impact while offsetting some of the GNP loss.

In Table 11 the tradeoff between prices and output is indicated for the median model result. This table displays the four-year average change in real output, unemployment, and prices. The oil shock in the absence of policy responses depresses real GNP by 2.2 percent and raises the GNP deflator by 1.8 percent on average for the period. The effect of each policy, relative to the shock (or no policy case), is reported directly below the shock results. Similar impacts are also shown for unemployment and the inflation rate, as is the incremental effect on the end-year's inflation rate.

The payroll tax reduction and the oil stockpile release reduce both the aggregate price level and the GNP losses. The investment tax credit reduces GNP losses but has no effect on prices, while the income tax reduction and monetary accommodation create additional pressure on prices while reducing the GNP losses.

The working group specified policy scenarios that encompassed single policies only. However, the potential for joint or combined policies for offsetting energy shocks appeared attractive. Although we did not model such combination of policies, it is possible to combine our single-policy results to estimate the results of policy combinations. The lower rows of Table 11 report the results of summing the impacts of individual policies. The benefits of combined policies appear most striking when the payroll tax cut is included in the package. This result reflects the fact that the payroll tax cut appears to be a particularly attractive individual alternative. The payroll tax cut counters the accumulation of price pressures induced by the other policies and by the price increase, while successfully offsetting losses in real output and employment.

The calculation above assumes that the combination of the two policies produces impacts that are additive and that the effect of one policy is not significantly magnified nor diminished in the presence of another. We have not tested that assumption as part of our study.

When confronted with the stagflationary conditions of an oil shock, i.e., higher prices and depressed activity, policymakers often must choose between curbing price increases or fighting depression. These results emphasize that GNP losses can be mitigated without exacerbating pressures on the aggregate price level if the policy response to energy shocks includes

Table 11: Average Annual Change in Real Output, Unemployment and Prices Over the Four Years

Policy	Four-Year Averages:				
	Real GNP Level	Aggregate Price Level	Unemployment Rate	Inflation Rate	4th-Year Inflation Rate
	(percent)		(percentage points)		
50 Percent Shock/No Policy[a]	-2.16	1.82	1.06	0.49	-0.07
Single Policies:[b]					
Monetary Accommodation	1.36	0.80	-0.51	0.34	0.20
Income Tax Reduction	0.51	0.08	-0.19	0.04	0.08
Investment Tax Credit Increase	0.82	0.01	-0.30	-0.01	0.02
Payroll Tax Reduction	0.63	-0.69	-0.24	-0.16	0.10
Oil Stockpile Release	0.40	-0.21	-0.15	-0.08	0.00
Joint Policies:[c]					
Monetary Accommodation plus:					
Income Tax Reduction	1.87	0.88	-0.70	0.38	0.28
Investment Tax Credit Increase	2.18	0.81	-0.81	0.33	0.22
Payroll Tax Reduction	1.99	0.11	-0.75	0.18	0.30
Income Tax Reduction plus:					
Investment Tax Credit Increase	1.33	0.09	-0.49	0.03	0.10
Payroll Tax Reduction	1.14	-0.61	-0.43	-0.12	0.18

Median model result.
[a]50 percent increase versus control.
[b]Policy versus 50 percent increase.
[c]Policy versus 50 percent increase.

efforts to reduce production costs. We have examined payroll taxes and oil stockpile releases as examples of efforts that have favorable macroeconomic effects but the general principles appear applicable to other options that reduce prices.[20]

[20]Other options include energy policies that reduce U.S. oil prices by decreasing U.S. oil imports as well as policies that reduce excise taxes. Currently, the United States has no federal excise tax that has a sufficiently large tax base for this purpose, although federally financed reductions in state and local excise taxes would represent such a policy. In

We believe that these results can be extended to apply in situations not caused by oil shocks. For example, these results also imply that recently implemented payroll tax increases will tend to raise prices and reduce real GNP more than otherwise.

5.3 Other Policy Criteria

A desirable combination of price and unemployment impacts is one of several criteria that could be used to evaluate particular policies. Other considerations might include the desirability of stimulating investment, equity, implications for the federal deficit, and the ease and speed with which the policy can be implemented and take effect during a disruption. For example, although the easier monetary policy induces the most inflation, it ranks relatively favorably on many of these other criteria.

Oil shocks will affect future output levels by adversely affecting investment. For this reason, actions that would alleviate the severity in the investment decline might be attractive. Table 12 shows that both the monetary accommodation and the investment tax credit increase are strongly oriented toward stimulating investment. Both policies encourage investment and capital formation by lowering the cost of capital, either through lower interest rates (monetary accommodation) or through lower taxes (investment tax credit increase). At the other end of the spectrum, the benefits of an income tax reduction are concentrated entirely in personal consumption by households. Even though output expands, investment does not increase because it is discouraged by higher interest rates. And finally, the gains in consumption and investment for the payroll tax cut appear more in proportion to their relative importance in the economy.

On the other hand, investment-oriented policies might be less effective for mitigating the rise in unemployment. Monetary accommodation or investment tax credit increases motivate a substitution of capital of labor. Because this substitution occurs, such policies would seem to be less effective in reducing unemployment than will be the other two policies, particularly the payroll tax cut, which encourages labor use through lower wages. However, the median impacts in Table 11 suggest that the unemployment gains are dominated by the expansion in output rather than by shifts between labor and capital. As a general rule, the median unemployment rate decreases by 0.37 percentage points for every 1 percent increase in output, regardless of

addition, a federal gasoline tax or other tax on energy use, if implemented, would provide the United States with such a policy option.

Table 12: Average Annual Change in Components of Real GNP (1972 $B) Over the Four Years

Scenario[a]	Consumption	Investment	Government	Net Exports
50 Percent Oil Shock	-26.3	-11.4	-2.2	2.3
Policies				
Monetary Accommodation	8.6	10.1	0.0	-1.3
Income Tax Reduction	13.0	-0.2	0.0	-1.8
Investment Tax Credit Increase	5.4	12.8	0.0	-2.3
Payroll Tax Reduction	6.3	1.3	0.0	-0.9

[a]Median model result. Reference case is the control solution for the 50 percent shock case and the 50 percent shock case for the policy scenarios.

which policy is considered. One model that departs substantially from this representative result is Hickman-Coen, which indicates that the payroll tax cut is noticeably more effective than the investment tax credit for reducing unemployment. This result occurs because the Hickman-Coen model includes a greater substitution between labor and capital than do the other models simulating these two policy cases.

The two supply-oriented policies may be seen as less desirable on equity grounds than the others because they would provide more favorable tax treatment for wealthier members of the society. Both policies directly lower taxes either on firms or investors rather than on all households. In addition, the payroll tax option would call for reducing the employers' contribution to social security while maintaining the employees' tax rate constant. Such a policy would thereby require either the partial funding of social security from general revenues or a reduction in benefits.

Certain policies may also be unattractive because they increase the federal deficit, a particularly important issue in today's economic climate. All fiscal policies considered in this study reduce government receipts by $30 billion before any induced effects on economic activity. Higher real output or lower prices in response to the policies could offset some of the initial deterioration in the deficit. Table 13 shows that the federal deficit does rise by more than $30 billion in response to two policies—the income tax reduction and the investment tax credit increase—but by less than $30 billion

Table 13: Change in Federal Deficit (Nominal $B) for 50 Percent Shock and Alternative Economic Policies Averaged Over the Four Years

Scenario[b]	Change[a] in Federal		
	Deficit	Expenditures	Receipts
50 Percent Oil Shock	16.1	23.7	5.7
Policies			
Monetary Accommodation	-19.3	-3.9	15.5
Income Tax Reduction	37.3	6.6	-26.6
Investment Tax Credit Increase	33.5	4.4	-24.4
Payroll Tax Reduction	26.3	4.2	-23.7

[a]Median model result. Thus, change in deficit will not necessarily be equal to difference between changes in expenditures and receipts.

[b]Reference case is the control solution for the 50 percent shock case and the 50 percent shock case for the policy scenarios.

in response to the payroll tax cut scenario. The only policy that reduces the federal deficit is easier money. Such accommodating monetary policy reduces the interest rate, thereby reducing interest payments on the federal debt, while increasing the tax base through greater output and higher prices.

The limited tax base for both of the aggregate supply policies may prevent them from being used as aggressively as was assumed in the scenario. The investment tax credit was more than doubled and the payroll tax was cut by one-third in the scenarios considered by the group. These are very large changes in tax rates, particularly when compared to the 10 percent reduction in tax rates that produced a comparable offset (in terms of initial revenues) with income taxes.

Finally, many of these considerations imply that any of these tax policies would require considerable debate and negotiations and could not be implemented quickly. To be useful during an energy shock, tax policies must be legislated prior to an emergency to be implemented under specified conditions. Otherwise, these policies are not likely to be appropriate for oil shocks, although they could still be effective when rapid action is not desired.

5.4 Differences Among Models

Differences among models appear more striking in assessing the various policies than in simulating the energy shocks. Although the models generally agree on the direction of the responses, they differ on which policy produces the largest impacts on inflation and real GNP. Some models show strong price and output responses to the income tax reduction case but weak responses when the money supply is expanded. Other models show the reverse. The differences among models appear even larger for the investment tax credit increase and payroll tax cut. These variations reflect less consensus among professional macroeconomists on the economy's response to different monetary and fiscal policies than in its response to oil price shocks. The model comparison chapter by Hickman, which identifies the key parameters and structures of the models, should be useful to potential users of these models in evaluating policy simulations.

Table 14 indicates the relative dispersion of the real GNP results in the shock and policy scenarios. For each scenario, an estimate of the range of results has been divided by the median impact. Half of the U.S. models estimate a second-year GNP loss due to the oil shock that lies within a range of 20 percent above or below the median loss reported in the lower half of the table. The relative dispersion for the GNP results in the policy cases are all larger than for the shock case, from 40 percent of the median result for the monetary accommodation to 130 percent for the investment tax credit.

5.5 Monetary Accommodation

Monetary accommodation initially increases the supply of real money balances, decreases interest rates, and stimulates investment. This investment response induces additional changes in income and consumption, which contribute to the economic expansion. However, by reducing excess capacity quickly and sharply, this policy also places upward pressure on prices that induces smaller real GNP gains in the later years. These trends are summarized by the median impacts in Table 15. In addition, this table shows a measure of the range of model results in parentheses.

Differences among models during the second year of this policy are highlighted in Figure 15. On the vertical axis are plotted predicted impacts on real GNP as percentages of the control levels. On the horizontal axis are plotted predicted impacts on the implicit GNP price deflator, also expressed

Table 14: Variation In Real GNP Results and Median For Oil Shock and Policy Cases

	Year			
Scenario	1	2	3	4
Relative Dispersion:[a]				
50 Percent Oil Shock[b]	0.33	0.20	0.33	0.41
Policies:[c]				
Monetary Accommodation	0.44	0.40	0.43	0.69
Income Tax Reduction	1.12	0.64	0.72	0.79
Investment Tax Credit Increase	4.52	1.29	0.85	0.78
Payroll Tax Reduction	0.84	0.98	0.86	0.43
Medians:				
50 Percent Oil Shock[b]	-1.42	-2.90	-2.54	-2.07
Policies:[c]				
Monetary Accommodation	0.72	1.64	1.53	1.33
Income Tax Reduction	0.58	0.87	0.68	0.76
Investment Tax Credit Increase	0.21	0.66	1.10	1.22
Payroll Tax Reduction	0.44	0.61	0.76	0.79

[a]Dispersion is measured as the semi-interquartile range, as defined in Table 5 and 15 through 18, divided by median impact.
[b]Relative to Control.
[c]Relative to 50% Oil Shock.

as percentages of the control levels. The base of each arrow shows combinations of GNP and inflationary impacts for the given model in the oil shock but without the policy. The point of each arrow shows combinations when the policy response to the shock has been simulated. Thus, the arrow for each model shows how the price and output effects in the shock are altered by the monetary policy. Longer arrows represent larger impacts for the policy.

In all models, the 50 percent oil shock raises prices and lowers output. This response for each model is represented in the figure by a point below and to right of the origin, which denotes no changes due to either the shock or a policy change.

Table 15: Key Impacts of Monetary Accommodation (versus 50 Percent Oil Shock)

	Median Result[a] for Year:			
	1	2	3	4
Real Output:				
GNP (1972 $)				
Percentage Deviation	0.72	1.64	1.53	1.33
	(0.32)	(0.65)	(0.66)	(0.92)
Price Level:				
Implicit GNP Deflator				
Percentage Deviation	0.11	0.42	1.03	1.24
	(0.12)	(0.40)	(1.00)	(1.65)
Unemployment Rate				
Absolute Deviation	-0.32	-0.62	-0.65	-0.48
	(0.13)	(0.29)	(0.22)	(0.39)

[a]For U.S. models excluding LINK. Semi-interquartile range is reported in parentheses and is calculated as 1/2 times the difference between the third and first quartiles.

Monetary accommodation increases real GNP in all models and increases prices in all but Mace, Michigan, and Wharton-LINK. These dominant results are indicated by arrows that move upward (decreasing GNP losses) but rightward (increasing price effects). FRB Multi-Country and MPS indicate that such an aggressive policy would be large enough to offset the real GNP losses in the second year, although both models reveal strong pressures on prices by the third year. An expansion in the money supply does little to change real GNP in the Chase and Hubbard-Fry models because interest rates in these models are not very sensitive to changes in money supply and real GNP is relatively unresponsive to interest rates. The relative unresponsiveness of GNP to interest rates is attributable to a combination of factors: declining interest rates stimulate little additional investment, and investment induces relatively small further effects on income and consumption.

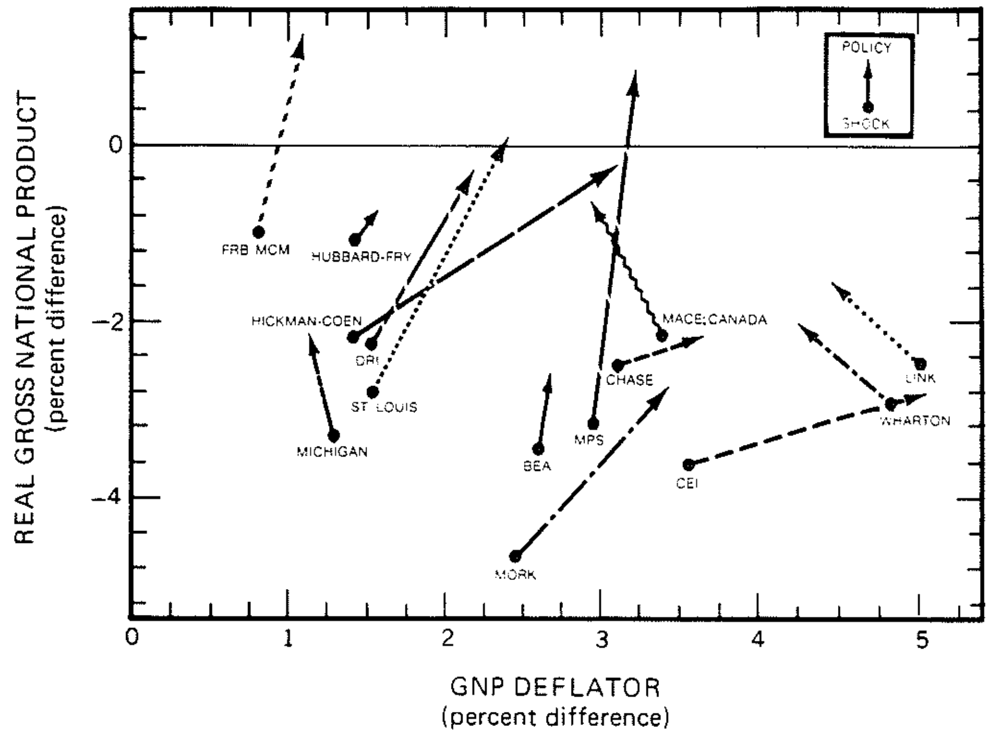


Figure 15: Second-Year Impacts of a Monetary Accommodation

Prices rise in most models because increased economic activity reduces unemployment, thereby increasing wages and unit labor costs. However, this effect will be mitigated by rising manhour productivity as economic activity improves. The manhour productivity effect is particularly strong in the Michigan simulation, resulting in a decline in unit labor costs and prices. In the Wharton-LINK simulation, prices fall as interest rates and the cost of capital decline with an expansion in the money supply. Prices in this model depend upon the cost of capital as well as on variable production costs for labor, energy, and materials.

5.6 Income Tax Reduction

The permanent reduction in income tax rates increases consumption by augmenting after-tax income, which induces additional stimulating effects on income and aggregate spending. This increased aggregate demand leads to greater real output but only moderately higher prices, based on the median responses reported in Table 16.

Table 16: Key Impacts of Income Tax Reduction (versus 50 Percent Oil Shock)

	Median Result[a] for Year:			
	1	2	3	4
Real Output:				
GNP (1972 $)				
Percentage Deviation	0.58	0.87	0.68	0.76
	(0.65)	(0.56)	(0.49)	(0.60)
Price Level:				
Implicit GNP Deflator				
Percentage Deviation	-0.03	0.00	0.09	0.17
	(0.06)	(0.10)	(0.38)	(0.57)
Unemployment Rate:				
Absolute Deviation	-0.25	-0.36	-0.48	-0.30
	(0.31)	(0.40)	(0.32)	(0.31)

[a]For U.S. models excluding LINK. Semi-interquartile range is reported in parentheses and is calculated as 1/2 times the difference between the third and first quartiles.

Considerable differences among models for this scenario are illustrated in Figure 16, which uses the same format as does Figure 15. This figure represents a sharp divergence from the previous one for monetary accommodation. The two cases are not directly comparable to each other because they represent unequal policy actions. Nevertheless, some models show monetary policy to be relatively more effective in offsetting real GNP while others show tax reductions to be more effective. For example, the changes in Figure 16 are small for the Claremont, DRI, Mork, MPS, and St. Louis models even though these models show large effects for monetary accommodation (Figure 15). These models reflect more of a monetarist perspective than others in that money supply changes have a relatively much larger impact on GNP than do fiscal instruments. In contrast, Chase and Hubbard-Fry reveal an absolutely larger GNP effect for the fiscal policy. These models reflect more of a fiscalist perspective.

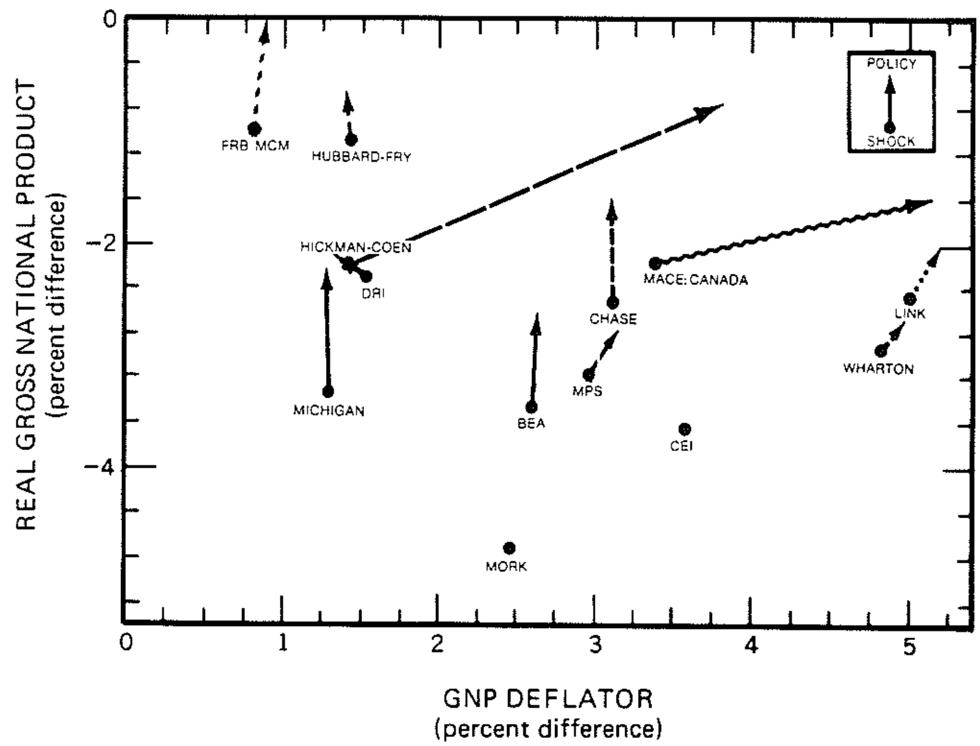


Figure 16: Second-Year Impacts of an Income Tax Reduction

These model-related differences will be analyzed more thoroughly at a later point in the report. The models will be distinguished by monetarist or fiscalist orientation, or by representing a blend of the two. At this point, it is important to emphasize that the estimated relative efficacy of the monetary and income tax policies is highly dependent upon the model used for evaluating such options.

5.7 Supply-Oriented Policies

Both of the policies that augment long-run supply generally operate by raising real GNP without increasing prices. However, the relative importance of price and output effects varies considerably among policies. The investment tax credit reduces real GNP losses but has virtually no impact on the aggregate price level (Table 17), while the payroll tax reduction lowers the real GNP losses and reduces prices (Table 18).

The increase in the investment tax credit effectively lowers the rental price of capital, thereby encouraging more investment and stimulating real

Table 17: Key Impacts of Investment Tax Credit Increase (versus 50 Percent Oil Shock)

	Median Result[a] for Year: 1	2	3	4
Real Output:				
GNP (1972 $)				
Percentage Deviation	0.21	0.66	1.10	1.22
	(0.95)	(0.85)	(0.94)	(0.95)
Price Level:				
Implicit GNP Deflator				
Percentage Deviation	0.00	-0.02	-0.02	-0.02
	(0.02)	(0.10)	(0.15)	(0.47)
Unemployment Rate:				
Absolute Deviation	-0.06	-0.22	-0.37	-0.40
	(0.16)	(0.27)	(0.37)	(0.41)

[a]For U.S. models excluding LINK. Semi-interquartile range is reported in parentheses and is calculated as 1/2 times the difference between the third and first quartiles.

output. The effects are shown in Figure 17, which adopts the format of the two preceding figures. However, the lower price of capital in most models does not directly reduce the aggregate price level, which responds instead only to induced changes in variable costs for labor and energy. The exception is Wharton-LINK, displaying a noteworthy horizontal shift in Figure 17. This price reduction occurs because prices in the Wharton model are highly sensitive to capital costs. In most other models, the investment credit produces effects similar to the income tax reduction, expanding aggregate demand without much affecting prices. In the Hickman-Coen model, however, prices are reduced because induced substitution of capital for labor increases manhour productivity and decreases unit labor costs.

The second supply policy lowers the effective wages paid by firms by reducing their contributions to payroll taxes. This change directly reduces variable production costs and prices, leading to an expansion in real output.

Table 18: Key Impacts of Payroll Tax Reduction (versus 50 Percent Oil Shock)

	Median Result[a] for Year:			
	1	2	3	4
Real Output:				
GNP (1972 $)				
Percentage Deviation	0.44	0.61	0.76	0.79
	(0.37)	(0.60)	(0.65)	(0.34)
Price Level:				
Implicit GNP Deflator				
Percentage Deviation	-0.50	-0.70	-0.79	-0.57
	(0.33)	(0.51)	(0.61)	(0.57)
Unemployment Rate:				
Absolute Deviation	-0.17	-0.30	-0.30	-0.31
	(0.17)	(0.28)	(0.24)	(0.23)

[a]For U.S. models excluding LINK. Semi-interquartile range is reported in parentheses and is calculated as 1/2 times the difference between the third and first quartiles.

These effects are shown in Figure 18, which uses the same format as the preceding figures.

Most models represented in Figures 17 and 18 show some shift in prices and real output for one or both supply-oriented policies. Exceptions include Claremont and Michigan, neither of which incorporates the effect of the investment tax credit increase on the cost of purchasing new equipment. In addition, the Michigan model implemented the payroll tax cut as a reduction in taxes but did not reduce the effective wages paid by firms. Therefore, their scenario was more like a tax cut augmenting disposable income than a reduction in production costs.[21] And finally, the Claremont model represents all tax policies as operating primarily through their effects on the

[21]If the incidence of the employers' share of the payroll tax fell completely on the employee, the tax cut would operate like an income tax reduction. Gross wages would not decline and the tax cut would augment workers' disposable income. However, the

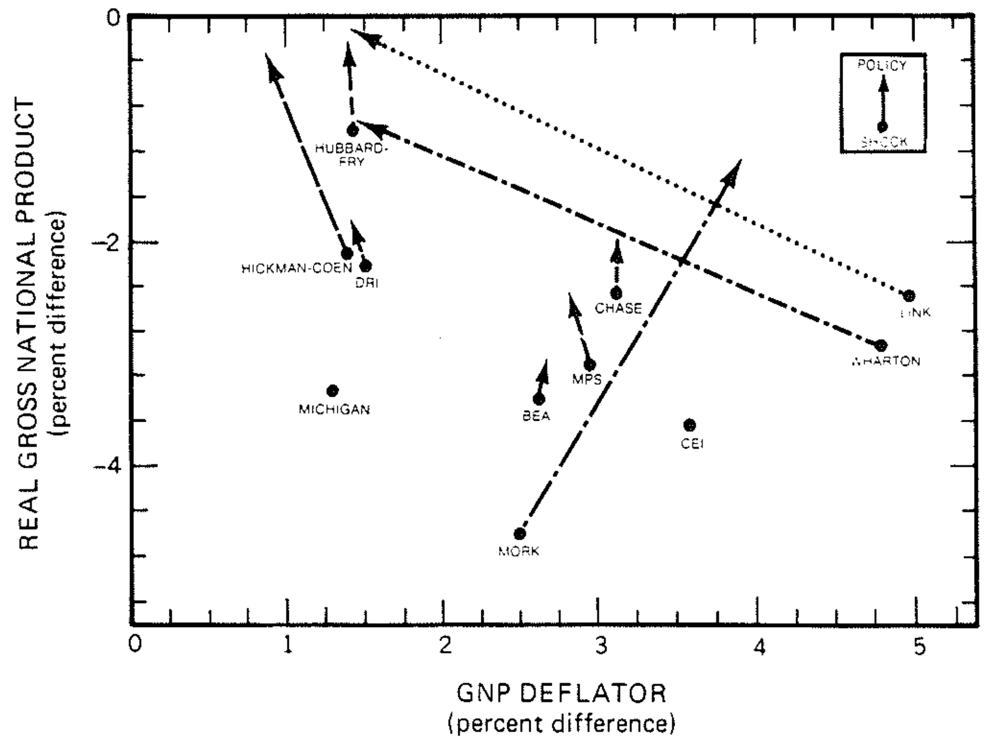


Figure 17: Second-Year Impacts of an Investment Tax Credit

federal deficit. Hence, it does not differentiate changes in payroll tax and investment credit from changes in income taxes.

5.8 Limitations of Policy Simulations

The comparison of model results provides a framework for understanding some important dimensions of economic policies for accommodating an energy price shock, or for that matter any other shock to the economy. However, the working group's findings must be qualified by noting important caveats in interpreting the results.

First, the baseline scenario depicts a slack economy that is not "overheated" —unemployment and excess capacity are high by historical standards. In response to the large gap between actual and potential output, inflation is declining in the baseline scenario. These conditions affect not only the estimated impacts of a shock, but also the effectiveness of different

Michigan result appears to reflect an oversight in the implementation of this scenario rather than in an explicit assumption like that above.

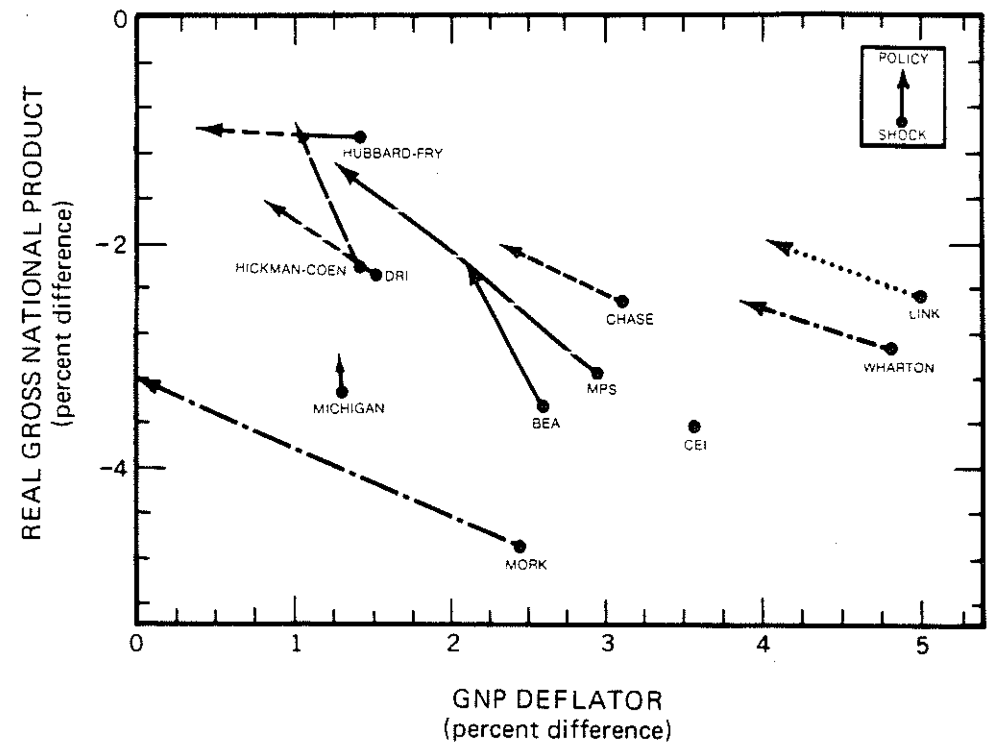


Figure 18: Second-Year Impacts of a Payroll Tax Reduction

macroeconomic policy responses. In a tighter economy, accommodating actions could place greater pressure on prices or employment and hence have less effect.

Second, logistical reasons forced the working group to consider only a limited menu of policy responses. This limit prevented the working group from fully exploring the combined effect of different policies. Moreover, given the restricted number of scenarios, the working group did not explore temporary policies to mitigate either temporary or lasting shocks. The accommodating policies have been simulated as permanent offsets to a permanent oil shock, either in the form of a tax decrease or an increase in the level of the money supply.

Third, for the same reasons, these scenarios do not address the important issue of timing the policy response to an energy shock. In the study the energy shock was immediately offset in the same quarter by a policy response. However, policies may not be implemented or become effective quickly enough to mitigate the serious impacts of a shock. Since they require legislative changes, the tax-cut policies may be particularly inappropriate if the shock is temporary or if the impacts of a permanent shock are short-lived. For example, both the Claremont and the St. Louis models show the maximal impact of a shock being reached after only about six quarters. Under either set of conditions, accommodating policies may be stimulating the economy well after it begins its recovery from the energy shock. This lag would cause mounting pressure on prices during this later period.

Fourth, the policy scenario results are sensitive to the modeling of expectations. In most empirical macroeconomic models, expectations about future outcomes are adapted with some delay from recent experiences of the decisionmakers. Such "adaptive" expectations generally mean that individuals and firms do not anticipate accommodating policies when making current decisions. Since these shocks and policies occur as "surprises", decisionmakers must first recognize these developments and then adjust to them.

A very different set of conditions could emerge if markets cleared instantaneously and decisionmakers could correctly predict future outcomes, particularly policy responses. Anticipated policy responses under these circumstances would have very different consequences from unanticipated ones because current decisions would not be distorted by informational lags or wage and price rigidities. Both the Claremont and Mork models incorporate such expectations (although not necessarily market-clearing assumptions) but both assume the policy responses to be surprises in these simulations. Their simulations would be quite different if these policy responses were assumed to be anticipated instead.

The twin issues of "rational expectations" and market-clearing have been the central macroeconomic theory debate over the last ten years. The role of expectations during energy shocks appears to be important in exploring dynamics in both the oil markets and the national economy. However, the current study is limited in its ability to differentiate between competing perspectives on this issue because of the paucity of operational empirical rational expectations models.

Fifth, national models of the U.S. economy do not generally incorporate the endogenous effects of international linkages on the U.S. economy. The responses of foreign prices and output were incorporated by standardizing these responses across models. However, shifts in U.S. policy in response to the shock could influence the responses of foreign economic activity through international trade. Moreover, coordination of economic policies across countries could change the nature of these responses. These issues have not generally been considered here, although LINK in this study did evaluate the effects of a coordinated OECD monetary policy on the impacts of a shock. They concluded that the U.S. macroeconomic response for the coordinated policy was not appreciably different from that for a unilateral monetary accommodation in the United States alone.

Similarly, the world oil price in these policy scenarios has been assumed to be exogenous in all models (even for the two that can determine this variable within the model). Therefore, the world oil price is assumed to be unaffected by changes in U.S. inflation induced by the shifts in economic policy. Those accommodating policies that raise U.S. prices therefore lower the effective oil shock in real terms, making these policies appear more effective than if world oil prices rose with the policy-induced inflation.

Analogously, policies that change oil demand could be expected to have feedback effects on the world oil price. Policies which stimulate the economy could be expected to increase world oil demand and thereby increase the magnitude of the price shock. Such effects are not incorporated into the simulations. To the extent that stimulative economic policies lead to increased oil price jumps, and those increased jumps lead to further economic losses, our scenarios overestimate the economic benefits of such policies. However, we have not attempted to quantify this bias since the feedback effects on world oil prices are subject to significant debate themselves.[22]

And finally, the macroeconomic models focus on changes in aggregate output, prices, and unemployment for evaluating the relative effectiveness of the various monetary and fiscal policies. However, some tax policies will introduce or reduce distortions in the economy. These changes can in turn

[22]Some shock and policy scenarios based upon an endogenous oil price were reported in this study by Knut Mork, "Energy Price Shocks, Rational Expectations, and Wage and Price Rigidities," Energy Modeling Forum WP 7.16, October 1983. He concluded that policy actions by the U.S. alone would not significantly alter the world oil price. Thus, the impact of the policy would not have been substantially different from the case where oil prices had been assumed fixed. Since this result could not be tested with the other models (except Hubbard-Fry), the working group did not try to probe the robustness of this result. However, several researchers have modeled the interactions between oil markets and the macroeconomy, including: R. Glenn Hubbard and Robert Fry, "The Macroeconomic Impacts of Oil Supply Disruptions." Energy and Environmental Policy Center, E-81-07, Harvard University, 1982; Richard Gilbert and Knut Mork, "Coping With Oil Supply Disruptions," in *Energy Vulnerability*, edited by James Plummer, Cambridge, Mass: Ballinger, 1982; Jaime Marquez, *Oil Price Effects and OPEC's Pricing Policy*, Lexington, Mass: Lexington; William Nordhaus, "Oil and Economic Performance in Industrial Countries," *Brookings Papers on Economic Activity*, Volume 2, 1980; and Harry Saunders, "A Note on Rowen and Weyant 'Reducing the Economic Impacts of Oil Supply Interruptions: An International Perspective' ", *Energy Journal* 5:55-59, October 1984.

cause resources to be allocated more or less efficiently in the economy. Such effects are excluded from the class of models utilized for our study.

6 Energy Policy Issues

Macroeconomic models can be used to cast insight on a number of energy policies which have been either utilized or proposed for dealing with the economic consequences of energy shocks. For this information role, these models can be quite useful. Yet, the models primarily represent the aggregate economy and are inappropriate for analyzing the detailed microeconomic issues. For this reason, the models are only incomplete guides for evaluating energy policies for coping with shocks. In this section we use study results to cast insight on the macroeconomic implications of three classes of energy policies: oil stockpile releases, disruption tariffs, and price controls. We neither advocate nor discourage use of these policies, since we have been able to examine only a limited set of issues associated with each.

6.1 Oil Stockpile Release

Many nations, including the United States, have built oil stockpiles, so that in the event of a world oil supply disruption these nations could release the stored oil and thereby cushion the shock. Our working group explicitly examined the economic consequences of drawing down such stockpiles at the time of the oil shock.

The economic consequences could come about primarily through two mechanisms. First, the released oil is a substitute for the disrupted supplies and therefore the drawdown reduces the extent to which world oil prices escalate. In addition, the release of oil domestically implies that less oil need be imported for a given level of oil consumption. Both of these mechanisms are included in the scenario we have run, although we have had to make somewhat arbitrary assumptions about the price impact of a given rate of stockpile release. In the ensuing discussion these two factors will be analyzed separately.

A difficulty with use of petroleum stockpiles could arise if the released oil had different characteristics from the oil being displaced and was available only in inappropriate locations. Additional complications could be introduced if the released oil were allocated by government fiat so as to meet national defense or equity objectives rather than allocated through market forces. These potential difficulties cannot readily be examined through the use of macroeconomic models; in our analysis we assume that stockpiles are managed so that such difficulties do not arise. Thus we view stockpile releases as characterized by but two primary changes—an import reduction and an oil price reduction—which in turn lead to a set of macroeconomic consequences which we have analyzed.

The first factor—the cushioning of the world oil price jump—is economically the more important of the two. This factor will have important impacts on GNP and on purchasing power as measured by the terms of trade. This price effect provides benefits to all users of oil, whether the users are in the United States or abroad and wherever the stockpile release occurs. Nor does it matter whether the released oil is used within the United States or eventually is used outside the country.

Our previous analysis of the economic impacts of an oil price reduction can be used to evaluate the GNP impacts of softening the price jump. On average, every \$1 per barrel decrease in the world price of oil was shown to augment real GNP during the first year by \$3.4 billion (1983 \$). In addition, each \$1 per barrel oil price change would provide a terms-of-trade benefit of about \$1.2 billion (B),[23] for a total gain of \$4.6 B in the first year.

The second factor—the reduction in the level of imports—will provide terms-of-trade benefits for the country releasing the reserve, in our scenario, the United States. However, it will have no noticeable effects on the GNP losses associated with the shock.

From a strict national income accounting perspective, the act of filling or drawing down the stockpile would itself have no impacts on GNP because it does not change the volume of goods and services produced in the United States. This conclusion can be seen in another way. GNP is equal to the purchases of goods and services by government, by firms and individuals for investment, and by individuals for consumption plus the net exports of goods and services. A stockpile release will reduce oil imports and hence will *increase* net exports. However,by selling the stockpiles, the government *reduces* its net purchases of goods and services by an equivalent amount. These two factors precisely balance one another, resulting in no change in GNP.

The oil import reduction itself (absent the lessening of the price jump) could reduce the GNP losses from the oil shock if the GNP losses depended significantly upon the level of oil imports. However, as discussed previously,

[23]This estimate incorporates the offsetting effect of lower U.S. export prices discussed previously in the context of oil price increases. U.S. oil imports in most models were approximately 4 million barrels per day after the stockpile release during a disruption.

the GNP losses are virtually independent of oil imports, although these losses can be expected to depend upon the levels of oil consumption. Since the stockpile release reduces imports but has no effect on oil consumption, the release will have no effect on GNP except through its impact on oil prices.

This analytical conclusion is supported by the model runs. The median result suggests that the stockpile release would increase real GNP in the first year by $3.2 B (1983 $) for every $1 per barrel reduction in the world oil price. This figure is only insignificantly different from the $3.4 B gain estimated for a change in the world oil price alone. Thus, our model runs support the idea that the GNP benefits of stockpile releases come almost entirely from the reduction of the oil price increase.

The terms-of-trade effects of the stockpile release do depend upon the reductions in oil imports. A 1 million barrel per day stockpile release will reduce annual imports by 0.365 billion barrels, thus avoiding the $18 per barrel price jump on that quantity of imports. The terms-of-trade benefits of an oil import reduction amount to $6.6 B per year for each 1 million barrels per day (MMBD) of release.

In summary, the benefits of oil stockpile releases are of two types. The release reduces the oil price, providing a first year GNP gain of about $3.4 B and a first year terms-of-trade gain of about $1.2 B for every $1 reduction in the world oil price. The release also reduces oil imports, providing a negligible GNP change but a $6.6 B annual gain for each 1 MMBD reduction in oil imports.

The total gains and the relative magnitude of the various classes of gains depend critically upon the relationship between stockpile releases and the resulting world oil prices. In our study we assumed that a stockpile release of 0.5 MMBD would reduce world oil price by $2.70 during the first year of the disruption. As a result of this price reduction, oil imports actually decline on average by 0.3 MMBD in the model results rather than by the full 0.5 MMBD represented by the release. Under these conditions, a GNP gain of $9.2 B would be obtained through the softening of the oil price jump and a terms-of-trade gain of $5.2 B would be enjoyed, with $3.2 B stemming from the oil price reduction and $2.0 B from the oil import reduction. Different assumptions about the world oil market dynamics would change these estimates but would leave unchanged the conclusion that significant gains are available through a release of oil stockpiles, *if* stockpiles already exist.

A more comprehensive analysis of the relative merits of an oil stockpile program would require us to consider the probability of a disruption as well as the costs, including the GNP and terms-of-trade losses, associated with purchasing and storing oil for building the stockpile. The purchases of oil for the stockpile would occur in undisrupted oil markets, when changes in oil demand should have smaller effects on oil prices, GNP, and the terms of trade than during a disruption. While our analysis does not reveal whether oil stockpiles would be a good policy option, the estimates presented here should be useful for those who use a comprehensive framework for studying this policy.

6.2 Disruption Tariff

A disruption tariff—a tariff to be imposed on oil imports at the time of the shock—has sometimes been advocated to reduce the transfer of wealth from oil importers to oil exporters during an oil price shock. The tariff could be expected to reduce the demand for oil in the United States, thereby reducing the world oil price in much the same way that a release of the petroleum stockpile would reduce oil prices. However, unlike the stockpile release, such a tariff would increase the oil price in the United States. The world oil price decrease and the U.S. oil price increase would each, by necessity, be smaller than the tariff, if the tariff's burden is borne by both producers and consumers. In addition, the tariff would collect revenues for the government; the disposition of these revenues would be a matter of significant consequence.

Our working group did not explicitly examine the economic consequences of imposing a disruption tariff. However, the results of other scenarios can be applied to analyze, at least partially, such a policy instrument. In what follows we will assume, for specificity, that the disruption tariff is chosen to be $10 per barrel.

The economic consequences would derive primarily from three mechanisms. First, because the world oil price decreases in response to the tariff, terms-of-trade benefits will accrue to the United States, and to all countries importing oil. Second, because such a policy would further escalate the rapid price rise in the United States, the GNP would be reduced. Finally, unless tax revenues are quickly and dependably redistributed to the population, there will be further recessionary forces placed on the U.S. economy. These three factors will be discussed in turn.

The terms-of-trade benefits occur if and only if the world oil price rise is dampened by the imposition of the tax. The price reduction lowers the cost of each barrel of oil imported by the United States in terms of the goods needed for exports. The net terms-of-trade benefits, as indicated above, equal roughly \$1.2 B for each \$1 per barrel drop in the world oil price, or \$12 B for a \$10 drop in the world oil price if the entire amount of the tariff were borne by the producers and non-U.S. consumers of oil. Conversely, if the U.S. price increases by the full \$10, the world oil price will remain unchanged and there would be no terms-of-trade benefits.

The increase in the U.S. price would further exacerbate the oil price jump and would further depress the U.S. economy. The increment to the oil price associated with the tariff is equivalent to the internally generated energy price shock examined by the working group. As has been shown above, the GNP losses of an internal shock are roughly equivalent to those of an externally generated shock. Thus, a \$10 per barrel increase in the U.S. price, an increase that would occur if world oil prices remained unaltered by the imposition of the tariff, would reduce GNP by about \$34 B. If U.S. oil prices were unchanged, but rather foreign oil prices were to drop by the amount of the tariff, there would be no direct impact on GNP.

Much attention has been paid to the third mechanism for influencing the U.S. economy. The disruption tariff would raise a significant amount of government revenue and would increase profits of domestic oil producers. Unless government spending was increased or that public revenue was "recycled" back to households, the aggregate demand for goods and services would be reduced further and the disruption tariff would cause further GNP losses. In our analysis we assume that these revenues are managed to eliminate any further loss from this mechanism. To the extent that assumption is invalid, our analysis tends to overstate the benefits of a disruption tariff.

The net benefits to the U.S. economy of a disruption tariff thus depend upon the balance between the GNP losses and the terms-of-trade gains associated with the tariff. In turn, this balance depends upon the fraction of the tariff that is passed on in terms of higher U.S. oil prices and the fraction passed back onto the producers of oil, an issue we were not able to examine using the models of our study.

Table 19 presents, for a set of possible tariff fractions passed through to U.S. consumers, very rough estimates of the first year terms-of-trade gains and GNP losses associated with a \$10 per barrel disruption tariff. For the final column of this table we have subtracted GNP losses from terms-of-trade gains to provide an estimate of net gains.

Table 19 indicates that if more than 25 percent of the tariff is passed through to U.S. consumers, the GNP losses will dominate the terms-of-

Table 19: Estimated Impacts of a \$10 per Barrel Disruption Tariff

Fraction Passed Through to U.S.	Change in U.S. Price	Change in World Oil Price	GNP Loss[a]	Terms-of-Trade Gain	Net Gain (Loss)
	(\$ per barrel)			(billions of 1983 \$)	
100%	10.00	0.00	34	0	(34)
75%	7.50	2.50	25	3	(22)
50%	5.00	5.00	17	6	(11)
25%	2.50	7.50	8	8	0
0%	0.00	10.00	0	12	12

[a]These estimates exclude any recessionary effect resulting from tax revenues not being quickly recycled back to households.

trade gains and the net gains will be negative. Hence, even if "recycling" of revenues posed no macroeconomic difficulties, the imposition of the tariff would be, on net, harmful to the U.S. economy, unless at least 75 percent of the tariff were borne by the producers and non-U.S. consumers of oil.

6.3 Price Controls

The United States and many other countries have adopted policies which are in some ways the opposite of disruption taxes. Controls on domestic oil prices have been implemented to cushion the economy from sudden price movements. Like disruption taxes, such policies can be expected to have terms-of-trade and GNP impacts, although price controls can be expected to lead to terms-of-trade losses and GNP gains. In addition, price controls lead to massive implementation problems and generate losses in economic efficiency, which cannot be evaluated using the models of this study nor even measured by the national income accounts themselves.

The working group did not attempt to model explicitly the effects of price controls nor of their removal. It was felt that these models could not adequately represent the oil shortages, the longer-term efficiency losses, and the administrative problems created by such controls nor the tendency for the controls to persist long after any benefit had evaporated. Thus, even though it would seem that Table 19 could be directly applied to the evaluation of price control, such a direct application of that table, or of any of the models, would be inappropriate; such an application that represents price controls as smaller price increases would systematically overstate the benefits of price controls. For analogous reasons, an analysis of oil price controls that focuses only on the oil market would exclude macroeconomic adjustment losses in GNP; such an analysis would ignore any short-term benefits from avoiding these losses.

6.4 General Caveats

The models used in our study, like all macroeconomic models, embody a highly aggregated representation of the economy. As such, they cannot be used for analyzing the detailed distribution of impacts by industry or region, intricate interfuel substitution or conservation possibilities within the energy sector, or the administrative difficulties entailed by many classes of energy policies. Nor can they appropriately be used for overall evaluation of policies which depend essentially upon such factors. Yet when used appropriately, they can cast light.

The analysis has illustrated a need for caution in the use of GNP as a measure of economic impacts of energy shocks or of policy initiatives. That need for caution would remain even if the models were perfectly accurate in their evaluation of GNP consequences of energy policies.

Gross National Product (GNP) is typically used as a measure of changes in the nation's total production of goods and services.[24] Based upon a well developed and widely accepted data base known as the National Income and Products Accounts, GNP has proven to be a very useful measure of cyclical fluctuations in aggregate output. As such, GNP can be used to judge how closely the economy is operating to its full-employment potential. But it does not reveal how efficiently resources are being used for competing purposes. And GNP excludes nonmarket activities, such as home production or leisure, and economic goods for which there are no markets, such as clean air and water. For these reason, GNP should not be construed as a measure of social or even economic welfare.

In addition, the GNP loss due to a foreign oil shock does not incorporate the reduction in purchasing power of U.S. income that occurs when the price of imported oil rises more than other prices in the U.S. economy. This terms-of-trade loss is entirely separate from the shrinkage in total output

[24]GNP also represents the income paid to U.S. workers and owners of plant and equipment, plus indirect taxes and depreciation.

measured by real GNP and would occur during an oil shock even if total production were unaffected. As shown in the analysis of specific policies, the terms-of-trade loss may move quite differently than does GNP in response to policy initiatives. Since both losses are important to consider, the GNP loss estimated using macroeconomic models should be supplemented with a separately calculated purchasing power (terms-of-trade) loss, as we have tried to do here.[25]

7 Model Structures

The previous sections discussed the major impacts of an oil shock and the various policies as represented by the group of models. This section[26] explores and explains some of the differences among model results.

7.1 An Analytical Framework

In order to understand differences among models, it is necessary to analyze more carefully the impacts of energy shocks on the economy. A simplified framework of aggregate supply and demand can be used to represent the principal mechanisms by which an oil price shock increases domestic prices and reduces real output.

Figure 19 presents such a framework. The aggregate demand for goods and services is represented as a decreasing function of the overall price level. The aggregate supply curve indicates that the overall price level will be an increasing function of aggregate quantity of goods and services supplied.

While the curves of Figure 19 look superficially like the supply and demand curves for a single market, they are quite different. The aggregate demand curve presented here shows the alternative pairs of price and output levels which could equilibrate the markets for goods and money. The aggregate supply curve shows the combinations which could satisfy conditions of production, employment, and pricing.

[25] The terms-of-trade loss can be estimated from the prices and quantities of oil imports and exports as discussed in the appendix. They can also be closely approximated with a microeconomic analysis of the oil market alone that determines the quantity as well as the change in price of oil imports. The similarity between the two approaches is demonstrated by Huntington and Eschbach, "Macroeconomic Models and Energy Policy Issues," in *Macroeconomic Impacts of Energy Shocks*, edited by B.G. Hickman, H.G. Huntington, and J.L. Sweeney, Amsterdam: North Holland, 1987 (Chapter 3).

[26] This section is based upon Hickman, op.cit.

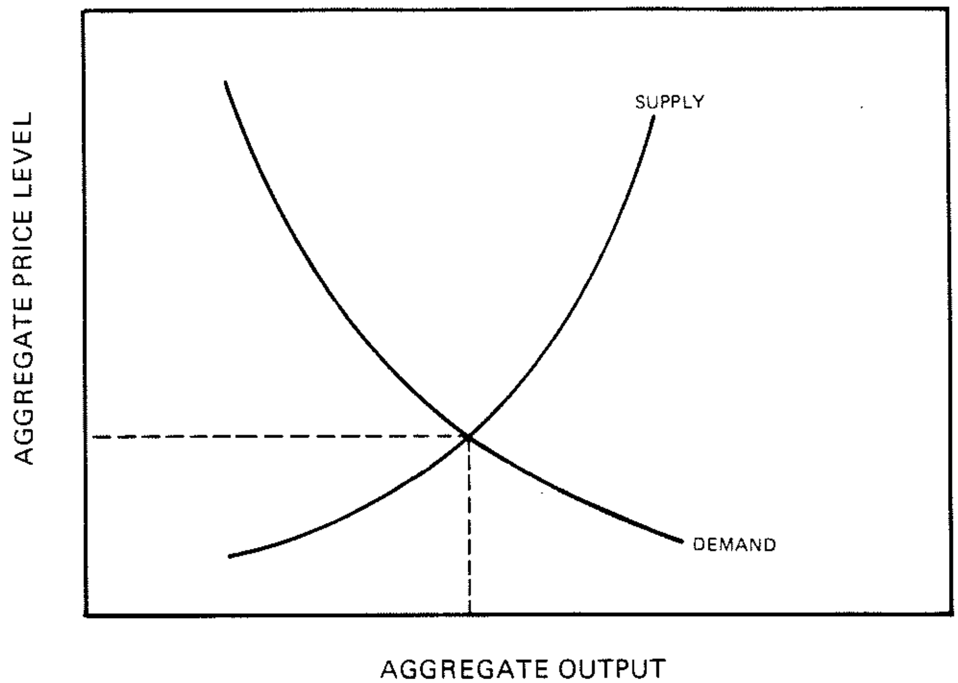


Figure 19: Short-Run Equilibrium of the Economy

The aggregate demand curve slopes downward, reflecting the observation that aggregate price increases will reduce the quantity of goods and services desired in the marketplace. The aggregate price level increase leads to a reduction in aggregate demand through several mechanisms: (1) The fixed nominal supply of money is reduced in real terms, resulting in higher interest rates and reduced investment and purchases of consumer durables. (2) Real consumption is reduced because the real value of financial assets held by households declines as prices rise. (3) Real government purchases may decline to the extent that they are held constant in nominal dollars. (4) Real net exports will be reduced as higher domestic prices make domestic goods less attractive and foreign goods more attractive. The direct effects of each mechanism are multiplied as reductions in demand lead to further reductions in income and wealth, which in turn lead to further demand reductions.

The aggregate supply curve slopes upward because increases in output raise the aggregate price level in the short run. As firms increase their planned levels of output, they increase their purchases of all inputs, including labor services. Reductions in the labor force unemployment rate encourage greater wage increases. Increases in demands for other productive factors likewise may increase their prices. These wage and price changes imply cost increases for firms leading to price increases for their products. Output increases thereby lead to increases in the overall price level as reflected in Figure 19.

The real output of goods and services and the aggregate price level tend to move toward the point in Figure 19 at which the aggregate supply and demand curves intersect. This quantity-price combination is typically referred to as the short-run equilibrium of the economy. If firms produce less output than the short-run equilibrium level, prices will be lower than equilibrium, the aggregate demand for goods and services will be higher, and inventories will be drawn down. These conditions will encourage firms to increase their output toward the equilibrium level. Similarly, if firms produce more output than equilibrium levels, the excess of supply over demand will motivate supply reductions, again bringing the economy toward the short-run equilibrium level.

The simple aggregate supply-demand framework can be used to analyze the effects of an oil shock and of the policy measures for mitigating its impacts. In particular, the shock and the policy responses may each shift the aggregate supply and demand curves, thereby shifting the short-run equilibrium of the economy. These new conditions will induce adjustment processes that bring the economy toward a new short-run equilibrium. It is just these processes that can be analyzed with the large-scale models compared in this study.

Figure 20 depicts the short-run effects of the oil shock. Prior to the shock, the economy rests in short-run equilibrium, in which the price and real output satisfy both the aggregate supply and demand relationships at the point of intersection, A.

A one-time increase in the price of oil raises the variable unit costs of production, given the existing wage and output levels. In response, firms set their product prices higher, shifting the supply curve upward in Figure 20. The supply shift will be greater for: (1) larger energy price changes; (2) a greater importance of energy expenditures in the total economy; (3) stronger "sympathetic" price movements for other inputs such as wage indexing for labor; and (4) less opportunity for substituting other inputs, primarily labor in the short run. The supply shift will be the dominant effect, and taken alone, would result in a higher price and lower output than the original equilibrium levels.

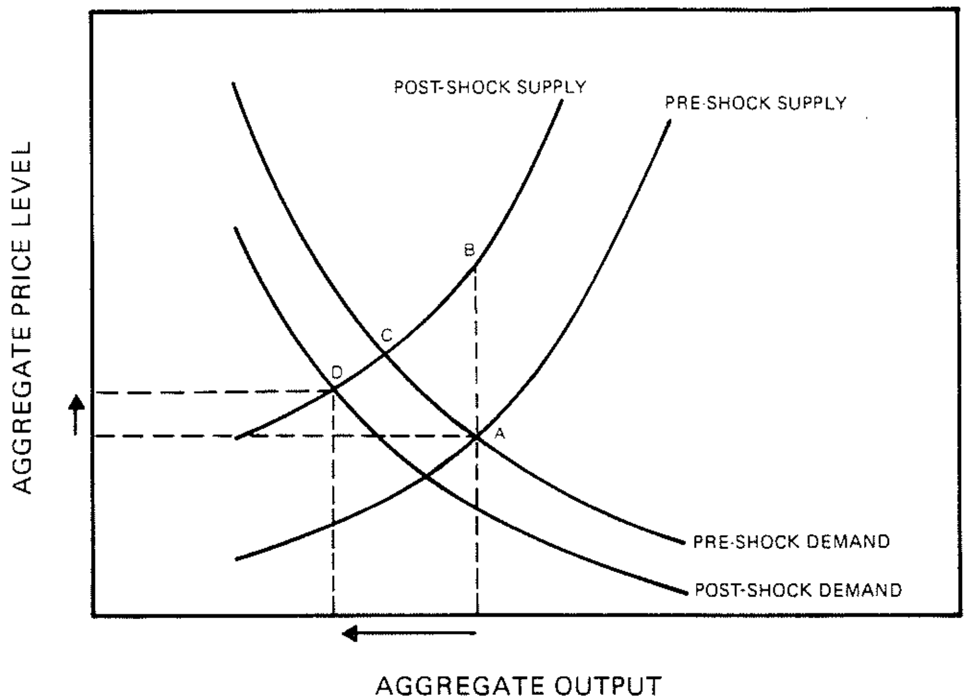


Figure 20: Short-Run Effects of the Oil Price Shock

If demand considerations were unimportant, firms might try to pass all these costs through completely and set prices at point B. However, the higher prices reduce total spending and increase unemployment. As a result, prices decline somewhat, as the economy moves from point B to C.

The aggregate demand curve may also shift leftward during an oil shock, reducing demand at each price level. Higher oil prices reduce the real disposable income of energy consumers, through the resulting terms-of-trade losses, and thereby reduce consumer demands for goods and services. In addition, real exports fall as economic activity in other oil-importing countries also declines.[27] In Figure 20 we show the demand curve shifting downward in response to these two changes.

A leftward shift in the aggregate demand curve would mitigate the price effects of the supply shift but would reinforce the fall in output. This effect

[27]Some of the downward shift in demand could be offset if foreign prices should rise more than domestic prices during the shock. Purchases of domestic goods would increase as U.S. exports increased and imports decreased.

is shown in Figure 20 as the economy moves to a new short-run equilibrium at point D, instead of point C.

Monetary, fiscal, and supply-side policies can modify the equilibrium point. An income tax cut or an increase in the money supply would move the aggregate demand curve upwards and to the right, thereby reducing the GNP loss but increasing the price impact. A payroll tax cut and an investment tax credit can move both the aggregate supply curve and the aggregate demand curve outward, increasing GNP and imposing an indeterminate impact on the overall price level. These qualitative conclusions are consistent with the quantitative findings derived through use of the macroeconomic models.

7.2 Key Parameters

This simple analytical framework can be used to evaluate the key quantitative relationships determining the impacts of an oil shock on GNP and on the overall price level. We consider first the case in which the aggregate demand curve is not shifted as a result of the energy shock. In this case, the short-run impact is a movement of the equilibrium from point A to point C, along the original aggregate demand curve in Figure 20.

The magnitudes of the price and GNP impacts will depend upon the degree to which the aggregate supply curve is shifted upward. The greater the upward shift in the aggregate supply curve, the greater the resulting impacts.

Likewise, the slope of the aggregate supply curve is important. The more nearly horizontal it is, the greater will be the impacts. This condition would prevail when wages and prices are relatively insensitive to increasing unemployment and excess capacity. As a result, the energy price increase is passed through without any significant price and wage moderation in the rest of the economy.

This second conclusion is illustrated in Figure 21, which contrasts the impacts of an oil price shock under two very different sets of conditions. In both panels the aggregate supply curve is shifted upward by the same amount from its initial position. The supply curve in the lower panel, however, is much flatter than its counterpart in the upper panel. This flatter curve represents a situation where wages and prices are virtually unresponsive to declining employment and capacity utilization. The contrasting situation in the upper panel represents a set of conditions where prices and wages are very flexible and labor and equipment remain near their full-employment levels during an oil shock.

Figure 21 shows that with the flatter aggregate supply curve, the oil shock causes larger impacts on both prices and output. The new short-run equilibrium price and output levels under these conditions are greatly different from their initial levels. Conversely, with the steeply sloping aggregate supply curve, the new equilibrium levels are only slightly different from the initial values.

The magnitude of the supply shift and the slope of the supply curve will determine whether the price and output effects will be large or small. A third characteristic, the responsiveness of aggregate demand to higher prices, will govern the division of the response between higher prices and reduced output. Inspection of Figure 20 should confirm this result. If aggregate demand is highly responsive to aggregate price, i.e., if the aggregate demand curve is nearly horizontal, the shock will result in a relatively large GNP reduction and a relatively small price increase. Conversely, if the aggregate demand is quite unresponsive to aggregate price, then prices will rise more but real GNP will fall less.

Similar conclusions still hold when the demand curve shifts along with the supply curve. In that case, however, the division of the response between price and output impacts is influenced also by the magnitude of the shift in the demand curve.

The EMF models are considerably more complicated and extensive in coverage than represented by the previous analytical framework. They usually exhibit complicated dynamic patterns and include other economic relationships affecting price and real GNP that were not mentioned above. Furthermore, many of the models seek to explain dozens or even hundreds of other economic responses in addition to those for the price level and real GNP. Nevertheless, the simple framework of Figure 21 provides a useful perspective for understanding the aggregate impacts of an oil shock.

7.3 Analysis of Model Differences in GNP and Price Effects

The GNP losses projected by the various models can be decomposed into factors suggested by the simple supply-demand framework. In what follows we will examine several factors that correspond broadly with the key determinants in Figure 20, assuming that the shift in the aggregate demand curve is insignificant: the extent of the upshift in the aggregate supply curve, the

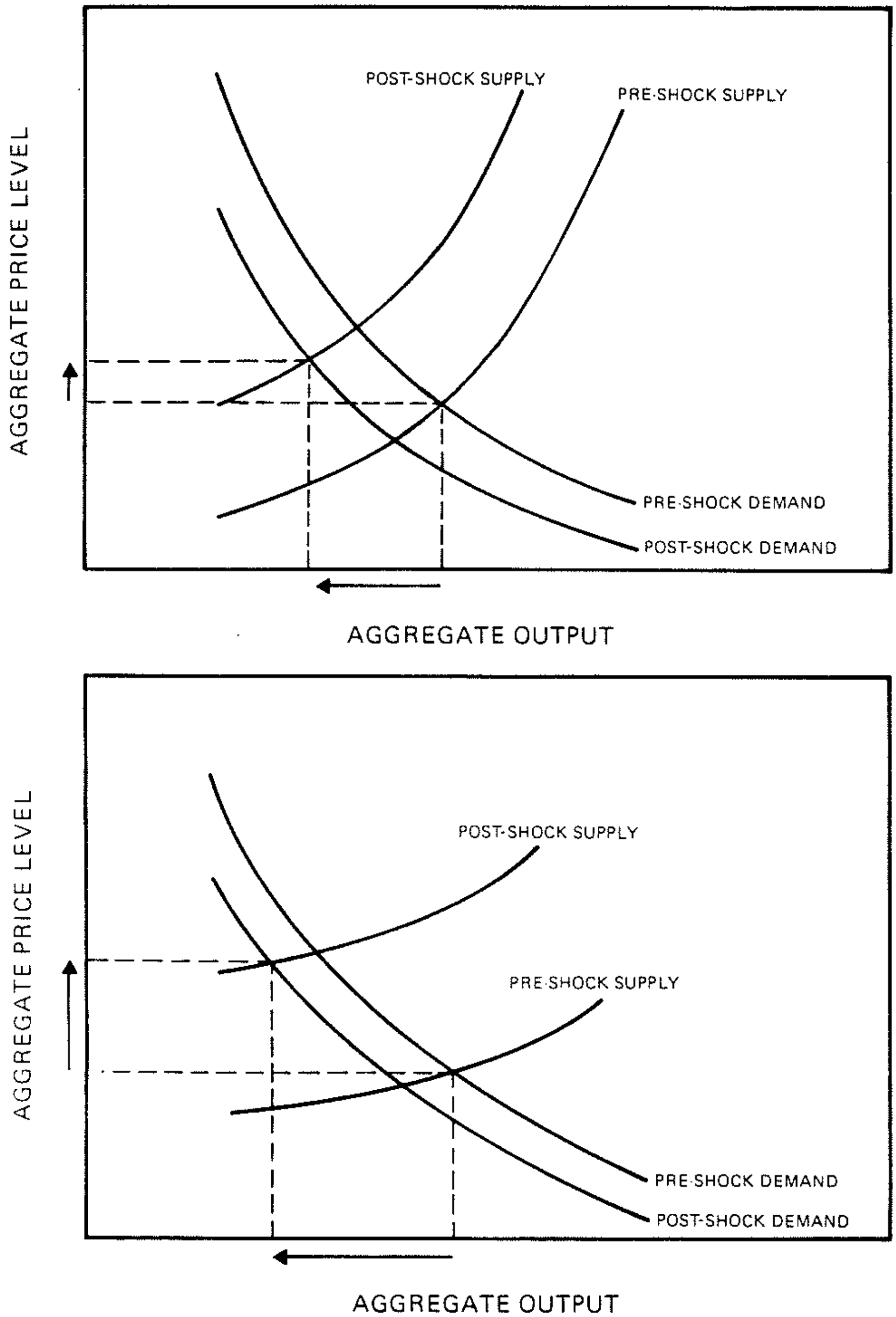


Figure 21: Flatter Supply Curves Cause Larger Price and Output Effects

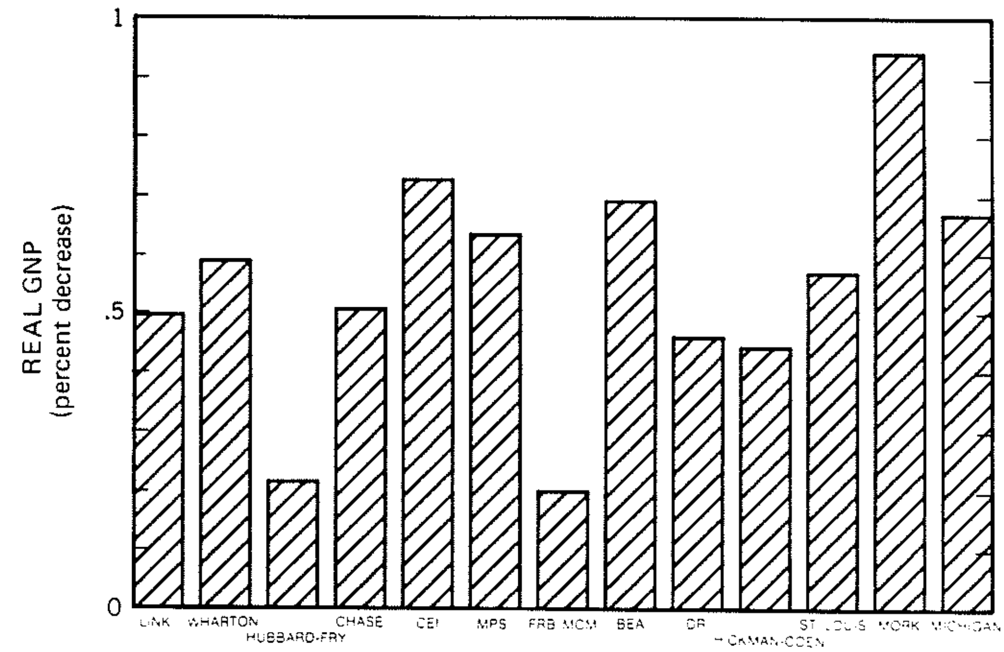


Figure 22: Second-Year GNP Response to a 10 Percent Increase in Oil Price

slope of the aggregate supply curve, and the slope of the aggregate demand curve.

The real GNP losses during the second year of an oil shock are compared in Figure 22. Since the model responses were shown to be virtually proportional to the size of the oil shock, the percentage reduction in real GNP for the 50 percent oil shock have been expressed in terms of a 10 percent increase in the price of imported oil.

Real GNP falls the least in the FRB Multi-Country Model (MCM) (0.20 percent) and Hubbard-Fry (0.20 percent) models, while the largest impact is observed for the Mork model (0.95 percent). All of the other models report effects that range between 0.4 and 0.8 percent. Using the median value, every 10 percent increase in the oil price leads to a 0.6 percent decrease in real GNP.

Figure 23 shows the response of real GNP to the aggregate price level for the various models in the second year of the shock. For comparison with the previous figure, the percentage GNP decline for a 10 percent increase in the implicit GNP deflator has been reported. If the aggregate demand

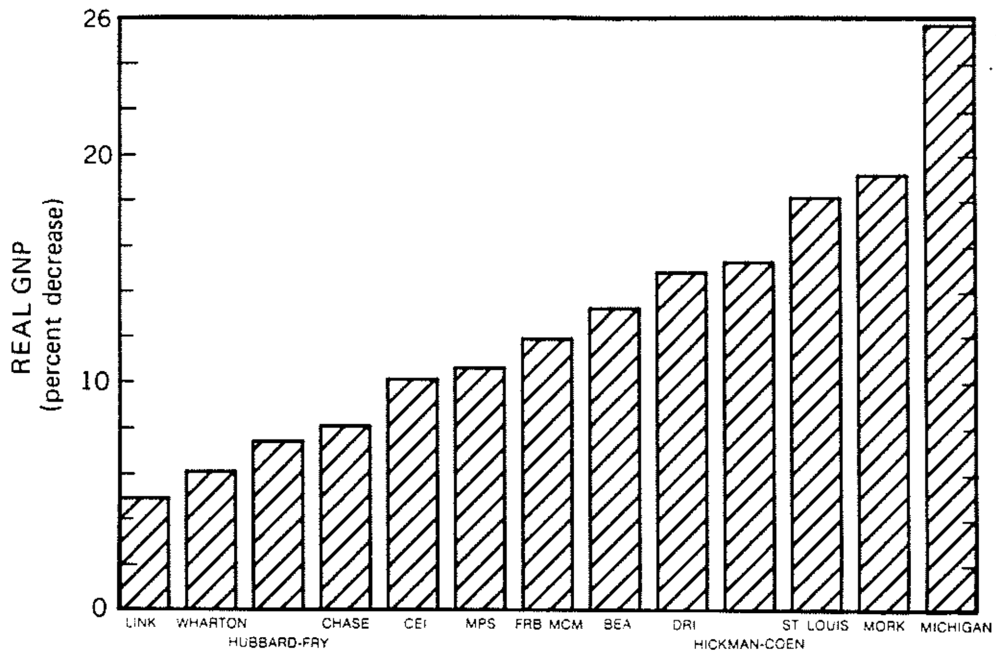


Figure 23: Second-Year GNP Response to a 10 Percent Increase in Price Level

curve is unchanged by the energy shock, these responses reflect the slope of the aggregate demand curve. We will adopt this assumption[28] for this discussion. When these responses are expressed in terms of the percentage reduction in real GNP caused by a one percent increase in prices, we can refer to them as the price elasticity of aggregate demand.

Figure 23 makes it clear that the models have been ordered according to the price elasticity of aggregate demand, with the elasticity increasing as one moves from the left to right. The ordering of models is the same on each graph.

Figure 23 emphasizes that the real GNP reduction is roughly proportional to the aggregate price increase for many models. For the median value, every 10 percent increase in the overall price level leads to a 12 per-

[28]Even if the assumption is not correct, neglecting the shift in the aggregate demand curve will not seriously bias the model comparisons. The bias operates in the same direction for all models. Moreover, the factors shifting the curve—oil import bill, export demand, federal purchases of goods and services, tax rates, and policy reactions—were standardized across models.

cent decrease in real GNP. These results also emphasize that the price elasticity of aggregate demand for many models lies in a relatively narrow range centered around unity. This observation reflects the fact that the money supply in the scenarios was explicitly assumed to be unchanged after the shock.

The "equation of exchange", a fundamental identity in monetary economics, states that the nominal expenditure on goods and services must equal the stock of money multiplied by its "velocity of circulation", the rate at which the stock of money turns over. In our simulations the stock of money remains constant. Thus if the velocity of money were unchanged, then the nominal expenditure on goods and services would neither be increased nor decreased by the shock. In that case every 1 percent increase in the price level would lead to a 1 percent decrease in real GNP: the price elasticity of aggregate demand would be unity.[29]

However, the velocity of circulation does vary with the interest rate and the real income. For those models projecting an increase in velocity after the shock, the price elasticity of aggregate demand is smaller than unity (GNP is reduced by a smaller percentage than price is increased) while the price elasticity is greater than unity for those models characterized by a decrease in velocity. Nonetheless, the range of velocity cannot be greater than the range of reasonable responses of the demand for real money balances. Therefore, the price elasticity of aggregate demand will not vary greatly from unity as long as the stock of money remains the same as in the absence of an oil shock.

The second-year effects of a 10 percent increase in imported oil prices on the overall price level are compared in Figure 24. At the high end of the range, the Wharton and LINK models project that every 10 percent increase in oil price will increase the implicit GNP price deflator by 1 percent in the second year of the shock. The median effect of 0.5 implies one-half as large a response. At the low end, MCM projects that a 10 percent increase in the oil price will increase the implicit GNP price deflator by less than 0.2 percent.

With but few exceptions, Figure 24 reveals a sharp decline in the price impact moving from the left to the right of the graph. This pattern demonstrates rather strikingly that lower aggregate demand elasticities are associated with larger increases in the projected general price impacts of oil price

[29] As explained in footnote 10 in Section 3.3, the GNP price deflator understates the increase in consumer prices during the shock by about 1 percent. This fact may explain why the price impacts appear to be proportionately less than the GNP impacts in Figure 23.

Figure 24: Second-Year Price Level Response to a 10 Percent Increase in Oil Price

shocks. This relationship is precisely that described by the simple aggregate supply-demand framework presented above.

The effect on real GNP in Figure 22 can be decomposed into two effects: the response of the aggregate price level to changes in the imported oil price (Figure 24) and the response of real GNP to changes in the aggregate price level (Figure 23). For example, the MPS model shows the general price level rising by 0.62 percent for every 10 percent rise in the oil price (Figure 24). The same model reports a 10 percent reduction in real GNP for a 10 percent increase in the general price level (Figure 23), or an elasticity of aggregate demand of unity. Combining these effects, we observe that the model shows real GNP to be reduced by 0.62 percent by a 10 percent oil price shock (Figure 22).

Similarities among models in GNP impacts of oil price shocks may in many cases hide real differences in the component responses of the models. For example, the Wharton and the Michigan models show very similar GNP impacts of the oil price shock. However, the Wharton model projects that the energy price shock will have a large impact on the overall price level but the price level has a relatively small impact on GNP. Conversely, the Michigan model attributes a much greater role to the effect of higher prices on real GNP.

Some differences in the real GNP losses can be partially explained by the decomposition into the two factors. For example, the Mork model projection of impacts on the GNP price deflator is close to the median. But since the Mork model assumes real GNP to be highly responsive to overall price level, that model projects a large impact of the energy shock on real GNP. MCM includes a near-median response of GNP to the overall price level. But because the model projects very little impact of oil price shocks on the prices of other goods, MCM projects very little overall real GNP declines. The Hubbard-Fry model shows relatively low values for each of the factors and thus it shows low overall impact on real GNP.

The responses summarized by Figures 22 and 24 can be presented in another manner. Figure 25 presents a scatter diagram showing the price impact of an oil shock on the vertical axis (from Figure 24) and the GNP impact on the horizontal axis (from Figure 22).

Conceptually, each point in Figure 25 could be connected by a line to the origin or point of zero impact, which is in the lower right corner of the figure. The slope of each such imaginary line would represent the aggregate demand elasticity corresponding to a particular model. Models above and to the right of the diagonal line in Figure 25 are characterized by price elasticities of aggregate demand below unity; those below and to the left by a price elasticity above unity: variations of projections away from the diagonal line simply reflect differences among the models in the price elasticity of aggregate demand.

Stated differently, the price elasticity of aggregate demand gives an indication of how a given impact on the economy will be split between price level increases and GNP decreases. But in order to determine the overall magnitude of the impacts—to determine how far out on the line the model result would lie—one needs to more fully analyze the aggregate supply conditions.

7.4 Aggregate Supply Curve Shifts

The effect of oil prices on the aggregate price level (Figure 24) can be further decomposed for seven U.S. models in order to probe differences among models in the aggregate supply curve shift resulting from the energy shock. These seven models provide projections of the impacts on the wholesale price

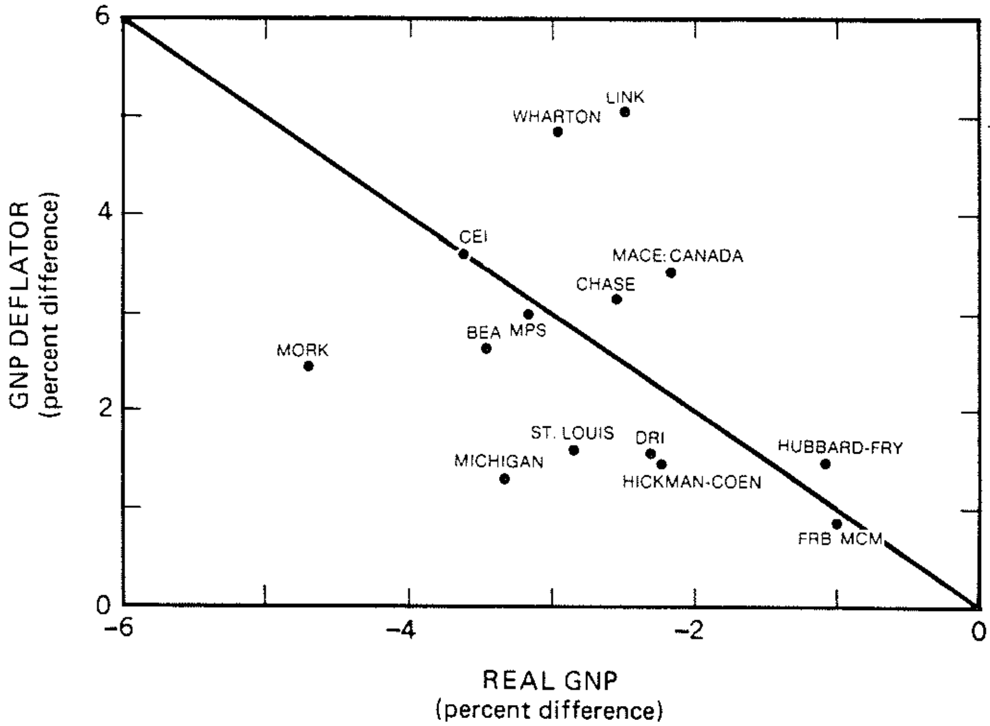


Figure 25: Second-Year Impacts of a 50 Percent Oil Price Shock on Price Level and GNP

of fuel and power. For these models, the increase in the implicit GNP price deflator can be divided into two parts: the effect of oil prices on the wholesale price of fuel and power (Figure 26) and the impact of this wholesale energy price on the implicit GNP price deflator (Figure 27).

Although the oil price increase was standardized to 50 percent for all models, this increase did not translate to an equal shift in the intermediate energy price—the wholesale price of fuel and power—for all models. Five of the models estimated or assumed that this intermediate price would increase by about 6 percent for each 10 percent increase in the price of oil. However, in the Wharton model (and the LINK system which includes the Wharton model) each 10 percent increase in oil price was projected to increase the wholesale price of energy by over 9 percent.

In each model the oil price influences the economy directly through the intermediate energy price, which feeds into the equation for prices of goods and services. Thus, large impacts on the wholesale energy price translate proportionately to projections of large GNP and price consequences. If the

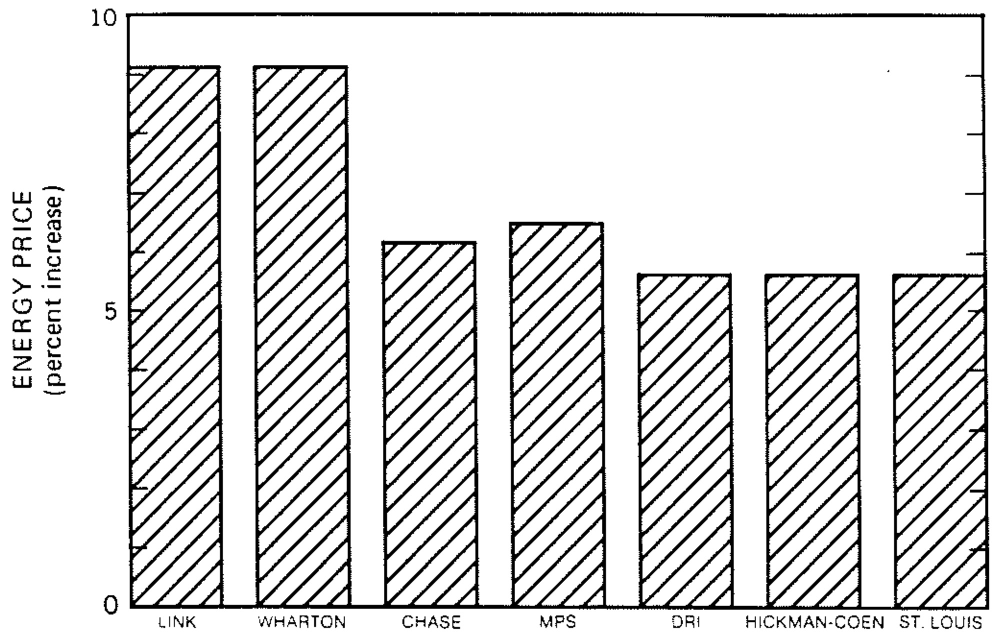


Figure 26: Second-Year Energy Price Response to a 10 Percent Increase in Oil Price

Wharton and LINK models had been adjusted to give the same impact on wholesale energy price as did the rest of the models, their projections of the price impacts in Figure 24 would be scaled down by 38 percent. In that case, these models would have projected that each 10 percent increase in energy price would increase the implicit GNP price deflator by about 0.6 percent. Thus, the range of this factor would be narrowed somewhat. Figure 24 would still show that lower price elasticities of aggregate demand are associated with projections of larger price impacts, but the slope would be less steep.

In addition, if the LINK and Wharton models were standardized as indicated for wholesale energy price changes, their projections of real GNP impacts would also be adjusted downward by 38 percent. In Figure 22, the Wharton and LINK models would project that each 10 percent increase in the oil price would reduce real GNP by less than 0.4 percent. This adjustment would yield a lower than average projected GNP loss for a model with the most inelastic aggregate demand, as would be expected from the supply-demand analysis.

7.5 Aggregate Supply Elasticities

Even after standardizing for the change in wholesale energy prices, or the upward shift in supply, however, the effect of an oil shock on the implicit GNP price deflator can vary across models. A principal source of difference can be attributed to the induced responses of wages and prices to declines in output, as summarized by the slope of the aggregate supply curve in the simple framework.

Figure 27 shows that a 10 percent increase in the wholesale energy price leads to an increase of just above 0.5 percent in the implicit GNP deflator for the Hickman-Coen, DRI, and St. Louis models on the low side. The remaining four models reveal an impact of almost twice that response. In general, the models with smaller price responses are characterized by steeper aggregate supply curves, as will be discussed shortly.

Six of the U.S. models do not provide projections of the oil price impacts on the wholesale energy price. Thus, their price impacts can not be analyzed to the same extent that the responses of the other models have. And these six include the two models showing the smallest overall impacts—the Hubbard-Fry model and MCM—and two showing particularly large impacts—the Claremont and the Mork models—as well as the Michigan and BEA models.[30]

7.6 Supply Elasticities: Another Perspective

Additional information can be gained about the slope of the aggregate supply curve for all models by considering the results from the monetary accommodation and the income tax reduction scenarios. The position of the economy's demand curve in Figure 20 is fixed by assumptions about the money supply and income tax rates among other factors. When these conditions are changed by government policy, the demand curve shifts, indicating a change in real output at each price level. How much price and output

[30] Three other models report the change in primary energy price, which excludes the price of electricity. Since the latter is relatively stable during an oil shock compared to other energy prices, the percentage change in the primary energy price will be more than that in the secondary or wholesale energy price, which includes electricity. We did not attempt to include these models in the present calculation because it would have required some arbitrary assumptions on the relationship between the two energy prices.

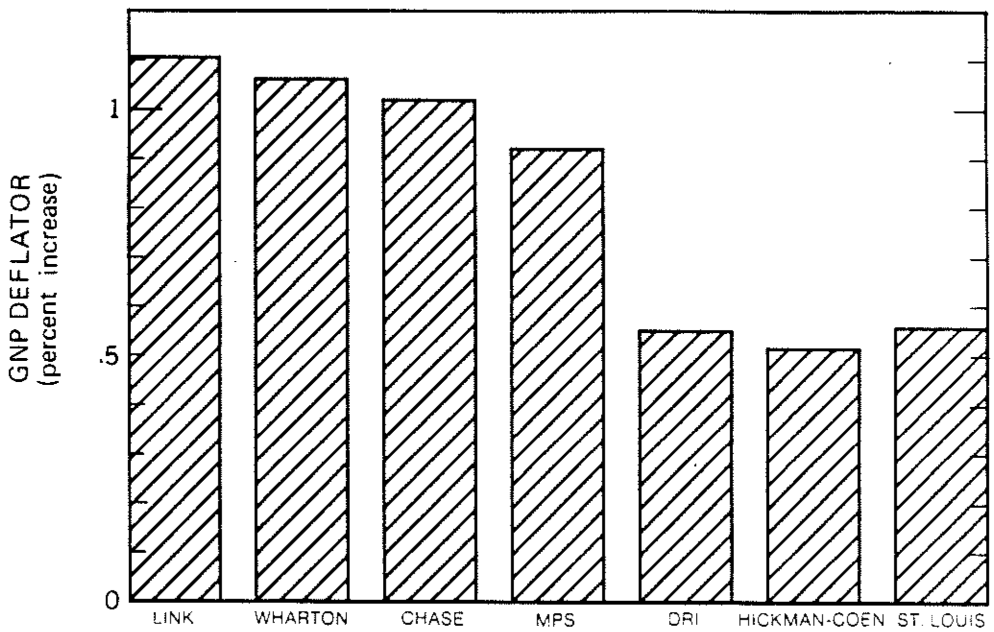
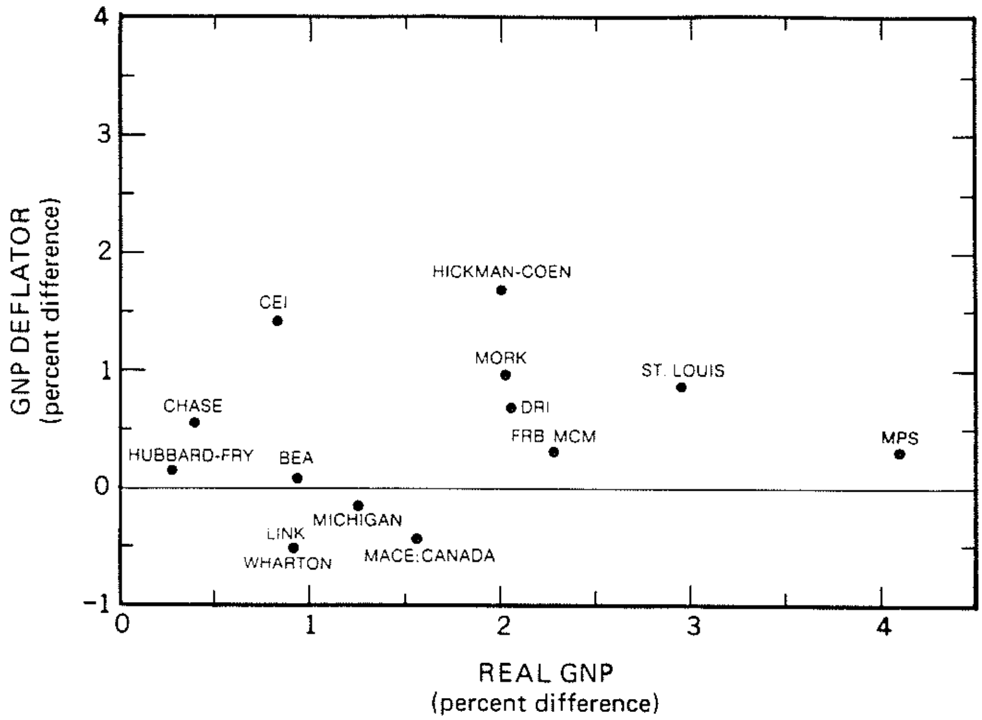


Figure 27: Second-Year Price Level Response to a 10 Percent Increase in Energy Price

change will depend upon the shape of the aggregate supply curve, unless it too shifts.

The assumption that the supply curve remains fixed during an expansion in money supply or a reduction in income tax rates may not be precise but appears to be approximately correct for most models. In these cases, the response of prices to increased output in these scenarios (relative to the shock case) will reveal the slope of the aggregate supply curve. Models showing smaller price responses will be characterized by flat or elastic aggregate supply curves.

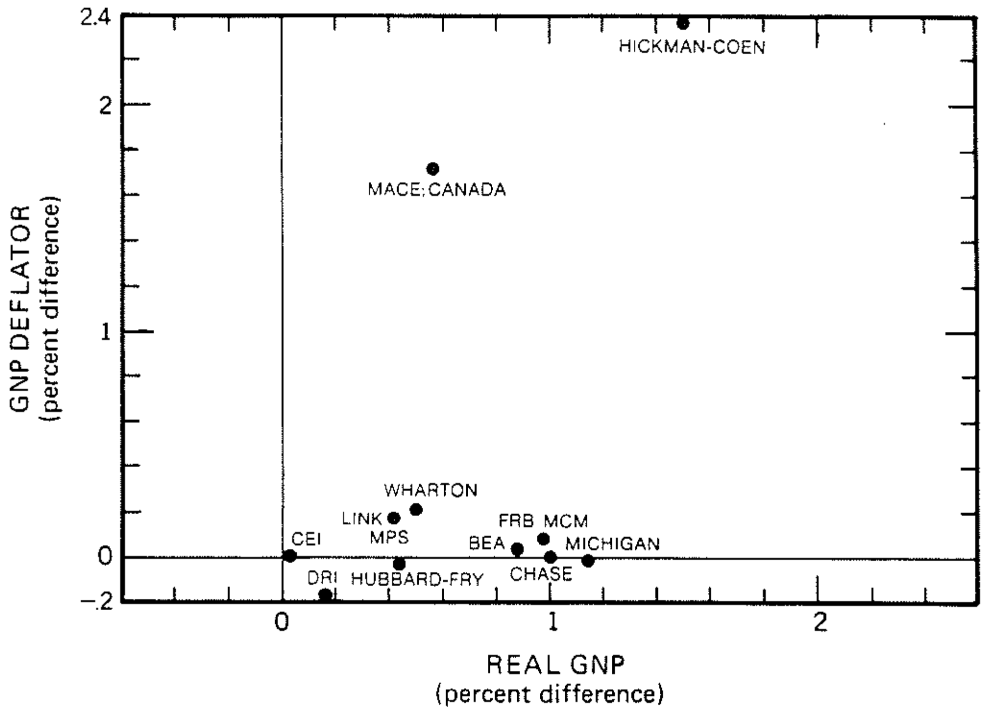
The percentage price and output responses to the change in monetary policy alone are shown in Figure 28 for all U.S. models. Figure 29 summarizes the comparable responses to the income tax reduction for all U.S. models except Mork and St. Louis, for which no responses were reported. In Figures 28 and 29 the slope of a line from the origin to the symbol for a specific model provides an approximation to the slope of the aggregate supply curve.



Note: LINK and Wharton responses are indistinguishable from each other.

Figure 28: Second-Year Price and Output Responses to Monetary Accommodation

The price level is not sensitive to changes in output in the short run for many models. A 1 percent increase in output will change the price level by less than 0.2 percent in MPS in the monetary case and in FRB Multi-Country, BEA, and Michigan in both policy scenarios. A very small price effect is also obtained for Data Resources in the monetary accommodation case, while its impact in the income tax case is too small to be a reliable indicator of this model characteristic. In addition, St. Louis and Mork also reveal relatively low price responses for the only available estimate—that from the monetary accommodation scenario. These models reveal that prices would rise by 0.5 percent or less for every 1 percent increase in output. Both Hickman-Coen and Claremont depart noticeably from this pattern by showing substantial price increase when output expands. Estimates from both policy scenarios confirm this result for the Hickman-Coen model, while the Claremont result is based upon the estimate available from the monetary



Note: LINK and MPS responses are indistinguishable from each other.

Figure 29: Second-Year Price and Output Responses to Income Tax Reduction

accommodation case. The impact in the other policy case is too small to be reliable for deriving a supply elasticity for this model.

The estimates for the other three models are more ambiguous. Relative to their output responses, prices increase substantially in the monetary case but only weakly in the income tax case for both Chase and Hubbard-Fry. In these models an expansion in the money supply growth rate during the first two years raises wages because workers anticipate greater future inflation. Thus, the price level rises due to inflationary expectations rather than to changes in output. These expectational pressures on wages are absent in the income tax case, which probably represents more accurately the effect of output on prices. For this reason, it is more likely that these supply curves are more like the ones in the first group above and do not reveal much price response when output expands.

Prices also respond strongly, but negatively, in the Wharton-LINK model when the money supply expands. Prices in this system depend upon the rental price of capital and thus decline as interest rates fall. Monetary accommodation depresses interest rates, and hence prices, at the same time it stimulates the economy and increases production. Once again, the price response during the monetary accommodation primarily reflects the change in money supply rather than the change in output. Therefore, the response of prices to output is probably measured more meaningfully in the income tax case, which shows a supply elasticity more comparable to those derived for DRI, St. Louis, and Mork.

Supply is so elastic that prices actually decline as output increases in some cases, even excluding the Wharton result for monetary accommodation. Although this result may appear to be counterintuitive at first, it can be explained. In the Michigan model, for example, wages do increase as output expands but do not increase greatly. In addition, short-run productivity increases as employment increases. This increase more than offsets the wage increase, unit labor costs decline as the economy pulls out of a recession, and as a result, prices decline.

In summary, the estimates from the two demand-side policy cases must be used cautiously for representing the shape of the economy's aggregate supply curve. After excluding those situations in which prices are responding to money supply changes rather than to output changes, we can conclude that the price response during the first two years is concentrated in the vicinity of 0.5 percent or less for a 1 percent increase in output. However, the individual model responses range from negligible to 1.6 percent for a 1 percent increase in output. All models reveal an increasing price response to output expansions during the third and fourth years.

7.7 Quantitative Use of the Simple Supply-Demand Analysis

The conceptual framework of Figure 20 emphasizes that the impacts of an oil shock will be governed by the shape of the aggregate supply and demand curves and the extent of the upshift in supply.[31] Thus, independent estimates of the impacts can be derived based upon the parameters describing the aggregate supply and demand curves. These independent estimates

[31] In applying the simple analysis, the percentage changes in price and in real GNP can be calculated simply. The percentage price change is equal to the percentage supply shift multiplied by a ratio of the supply elasticity to the sum of the supply elasticity plus the demand elasticity (with demand elasticity written as a positive number). The percentage GNP change equals the percentage price change multiplied by the price elasticity of aggregate demand. It is just these calculations which underly the graphs that follow.

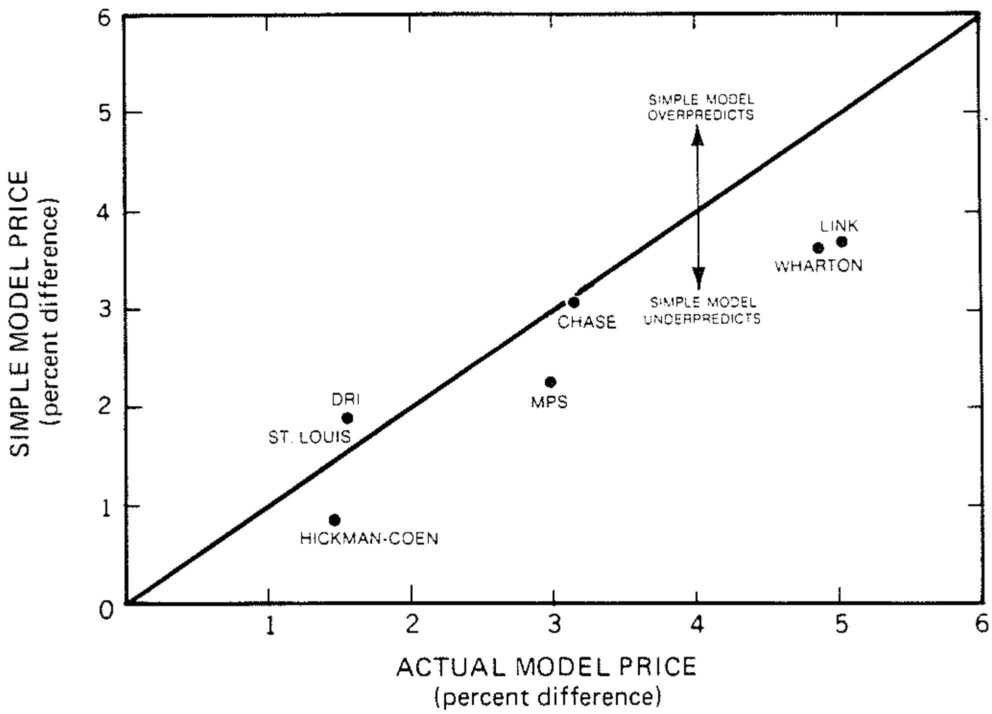
can be compared to the impacts actually reported by each model to check whether the framework is an adequate representation of a shock.

In applying this framework to explain the observed projections of a specific model, we use the price elasticity of aggregate demand for that model as reflected in Figure 23. The aggregate elasticity of supply is derived from Figure 28 as the ratio of the output and price impacts in the monetary accommodation case. This procedure allows us to use a common policy scenario for all estimates. For DRI and St. Louis, we are restricted by the available estimates to this case only. However, for the Chase and Wharton-LINK models we use the supply elasticity from the tax reduction scenario, in order to avoid the problems with the monetary simulation just discussed.

In response to a 50 percent oil price shock, the supply curve is assumed to shift upward by the median energy price increase (28 percent) multiplied by an approximation to the current value share of energy expenditures in the U.S. economy (10 percent). We assume that each elasticity is constant for the relevant range of changes.

The calculation of the results using the simple supply-demand framework was limited by necessity to those U.S. models that reported changes in the wholesale price of fuel and power. Figure 30 compares the second-year impact on the aggregate price level based upon the simple supply-demand analysis with the actual model projection reported for the oil shock. The two estimates are quite comparable for most of the models. This can be observed by noting that most points lie on or near the 45-degree line that equates the two separate estimates. For the Wharton and LINK models, the simple framework underpredicts these price impacts. If we were to scale down the Wharton and LINK actual impacts by 38 percent or scale up the simple model impacts for these models, to account for their difference in energy price impacts, these model results would also be almost precisely on the 45-degree line.

Figure 31 compares the two estimates for the second-year impact on real GNP. The estimates from the simple framework diverge more from the reported projections than in the previous figure, suggesting that the framework is more appropriate for explaining differences in the price impacts than the reduction in real GNP. Even so, the simple model results predict the correct order, from the lowest to highest GNP impacts, of four models: Hickman-Coen, Link, Wharton, and MPS. Moreover, the disparity between the two estimates would be less if we were to adjust the Wharton and LINK results as indicated above by decreasing their actual impacts (moving the points to the right).



Note: DRI and St. Louis responses are indistinguishable from each other.

Figure 30: Second-Year Impact of an Oil Price Shock on the Price Level: Simple Model versus Actual Model

Figures 30 and 31 suggest that some important differences in model projections can be explained by differences in three key characteristics of the models: the price elasticity of aggregate demand, the aggregate supply elasticity, and the magnitude of the aggregate supply curve shift. Models will project higher price impacts when: (1) the price elasticity of aggregate demand is low, (2) the aggregate elasticity of supply is high, or (3) the aggregate supply curve is assumed to shift up a large amount. Similarly, models will project higher GNP impacts when: (1) the price elasticity of the aggregate demand is high, (2) the aggregate elasticity of supply is high, or (3) the aggregate supply curve is assumed to shift up a large amount.

7.8 Relative Importance of Parameters

Our simple supply-demand framework can be used to show quantitatively the importance of the three underlying characteristics for projecting the impacts of energy shocks on GNP and inflation. Using the median values

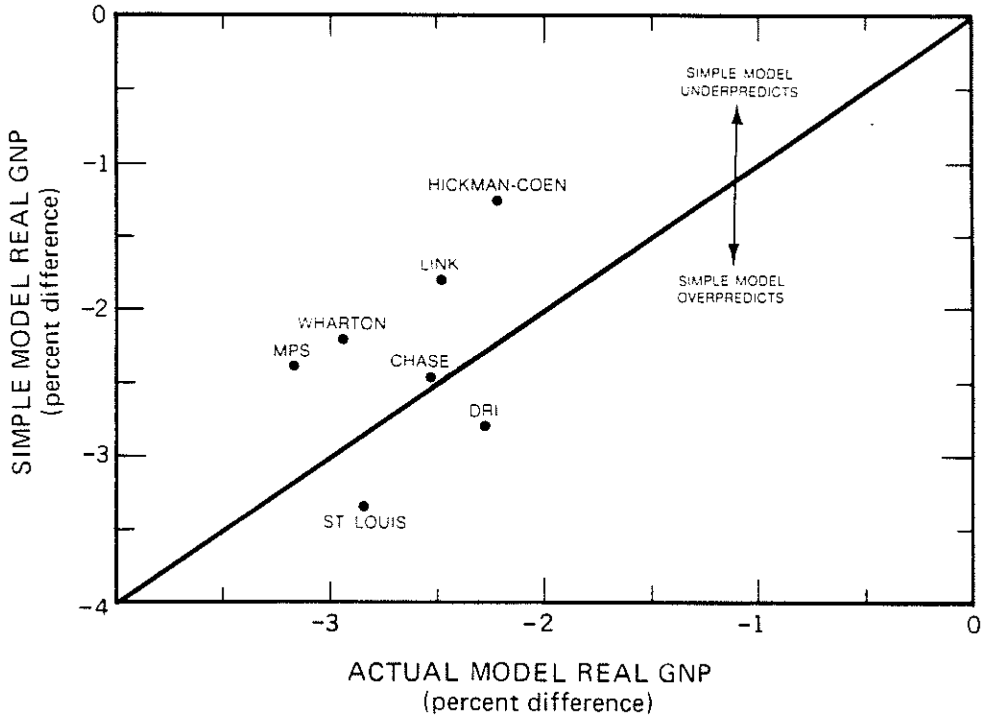


Figure 31: Second-Year Impact of an Oil Price Shock on Real GNP: Simple Model versus Actual Model

of the various parameters—1.2 for the demand elasticity, 3.4 for the supply elasticity, and 28 percent for the magnitude of the change in the wholesale energy price—we can calculate using the simple framework the estimated impacts on real GNP and on the implicit GNP price deflator. This result is plotted on Figure 32, which has precisely the same format as Figure 23. This point is labeled "DE=1.2, SE=3.4, SS=28%".

In addition, results were generated using the simple framework by varying one parameter at a time and these results were also plotted on Figure 32. For example, the point labeled "SE=300" has been generated by keeping all parameters constant except for the supply elasticity, which was increased to represent a horizontal supply curve. The effects of negative supply elasticities are illustrated by the point labeled "SE=-8", which is based upon a supply elasticity of -8 for the Michigan model. Small positive supply elasticities are illustrated by the point labeled "SE=0.5", which incorporates a 0.5 supply elasticity.

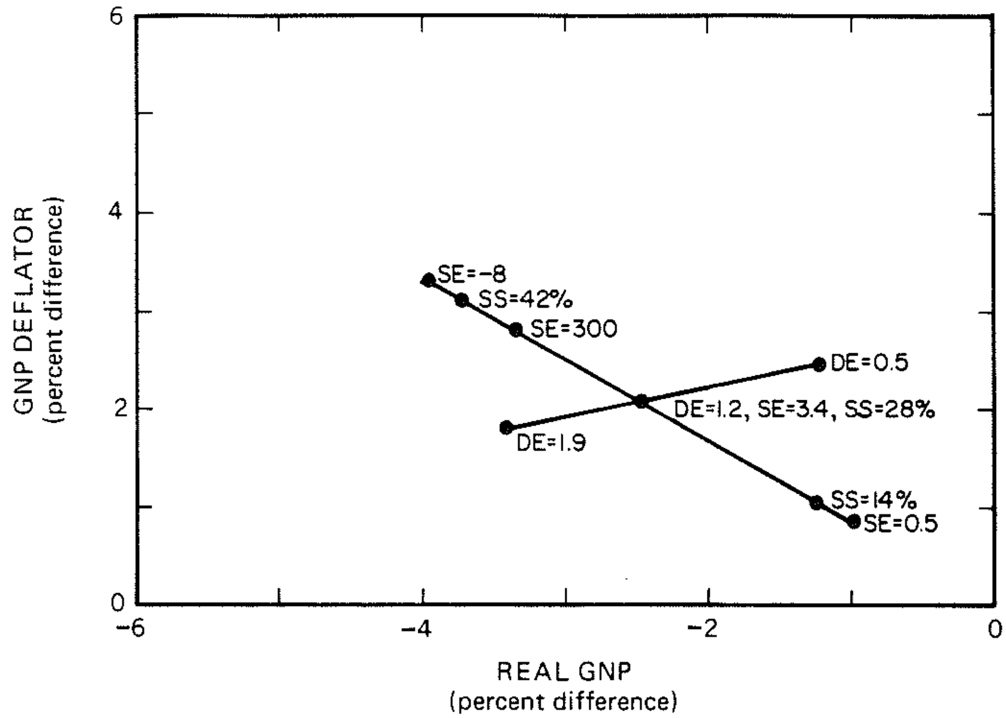


Figure 32: Second-Year Impacts of a 50 Percent Oil Price Shock on Real GNP and Price Level For Different Parameters

The locus of points generated by varying the supply elasticity illustrates that as this parameter increases the effects of an oil price shock on both the aggregate price level and real GNP become larger.

The magnitude of the energy price shock was varied from 14 percent (SS=14%) to 42 percent (SS=42%). This variation traces out a similar locus to that traced as the supply elasticity varied. The similarity arises because in either case the economy is moving along a fixed aggregate demand curve.

The relative magnitude of the two types of variation should be noted. Varying the supply elasticity over a range similar to that found in the collection of EMF 7 models gives a variation in economic impacts slightly greater than the variation associated with 50 percent increases or decreases in the magnitude of the initial shock. Thus the aggregate supply elasticity is an extremely important and highly uncertain model characteristic conditioning the projections.

Sensitivity of the price elasticity of aggregate demand has been analyzed by decreasing that elasticity to 0.5 ("DE=0.5") and increasing it to 1.9

("DE=1.9"), this range exhibited among the EMF 7 models.[32] Lowering the demand elasticity increases the impact on prices and decreases the GNP losses of an energy shock whenever the supply elasticity is positive.

Given the high supply elasticities observed for this set of models, the demand parameter has a substantially larger effect on real GNP than on prices. Projected GNP impacts range between 1 to 3.5 percent, while projected price impacts are concentrated around 2 percent.

The range of results traced by variations in the supply elasticity tends to dominate the price impacts revealed in Figure 32. Projected GNP losses vary from 1 to 4 percent, while projected price increases vary from 1 to 3.5 percent as the supply elasticity changes. Changes in the demand elasticity can have almost as large impacts on real output but have relatively little impacts on prices. Most of the actual model results reported in Figure 25 for the 50 percent oil shock fall within these ranges.

The analysis can be pushed to a somewhat deeper level as well if we can begin to explain the basis of the differences in the three characteristics. While we do not pursue these issues in any depth here, the interested reader is referred to Hickman's analysis.[33]

The price elasticity of aggregate demand itself depends upon many factors. The smaller the degree to which demand for money balances varies in response to economic forces, the greater will be the price elasticity of aggregate demand. Similarly, the more fully are government expenditures tied to a nominal level, the greater will be the price elasticity.

The aggregate elasticity of supply depends upon the degree of inertia in wages and price in the economy. The more responsive are wages to changing output, the lower will be the aggregate elasticity of supply.

The shift in the aggregate supply curve depends directly on: (1) the quantity of oil being consumed, (2) the degree to which oil price increases spill over to other energy prices, and (3) the quantity of other energy commodities being consumed. Increases in any of these factors will increase the magnitude of the shift in the aggregate supply curve.

[32] The high Michigan demand elasticity of 2.6 was excluded because it is the one response that could be seriously overestimated by our methodology. Michigan shows the largest OPEC wealth loss or "tax" as well as the second highest GNP response to the fiscal policy (tax cut) case. If an OPEC "tax" operates similar to a change in government tax rates, the demand curve for Michigan during the oil shock could be shifting inward enough to bias the estimated demand elasticity significantly.

[33] This analysis is developed in Hickman, op.cit., and will be but briefly considered here.

7.9 Model Differences in Simulating Policy Interventions

The marked diversity in model responses to the policy interventions was discussed previously. These differences reflect the lack of consensus among professional macroeconomists on the relative effectiveness of aggregate economic policies. This issue can be illuminated by considering the aggregate demand policies of an expansion in the money supply and a reduction in income taxes.

The effectiveness of a policy for expanding demand can be severely curtailed by its impact on prices. Both policies shift the aggregate demand curve outward, while for the most part leaving the aggregate supply curve unchanged. Thus, the shape of the supply curve can be quite important in determining the relative price and output responses to these policies. If prices respond very little, the demand stimulus will translate primarily into more output growth. If prices respond strongly, as they do in the Hickman-Coen and Mace models, then the same shift in demand will result in a smaller expansion in output.

Moreover, the Chase and Hubbard-Fry models directly link a monetary expansion with increased wage inflation. As a result, prices respond strongly with this particular policy in these models. In essence, the economy's short-run supply curve shifts upward as well.

Even if all models possessed the same supply curve which remained fixed throughout the policy, the impacts of these policies could differ widely among models. Some models could show a particular policy shifting the aggregate demand curve outward by a significant amount, while other models could reveal only a modest shift. The source of this difference is the interaction between the supply and demand for money and for goods and services.

7.10 Income Tax Reduction

Aggregate demand includes some expenditures that are influenced by interest rates (e.g., investment) and other expenditures that are governed by disposable income (e.g., consumption). A reduction in income tax rates will directly increase disposable income and hence expenditures. This initial stimulus to real spending will be magnified by the multiplier effect, or the additional spending which is spurred by the first round of spending.

However, this expansion in the market for goods and services can be mitigated or even offset by conditions in the money market. Higher demand for goods and services will raise the demand for money. Without a change in the supply of money, interest rates will rise and investment and other interest-sensitive expenditures will fall. Again, multiplier effects will magnify this initial decline in such expenditures.

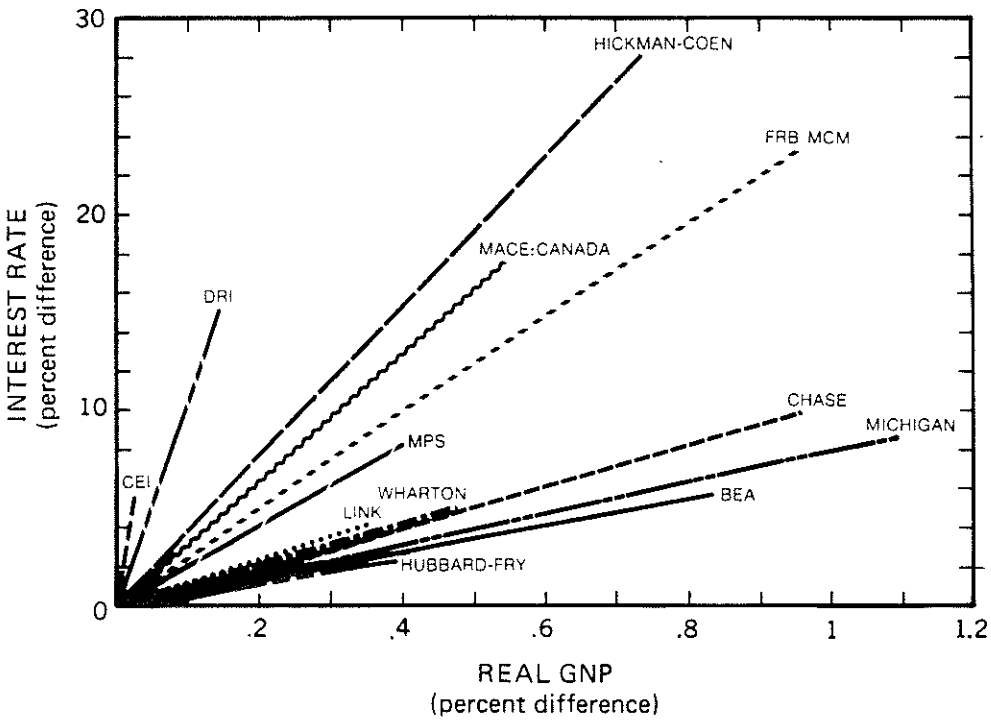
The nature of the demand for money is important for explaining how much interest rates will move relative to real income. The demand for real money balances varies inversely with the interest rate and directly with the real income. For any given expansion in real income, interest rates will have to increase more, the greater is the effect of real income on the demand for money. Moreover, interest rates will have to rise more to restore a supply-demand balance in the money markets, the less sensitive the demand for money is to the interest rate.

Due to this interaction between markets for money and for goods, an income tax reduction should raise both interest rates and real output. This result is confirmed in Figure 33, which shows for each model the proportional effects of the tax cut on interest rates and real GNP after two years. Note that the impact on interest rates is expressed as a percent change rather than a change in percentage points. An increase of one percentage point from a base of 8 percentage points would appear in the figure as a proportional change of 12 percent in the interest rate.

Each point in Figure 33 can be connected by a straight line to the origin. These lines show for each model the set of interest rates and real income that will match the amount of money supplied with its demand. In this sense, the money market will be in equilibrium for these pairs of interest rates and real income.

The lines in Figure 33 also represent the frontier for fiscal policy effectiveness embodied in each model. They show how severe a constraint the money markets will be to expansions in the demand for goods and services through increased government spending or reduced taxes. A steeper line indicates that fiscal policy will be less effective because an initial demand stimulus leads to a larger increase in interest rates and a smaller increase in real income. Inspection of Figure 33 confirms a wide range of plausible estimates for this frontier.

Higher interest rates appear to "crowd out" investment quite significantly in Data Resources, resulting in a very small net increase in real output. Thus, the money-market conditions operate as a significant constraint on the initial expansion in the market for goods and services. By contrast, output responds strongly and interest rates only weakly in Wharton, LINK, Hubbard-Fry, BEA, Chase, and Michigan.



Note: Hickman-Coen responses are scaled by half for this figure.

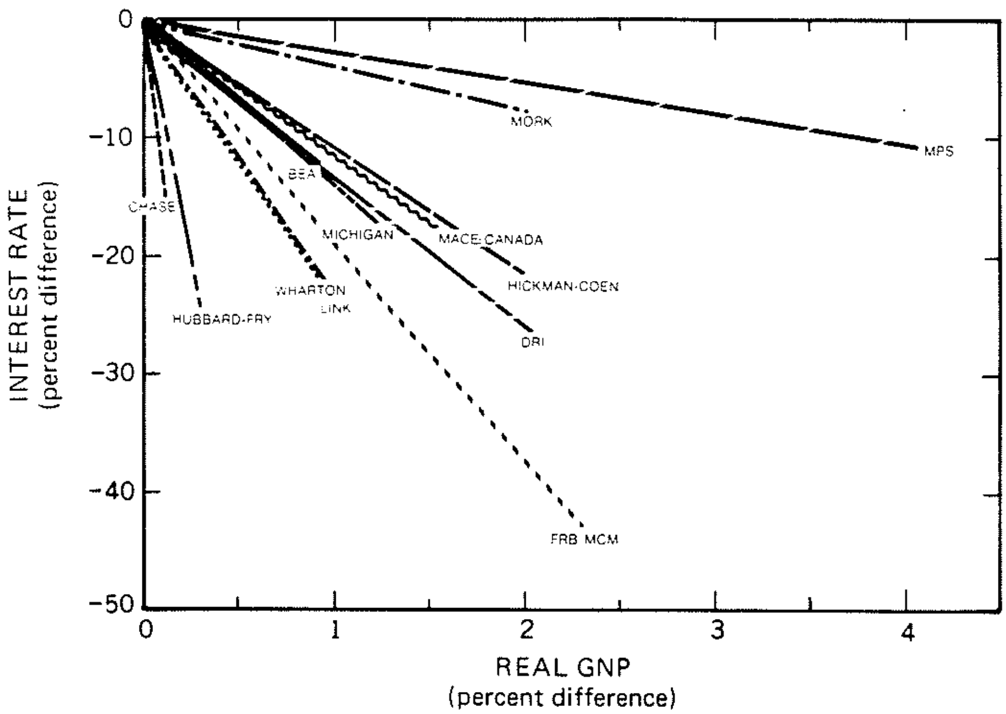
Figure 33: Second-Year Interest Rate and GNP Responses to Income Tax Reduction

7.11 Monetary Accommodation

When the monetary authorities increase the supply of money, interest rates must fall to encourage people to hold or demand more money. This decline in interest rates will affect the market for goods and services by inducing more investment and other interest-sensitive expenditures. This initial stimulus will eventually lead to additional spending through the multiplier effect.

This interaction between the markets for goods and for money should lead to a reduction in interest rates and an increase in real output when the money supply is expanded. These results are confirmed for all but the Claremont model in Figure 34, which adopts the same format as Figure 33. Differences among model responses again appear to be significant.

A frontier for monetary policy effectiveness can be constructed for each model by connecting the appropriate point to the origin, which appears at the left and toward the top of the figure. Each line shows for a particular model the interest rate and level of real income necessary to maintain the



Note: LINK and Wharton responses are indistinguishable from each other.

Figure 34: Second-Year Interest Rate and GNP Responses to Monetary Accommodation

market for goods and services in equilibrium, where the amounts supplied and demanded are in balance.

This frontier reveals how strongly the demand for goods in a particular model responds to changes in the money market through the interest rate. Steeper lines signify conditions under which interest rate declines have less influence on real goods and services. These conditions prevail when: (1) real expenditures increase less with lower interest rates, and (2) the expenditure multiplier is smaller.

Chase, Hubbard-Fry, Wharton, and LINK show the monetary policy to have smaller real GNP effects for any given decline in interest rates. Conversely, Mork and MPS reveal substantially greater effects on real GNP for this same change in interest rates.

7.12 Relative Policy Effectiveness

These frontiers represent equilibrium conditions in the money market (Figure 33) and the goods market (Figure 34). Together, they jointly determine the relative effectiveness of monetary and fiscal policy interventions.[34]

Models will be predominately "monetarist" when the money market effectively constrains a demand expansion in the goods market. These conditions will occur when rising interest rates "crowd out" investment, offsetting the initial demand stimulus. For "crowding out" to happen, interest rates must react strongly to higher levels of real income, as represented by a steeply sloped line in Figure 33. Moreover, real expenditures must be highly sensitive to changes in interest rate, as represented by a relatively flat frontier in Figure 34. The Data Resources model possesses these characteristics and hence can be considered "monetarist" in this set of simulations. Moreover, Mork and St. Louis also appear to be strongly "monetarist", although they did not report results for the income tax cut.

When these conditions prevail, fiscal policy will be relatively ineffective in shifting aggregate demand outward. On the other hand, monetary policy will be relatively more effective in stimulating demand. The interest rate will fall more with an expansion in the money supply. Moreover, expenditures will respond more strongly to any given reduction in the interest rate.

Models will be predominately "fiscalist" when the money market does not constrain a demand expansion in the goods market. The conditions for this outcome are the converse of those outlined above. Interest rates are not greatly influenced by greater real income (Figure 33), and real expenditures respond relatively weakly to interest rate changes (Figure 34). Chase, Hubbard-Fry, Wharton, and LINK appear to be representative of this type of model.

From the previous discussion, the models can be ranked according to the relative effectiveness of fiscal policy as exhibited by the two frontiers. Models will rank high in this index when their fiscal policy frontier is flatter relative to the monetary policy frontier.[35]

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[34] See Hickman, *op.cit.*, for an explanation of how these frontiers are developed as well as for a diagrammatic framework showing how these curves jointly determine the interest rate and level of income.

[35] This index is calculated in two steps. First, each frontier for a model is expressed as an elasticity by calculating the ratio between the percent changes in real GNP and interest rates. Then, the elasticity for the frontier for fiscal policy effectiveness (Figure 33) is divided by its counterpart for monetary policy effectiveness (Figure 34).

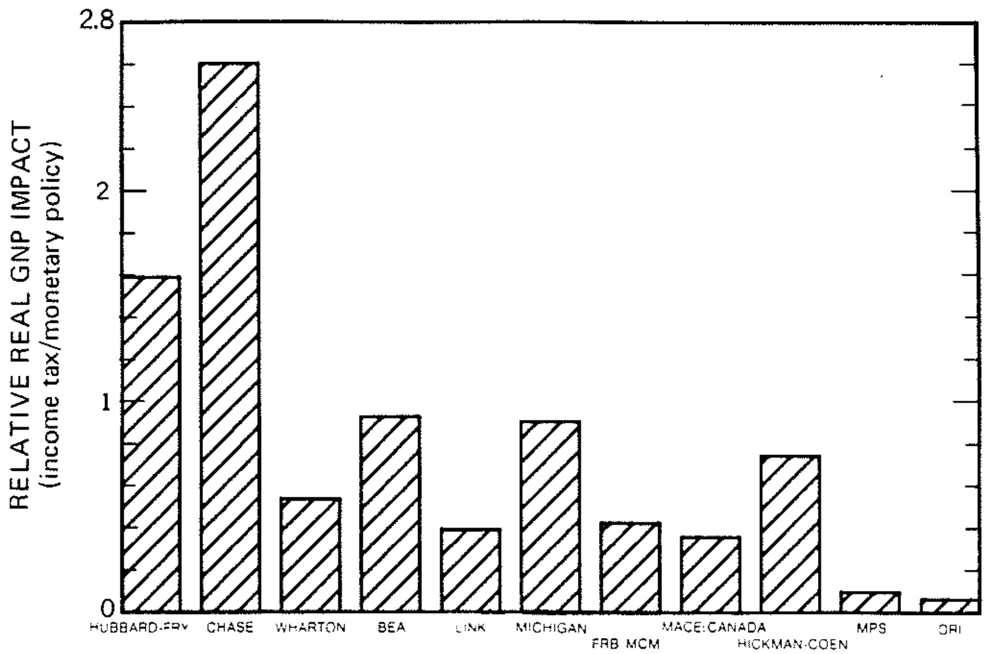

Figure 35: Second-Year Real GNP Response to Income Tax Reduction Relative to Monetary Accommodation

Figure 35 compares the observed response in real GNP due to the fiscal policy relative to its counterpart for the monetary policy. The models have been arranged in order, moving from left to right, according to the previously described index of relative fiscal policy effectiveness.

Chase and Hubbard-Fry show observed GNP responses to the fiscal policy substantially larger than their monetary policy counterparts. These models appear to the left of the figure where the models have relatively flat fiscal policy frontiers and steep monetary policy frontiers. By contrast, Data Resources and MPS reveal fiscal policy responses that are less than 20 percent of the monetary policy responses. These models appear to the right of the figure. The relative shapes of the two frontiers for policy intervention do appear to conform quite closely to the observed model responses to the two policy cases, particularly for models at either end of the range. The remaining models show that "money matters a lot" but that government expenditure and tax policies also influence aggregate spending.

This index also provides additional information about the price elasticity of aggregate demand discussed previously. A major reason for the negative relationship between the aggregate price level and real expenditures is the effect of prices on the real supply of money. A higher price level reduces real money balances, causing interest rates to rise and expenditures to fall. Thus, this effect is similar in concept to direct changes in the money supply itself.

The price elasticities for aggregate demand displayed in Figure 23 were estimated from information on the oil shock alone. Since these estimates were only approximations of the actual relationships embodied in the models, it is useful to check our previous estimates with this new information on the relative effectiveness of monetary policy.

Figure 36 graphs the price elasticity of aggregate demand for each of seven models in which interest rates rose during the first two years of the oil shock. The models are arranged according to the same relative effectiveness index, from highest to lowest, used in Figure 35. The revealed pattern does suggest that models with higher price elasticities are those on the right side of the figure, where monetary policy is relatively more effective (and fiscal policy less so).

This particular explanation for the shape of the demand curve is not appropriate for BEA, FRB Multi-Country, Michigan, and Mork. These models reported interest rates initially falling during the oil shock, revealing that the effect of rising prices on aggregate spending in these models can not be attributed primarily to reduced real money supply and higher interest rates. Indeed, these models generally showed large reductions in real government spending, and sometimes consumption expenditures, as a result of the increased price level.

7.13 Model Characteristics: A Summary

By simulating both oil shocks and economic policies, we have been able to identify the salient characteristics of U.S. macroeconomic models. For a short-run analysis of the first two years, these characteristics include:

- The effects of a standardized oil shock on the wholesale price of aggregate energy varies considerably across models. This variation is important for explaining differences among models in the estimated impacts on prices and real output.

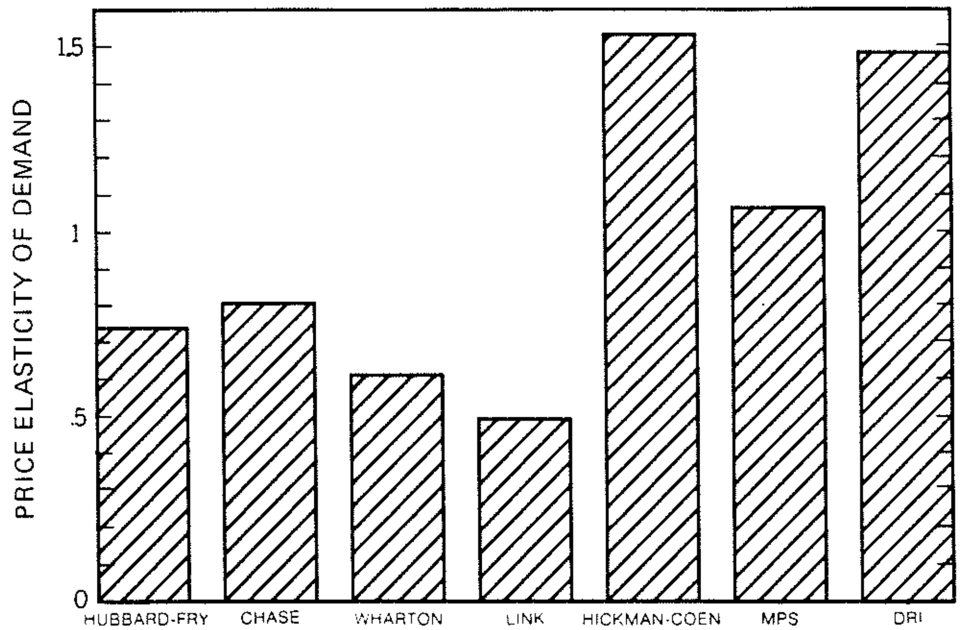

Figure 36: Second-Year Price Elasticity of Demand

- The short-run aggregate supply schedule for most models reveals substantial wage and price inertia as output declines and unemployment increases. However, there remains a considerable range of price responses across models. This wide range contributes importantly to differences among models in their estimated impacts of energy shocks.

- The estimated inflationary effects of an oil price shock are dominated by characteristics of the implicit aggregate supply curve in a model: its elasticity and the extent of its estimated upshift.

- The elasticity of total demand to the aggregate price level centers around unity and exhibits less variation than does the supply elasticity. This result implies that larger aggregate price effects of an energy shock will be associated with larger real GNP losses, if the money supply does not change with the shock.

- The substantial differences among models in their responses to economic policies primarily reflect different perspectives on the demand for money and its sensitivity to interest rates and economic activity and on the response of aggregate demand for goods and services to changes in the interest rate.

8 Conclusion

We have compared the responses of virtually all of the widely used models of the U.S. economy to energy price shocks and macroeconomic policies. There was widespread agreement that a 50 percent oil price shock would severely reduce U.S. real output and international purchasing power. Moreover, oil price reductions were generally found to be favorable to the U.S. economy, although some sectors might be negatively affected.

Real GNP measures the economy's output in constant dollar terms. It does not incorporate the losses in purchasing power that result when imported oil prices rise more rapidly than prices for domestic goods. About 70 percent of the output and purchasing power losses were represented by the estimated real GNP losses in the simulations for this study.

When offsetting the real output losses from an oil price shock, supply-oriented policies would have an important advantage over demand-oriented policies. An oil price shock would raise the prices of goods and services while reducing real GNP. Supply-oriented policies, like the payroll tax reduction or the oil stockpile release, would reduce the increase in prices while replacing some of the lost real GNP. In contrast, demand-oriented policies, like the income tax cut and monetary accommodation, would place additional upward pressure on prices while restoring some of the real GNP losses. However, supply-oriented policies may not be easily implemented. A reduction in the employers' share of the payroll tax may not be politically acceptable, and the building and maintenance of oil stockpiles would incur some costs.

Although there was generally strong agreement on the direction of the impacts of the various economic policies, there were substantial differences in the estimated magnitude of these impacts. The range of observed responses to economic policies appeared to be considerably greater than those to oil price shocks. This lack of consensus reflects legitimate differences among professional macroeconomists on the relative effectiveness of alternative economic policies.

Energy security policies have been advocated for reducing oil imports as well as the world oil price. Our simulations suggest that oil-importing countries should avoid energy policies like disruption tariffs, which reduce world oil prices and oil imports by raising domestic oil prices. While such policies may reduce purchasing power losses through lower world oil prices and oil imports, they induce an additional domestic oil price shock that reduces real output in the economy. On the other hand, policies like an oil stockpile release have an advantage over the disruption tariffs because they reduce domestic oil prices while reducing oil imports.

Reducing the size of the oil price shock can be quite beneficial in terms of limiting the real GNP losses. The effects of oil shocks on real GNP in this study were directly related to the amount of the oil price increase and to the induced effects on other prices in the economy. The level of energy imports at the time of the disruption was relatively less important for determining the reduction in the economy's real output. Even countries that were self-sufficient in energy would experience the macroeconomic adjustment losses highlighted in this study. However, the level of energy imports would still be important for determining the loss in purchasing power through the terms-of-trade effect.

Appendix 1A: Energy Shock and Policy Scenarios

In addition to a control or reference case, the working group requested the modelers to simulate nine other scenarios (Table 3 of the report). These included four energy price shocks, four macroeconomic policy responses, and an oil stockpile release. The five policy cases were simulated in conjunction with the biggest oil price increase (50 percent).

The scenarios were developed during a time of unusual uncertainties and major policy shifts. Thus, the working group did not consider the control case as a forecast but viewed it simply as a reference case for comparing the energy shock scenarios. Developing the control solution required extensive and explicit specifications for a number of government policy variables, e.g., money supply, government spending, and tax rates. In addition, relatively flat oil and gas price projections were specified, ruling out any oil price reductions or sudden natural gas price changes. This approach avoids any sharp energy price changes in the control case. And finally, oil import levels were also standardized in this case but were to be determined endogenously in the other scenarios by those models (a majority) that normally did so.

The control case in all the models showed an economy recovering from the 1982 recession with positive but falling inflation rates. Most importantly, considerable excess capacity and unemployment remained throughout the four years. Had the models simulated an economy with less excess capacity, the shocks could have induced greater price pressures, resulting in larger output losses.

The three international oil shocks were simulated as a one-time percentage step increase or decrease. In order to standardize these shocks, a number of additional specifications had to be implemented. These are listed in Table A.1. The most critical are the constant real federal purchases, unchanged tax rates, and the unchanged rate of growth of nominal money supply. In addition, earlier simulations of a shock and control case from Project LINK were used to develop response ratios for real exports, or for foreign activity levels and prices where exports are determined by the model.

Domestic crude oil prices were assumed to rise by the full amount of the international oil shock. Spillover effects on liquified petroleum gases and imported natural gas were incorporated by assuming that these prices increased fully with those for refined petroleum products. The link between oil and other energy prices is ambiguous, particularly in the response of domestic natural gas prices to the shock. In a deregulated market with no rigidities imposed by long-term contracts, these prices should move with the price of residual oil. However, the study design was developed at a time when natural gas prices were being controlled at levels that many thought would remain below oil prices at least until 1985. A Department of Energy analysis available at that time suggested that spillover effects on regulated gas prices, electricity prices, and coal prices would not be large: their neglect would understate the change in energy costs by about 5 percent.[36] Since these alternative fuel price changes enter the various models through different variables, standardization problems could be avoided by neglecting the small spillover effects. At appropriate places in this report, however, the impact of an oil price shock is discussed in relation to the resulting change in aggregate energy costs in the various models. This allows some consideration of different assumptions about the spillover effects on other fuel prices.

The relative magnitudes of the different price shocks are summarized in Table A.2. The initial change in the oil import bill (billions of dollars) is calculated in the first column by multiplying the preshock level of oil imports by the price change. The second column shows a similar computation for total expenditures on oil and natural gas. The third and fourth columns

[36]Further discussion of this DOE analysis is contained in Appendix 4A of B.G. Hickman and H.G. Huntington, "EMF 7 Study Design", *Macroeconomic Impacts of Energy Shocks*, edited by B.G. Hickman, H.G. Huntington, and J.L. Sweeney, Amsterdam: North-Holland, 1987 (Chapter 4).

Table A.1: Standardized Assumptions for Shock Scenarios

Energy prices	
Imported oil and natural gas	One-time percentage step increase or decrease beginning 1983 Q1
Domestic energy (oil, natural gas, coal, and electricity)	Crude oil, petroleum product, and LPG prices rise fully with imported prices. No additional increase for others.
Oil imports	Endogenously determined, except exogenous estimates by EMF staff for some models
Real exports of goods and services	Response based on Project LINK simulations
Money suppy (M1) growth	Held constant at control solution rate
Government expenditures	
Federal purchases	Constant in real terms
Federal transfer	Indexed to personal consumption deflator
Federal grants-in-aid	Constant in nominal terms
Social security and interest payments	Indexed to personal consumption deflator and interest rates
State and local government expenditures	Endogenous or held constant in nominal terms
Government receipts	
General revenues	Determined endogenously by holding constant all relevant tax parameters
Windfall profit tax	Indirect business taxes increase by \$0.6 B (nominal) for each \$/bbl increase in oil price. These revenues decrease federal deficit and are not spent.

Table A.2: Size of Shocks in Terms of Increased Expenditures on Oil Imports and on Total Oil and Gas Consumption

	1983 $B		% of GNP	
Case[a]	Oil Imports	Total Oil (Gas)[b]	Oil Imports	Total Oil (Gas)[b]
Hypothetical EMF Shocks:				
50% Oil Price Increase	33	99	1.0	3.0
20% Oil Price Increase	13	39	0.4	1.2
20% Oil Price Decrease	-13	-39	-0.4	-1.2
Natural Gas Price Increase (80%)	0	38	0	1.2
Past Oil Shocks:				
1973-1974	34	53	1.3	2.0
1979-1980	56	106	1.8	3.4

[a]Estimates for the EMF shocks are based upon a fixed total oil consumption of 15 MMBD, oil imports of 5 MMBD, and gas consumption of 17 Tcf. See next table for specific calculations for EMF and for past shocks.

[b]For EMF oil shock cases this column reports changes in expenditures when domestic oil prices rise by the same percent as imported oil price. Estimates do not incorporate the interfuel substitution effects of oil prices on natural gas and vice versa.

show these impacts as a percent of the 1982 GNP level. Although the largest oil price shock of 50 percent is smaller in percentage terms than the quadrupling and doubling of world oil prices in 1973 and 1979-80, respectively, total oil expenditures in the baseline represent a larger proportion of total expenditures in the economy due to the higher oil prices. As a proportion of aggregate output, the increase in oil imports is only slightly smaller than in the 1973 oil shock.[37] Note further that the 80 percent gas price shock was chosen to be equal to the 20 percent oil price increase in terms of total oil and gas expenditures, but it does not raise the cost of imported oil.

In the gas price shock, the average domestic wellhead price was assumed to increase by 80 percent above the control solution path for 1983-86, beginning in the first quarter of 1983. This scenario simulates an internal price shock associated with a domestic energy source, in this case natural gas. No effort has been made to link this scenario with proposals to dereg-

[37]This comparison is developed in Appendix 1B.

ulate domestic natural gas prices. It is unclear in today's energy market whether deregulation would lead to rising or falling gas prices. Even if gas prices were increased, natural gas price deregulation could involve important gains in economic efficiency. Many working group members thought that such gains could not be adequately incorporated without extensive further analysis external to the models. Modelers were instructed to ignore all such considerations and treat the shock solely as a domestic energy tax that brought natural gas prices up to parity with oil prices. It was assumed that the additional tax revenues were redistributed so as to leave the income distribution unaffected by the tax change.

The purpose of this scenario is to differentiate analytically between the macroeconomic impacts of an internal price shock and an external one. This internal price shock differs from the external oil shocks on these points: (1) the resource cost of energy is not increased by a reduction in its availability, (2) the prices of foreign goods are initially unchanged, and (3) all the increased energy expenditures are retained within the United States rather than flowing in part to foreign energy producers.

All policy scenarios were implemented to mitigate the GNP losses associated with the 50 percent oil price shock. A temporary spurt in the money supply growth (monetary accommodation) and a permanent reduction in income tax rates were simulated to represent policies for cushioning aggregate demand during a shock. In the first demand policy scenario, the money supply (M1) growth rate was increased by 3 percentage points over the control case in 1983 and by 1 1/2 percentage points in 1984, returning thereafter to the control case growth rate. Thus, the money supply level was 4 1/2 percent higher than the reference case after the second year of the simulation period. In the second scenario, marginal income tax rates were reduced by 10 percent across all groups for the 1983-86 period.

An increase in the investment tax credit and a reduction in the employers' share of payroll taxes represented supply-oriented policies that lower production costs in addition to affecting aggregate demand. Both policies were designed to be comparable to the income tax reduction case in terms of their initial impact on the budget. All three fiscal policies would initially reduce government receipts by $30 billion before any induced effects upon economic activity. The investment tax credit aims to increase investment by lowering the rental cost of capital. In this scenario the credit for equipment was raised from 9 percent to 22 percent, which is an extraordinarily large shift in this parameter. In the second supply-oriented policy measure, the employers' share of payroll taxes was reduced by 2.1 percentage points in one permanent step.

The final policy scenario represented a "stylized" oil stockpile release, which reduced both the price and level of oil imports relative to the 50 percent oil shock case. On the basis of the EMF's *World Oil* report and other analysis, an OPEC price reaction function was adopted that showed world oil prices falling by \$3 per barrel for a 0.5 million barrels per day stockpile release. This oil price change was implemented in approximate terms as a 5 percent reduction in oil prices from the shock trajectory.

A stockpile release can be an effective policy for offsetting a spike in the price of oil, i.e., when the price rises quickly and then falls back between its peak and beginning levels. Under these conditions the temporary stockpile release would smooth the price path to avoid the spike. However, a once-and-for-all stockpile release in the face of a permanent step increase in oil prices would serve mainly to delay the price shock from 1983 to 1984. This did not seem to be a particularly interesting case to analyze. For this reason, the stockpile release was implemented as a permanent increase in oil supply that reduced both the price and level of oil imports for the 1983-86 period. As formulated, the scenario serves two useful purposes. First, it provides an estimate for the first-year impacts of a temporary stockpile release. Second, it allows one to assess how the models treat a simultaneous reduction in both the price and level of oil imports in contrast with a direct change in the price alone.

Appendix 1B: Special Calculations

This appendix documents several calculations and conclusions that support the conclusions in the main report.

Size of the Shock

Table B.1 shows the fixed quantities as well as the energy price changes used for comparing the hypothetical and past shocks in Table A.2 in the previous appendix. The fixed quantities for the EMF shocks are approximate 1983 values. Those for the past oil shocks are simple averages of the quantities for the two years.

In the case of historical shocks, the price change is the observed price difference in 1983 dollars between the two years. All past nominal prices and

Table B.1: Oil and Gas Price Changes and Fixed Quantities for Calculations of the Size of a Shock

	Price Change[a] (1983 $)		Quantity[b]	
	Average	Imports	Total	Imports
Hypothetical EMF Shocks:				
50% Oil Price Increase	18.00	18.00	15	5
20% Oil Price Increase	7.20	7.20	15	5
20% Oil Price Reduction	-7.20	-7.20	15	5
Natural Gas Price Increase (80%)	2.24	—	17	—
Past Oil Shocks:				
1973-74	8.53	15.17	17	6.2
1979-80[c]	16.06	20.07	18	7.6

[a]Dollars per barrel for oil shocks; dollars per thousand cubic feet (mcf) for the natural gas shock.
[b]Million barrels per day (MMBD) for oil shocks; trillion cubic feet (tcf) per year for the natural gas shock.
[c]Price change is calculated as annual 1980 price relative to annual 1978 price.

quantities are those reported in Department of Energy, Energy Information Administration, *1983 Annual Energy Review*.

Induced Gas Price Increase

The response of gas prices to oil prices in the short run was an issue that lacked precise definition. This issue continues to be ambiguous given today's slack gas market with considerable "excess deliverability".

The EMF results can be generalized to the case where oil price increases induce upward movements in domestic natural gas prices. The incremental impact on real GNP will be the product of the following:

Contribution of domestic natural gas to producer price index for fuel and power	.07
Increment in refined petroleum product price	43%
GNP-energy price elasticity (median EMF study result)	.085

Thus, the proportional loss in real GNP due to the 50 percent shock could be as much as 0.26 percentage points more (about \$7.7B in 1983 dollars) than reported, if gas prices were to move fully with refined petroleum product prices.

Total Losses

The total losses due to an oil shock include: (1) the estimated reduction in real GNP as measured by the models, and (2) the decline in the terms of trade as calculated from model results on the change in real prices of oil imports and total exports. The terms-of-trade losses were calculated from the equation below as the difference between: (1) the change in real export prices times real exports, and (2) the change in real oil import prices times real oil imports. For this calculation, real export and oil import levels were held constant at the average in the shock and control cases. For most models, the terms-of-trade effect is dominated by the oil wealth transfer incorporated by the real price change for imported oil. The discussion below explains the calculation for the terms-of-trade losses.

The terms-of-trade losses measure the decline in U.S. wealth when the prices of goods purchased by the United States (including imports) rise more than the prices of goods produced within in the United States (including exports). Total domestic purchases or absorption can be defined as the sum of consumption, investment, and government purchases. It differs from the more conventional measure, GNP, by the absence of expenditures in the foreign trade sector of the economy. This can be seen by first defining nominal GNP (Y) and absorption (A) as:

$$Y = C + I + G + X - M$$

and:

$$A = C + I + G$$

where C is consumption, I is investment, G is government purchases, and X and M are exports and imports, respectively, as defined above. Then, subtracting A from Y yields:

$$Y - A = (X - M).$$

If the price deflators are allowed to change but the real expenditures (denoted by small letters) are held constant, the relationship between nominal GNP and absorption becomes:

$$y\Delta p_y - a\Delta p_a = x\Delta p_x - m\Delta p_m$$

Upon substitution of $a = y - x + m$ and rearrangement of terms, this equation provides an estimate of the wealth effect:

$$y(\Delta p_y - \Delta p_a) = x(\Delta p_x - \Delta p_a) - m(\Delta p_m - \Delta p_a)$$

It is important to separate nonoil from oil imports in the second term because the price deflator for total imports can change not only when nonoil and oil prices rise but also when the composition of imports changes. Since prices for nonoil imports were not reported by the modelers, we made the reasonable assumption that they rise with world inflation, which in turn could be approximated by the U.S. inflation rate. Thus, the real price change for nonoil imports become zero and this term can be eliminated.

Exports and Imports

The EMF oil shock causes a larger percentage decline in the volume of imported goods and services than in the volume of exports. While real exports uniformly decline by less than 2.5 percent by the second year, real imports are reduced by more than 2.5 percent in all but one model.

Even after excluding petroleum imports, real U.S. imports fall more than proportionately in the oil price shock scenarios. Table B.2 suggests the role of U.S. and foreign economic activity in these results. The GNP loss for the United States in these simulations exceeds the proportional decline in foreign OECD output. The latter is an assumption that has been derived from a special Project LINK simulation for standardizing the response of U.S. exports. In this special scenario, foreign governments were assumed to adopt more accommodating economic policies, which explains some of the differences between U.S. and foreign GNP effects. Using median EMF results, Table B.2 shows that once allowance is made for these differential GNP effects the decline in U.S. nonpetroleum imports does not appear more severe.

Simple Model

Figure 30 of the report demonstrated a striking consistency between the changes in the GNP deflator reported by the models and those derived from a separate analysis based upon estimates of the model characteristics. The simple model used to project the second set of impacts consists of an aggregate supply and demand curve of the following form:

$$Y_s = S_o P^a$$

Table B.2: Nonpetroleum Imports and Total Exports Standardized for Economic Activity, 50 Percent Shock versus Control

	Year			
	1	2	3	4
Real U.S. Non-petroleum Imports[a]	-1.9	-3.3	-3.5	-3.4
Real U.S. GNP[a]	-1.4	-2.9	-2.5	-2.1
Imports/GNP Ratio	1.4	1.1	1.4	1.6
Real U.S. Exports[a]	-0.9	-1.8	-1.4	-0.8
Real OECD GDP (excluding the U.S.)[b]	-0.9	-1.1	-1.3	-1.3
Exports/GDP Ratio	1.0	1.6	1.9	1.6

[a]Median percent change for U.S. models.
[b]Percent change from special Project LINK simulation used by each model for standardizing the response of U.S. exports to the shock.

$$Y_d = D_o P^{-b}$$

where Y_s is aggregate supply, Y_d is aggregate demand, P is the GNP deflator, a and b are the price elasticities of aggregate supply and demand, respectively, and S_o and D_o are constants. The model can be solved for an equilibrium price by setting $Y_d = Y_s = Y$.

The percentage change in any variable will be the difference between the logarithms of the shock and control values, denoted by Δln. In P-Y space, an upward shift in the supply curve due to an exogenous increase in the GNP deflator (e.g., reflecting the induced effects of higher oil prices) can be represented as:

$$\Delta lnP_o = -[1/a]\Delta lnS_o$$

in terms of the parameters of the model. When this substitution is made, the supply-demand equilibrium results in the following proportional impacts on real GNP and the GNP deflator:

$$\Delta lnY = [a/(a+b)]\Delta lnD_o - [ba/(a+b)]\Delta lnP_o$$

$$\Delta lnP = [1/(a+b)]\Delta lnD_o + [a/(a+b)]\Delta lnP_o$$

Table B.3: Percentage Change in Price Level for 1 Percent Increase in Oil Price, Second Year: Reported and Estimated from Model Characteristics

Model	Energy Price (%ch)	Elasticities		% Difference in Price Level	
		Supply	Demand	Reported	"Estimated"[a]
	(1)	(2)	(3)	(4)	(5)
LINK	.912	∞[b]	-0.5	.101	.091
Wharton	.912	∞[b]	-0.6	.097	.091
Chase	.617	304	-0.8	.063	.062
MPS	.648	14	-1.1	.059	.060
Data Resources	.562	3.0	-1.5	.031	.037
St. Louis	.562	3.4	-1.8	.031	.037
Hickman-Coen	.561	1.2	-1.5	.029	.025

Source: Hickman, op.cit.
[a]See equations in Appendix text.
[b]Estimated negative elasticities have been assumed to be perfectly elastic for this table.

The derived impacts were calculated for each model by setting $\Delta lnD_o = 0$ by assumption and $\Delta lnP_o = 0.1[\Delta lnP_e]$, where P_e is the wholesale price of fuel and power reported for each model.

Table B.3 shows the necessary data for the estimated impacts. These responses have been drawn from Hickman, op.cit.(Chapter 2). The supply elasticities are those derived from the monetary accommodation case, except for Chase. The estimated supply elasticity under a monetary shock is inappropriate for Chase, because there are large and important shifts in aggregate supply as money supply growth affects inflation expectations and hence wages in that model.

The price effects estimated by this simple model are reported in the last column. The output effects would be the estimated price effects times the demand elasticity and are not reported in this table. Where this approach underestimates the price response, it will also underestimate the impact on real GNP. For a given underestimate or overestimate of the price response, the difference between reported and "estimated" real GNP impacts will be greater for models with higher demand elasticities.

Table B.4: Summary Measures of Short-Run Structural Properties of U.S. Models

Model	Real GNP Responses[a] FIS	Real GNP Responses[a] MON	Real GNP Responses[a] (1)/(2)	Elasticities IS (MON)	Elasticities LM (FIS)	Elasticities AS (MON)	Elasticities AS (FIS)	Elasticities AD (OIL)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BEA	0.87	0.94	0.93	-0.07	0.14	10.7	20.5	-1.3
Chase	0.99	0.38	2.61	-0.01	0.10	0.7	304.4	-0.8
Claremont	0.02	0.83	0.02	N.A.	N.A.	0.6	N.A.	-1.0
DRI	0.14	2.05	0.07	-0.07	0.01	3.0	N.A.	-1.5
FRB MCM	0.97	2.28	0.43	-0.05	0.04	7.4	12.6	-1.2
Hickman-Coen	1.50	2.01	0.75	-0.09	0.03	1.2	0.6	-1.5
Hubbard-Fry	0.43	0.27	1.59	-0.01	0.17	1.9	-13.9	-0.7
LINK	0.50	0.93	0.54	-0.04	0.09	-1.8	2.4	-0.5
Michigan	1.14	1.26	0.90	-0.07	0.13	-8.2	-56.1	-2.6
Mork	N.A.	2.02	N.A.	-0.24	N.A.	2.1	N.A.	-1.9
MPS	0.41	4.09	0.10	-0.36	0.05	14.1	2.4	-1.1
St. Louis	N.A.	2.96	N.A.	N.A.	N.A.	3.4	N.A.	-1.8
Wharton	0.37	0.94	0.39	-0.04	0.08	-1.8	2.1	-0.6

Source: Hickman, op.cit., Tables 1, 2, and 5.
[a]Percentage differences between policy and 50% oil shock simulations.
N.A.—Not Available
FIS—Measures from income tax simulation, relative to 50 % shock.
MON—Measures from monetary accommodation scenario, relative to 50 % shock.
OIL—Measures from oil shock scenario, relative to control.

Estimated Model Elasticities

A complete set of elasticities for aggregate supply (AS) and demand (AD) as well as the fiscal (LM) and monetary (IS) policy frontiers, as estimated by Hickman, op.cit., are shown in Table B.4. These elasticities refer to the second-year responses of each model.