THE ENERGY PRICE SHOCK
AND THE 1974-75 RECESSION

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I. Introduction

The rapid escalation of energy prices in late 1973 and early 1974 has a dominant role in most accounts of the deep recession of the mid-1970s. This paper attempts a quantitative appraisal of that role with respect to real output, prices, and employment in the US economy. It finds that some but not all of the traumatic features of the recession can be reproduced within a simple macroeconomic model with an energy sector. Part of the large decline in real output and in employment can be attributed to the two mechanisms that have been proposed to link energy price shocks to aggregate economic activity: higher energy prices drive up interest rates and depress investment on the one hand, and reduce real incomes and so depress consumption on the other hand. But our results do not fully explain another critical feature of the recession -- the worsening of inflation in 1974 and its continuation at a high level in 1975. Either this inflation is partly attributable to conditions in labor and product markets that were much stronger than the unemployment rate of around five percent suggested, or our characterization of the influence of energy prices on wages and other prices is deficient. Much remains to be understood about the inflation of the 1970s.

Our model incorporates the modern hypothesis of rational expectations, but it is also somewhat Keynesian in treating money wages as predetermined in the short run. In a purely classical economy where wages clear the labor market instantaneously, an unexpected energy price increase would have little or no impact on output, employment or prices. When the price of one factor, energy, increases, the prices of other factors, especially
the wage, would fall to offset it. Full employment should always prevail, and the price level should be linked directly to the money stock. In our model, on the contrary, wages respond slowly to unexpected changes in energy prices (and to all other surprises in the economy). During the period following an energy price increase but before the accommodating change in the wage, labor is priced too high for full employment. The model contains an explicit treatment of this aspect of the effect of an energy price shock; investment and interest rates play an important role in the relation between the sticky wage rate and the resulting level of employment.

When energy is partly imported, as in the US of the 1970s, another consideration links output and employment to an unexpected increase in energy prices -- higher prices make the US poorer and so reduce the level of consumption in real terms. Often this is compared to the imposition of a tax on US consumers with the proceeds going to foreigners. As the US is made poorer, energy-supplying nations become richer. They acquire claims upon the US and face the choice of accumulating the claims (as government or corporate bonds, stocks, direct investments and so on) or cashing them in for goods produced in the US. At one extreme, if oil producers decide to accumulate all of their claims, the fall in aggregate demand associated with the decline in US real income is not offset at all. Placing purchases in third countries would have the same effect on the demand for US goods, at least temporarily. At the other extreme, oil producers might take all of their proceeds in the form of US goods, in which case there would be a full offset of the reduction in US consumption, and aggregate demand would be unaffected on this account. Our model does not attempt to explain the choices of oil producers in this regard, but uses a guess that oil producers
consume out of their new income at the same rate as domestic consumers. If anything, this is probably an understatement of the effect that this transfer of wealth had on the demand for goods.

The model does keep track of one important feature of the balance of payments aspects of the energy price shock that is often overlooked -- as foreigners accumulate the debt of the US, the US capital stock increases accordingly. Though the deficit in the balance of payments is generally considered an adverse outcome of the energy price increase (and is, from the perspective of aggregate demand), it can also be viewed as a capital inflow adding to the productive capacity of the US economy. This inflow has a favorable effect on aggregate supply.

II. The Model

The model used here is an extension of one described by Hall (1978); some of its details are explained more fully there. The present model treats the economy as having two sectors, goods and energy. Goods include all goods and services, including finished energy products. Labor, capital, and energy produce goods. Total goods production is allocated among investment, consumption, government expenditures, net exports of goods, and deliveries of goods to the energy sector. It differs from real GNP by the amount of the last item, which is small, and net energy imports. Only the goods sector is fully represented in the model. The energy sector is viewed as establishing a predetermined dollar price of energy, at which it will supply any amount of energy demanded by the goods sector. The energy sector uses labor, capital and goods to extract energy. Its product is primary energy such as crude oil, natural gas at the wellhead, and coal at the mine mouth. For simplicity, there is
a single price of energy, though it should be recognized that this is
only a rough approximation. Note that energy demand not satisfied by
domestic production is met by imports. The price elasticity of domestic
energy supply is not considered here.

Within the goods sector, the critical elements of the model are the
production function, the specification of the investment process in-
cluding lags, the specification of the lag in wage determination, and the
demand function for money. The production function can be described in
the following way: Labor and capital together produce an intermediate
product called value added, according to a Cobb-Douglas production function.
Then value added combines with energy to produce goods, in fixed ratios.
This accord with Mork's (1978b) finding that the demand for primary energy
is nearly inelastic in the short run and his evidence and that of many
earlier investigators that the elasticity of substitution between capital
and labor is around one.

In the short run, the model assumes that the economy's ability to
adjust the capital stock is limited. Part of the investment in the next
demand function for

few years is already committed today and cannot be adjusted in response to
new information. The details on the incorporation of this consideration

The lag in wage determination is incorporated in a similar way,
except that it is the nominal wage, not the quantity of labor services,
that is committed in advance. When wages are set, they clear the labor
market, or come as close as they can given current information about
future demand for labor. When unexpected events occur, such as the
doubling of the price of energy considered here, the demand function for
labor determines the level of employment, which may then be well below the supply of labor. This characterization of the Keynesian hypothesis of wage rigidity is described in more detail in Hall (1978). It is an attempt to embody the view that the labor market achieves equality of supply and demand in the long run but that the process takes time. It implies a kind of Phillips curve for the economy. However, in place of the expected inflation term that has been the source of so much instability and conceptual ambiguity in the literature on the Phillips curve, expectations of future labor demand are formed using the model itself. In particular, feedback from prices to wages occurs in the model to the extent that price increases signal current or future increases in the demand for labor (as they typically do). However, as will emerge in the ensuing discussion, there is a negative, not a positive feedback from energy prices to wages. Wage setters are viewed as knowing that higher energy prices depress the demand for labor, with the money stock held constant. In the light of this knowledge, wage inflation is moderated when energy prices rise. One alternative to this view is the following: Because price increases generally signal increased demand for labor, employment contracts are explicitly or implicitly linked to prices by cost of living escalators. Then the initial impact of an energy price increase is to raise wages, even though the eventual response of wages is to fall. We have not so far incorporated this phenomenon in the model.

In the money demand function, the major issue is the specification of the variable that measures the dollar volume of transactions. The use of nominal gross national product for this purpose is one of the many reasons that macroeconomic models in existence in 1973 were unable
to deal effectively with the energy price shock (see Pierce and Enzler, 1974) -- nominal GNP subtracts imports and so cancels out much of the effect of higher energy prices. We use the dollar volume of output from the goods sector as a proxy for transactions. This variable makes sense in view of the fact that much of the money stock is in the hands of consumers, not businesses. We neglect the small contribution to the demand for money that might come from the energy sector (recall that all energy passes through the goods sector on its way to final demand).

The total gross output of goods is divided between gross investment and what we will call predetermined expenditures; this relationship is the equivalent of the GNP identity of a one-sector model. Note that it is stated in terms of the gross output of goods, not value added. Predetermined expenditures include the following:

- Consumption of goods
- Net exports of goods (excluding trade in energy)
- Government expenditures on goods
- Deliveries of goods to the energy sector

The reasons for avoiding a "consumption function" to provide an explanation of the movements of consumption are discussed by Hall (1978). Briefly, the empirical evidence seems to support the view that consumption decisions are based on intelligent appraisals by consumers of their total well being, including the present value of future income. As a result, there is no simple relationship between consumption and current or lagged values of income or other variables. The marginal propensity to consume out of a change in income depends on the context of the change. Rather than try to
build a model of this kind of behavior, we have chosen at this stage to use an outside estimate of the effect of the oil price increase on consumption.

Our treatment of the net exports of goods is similar. A proper model of the decisions of foreigners about the timing of purchases in the US is even more difficult, though many of the same principles are involved. Further, as is conventional in macroeconomic models, government expenditures are taken as exogenous. Finally, the model does not attempt to deal with the technology of the energy sector itself. The small flow of goods to that sector is considered exogenous.

III. Mathematical statement of the model

Variables of the model are:

- **Y**: Gross output of goods in 1972 dollars
- **X**: Real value added in goods production in 1972 dollars
- **L**: Employment, millions of workers
- **K**: Capital stock, billions of 1972 dollars
- **E**: Total domestic energy use, billions of 1972 dollars
- **I**: Investment in equipment, structures and inventories, billions of 1972 dollars
- **Z**: Predetermined expenditures on goods, billions of 1972 dollars
- **p**: Price paid by buyers of goods, 1972 = 1.000
- **p_x**: Price received by sellers for value added, 1972 = 1.000
- **p_E**: Price of energy, 1972 = 1.000
- **v**: Real rental price of capital, dollars per dollar of capital per year
r: nominal interest rate, per year
M: Money stock, currency and demand deposits, billions of current dollars

The basic equations are:

Central accumulation

\[ K_t = I_t + \frac{1}{1 + \delta} K_{t-1} \]

\( \delta = \text{rate of depreciation} \)
\( = 0.10 \)

Allocation of output

\[ Y = I + Z \]

Money demand

\[ \log \left( \frac{DV}{M} \right) = \psi_0 + \psi_1 r + \mu_2 t \]

\( \psi_1 = \text{coefficient of the interest rate} \)
\( = 2.0 \)

\( \mu_2 = \text{trend rate of growth of velocity} \)
\( = .027 \)

Equality of nominal rate of return on capital and nominal interest rate

\[ v - \delta - \theta + \frac{p_{t+1} - p_t}{p_t} = r \]

\( \theta = \text{rate of taxation of capital} \)
\( = 0.1846 \)
Production function

\[ Y = \min \{X/\gamma, E/(1-\gamma)\} \]

\[ \gamma = \text{units of value added required per unit of output} \]

\[ = 0.9766 \]

\[ X = a_o e^{\mu_1 t} L^\alpha K^{1-\alpha} \]

\[ \mu_1 = \text{rate of growth of productivity} \]

\[ = .019 \]

The additional complications in the production function to take account of investment and wage commitments are described in Hall (1978) and are not repeated here. The distribution of investment commitments is such that 17 percent of investment is flexible in the first year, 44 percent within the first two years, 72 percent within the first three years, and is entirely flexible within four years. The distribution of wage commitments is such that 17 percent of wages are flexible within the first year, 33 percent within the first two years, 50 percent within the first three years, 67 percent within the first four years, 83 percent within the first five years, and they are entirely flexible within six years.

IV. Estimates of the effect of the energy price shock

Our first step was to prepare a base case describing the possible evolution of the economy from 1973 in the absence of the abrupt increase in the price of energy. Table 1 shows the assumptions in the base case and the model's corresponding projections. The price of energy was assumed to rise at 6.5 percent per year. The other determinants of inflation, the committed wage and the money stock, were assumed to rise at about 7.5 percent
per year and 6 percent per year respectively. Investment commitments in existence at the beginning of 1974 extended forward to 1976 and were assumed to be at the same level in 1975 as 1974 and then to rise moderately in 1976. The labor force, expressed as the natural rate of employment, was assumed to grow at about 1.4 percent per year.

The model's projections are based on the absence of any surprises or shocks. The employment rate is close to its natural or equilibrium rate of 6 percent. The wages actually set (the "flexible wage rate") are close to the committed levels. Actual investment is also close to its committed levels. Real output grows smoothly and inflation proceeds at just over 5 percent each year.

Table 2 presents the model's estimates of the effects of an unexpected increase in the price of energy starting in 1974. Here the price of energy takes an unexpected jump of 80 percent in 1974 relative to its value in the base case. There is an additional but much smaller surprise in 1975, so in that year and all subsequent years the price of energy is 95 percent higher than in the base case. These figures were chosen to approximate the actual events of 1973-1975. Note that the increases are in addition to the expected annual increases of 6.5 percent per year that appear in both cases.

As we explained earlier, the model does not attempt to deal with the effect of the oil price increase on consumption or on the demand of the rest of the world for US goods. We approximated the net response to the loss in permanent income, caused by the recession, by making a downward adjustment in predetermined expenditures of an equal percentage amount in
### Table 1

#### Base Case Projections

<table>
<thead>
<tr>
<th>Year</th>
<th>Real Output</th>
<th>Price Level</th>
<th>Rate of Inflation</th>
<th>Investment</th>
<th>Employment</th>
<th>Unemployment Rate</th>
<th>Wage Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>1231.8</td>
<td>1.219</td>
<td>5.3</td>
<td>177.5</td>
<td>86.7</td>
<td>6.1</td>
<td>10.9</td>
</tr>
<tr>
<td>1975</td>
<td>1278.2</td>
<td>1.284</td>
<td>5.3</td>
<td>183.1</td>
<td>88.0</td>
<td>6.0</td>
<td>11.7</td>
</tr>
<tr>
<td>1976</td>
<td>1330.7</td>
<td>1.352</td>
<td>5.3</td>
<td>193.1</td>
<td>89.5</td>
<td>5.8</td>
<td>12.6</td>
</tr>
<tr>
<td>1977</td>
<td>1379.9</td>
<td>1.423</td>
<td>5.3</td>
<td>198.3</td>
<td>91.6</td>
<td>5.9</td>
<td>13.6</td>
</tr>
<tr>
<td>1978</td>
<td>1431.6</td>
<td>1.497</td>
<td>5.2</td>
<td>204.2</td>
<td>91.7</td>
<td>6.0</td>
<td>14.7</td>
</tr>
</tbody>
</table>

#### Assumptions

<table>
<thead>
<tr>
<th>Year</th>
<th>Money Stock</th>
<th>Committed Wage Rate</th>
<th>Investment Commitment</th>
<th>Natural Level of Employment</th>
<th>Predetermined Expenditure</th>
<th>Price of Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>270.0</td>
<td>10.9</td>
<td>180.0</td>
<td>86.8</td>
<td>1054.3</td>
<td>1.238</td>
</tr>
<tr>
<td>1975</td>
<td>287.0</td>
<td>11.7</td>
<td>180.0</td>
<td>88.0</td>
<td>1095.1</td>
<td>1.321</td>
</tr>
<tr>
<td>1976</td>
<td>304.2</td>
<td>12.6</td>
<td>190.0</td>
<td>89.2</td>
<td>1137.6</td>
<td>1.410</td>
</tr>
<tr>
<td>1977</td>
<td>322.5</td>
<td>13.6</td>
<td>---</td>
<td>90.5</td>
<td>1181.6</td>
<td>1.504</td>
</tr>
<tr>
<td>1978</td>
<td>341.8</td>
<td>14.7</td>
<td>---</td>
<td>91.7</td>
<td>1227.4</td>
<td>1.605</td>
</tr>
</tbody>
</table>
all years starting in 1974. We chose the magnitude of the adjustment -- 0.8 percent -- according to the following criterion: Excessively high levels of predetermined expenditures bring about a growing condition of capital shortage in the US economy. Real interest rates rise over time, output falls, and eventually the capital stock falls to zero. This indicates that predetermined expenditures have been set at too high a level. On the other hand, levels of predetermined expenditure that are too low bring about capital saturation, with the real yield of capital eventually dropping below zero. There is a unique permanent adjustment in predetermined expenditures that maintains the economy in an approximate steady state, with neither capital shortage nor saturation. By extrapolating the model's solution to 1992, we were able to find the appropriate adjustment. Since the extrapolation is necessary to find the initial price level for reasons given by Hall (1978), this did not involve any extra effort.

We also made a 1% upward adjustment of the committed wage rate. This may be interpreted either as the effect of escalator clauses in wage contracts or as an adjustment that corrects for the exaggerated price flexibility in the model.

The energy price shock generates a recession in the model, although a somewhat modest one. The shock works its way through the model in the following way. Since wages are largely predetermined in 1974, the sharp energy price increase causes a jump in the price level. As a consequence, the demand for money increases, i.e., the LM-curve shifts to the left. The financial tightening drives up interest rates, thus discouraging
### TABLE 2

**Estimated Impact of the Energy Price Shock**

<table>
<thead>
<tr>
<th>Year</th>
<th>Real Output</th>
<th>Price Level</th>
<th>Rate of Inflation - Diff. in % points</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absol. diff.</td>
<td>% diff.</td>
<td>% diff.</td>
<td>Absol. diff.</td>
</tr>
<tr>
<td>1974</td>
<td>-20.9</td>
<td>-1.7</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>1975</td>
<td>-30.6</td>
<td>-2.4</td>
<td>2.0</td>
<td>-0.2</td>
</tr>
<tr>
<td>1976</td>
<td>-31.2</td>
<td>-2.3</td>
<td>1.9</td>
<td>-0.2</td>
</tr>
<tr>
<td>1977</td>
<td>-29.0</td>
<td>-2.1</td>
<td>1.8</td>
<td>-0.1</td>
</tr>
<tr>
<td>1978</td>
<td>-25.5</td>
<td>-1.8</td>
<td>1.8</td>
<td>-0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Employment</th>
<th>Unemployment Rate</th>
<th>Wage Rate</th>
<th>Assumptions</th>
<th>Price of Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absol. diff.</td>
<td>% diff.</td>
<td>diff. in Level</td>
<td>% points</td>
<td>% diff.</td>
</tr>
<tr>
<td>1974</td>
<td>-1.8</td>
<td>-2.1</td>
<td>7.6</td>
<td>1.5</td>
<td>0.6</td>
</tr>
<tr>
<td>1975</td>
<td>-2.3</td>
<td>-2.6</td>
<td>7.9</td>
<td>1.9</td>
<td>-0.3</td>
</tr>
<tr>
<td>1976</td>
<td>-1.7</td>
<td>-1.9</td>
<td>7.2</td>
<td>1.4</td>
<td>-0.9</td>
</tr>
<tr>
<td>1977</td>
<td>-1.2</td>
<td>-1.3</td>
<td>6.8</td>
<td>0.9</td>
<td>-1.5</td>
</tr>
<tr>
<td>1978</td>
<td>-0.5</td>
<td>-0.5</td>
<td>6.5</td>
<td>0.5</td>
<td>-1.9</td>
</tr>
</tbody>
</table>
investment, and hence output. The resulting loss in real wealth depresses consumption both now and later, which reduces investment even more.

In 1974, the model estimates that the total impact of the energy price shock on real output was a reduction of about 21 billion 1972 dollars, or 1.7 percent. Of this, 9 billion is the direct effect of the decline in predetermined expenditures and another 12 billion is a decline in investment induced by the mechanism described above. The negative effect on GNP is largest the second and third years after the shock, in 1975-1976, when real output is down by more than 30 billion 1972 dollars. The bulk of this is decreased investment. The fall in real output is accompanied by a decline in employment of nearly 2 million workers in the worst year, 1975, and a corresponding increase in unemployment of 2.1 percentage points. It is worth mentioning here that the model does not attempt to take account of cyclical variations in productivity, so it overstates the size of the employment and unemployment effects of a given decline in output. The model does not do justice to Okun's Law.

The model predicts very modest effects of the energy price increase on the overall price level. The effect is largest in the first year, 1974, when it is 2.2 percent. In 1975 and later years, the effect on the price level is smaller than this, so the model makes the interesting prediction that the energy price increase that took place in 1974 slightly reduced the rate of inflation in later years; it concentrated most of its effect on the rate of inflation in 1974. In the model, something that is known to have a one-time influence, such as the energy price increase, does not have a persistent upward effect on the rate of inflation. A larger price
effect for 1974 could have been obtained with a different specification of the technology, as discussed below. Interestingly, however, this would have strengthened rather than weakened the dampening effect on future inflation rates.

For comparison, the actual behavior of the US economy 1974-1977 is displayed in Table 3. The picture is one of higher inflation and a deeper recession than our model generates. The recession predicted by the model seems very tame in comparison with the actual experience in 1974 and 1975, when real GNP fell below its predicted value by 4 percent in 1974 and nearly 9 percent in 1975. In part this reflects a much larger actual reduction in consumption and exports of something like 50-60 billion in 1972 dollars rather than the 8 or 9 billion used in Table 2. This decline comes mostly from consumption as net exports did not decline until 1976. The rest of the fall in GNP is a much larger decline in investment in 1975 than is predicted by the model. We solved the model with the actual drop in predetermined expenditures and found that the predicted total reduction in real output was about the same as the actual reduction for 1974 and one half of actual for 1975.\footnote{Under this assumption, the drop in investment turned out much smaller than in Table 2.} In other words, part of the severity of the 1974-1975 recession is attributable to a much larger drop in consumption and exports than makes sense within our model, and the rest is a larger drop in investment than would be predicted by the model even if it accepted the actual drop in predetermined expenditures.

The unemployment rate predicted by the model is much closer to actual than output is. This is, however, somewhat deceiving since
### TABLE 3

Actual Performance of Key Macroeconomic Variables, 1974-77, Deflated by the Consumer Price Index

-- Deviations from Forecasts Based on Table 1

<table>
<thead>
<tr>
<th></th>
<th>GNP</th>
<th></th>
<th>CPI</th>
<th>Rate of Inflation</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolute</td>
<td>% diff.</td>
<td>Growth</td>
<td>% diff.</td>
<td>Absolute</td>
</tr>
<tr>
<td></td>
<td>diff.</td>
<td></td>
<td>rate</td>
<td></td>
<td>diff.</td>
</tr>
<tr>
<td>1974</td>
<td>-46.0</td>
<td>-3.9</td>
<td>-2.5</td>
<td>5.3</td>
<td>5.7</td>
</tr>
<tr>
<td>1975</td>
<td>-114.3</td>
<td>-8.8</td>
<td>-1.7</td>
<td>9.2</td>
<td>3.8</td>
</tr>
<tr>
<td>1976</td>
<td>-92.1</td>
<td>-7.3</td>
<td>6.4</td>
<td>9.7</td>
<td>0.5</td>
</tr>
<tr>
<td>1977</td>
<td>-91.2</td>
<td>-7.0</td>
<td>4.0</td>
<td>10.9</td>
<td>1.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Consumption, Government Exp., and Net Exports</th>
<th>Unemployment Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolute diff.</td>
<td>% diff.</td>
</tr>
<tr>
<td>1974</td>
<td>-46.6</td>
<td>-4.4</td>
</tr>
<tr>
<td>1975</td>
<td>-69.1</td>
<td>-6.3</td>
</tr>
<tr>
<td>1976</td>
<td>-71.9</td>
<td>-6.3</td>
</tr>
<tr>
<td>1977</td>
<td>-90.2</td>
<td>-7.6</td>
</tr>
</tbody>
</table>
the model has no cyclical fluctuation in labor productivity and therefore overstates the effects in the labor market.

There are a number of ways that the model could have been changed that would have helped generate a more severe recession. The event that sets off the recession in the model is the exogenous increase in the price level. Thus, any modification that could give a higher impact on the price level of an increase in the price of energy would also produce a deeper recession. It may thus be worthwhile to consider the short-run price mechanism in our model in a little more detail.

The price of energy covers all forms of crude energy: crude oil (and refined imports), natural gas, coal, hydroelectric power, and nuclear power. For oil, the price is assumed to be the crude oil WPI (which covers domestic oil only), multiplied by the ratio of average to domestic crude oil price as quoted by the Monthly Energy Review. In this sense, we have assumed that the price equalization program was effective. For natural gas, we have assumed that the effective price rose by the full amount of the average oil price increase (in BTU equivalents) and the price regulations merely transferred rents from producers to those consumers with access to gas. For coal, the WPI was assumed to be satisfactory. The prices of hydro and nuclear power were assumed to have followed the price of coal. We then computed the price of energy in the model as a Divisia index based on the oil and coal prices.

The implicit "price equation" of the model has a simple linear form: the price of goods is a weighted average of the price of energy and the price of value added (the latter is a geometric average of the wage and
the price of capital). The weights are technical coefficients of the fixed coefficients production function: 0.023 for energy and 0.977 for value added, which closely matches energy use in the US economy over the 1970s. With the price of value added held constant, an increase of the energy price index from 1.32 to 2.57, the increase for 1975 incorporated in Table 2 should raise the price level by .029 or 2.2 percent of its 1975 level in the base case. Thus the direct effect of the energy price increase, abstracting from any feedback through the wage or price of capital, is itself quite mild in our model.

The price level response also depends on the assumption of pricing behavior. Our model assumes marginal cost pricing in the short as well as the long run. We are aware that many economists believe that standard unit cost pricing is a better approximation to reality. With the same technology specification, this would have raised the price level increase from 2.2 to 3.2 percent because of the feedback through the price of capital. This relationship between marginal cost and average cost pricing does not hold universally, however, but depends crucially on the form of the technology. Thus Mork (1978c) finds a partial response of 5.6 percentage points over the period 1973:2-75:4. The reason for the difference is that Mork's technology specification is homothetic in the short run (i.e., in labor-energy space) whereas ours is not. Inclusion of this technology specification in our model could have changed our results substantially. The reasons why this has not been done at the present stage are partly technical. Also, since our results are so sensitive to
such details, more careful research is needed before firm conclusions can be drawn.

The net effect of the energy price increase on the price level depends on some important indirect effects. The price of value added responds to the price of energy in a number of ways within the model. First, energy prices affect the prices of capital goods. This effect takes time; only when investment is flexible does the price of capital influence the marginal cost of production. Second, energy prices affect interest rates, though this turns out to be numerically unimportant as an influence on the price level in the model. Third, energy prices affect total output, which in turn influences prices through a "demand effect" in the implicit price equation of the model. Since marginal cost pricing is assumed, this effect is quite strong in our model; it lowers the 1975 price level by about 1 percent in 1975. This is contradicted by most empirical evidence but is kept in the present version of the model mainly for technical reasons. Since the observed price rigidity can be interpreted as the influence of cyclical variation in labor productivity (cf. Mork (1978a)), it might be possible to generate rigid prices within our framework of marginal cost pricing if a cyclical component of productivity is added to the model. Fourth, wages respond to the various economic effects of the energy price increase. This turns out to be the critical issue. As we mentioned earlier, not only is the magnitude of this response a matter of debate, but even its direction. To the extent that wages are indexed to the cost of living by escalator clauses, the immediate effect on an energy price increase, or any other price increase, is to push wages up.
However, in our model, wages are re-negotiated every few years according to the overlapping schedule described in an earlier section. At the time of re-negotiation, wages are set so as to provide employment for all of the relevant labor force. Then the effect of a price increase depends on its context. If it is part of a general pattern of inflation, wages will rise. If it is the result of a higher price for energy, however, wages will fall -- everything else held constant, the demand for labor declines in the short as well as the long run when the price of energy rises. This effect is even slightly exaggerated in our model because of the overstatement of the labor market effects discussed above. Whether this is the way that wages are actually determined is unsettled. Note that the strong historical correlation of wages and prices provides no evidence on the point. Most changes in both prices and wages have resulted from the general process of inflation and are consistent with both views about wage determination. Further, the fact that both wage and price inflation accelerated around the time of the energy price shock is not by itself evidence that energy prices have a strong positive effect on wages, since both may have been influenced by an inflationary shock from another source.

As mentioned above, our model is extreme in the sense that the energy price increase has only a negative impact on the wage level. Partly as an \textit{ad hoc} correction for this, and partly as a compensation for the strong demand effect in the model, the committed wage rate was adjusted upwards 1\% in the simulation run underlying Table 2. As shown there, this is offset by a 0.4\% wage decrease in 1974. As more and more wages are re-negotiated, the negative influence of energy prices on wages becomes
evident, reaching 1.9 percent in 1978. Because of the growing strength of this negative influence, the net effect of the energy price increase on the price level declines over time. Further, part of the inflationary impact in the early years is offset by the effect of decreased real output on prices.

A key assumption about policy in these results is that the money stock is not influenced by the energy shock. Monetary policy is pushed in opposite directions by the price shock. On the one hand, expansion could limit the adverse effect on real output and employment. On the other hand, contraction could limit the inflation resulting from the shock. Various monetary reactions are considered in the next section. For now, the assumption of no monetary response together with the "neutrality of money" in the long run within the model limits the effect of energy prices on the general price level. In the long run, the money stock is the primary determinant of the price level, and this strongly limits the potential long-run effect of the energy price shock on the price level under our assumption of no monetary response. In the short run, a burst of inflation from energy or any other source other than money supply has an adverse effect on real output. Our model predicts that this effect is quite strong relative to the predictions of other models. The comparatively small effect of the energy price shock on real output comes from the small magnitude of the shock, not from the weakness of its link to real output. Thus, a larger price response of the energy price shock would increase the magnitude of the recession generated by the model.

A deeper recession would also be the outcome if one specified energy
and capital as complementary in production. A number of researchers have found this complementarity in their data, but it is still a matter of controversy. The implication it would have in our model is an additional incentive to low investment in the years following the shock. Since investment represents the marginal adjustment of capital, a large reduction in investment could be produced even by a modest degree of complementarity.

Missing from this calculation is any attempt to deal with the impact of the oil shock on the export demands of other countries for US goods. By making exports fall far enough, we could have simulated a recession as severe as the one that actually occurred. This would be a relatively uninteresting exercise, however. If the oil shock could cause only a minor disturbance in the US economy considered independently, there seems little reason for it to induce a worldwide recession. That is, the observed decline in export demand cannot necessarily be attributed to the energy price increase.

Finally, we have not considered any direct effects of the oil embargo. Findings by Mork (1978b) indicate a genuine shortage of primary energy may have existed in early 1974. The impact of this cutoff of supply on the rest of the economy is a topic of future research.

In summary, we have been able to explain a part of the 1974-75 recession as the result of the energy shock. With a better model specification it may be possible to explain more. We are doubtful, however, that it would be appropriate to ascribe the whole recession to this shock alone.

V. Policies to Offset the Macroeconomic Impact of the Energy Shock

Though the effects of the energy price shock on output, employment, and prices predicted by our model are not large, their form could have been altered by manipulation of macroeconomic policy instruments. For example, with a suitable expansion of the money supply, the effects of the
shock on output and employment could be attenuated or even eliminated, at
the cost of more inflation. Table 4 illustrates such a policy. In the
base case, the rate of money growth was around 6 percent in all years.
By assumption, the rate of growth remained unchanged in our analysis of
the impact of the price shock in the previous section of the paper. The
third column of Table 4 shows the rates of monetary expansion needed to
eliminate the effect of the energy shock on real output. In the main
year of the shock, 1974, almost four extra percentage points of
monetary growth are needed -- 10.2 percent in place of 6.3 percent. A
small amount of extra money growth is also needed in 1975 -- 7.9 percent
in place of 6.3 percent. In 1976 and subsequent years, no further expansion
is needed beyond that assumed in the base case.

Monetary policy does not liberate the economy from the tradeoff
between inflation and unemployment. Eliminating the effect of the energy
shock on output and unemployment brings about more inflation, as the
middle columns of Table 4 show. In the base case, inflation was about 5.3
percent in all years. As discussed in the previous section, the energy
price shock by itself raised inflation in 1974 when wages were largely
unable to respond, but in subsequent years, inflation was less in the
aftermath of the energy shock than in the base case. The monetary policy
that eliminated the effect of the shock on output and employment amplifies
the inflationary response. The inflation attributable to the shock in-
creases by 50 percent in 1974 in the presence of the monetary response --
it is 3.2 percentage points higher (8.5 percent as against 5.3 percent in
the base case). Without the monetary response, the energy shock brought
about only 2.3 percentage points of extra inflation. In subsequent years,
### TABLE 4

**Effect of a Monetary Response to the Energy Shock**

<table>
<thead>
<tr>
<th></th>
<th>Rate of Money Growth</th>
<th>Rate of Price Inflation</th>
<th>Rate of Growth of Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>6.3</td>
<td>6.3</td>
<td>10.2</td>
</tr>
<tr>
<td>1975</td>
<td>6.3</td>
<td>6.3</td>
<td>7.9</td>
</tr>
<tr>
<td>1976</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>1977</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>1978</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
</tr>
</tbody>
</table>
inflation settles back to about the same level as in the base case. It
does not dip below as it did in the case of a pure energy shock.

We could also study the effect of a monetary policy that insulated the
price level against the impact of the energy shock, at the expense of ampli-
ifying the effect on real output and employment, but the rough magnitude
of those calculations can be inferred from the results just presented.
An extra four percentage points of money growth brings about an extra 0.9
percentage points of inflation and an extra 1.9 percentage points of real
output growth. Thus, elimination of the 2.3 percentage points of inflation
in 1974 attributable to the energy shock would have required a reduction in
money growth of about 10 percentage points. This in turn would have
retarded real output growth by about 4.8 percent, and brought it down to
-1 percent in 1974. Even with the monetary authorities taking such an
extreme anti-inflationary stance, the economy would not attain the large
negative rates of output growth actually observed in 1974 and 1975. Again
it does not seem credible that the severe downturn of those years can be
attributed solely to the energy shock.

The other macroeconomic policy instrument that was advocated as a
method for offsetting the effects of the energy shock is fiscal policy.
Changes in government expenditures bring about changes in aggregate demand
directly, or changes in income taxes can influence consumption and thereby
operate indirectly. Since our model does not contain a consumption function,
we do not try to answer the question of how large a tax cut is needed to
stimulate consumption by a given amount. Rather, following Hall (1978),
we simply analyze the effect of a shift in the predetermined expenditures
variable, which contains both government expenditures and consumption.

The extra expenditures needed to stabilize the unemployment rate at roughly 6 percent in the face of the energy shock are shown in the first column of Table 5. These are measured relative to the level of predetermined expenditures used in our simulation of the energy shock. Recall that we lowered expenditures in that case by a few billion dollars to take account of the effect of the recession on the well-being of consumers in the long run. In Table 5, there is effectively no recession because of the offsetting fiscal policy. Thus the "extra expenditures" include the favorable response of consumers to the fiscal policy. In Keynesian terms, the first column includes not just the direct increase in government expenditures, but also the multiplier response of consumption. For example, the increase in expenditures of 40 billion 1972 dollars required in 1975 might have been achieved by a combination of an increase of 20 billion in expenditures plus a multiplier effect of the same magnitude.

In the short run, the fiscal stimulus is just as inflationary as the monetary stimulus examined earlier. Fully offsetting the effects of the energy shock on unemployment and real output pushes the rate of inflation in 1974 to 8.5 percent, as against 7.6 percent in the absence of any policy response. In the year after the shock, 1975, fiscal policy is a bit more inflationary than monetary policy -- 6.6 percent inflation as against 5.7 percent -- even though the fiscal policy generates a slightly lower rate of real growth. Output growth is also low in 1976, and then rebounds in 1977 and 1978. The period of low growth coincides with the two years of large increases in expenditures, and is not accidental. When government and consumers are demanding a larger volume of output, investment must
### TABLE 5

**Effect of a Response of Public Expenditure to the Energy Shock**

<table>
<thead>
<tr>
<th>Year</th>
<th>Extra Expenditures (billions of 1972 dollars)</th>
<th>Rate of price inflation</th>
<th>Rate of growth of output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Base</td>
<td>Energy shock</td>
</tr>
<tr>
<td>1974</td>
<td>10.2</td>
<td>5.3</td>
<td>7.6</td>
</tr>
<tr>
<td>1975</td>
<td>40.2</td>
<td>5.3</td>
<td>5.2</td>
</tr>
<tr>
<td>1976</td>
<td>30.3</td>
<td>5.3</td>
<td>5.1</td>
</tr>
<tr>
<td>1977</td>
<td>6.3</td>
<td>5.3</td>
<td>5.2</td>
</tr>
<tr>
<td>1978</td>
<td>-10.1</td>
<td>5.2</td>
<td>5.1</td>
</tr>
</tbody>
</table>
necessarily be lower than it would be otherwise. Capital accumulation suffers, and output falls because capital is an important input to production. When capital accumulation accelerates in 1977 and 1978, real growth resumes.

Accompanying this shortfall in output in the years of heavy government expenditure is a slight acceleration of inflation. In this simulation, the money stock is held constant. When real output falls, the price level rises. The effect lasts only two years. When capital accumulation moves above its rate in the base case in 1977 and 1978, price inflation dips below its rate in the base case.

The negative addition to spending in 1978 is done in order to offset the shortfall of investment in 1974-76. It turns out that the reduction in productive capacity becomes catastrophic in the long run unless consumption or government expenditures is reduced at a later date. Offsetting the recession by increased spending now requires reduced spending later.1 We solved this problem in the model by reducing spending by about 10 billion dollars for ten years starting in 1978. This dynamic aspect of fiscal policy is largely ignored in Keynesian models with a weak representation of the supply side.

The use of government stockpiles of fuels may be considered a third type of policy to offset an energy price shock. The argument would be that increased supply would postpone the price increase and thus eliminate the surprise effect. It may be argued that this is consistent with the rational expectations hypothesis.

1Note that this has nothing to do with the government's budget constraint since none exists in the model. It is, however, related to the constraints on the economy in a deeper sense.
It is, however, highly doubtful that this policy could be successful. Since fuels are storeable, the market price is likely to increase already at the time a future price increase is announced. Energy buyers are given an incentive to hoard, as are producers to hold back supply. Thus, although a sufficient postponement of the price increase would eliminate the recession in our model, this policy cannot be considered a serious alternative to monetary and fiscal policy.

VI. Conclusions and Agenda for Further Research

We conclude that we have been successful in constructing a reasonable macroeconomic model that is capable of generating a recession as the result of a sharp, unexpected increase in the price of energy. It is worthwhile repeating the mechanism that makes this happen. With wages rigid in the short run, the energy price increase pushes the price level upwards. With an unchanged level of real transactions, this creates an excess demand for money for transaction purposes. The resulting financial tightening increases the cost of capital and thus discourages investment. On the other hand, consumers realize that they are worse off because the growth potential of the economy has been diminished. Thus, consumption falls as well as investment, and the economy is in a recession.

The model is less successful in retracking the inflation of the late 1970's. A few changes in the model could improve this result. First, the direct impact on the price level of an energy price change could be increased by modifying the implicit price equation in the model. Secondly, the indirect effects -- the demand effect and the effect on wages -- could be made more realistic by including cyclical productivity and a better
representation of the effect of inflation on wages in the medium run.
Thirdly, the assumption of exogenous monetary policy may be relaxed.

The recession generated in the model economy is much smaller than the
one observed in 1974-75. To some extent we believe this is right; other
forces than the energy shock are likely to have been responsible as well.
On the other hand, it seems reasonable to look for changes in the model
that could contribute to a more realistic recession. One such change is
to make the price response stronger, because the recession is caused by the
inflationary shock. Capital-energy complementarity is another because it
would allow a larger drop in investment. Thirdly, it might be worthwhile
exploring direct cutoff effects of the embargo. Finally, introduction of
cylical productivity would give a more realistic response of employment to
fluctuations in output.

This long list of possible changes means, of course, that much remains
to be understood about the 1974-75 recession and inflation. Nevertheless,
we feel satisfied that we have clarified one important aspect which, in the
very least, is a necessary ingredient of any complete explanation.
References


