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INTRODUCTION

The oil shocks of the 1970s caused severe adjustment problems for oil-importing nations. Rapidly increasing oil prices created widespread joblessness and sharply higher consumer prices in these economies. These conditions confronted policymakers with a particularly pernicious trade-off. Pressure on consumer prices could be eased by adopting restrictive policies that slowed down aggregate economic activity and worsened unemployment. Alternatively, policymakers could try to protect jobs at the expense of possible increased inflation.

During the past several years oil prices have been falling, while inflation has weakened considerably. This more recent experience has reinforced the general public's perception that oil prices and inflation are very much interrelated. Monthly reports on inflation are usually accompanied by the latest estimates of the change in energy prices.

This paper reviews several key aspects of the relationship between oil prices and inflation. There has developed over the years an extensive literature on inflation that has been adequately reviewed elsewhere.[2] Moreover, several other sources lucidly describe the interactions between oil prices and the general inflation process.[3] Rather than duplicate these efforts, this paper will emphasize the available estimates of the effect of oil price increases on inflation in the United States.

[1] Abbreviation used: EMF, Energy Modeling Forum.

[2] Two such reviews include Trevithick & Mulvey (2) and Santomero & Seater (3). Moreover, see *Economic Report of the President* (4: pp. 32–47), or for a useful textbook treatment, Dornbusch & Fisher (5: pp. 419–65).

[3] See Congressional Budget Office (6) on the subject of energy shocks and inflation. Solow (7) and Poole (8) appraise macroeconomic policy for responding to inflation and unemployment following the 1973 OPEC shock.

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These estimates are derived from detailed macroeconomic models of the United States economy. These models were initially developed for explaining fluctuations in economic activity over the business cycle. Based on responses to economic conditions observed during the period following World War II, they focus on the determination of prices, expenditures, and income in the national economy. Since the 1970s, they have been extensively revised and expanded to incorporate important energy variables in order to study the consequences of oil shocks.

We develop in the next section several key conceptual points about the general inflation process. This discussion provides the appropriate background for the following section's consideration of available estimates of the effect of oil prices on consumer prices during the 1970s. Next, we focus on some more recent estimates of this relationship available from an Energy Modeling Forum (EMF) study on the macroeconomic impacts of energy price changes. This study focused on the effects on output, inflation, and unemployment during the four years after a hypothetical oil price change in the 1980s. It compared the responses of 14 prominent models of the aggregate economy (13 US models and 1 Canadian model) to energy price changes and to policies for cushioning the loss in real gross national product (i.e. adjusted for inflation) that results from sharp price increases.

The EMF results are discussed in two parts. We emphasize initially the broad conclusions about oil shocks and consumer prices that emanate from the comparison of models. In a second section we relate differences in these estimates among models to differences in observed characteristics of the participating models. A final section summarizes the key findings from this review of available estimates of the relationship between oil prices and inflation.

INFLATION

An appreciation of the estimated effect of oil prices on consumer prices requires some rudimentary knowledge of the general inflation process. We address only a few salient aspects of a complicated issue in order to highlight these important points: 1. economists make a sharp distinction between an increase in the price level for consumer goods and services and inflation (or the rate of increase in such prices); 2. the inflation experienced by an economy will depend on the amount of excess capacity and the aggregate economic policies (monetary, tax, and government spending) adopted by the government; and 3. due to the role of expectations, consumer prices should respond more strongly to expansions and contractions in economic activity over time. The third point becomes important for understanding the response of consumer prices to oil shocks over time.

Relative Prices and Inflation

Economists define inflation as a persistent tendency for a wide range of prices in the economy to rise over time. This definition excludes several phenomena.

First, inflation is not simply a rise in the price of one commodity while other prices remain unchanged. For example, the price of sugar or coffee can suddenly increase without inducing price increases in a wide range of commodities purchased by consumers. This increase in sugar or coffee prices relative to other prices would have very small effects on the general price level.

Second, even if other prices are significantly influenced, as happens during a widespread crop shortage or an oil disruption, this increase in the general price level will not necessarily continue for many periods after the initial jump in prices. Although measured inflation as represented by a variety of price indices will rise temporarily, economists do not consider these price increases as inflation unless the process continues.

It is sometimes argued that a sharp increase in oil prices will not raise the general price level, since other prices will fall over time. This statement that only relative prices are changing is seriously misleading on several accounts. In particular, many prices are sticky in a downward direction in the short run, and many others may actually move upward in sympathy with the oil price shock. Moreover, even with full employment and perfectly flexible prices, an oil price shock will result in a higher general price level. The energy shock will reduce total output by reducing energy use and capital formation. As output and income fall, households and businesses will demand less money than before. If the government does not alter the money supply (in current dollars) in response to the oil shock, the supply of money will exceed its demand. Prices must rise to maintain the demand for money balances (in current dollars) to satisfy the fixed supply of money.[4]

Thus, oil shocks will raise the general price level but will not necessarily lead to continued higher inflation rates.

[4] A simple monetarist explanation of this result would employ the basic "equation of exchange" relating nominal expenditures to the money supply, $MV = PY$, where M is the stock of money, V is its velocity or rate of turnover, P is the price level, and Y is real GNP. If both the money stock (M) and its income velocity (V) are fixed, reductions in real output (Y) would result in increases in the price level (P). Ott & Tatom (9) develop this monetarist perspective more fully and explain why they think that the income velocity (V) will be constant during an energy shock.

Inflation and Excess Capacity

Although inflation will be emphasized in this paper, this issue is closely associated with economic growth and unemployment. This point deserves some explicit consideration before we discuss estimates of the impact of oil prices on inflation.

Prices tend to rise more rapidly when there is less excess capacity and unemployment. Thus, a government can fight a burst in inflation by adopting more restrictive policies that limit economic activity and induce greater unemployment. Alternatively, it can accommodate the burst with more expansionary policies that will cushion the real GNP loss during the first few years. However, the latter policy will put greater inflationary pressure on the economy. As a result, the government faces a particularly pernicious trade-off between inflation and economic activity under these conditions.

This trade-off can be represented as a "reaction" function that relates the percentage change in money wages to the excess supply of labor. Since wages are a dominant factor in determining product prices, this relationship forms an important link to inflation. The degree of excess supply of labor is often measured as the unemployment rate, even though the latter has well known imperfections for this purpose.[5]

This "Phillips curve," shown in Figure 1, is not significantly different in concept from the OPEC price reaction functions that some world oil analysts have employed.[6] Both reaction functions show the response of suppliers, who have some discretion over setting prices, to the degree of slack in the markets in which they sell. With no further embellishments, this framework applied to the aggregate economy implies that a government could adopt an expansionary policy that lowered unemployment but increased inflation (moving from an original point A to point B) or a restrictive policy that lowered inflation but increased unemployment (moving from point A to point C).

An oil price shock will worsen both measured inflation and unemployment in the short run, pushing the trade-off outward from the origin. The economy's new position might be at D along curve II, as shown in Figure 1. The government might try to use aggregate demand policies to return

[5] Measured unemployment reflects decisions on entering and leaving the labor force as well as shifts in labor demand. Some economists have tried to overcome this problem by measuring job vacancy rates.

[6] Many of the world oil models discussed by the Energy Modeling Forum (10) used such reaction functions, relating the change in oil prices to the amount of excess productive capacity for oil.

temporarily to the lower unemployment rate at A, but inflation will be worsened as the economy moves to E.

Expectations

Over time, expectations become important and reduce the scope for expansionary policy for mitigating unemployment problems. Workers are concerned with their real wages (adjusted for inflation) rather than their money wages. Like OPEC, they seek a higher real price when high aggregate demand tightens the market. When the government embarks on an expansionary program, both money wages and expected future prices begin to rise. Workers base their new wage demands not only on the lower unemployment rate (as in Figure 1), but also on the higher anticipated inflation.

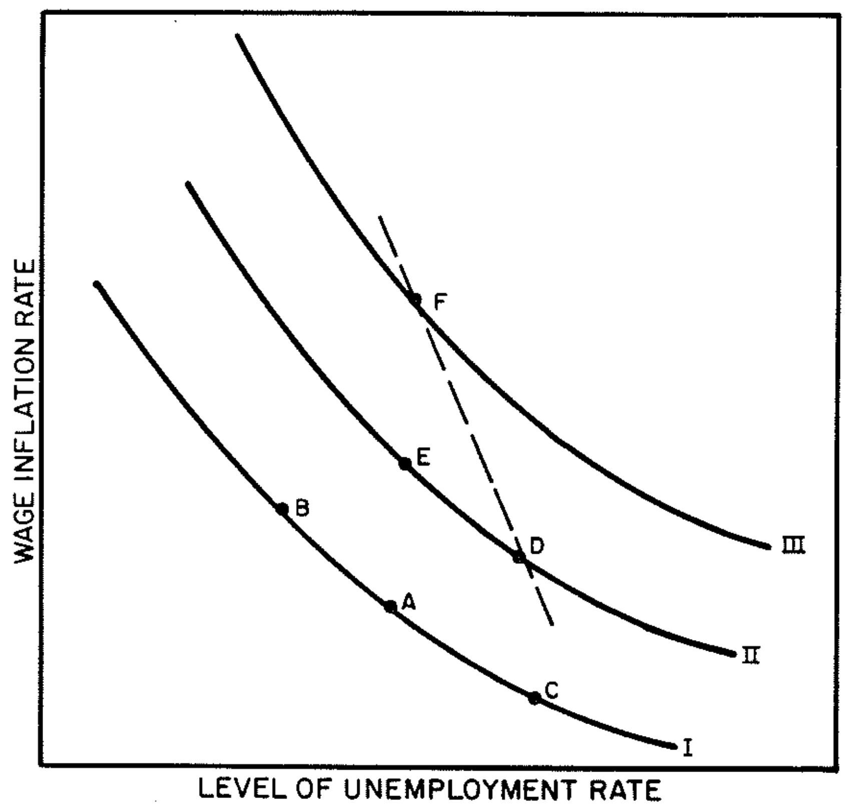

Figure 1 Short-run trade-off between wage inflation and level of unemployment rate (excess capacity).

Each time the anticipated inflation rate rises, workers demand a higher money wage rate at the old level of unemployment. These conditions are represented as an upward shift in the Phillips curve from II to III in Figure 1, implying that maintaining the old unemployment rate requires greater inflationary pressures. With the expansionary policy, the economy moves from point D to point F (rather than point E). Thus, over an extended period, the longer-run trade-off between inflation and economic expansion (represented by the dashed line) can become substantially steeper because anticipated inflation is increasing both actual inflation and unemployment in each period (through shifts of the curve upward and to the right).[7]

Expectations can also complicate the economy's response to restrictive policies for lowering inflation. Reductions in current output and labor demand should moderate wage demands, providing some inflationary relief. However, workers may believe that the government will not commit itself to a long-run strategy of high unemployment and that it will ultimately reverse itself by adopting an expansionary program in the future. The effect of these expectations may be buttressed by multiyear wage contracts and informal agreements and practices that avoid sharp wage reductions during slack times. Over time, wages and prices will adjust, although some economists believe that government policy must become very restrictive and unemployment very widespread (as happened during 1981–1982) before inflationary expectations are weakened enough to moderate wage demands.

The trade-off summarized by the Phillips curve is explicitly or implicitly imbedded in the macroeconomic models used to generate the estimates of inflation's response to oil shocks. Different assessments about the nature of this trade-off can be an important source of variations in the estimates to be discussed in the next several sections. One model may represent this trade-off as vanishing very quickly over time, i.e. the Phillips curve becomes steeper within a short time period. Another model may consider this trade-off as lasting longer.

In addition, this discussion emphasizes that these estimates are sensitive to the underlying aggregate economic conditions and policies during the oil shock. While very illuminating, the historical estimates from the 1970s and the representative ones for the 1980s may be inappropriate under a significantly different set of economic and policy conditions.

[7] These shifts result in a long-run Phillips curve that is considerably steeper than its short-run counterpart. In fact, when expectations correctly anticipate the experienced inflation rates, the Phillips curve becomes completely vertical, implying no long-run trade-off between inflation and unemployment.

PAST OIL SHOCKS

Declining world economic growth and mounting inflationary pressures characterized the 1970s after the oil price shocks of 1973 and 1979–1980. The United States' stagflationary experience is 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 1979–1980, 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 petroleum. Economic growth slowed dramatically during the severe recession of 1973–1975; the growth rate in real gross national product (GNP) declined from 3.6% for the four previous years to −0.9% for this two-year period. As a result, the real GNP level was 7–8% lower by 1975 than it would have been if it had increased by 2.5–3% per year during these years. Inflation as measured by the GNP deflator increased from about 5% to 9% per year during this same period.

Past studies of this 1973–1975 period assign a significant part of this poor

Table 1 Economic growth, inflation, and unemployment during 1969–1980

	1969–1973	1973–1975	1975–1978	1978–1980
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 (%), end of period	4.9	8.5	6.1	7.1

Source: *Economic Report of the President*, 1983.

economic performance to the first oil price shock during the last quarter of 1973. Previous simulation studies with macroeconomic models suggest that the 1975 GNP level was reduced by about 3.0–5.5% by the oil shock alone.[8] These same models attributed about 2 percentage points 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 1975–1978 was far higher than its long-term trend, reflecting the economy's rebound from the 1973–1975 experience. Moreover, inflation was increasing throughout this period, reaching 7.4% (as measured by the GNP deflator) by 1978. Finally, major shifts in US macroeconomic policy and the substantial appreciation of the US dollar complicate 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 US economy. It was estimated that the level of real GNP would have been about 2–4% higher and prices 1–3% lower by the second year if the second oil price shock had not happened.[9]

This review of the 1970s experience suggests that each oil shock raised prices throughout the US economy by 2% or more, but that measured inflation subsided in later years. Expansionary macroeconomic policies in the mid-1970s (after 1975) kept inflation from returning to its pre-1973 level. While these increases were significant enough to cause hardships and widespread public concern, they appear to be moderate compared to the underlying inflation rate that was increasing over time. Inflation in the United States rose from about 1% per year in the early 1960s to 4–5% by the end of that decade. After the first OPEC oil price shock it returned to 6–7% through the 1976–1978 period. By 1980–1981, it peaked at 9–10% following the second oil price shock, beginning in 1979. Later, annual inflation rates fell to 3–4% during the last three quarters of 1983. This break in the inflation rate demonstrates that inflation can be curtailed if the country is willing to allow substantial and widespread unemployment. An important policy dilemma is how much economic activity should be foregone to achieve this lower inflation rate.

[8] Dohner (11) derives this conclusion after reviewing simulation studies performed with the MIT-PENN-SSRC (MPS), Michigan, Data Resources (DRI), Mork, and Fair models.

[9] The lower estimates for the second OPEC shock are from simulations with the DRI model reported by Eckstein (12); the higher ones are reported for the Mork model by Mork & Hall (13).

THE ENERGY MODELING FORUM STUDY

In 1982–1983 the Energy Modeling Forum undertook an effort to compare the responses of macroeconomic models of the United States to hypothetical future oil price shocks and to policies for mitigating the adverse real GNP effects of such events. The participating models and specific assumptions of the 10 scenarios simulated in that study are described at length by the Energy Modeling Forum (1). A complete list of the participating models appears in Table 2.

Importantly for this discussion, the working group specified oil shock simulations in which there were no conscious government efforts to mitigate either the higher prices for all goods and services or the reduced real GNP. The estimated inflation effects would have been lower than reported here if restrictive policies for holding down inflation, such as a tighter monetary policy, had been assumed. They would have been higher if expansionary policies for stabilizing real GNP had been included. The working group also simulated the effects of expansionary or accommodating policies in separate policy scenarios, which are reported in the Energy Modeling Forum (1) but not here.

The estimated impacts in the study are also sensitive to the underlying economic trends that were assumed to prevail in the absence of a change in oil prices. Specifically, considerable excess capacity and unemployment remained throughout the four-year horizon of the study, although the economic slack decreased over time, as has happened during the 1980s. Had the models simulated an economy with less excess capacity, the estimates would have shown greater pressures on prices in the economy.

Oil Price Increases

The EMF results indicate that an oil price shock would produce an immediate short-run burst of inflation, which is considerably weakened by the third and fourth years. For a sustained 50% increase in the oil price, the prices of goods and services purchased in the United States would rise by about 2% in the first year and by another 1% in the following year. These results are similar to the previously reported effects caused by the historical oil shocks of the 1970s, which were roughly comparable in size to the 50% shock in terms of increased expenditures for oil imports. While these impacts are significant, they are not overwhelming in the context of inflation rates experienced during the past decade.

The price level for all goods and services, as measured by the implicit price deflator for GNP in Figure 2, 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

Table 2 Features of participating models

Model	Stochastic equations	Parameter estimation period	Data frequency		Endogenous oil import		US macro forecasting and policy	Linkage
			Q	A	Price	Quantity		
Large US								
BEA Quarterly Econometric	150	1959–1979	×				×	
Chase Quarterly Macroeconomic	250	1958–1980	×			×	×	
Data Resources Quarterly	424	1960–1980	×			×	×	
LINK	3000[a]	1955–1980	×		×	×		International Macro
Michigan Annual Econometric	64	1954–1979		×			×	
MPS (MIT-PENN-SSRC)	130	1946–1980	×			×	×	
Wharton Quarterly	432	1955–1980	×			×	×	
Small US/International								
Claremont Economics Institute Domestic	10	1970–1980	×				×	
FRB Multi-Country (MCM)	500[b]	1960–1975[c]	×			×		International Macro
Hickman-Coen Annual Growth	60	1949–1979		×			×[d]	
Hubbard-Fry	80	1960–1980	×		×	×		Energy-Macro
MACE (Macro Energy)	23[e]	1955–1980		×		×		Canadian
								Energy-Macro
Mork Energy-Macroeconomic	15[f]	f		×	×	×		Energy-Macro
St. Louis (FRB) Reduced-Form	3	1955–1981	×					Energy-Macro

[a] Total for 32 countries.
[b] 100 for each of five countries (Canada, Germany, Japan, United Kingdom, and United States).
[c] Oil and exchange rate equations are estimated through 1980.
[d] Long run as well as short run.
[e] Macroeconomic sector only.
[f] Parameters are judgmental rather than estimated.
Source: EMF (1).

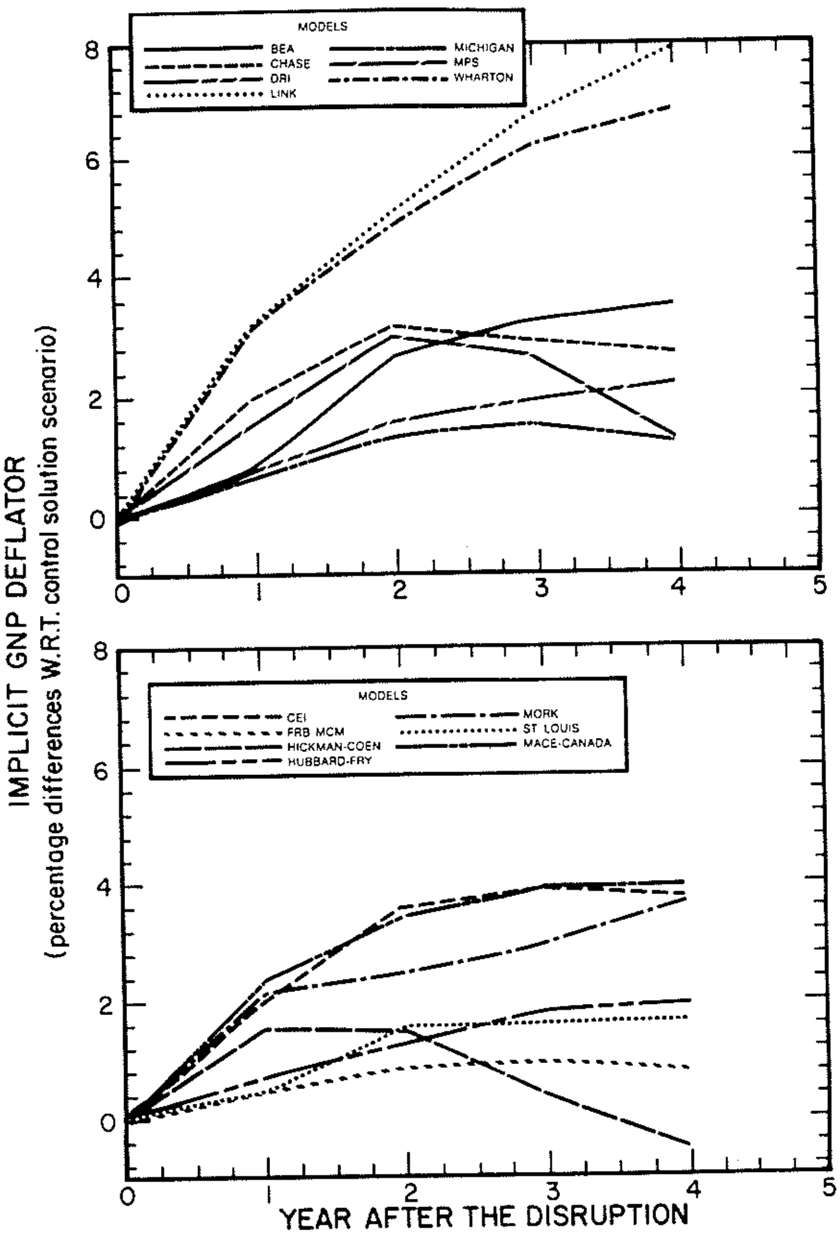

Figure 2 Effect of 50% oil shock on aggregate price level by year.

as growing unemployment and excess productive capacity moderate 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 all goods and services in all models. However, it does not alter the underlying inflation rate, or 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 its rate prevailing without an oil shock. This conclusion is represented more directly in Figure 3, 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 be not much above zero. 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.

Measurement of Inflation

The inflation effects have been measured by the GNP deflator because it is the one price index reported by all modelers. 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 the final goods and services purchased in the United States. Therefore, it does not directly include the price of oil imports (or other imports) and hence will understate the inflation induced by an oil shock.[10]

Three other indicators in Table 3 represent different measures that

[10] The implicit GNP deflator is calculated as:

$$\frac{PC \times C + PI \times I + PG \times G + PX \times X - PM \times M}{C + I + G + X - M}$$

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. Actually, 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.

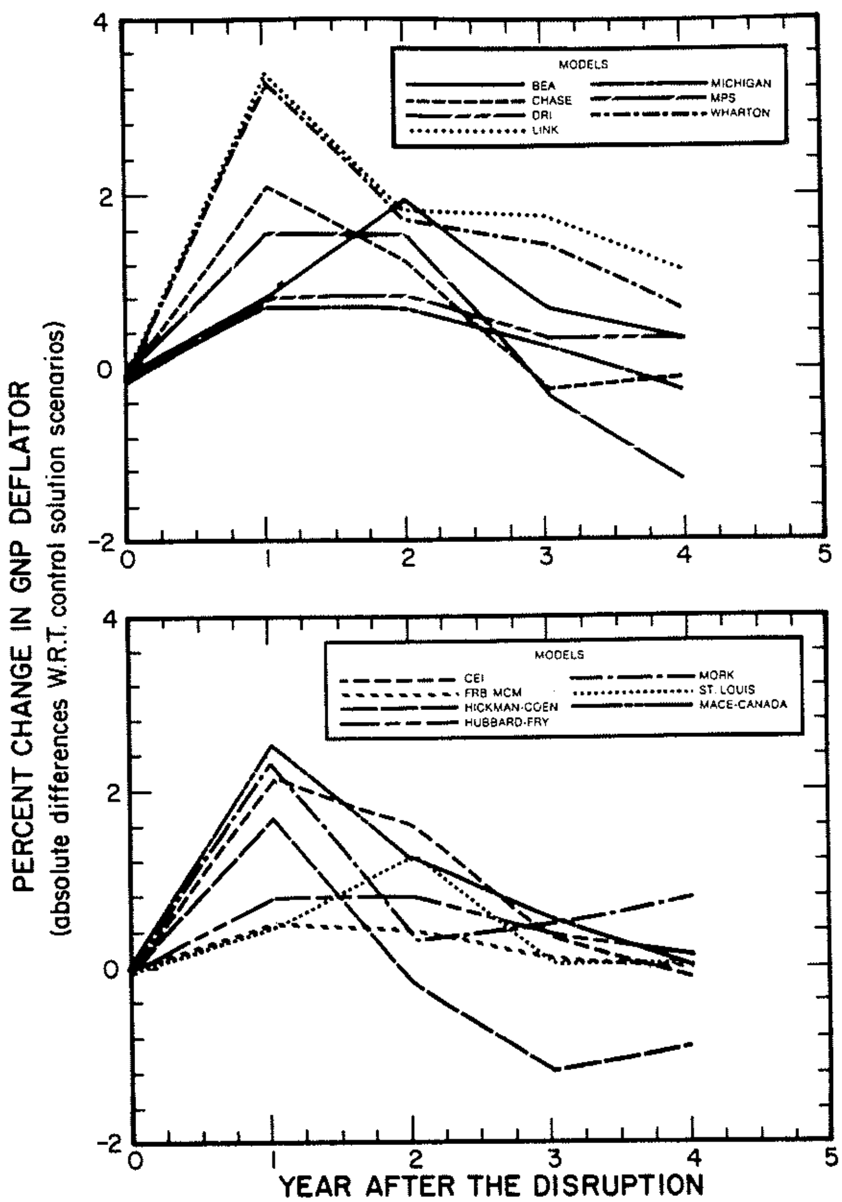

Figure 3 Effect of 50% oil shock on inflation rate by year.

overcome this problem by measuring prices of goods consumed in the United States including imports. These include the price deflators for gross domestic purchases and personal consumption expenditures and the consumer price index. The last measure represents the cost 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 for consumption.

The main difference among 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 predominantly indirect results of the previous rise in the price of imported oil. Nevertheless, the absolute level of the GNP deflator remains permanently lower than those of the other indices. This occurs because the oil price shock has no direct effect on the GNP deflator but does directly increase the three other measures.

As a result, the inflation effects shown in Figures 2 and 3 will be similar to those based on 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 was used or 0.8 percentage points higher if the

Table 3 Comparison of different inflation measures for 50% oil shock case (Median Model results) for US models, excluding LINK

Inflation measure	Absolute difference in inflation rates with respect to control solution scenario for 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

[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.

deflator for personal consumption expenditures was used. From Table 3, we conclude that inflation from the consumer's perspective would increase by about 2 percentage points in the first year and by an additional percentage point in the second year.

Direct and Indirect Price Effects

Oil price shocks have both direct and indirect effects on the prices paid by consumers. The direct effects occur as crude oil prices raise the price of gasoline and heating oil used by households. In addition, crude oil prices will indirectly raise the prices of final products that use energy.

A very significant part of the first-year effect on the general price level originates with the price increases experienced directly by households. A 50% increase in crude oil prices will translate into a substantially lower percentage price increase for petroleum products purchased directly by households, because of the difference in price levels between crude oil and products. Table 4 shows that the 1983 crude oil price was approximately 60% of the product price level and that motor gasoline and heating oil combined accounted for slightly more than 5% of total personal consumption expenditures by households. A somewhat simplistic but revealing benchmark estimate of the direct price effects can be derived from these expenditure shares by assuming that a 50% crude oil price shock raises product prices by 30%. Under such conditions, the table highlights that the combined effect of higher oil prices on the price deflator for total personal consumption expenditures would be about 1.6%, or 80% of the first-year effect reported in Table 3.

The indirect price effects play a more dominant role by the second year. The estimated 1.6% of direct effects represents about 60% of the total combined inflation impacts over the first two years. A significant part of the indirect effect can be accounted for by wages, which rise by about 0.9% for the median model result by the second year. (Total employee compensation represents about 75% of total national income, which excludes capital

Table 4 Estimate of direct price effects of 50% oil shock on households

	Ratio of crude to product price	% of total personal consumption expenditures	Estimated direct effect of 50% oil price increase
Gasoline	0.60	4.2	1.3
Fuel oil[a]	0.64	1.0	0.3
Combined	—	5.2	1.6

[a] Expenditures are for fuel oil and coal.

depreciation allowances.) Changes in labor productivity can also be important, because firms are viewed as setting prices based on unit labor costs in these models. Unit labor costs rise with wage increases but fall with gains in labor productivity.

Oil Price Reductions

There has been recent interest in the effects of oil price reductions on inflation and the US economic recovery. Some say that the economy can only benefit from an oil price reduction, while others think that financial constraints and adjustment costs could be harmful to the economy.

When the economy is experiencing significant unemployment, the economic gains from an oil price reduction are equal but opposite to the losses induced by an oil price increase of comparable size. The model results suggest that, by the second year after a 20% reduction in the world oil price, real GNP would be about 1.2% greater than otherwise, while the inflation rate as measured by the GNP price deflator would be about 0.4% lower in each of the first two years. Table 5 summarizes the principal impacts on economic activity and inflation in terms of each $2 per barrel reduction in the world oil price. The models show unambiguously that an oil price reduction will have a net benefit to the economy. Oil price increases during the last decade contributed to the stagflationary conditions of greater short-term inflation and lower economic output; conversely, an oil price reduction in today's economy should ease short-term inflationary pressures and aid the economic recovery.

Table 5 Economic impacts of future oil price reductions: based on results of the EMF study

Impacts resulting from a $2 per barrel reduction	Impact in year[a]:	
	1	2
Incremental effect on:		
Real GNP level (%)	0.15	0.33
Price level/GNP deflator (%)	−0.12	−0.22
Unemployment rate	−0.06	−0.14
Change in inflation rate:		
GNP deflator	−0.12	−0.12
Consumer prices	−0.24	−0.12

[a] Table should be read as follows: During the second year after an oil price reduction of $2 per barrel, the GNP level will be 0.33% higher, the price level as measured by the GNP deflator will be 0.22% lower, and the unemployment rate will be 0.14% less than otherwise. Inflation rates would be 0.12% lower.

All these developments represent an unqualified gain for the US economy. Of course, sudden price changes, rising or falling, will create adjustment problems for certain firms and individuals. These problems 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 affect all economies by depressing world economic trade. While these caveats are important to note, they do not invalidate the EMF conclusions that moderate oil price reductions are beneficial for the US economy.

DIFFERENCES AMONG MODELS

The previous results emphasized a strong consensus among participating models in describing the dynamic response of inflation to oil price changes. A short-term burst in prices throughout the economy was eventually weakened by the third and fourth years. However, the models did show noticeable differences in the effect of oil prices on the aggregate price level for goods and services during the first two years. In this section we probe the differences between models by concentrating on changes in the aggregate price level rather than inflation rates.

Important differences in estimated inflation effects of an oil shock can be attributed to varying model structures and assumptions about key parameters. Hickman (14) used the results from the oil shock and policy scenarios simulated in the EMF study to derive certain key parameters associated with the participating models. The full analytical framework, outlined in detail by Hickman (14) and more briefly by the Energy Modeling Forum (1), is based on an analysis of aggregate supply and demand conditions in the economy.

Size of the Energy Shock

One important parameter that determines the estimated responses to oil shocks is rather straightforward. The models demonstrated a striking difference in the effect of oil prices on the aggregate price of energy. The latter is measured at the secondary level in most models, as the wholesale price index for fuel and power. It incorporates the wholesale prices of refined petroleum products, natural gas, coal, and electricity, as well as the average crude oil price to refiners.

The differences between models on the magnitude of the energy price shock is a little surprising, because the EMF study design attempted to standardize for the price responses associated with other energy sources. Some models used an input–output approach to determine the initial impact of the oil price shock on the producer price index for fuel and power. If oil prices accounted for 50% of the total value of energy costs, a 50% oil price increase would translate into a 25% increase in the producer price index for energy. In general, the energy price index changes by a similar amount across these models. Other models used a historical regression of the producer price index on the cost of oil and other variables. These models indicated energy price changes that differed from each other as well as from those in the first group of models. While there was some criticism of the input–output approach on the grounds that the weights were from 1967 or 1972 input–output tables and hence might be out of date, at least one modeling group decided to revise its results by rescaling its energy price shocks to be consistent with the models based on the input–output approach. This revision, however, was not uniformly accepted, and differences in the treatment of linkages between oil and energy prices remain.

This issue remains an important source of differences between models. Ironically, it reflects different approaches for estimating the link between energy prices rather than variations in the key macroeconomic relationships represented in the models.

Price Stickiness

A second significant parameter is the response of the aggregate price level for all goods and services to the excess capacity or unemployment rate. Prices in the economy are usually represented in these macroeconomic models as set by firms on the basis of markups above the average unit costs of variable inputs like labor, energy, and other materials. Labor costs form a large share of these costs. As discussed previously, the money wage rate negotiated by labor can be quite sensitive to the unemployment rate. As firms curtail their planned levels of output, they decrease their demand for labor, putting downward pressure on money wages and final prices of goods and services. In addition, the markups used by firms can also be sensitive to the degree of excess capacity, decreasing somewhat at higher levels of unemployment. Both factors contribute to reduced pressure on the general price level for goods and services when falling economic activity increases unemployment during an oil shock. These effects partially counter the upward movement in prices generated by the increase in oil prices.

Cyclical changes in labor productivity will tend to weaken but not reverse the response of the aggregate price level to the unemployment rate. During a recession, output falls more rapidly than labor demand because firms try to maintain their labor forces in anticipation of better times in the future. Immediate layoffs would require costly retraining when the economy begins its recovery. As a result, a reduction in economic activity accompanied by a less than proportional decline in employment lowers output per worker immediately after an oil shock. [This temporary decline is separate from any longer-term deterioration in labor productivity, as discussed by Dohner (11).] This cyclical deterioration in output per worker raises unit labor costs, which are passed through by firms to the final prices of goods and services.

The effect of output reductions on the aggregate price level in the economy is often summarized in terms of an aggregate supply curve for the economy. The shape of this function represents the price elasticity of output, which measures the proportional decline in output associated with a 1% decrease in prices. Higher price elasticities denote greater insensitivity of prices to changes in output.[11]

Aggregate Demand Responses to Price

The estimated effects of an oil shock on the price level in the various models are dominated by the two preceding model characteristics: the effect of oil prices on the wholesale price index of fuel and power and the price elasticity of aggregate supply. In fact, a simple analysis based only on these characteristics is extremely effective in explaining much of the difference between models. However, the macroeconomic effects depend conceptually on a third parameter, the price elasticity of aggregate demand (the response of total spending to a higher price level for goods and services).

When the aggregate price level rises, real output can be directly discouraged through several mechanisms: (*a*) The fixed nominal supply of money will be reduced in real terms, resulting in higher interest rates and reduced investment and purchases of consumer durables; (*b*) real consumption may be reduced by a decline in the real value of assets held by households due to higher prices; (*c*) government purchases may decline to the extent that they are not indexed or adapted to the higher price level; and (*d*) real net exports will be reduced as higher domestic prices make domestic goods less attractive and foreign goods more attractive, under the assumption of fixed foreign prices. In all these cases, the initial declines in aggregate demand due to rising prices will induce further reductions in consumption and investment expenditures through multiplier and accelerator effects.

The price elasticity of aggregate demand was not as important for explaining model differences in the EMF study, because it tended not to vary greatly from unity in most models. With an unchanged nominal

[11] Conversely, output is more responsive to price for higher price elasticities. Energy economists often use a similar concept to measure the flexibility in energy demand when energy prices are changing.

supply of money, a rising price level reduced real spending on goods and services by an approximately equal proportion. By the second year, nominal GNP (the GNP deflator times real output) was not substantially below its reference levels in many models.

A simple supply–demand model of the aggregate economy was developed during the study to try to explain the key differences between the models. This framework allowed one to develop some basic relationships among prices, economic output, and energy price changes. The key parameters identified previously were derived from the policy and oil shock scenarios by Hickman (14), who discusses extensively the important assumptions and caveats necessary for interpreting these estimates correctly.

Figure 4 emphasizes how closely the reported model results for the change in the aggregate price level during the 50% oil shock conform to this simple supply–demand framework. The figure compares the percentage increases in the GNP deflator reported by the models with those calculated from the simple analytical framework, using Hickman's estimates of the model parameters. The analysis was restricted to the US models that reported a variable for the change in the wholesale price of fuel and power.[12] Further discussion of the approach is included in the appendix of the full EMF report (1984).

All models lie either on or near the 45° line that indicates when the calculated impacts equal those reported by the models. Moreover, the simple model preserves exactly the ordering of the reported price responses, from the model showing the highest impact to the one revealing the smallest effect. The effects on the aggregate price level depend positively on: (*a*) the size of the shock in terms of its effect on the wholesale price for aggregate energy and (*b*) the degree of inertia in wages and prices with increasing unemployment; and negatively on (*c*) the responsiveness of total spending to changes in the aggregate price level.

The Wharton results show the largest effect on the aggregate price level because oil prices in the Wharton model influence energy prices more, while wages and prices are less responsive to unemployment than in other models.[13] For the opposite reasons, the Data Resources, St. Louis, and

[12] 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 change in the primary energy price will understate that in the secondary or wholesale energy price that includes electricity. We did not attempt to include these models in the present calculation because it would have required some arbitrary assumptions about the relationship between the two energy prices.

[13] The aggregate price level in the Wharton model also depends on the cost of capital, which increases when interest rates rise in response to the oil shock. This specification, which is not found in the other models, makes prices appear less responsive to increased unemployment.

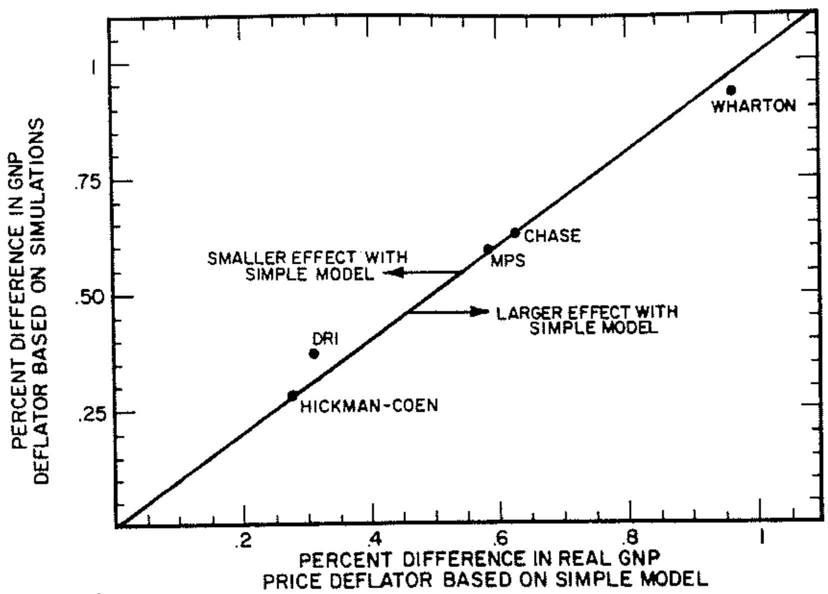

Figure 4 Comparison of second-year effects on aggregate price level with estimates from basic supply–demand analysis.

Hickman-Coen results reveal smaller impacts on the general price level. While the estimated response of prices in the economy to oil price shocks will vary across models, these differences can be attributed to structural characteristics that can be clearly identified.

As explained earlier, the general price level begins to moderate over the four-year period considered in the EMF study. The oil shock triggers a wage–price spiral that puts upward pressure on the prices of all goods and services. However, over time these prices become more sensitive to the unemployment that accompanies the initial spurt in prices. This charac-

Table 6 Average price elasticity of aggregate supply as revealed in EMF income tax reduction scenario

	Year:			
	1	2	3	4
Estimated price elasticity of aggregate supply[a]	20.0	2.61	1.04	0.55

[a] Measures the proportional decline in economic output for every 1% reduction in the general price level, when aggregate demand falls.

teristic of the models provides an important explanation of why the initial spurt in prices is not maintained and translated into a permanent inflationary spiral. In the absence of accommodating policy (e.g. an expansionary monetary policy), reductions in aggregate output will place increasing downward pressure on wages and prices. This response is summarized in Table 6, which shows that the average price elasticity of aggregate output, as estimated from the EMF policy scenario of a reduction in income tax rates, decreases markedly over the four years of the simulation period.

CONCLUSIONS

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 inflationary relief has resulted from the recent oil price reductions.

The EMF 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 would rise an additional 2% during the first year and 1% during the second year as a result of the 50% oil price increase. Moreover, the inflation effects in the 50% shock case do not last; they moderate over time and become negligible by the fourth year. A one-time increase in the price of imported oil cannot permanently alter the underlying inflation rate so long as economic policy, particularly the growth rate of the money supply, is not changed in response to the oil shock.

These results suggest that a prudent policy for future oil market disruptions should avoid combatting the short-lived burst in measured inflation by purposely reducing economic activity (through restrictive monetary, tax, and expenditure policies). While painful during the first year or two, these price increases would shortly be weakened by the slowdown in economic activity that results from the oil shock itself. Adopting more restrictive macroeconomic policies, as was done after the 1973 OPEC embargo, appears to be both unnecessary and extremely costly under these conditions. A more difficult question, which is not addressed here but considered in the EMF study (1), is to what extent discretionary economic policy should be used to offset declines in economic activity, with possible adverse effects on inflation.

By analogous reasoning, we should not expect long-term relief from inflation to materialize from one-time decreases in world oil and other energy prices. The oil price reduction in 1983 and softening domestic energy prices have lowered the general price level for all goods and services below what it would have been otherwise, thereby temporarily reducing measured inflation. However, these energy price reductions will not permanently lower the underlying inflation rate of the economy during the 1980s, unless fuel and electricity prices continue to fall throughout the decade.

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