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Energy Price Shocks and Macroeconomic Adjustments

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INTRODUCTION

This paper has three objectives. The first is to provide a brief overview of the various ways in which changes in energy prices—gradual changes or, alternatively, sharp and sudden "shocks"—affect macroeconomic variables such as inflation, employment, real output, and investment. The second objective is to summarize the results of our recent work on the dynamics of energy use in industrial production, and discuss what those results show about the effects of energy price shocks on investment, employment, and industrial energy use. The last objective is to discuss the implications for policy—both economic policy and energy policy.

Future energy prices remain highly uncertain for a number of reasons. The discovery of new energy supplies and the development of new energy technologies are largely unpredictable. The continued ability of OPEC to agree on production allocations and avoid competitive price cutting is questionable. Added to this is the inherent instability of the Persian Gulf, and the world oil market in general. As a result, one cannot have very much confidence in any forecast of future energy prices.[1] In the future, energy prices may rise or fall unpredictably and, as we have seen in the past, this could have important implications for the performance of the American economy and the other industrial economies.

We should stress at the outset that energy shocks refer to *price* shocks, as opposed to unexpected shortages of energy. Barring a major war with widespread disruption of oil shipments, shortages are almost impossible at the level of the world oil market. As long as some oil is being produced and shipped, any country can import as much as it demands by offering a high enough price. The function of the world oil market, and in particular

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1. For a discussion of problems associated with predicting oil prices, *see* R. S. Pindyck, *OPEC Oil Pricing and the Implications for Consumers and Producers* in OPEC AND THE BEHAVIOR OF WORLD OIL PRICES (J. Griffin and D. Teece, eds., 1982).

the spot market, is to let prices equalize supply and demand.[2] Shortages at the *retail* level, on the other hand, continue to be a distinct possibility. They can result from government attempts to hold fuel prices below market-clearing levels. Fortunately, the United States has removed price controls on crude oil, and interstate natural gas markets will be in large part deregulated by 1986. Unless controls are revived during periods of rapid increases in energy prices, a repetition of the gasoline and natural gas shortages in the United States witnessed in the past is unlikely. Although shortages are unlikely (or rather, would be of our own making), price shocks can occur quite easily.

An energy price increase can have two different effects on an industrial economy. First, a higher price of energy has a direct effect by reducing the total real national income available for domestic consumption and investment. It does not matter whether the cost of energy rises because it is imported and a cartel raises its monopoly price, or because depletion of potential and proven reserves makes domestic energy sources more difficult to tap. Nor does it matter whether the price increase occurs slowly or rapidly. In each case the higher cost of energy will mean a lower real national income—*i.e.*, a loss of real purchasing power. This in turn will mean lower real wages, profits, and consumption levels. Furthermore, no economic policy can eliminate this direct effect. The reduction in real income will occur even if monetary and fiscal policies are used to keep the economy close to full capacity output and employment.

The second effect of energy price increases, the adjustment effect, occurs when those increases are rapid and unexpected. An energy price shock will raise the rates of inflation and unemployment, and reduce investment levels. This will cause a further change in real national income and may well magnify the direct reduction discussed above. The adjustment effect occurs because of the rigidities that characterize our economy—rigidities in prices, in the use of inputs to production, and in wages. Adjustment effects cannot be eliminated entirely, but they can be reduced significantly through the proper use of economic policy. The wrong policies, however, can magnify adjustment problems, so that they become a serious threat to economic growth and stability.

The proper economic policy response to an energy shock is continued, moderate growth of the money supply, restraint on fiscal expansion, and,

2. Likewise, it is impossible for the Arab members of OPEC to create an energy shortage by imposing an oil embargo. The oil-producing countries can determine the quantity of oil they produce, but they cannot determine where that oil will ultimately be shipped, and this makes it impossible for an embargo to be effective against any single country or group of countries. An embargo can result only in production cutbacks, thereby reducing the oil available to *all* importing countries, and driving up the price of oil until demand falls. The problem arises from the sharp increase in prices, and not from the possibility that oil might be unavailable at any price.

if possible, reductions in payroll and excise taxes. As for energy policy, a tariff on imported oil should be imposed now, before another shock occurs. Such a tariff could be reduced during a shock, thereby insulating the economy from sharp price changes. A large tariff may be preferable to a major expansion of the Strategic Petroleum Reserve. In addition, there is no need for "recycling" schemes that channel money back to consumers in the wake of a price shock—those schemes would be counterproductive.

DIRECT EFFECTS OF RISING ENERGY PRICES

The direct effect of an energy price increase is simply an implication of the fact that more domestic resources must be "traded" for each Btu of energy. The magnitude of this direct effect therefore depends on the structure of energy demand, and in particular on the cost share of energy in GNP, and the ability of household and industrial consumers to substitute away from energy when it becomes more expensive.

The cost share of energy as a fraction of GNP sets an upper bound on the extent to which an increase in the price of energy will reduce real national income. If there were no substitution possibilities (*i.e.* energy demand were completely price-inelastic), and if the supplies of capital and labor were constant, output would remain fixed, and the drop in real national income would be $S/(1-S)$ times the percentage price increase, where S is the share of energy in GNP (about 8% in the United States). In other words, for a one percent increase in energy prices, an additional $S/(1-S)$ percent of our (fixed) output would have to be traded for the same amount of energy. The impact on real national income would be smaller the more elastic the demand for energy. A very rough estimate of the overall price elasticity of energy demand in the United States is about -0.6, which would imply that a 10% increase in the price of energy would reduce real national income by about 0.6%.[3]

The analysis above does not depend on whether energy is used as an intermediate input or as a final product. In particular, even if all energy is used by households for heating and transportation, if the amount of energy consumed does not change in response to price changes, the fall in real national income is still given by $S/(1-S)$ times the percentage price increase.

While the direct effect of an energy price increase implies a reduction in real national income, it need not imply very much of a reduction in

3. This is discussed in Hall & Pindyck, *Oil Shocks and Western Equilibrium*, TECHNOLOGY REVIEW 32–40 (May 1981). For estimates of residential, industrial, and transportation energy demand elasticities in the United States and elsewhere, *see* R. PINDYCK, THE STRUCTURE OF WORLD ENERGY DEMAND (1979).

real GNP and, therefore, in productivity. This is particularly the case if much of the energy is imported. The reason is that GNP is a measure of final output, and not the real flow of goods and services available for domestic use.[4] If the elasticity of substitution between energy and other inputs to production is small, domestic production will be largely unaffected by higher energy prices. The problem is that more of that production must be bartered away for the more expensive energy, and this is why real income falls. The larger the elasticity of substitution between energy and other production inputs, the larger will be the reduction in real GNP resulting from an energy price increase, but the smaller will be the reduction in real income (and thus in our standard of living).

For this reason it is important to focus on the real income losses connected with energy price increases, and not GNP or productivity losses. For example, policies that speed up the replacement of energy-inefficient capital (a gas-guzzling car) with energy-efficient capital can reduce productivity, because they accelerate the use of energy-efficient, but labor-inefficient technologies. For an oil-importing country, this means a reduction in imports and improvement in the terms of trade, so that output may fall, but income will rise.[5] In the long run, the problem with steady increases in energy prices is not that they will drain away our output and productivity growth, but that they will drain away our real incomes and standards of living.

In addition to having a direct effect on national income, energy price shocks influence the demand for energy itself and the demands for various types of durable goods. Moreover, the initial impact of a price shock may be followed by various repercussion effects. Consider, for example, the reaction of households to higher energy prices.

Households use energy mainly for transportation and heating. Their demand for energy is thus a demand for services which also require the use of durable goods (like houses, cars and refrigerators). As is well known, different durable goods of the same class (*e.g.*, cars) yield the same services when combined with different amounts of energy. Thus, an unexpected increase in the price of energy has two effects. First, it reduces the usage of the existing stock of durable goods, thus reducing energy consumption. Second, it changes the demands for different types

4. Actually GNP is a measure of domestic value added, *i.e.*, the *net* output of the domestic economy. Therefore, if energy is imported, *total gross output*, which includes the value of imported energy, may fall even if GNP (which measures the productivity of domestic factors) is unchanged.

5. This example can be found in Nordhaus, *Policy Responses to the Productivity Slowdown*, in THE DECLINE OF PRODUCTIVITY GROWTH (Federal Reserve Bank of Boston, Conference Series No. 22, 1980). For general discussions of the relationship of energy to output and productivity, *see* Berndt, *Energy Price Increases and the Productivity Slowdown in United States Manufacturing*, in THE DECLINE OF PRODUCTIVITY GROWTH (Federal Reserve Bank of Boston, Conference Series No. 22 (1980)).

of durables, raising the demand for insulation, energy-efficient cars, etc. It will take time, however, for the composition of the stock of durables to change in response to this change in demand. So, in the short run, the relative prices of durables will be affected. For example, owners of large automobiles effectively incur capital losses, since the durable they own is now worth less, while owners of energy-efficient appliances effectively accrue capital gains.

The capital gains and losses would be smaller if people knew ahead of time when the energy price increase would occur. If people knew now that the price of energy will increase at some point in the future, they would alter their purchases of durable goods now and this would induce a change in their demand for energy. In particular, they would purchase energy-efficient appliances, thus lowering their current energy consumption. This suggests that one should not strive to obtain a single price elasticity of the demand for energy. The response of energy demand depends in part on people's perception of future energy prices, and in particular on inferences about future energy prices based on observations of current ones.

These dynamic effects of energy price shocks are just as important when considering the industrial sector. In general, a changing energy price will imply a change in the mix of productive factors which firms employ. It may lead, for example, to less investment, and reduce capital accumulation in the future. Since changes in investment have serious implications for aggregate economic activity, it is important to understand the ways in which an energy price shock will affect the demands for factor inputs to production. We turn to that in the next section.

Energy Price Changes and Industrial Factor Use

Estimating the direct impact of energy price changes on investment behavior, employment, and energy use requires a description of the structure of industrial production, *i.e.*, a model of factor demands. If energy prices change sharply and suddenly, *i.e.*, there is a price shock, it is essential that such a model be dynamic, and that it account for anticipations regarding future prices.

To understand why, note that in response to sharp energy price changes firms want to change not only their energy purchases but also their usage of capital. Insofar as it is costly to change the stock of capital quickly, capital responds slowly to sharp price changes, and the long-run elasticity of energy demand is different from the short-run elasticity. Much of the disagreement over recent estimates of industrial energy demand elasticities has focused on whether these estimates pertain to the short or long run. Moreover, the size of the costs of adjusting capital also influences the extent to which energy demand, and the demands for other factors, respond to prospective changes in the price of energy.

Recently, we developed a dynamic factor demand model which retains the generality of functional form that has characterized much of the recent static modeling work.[6] In addition, this model is consistent with producers holding rational expectations and optimizing dynamically in the presence of adjustment costs. The parameters of the model were estimated using aggregate data for the U.S. manufacturing sector, treating energy and materials as flexible inputs, but capital and labor as quasi-fixed (adjustment costs on labor were found to be very small).

This model can be used to show how factor inputs change over time in response to various kinds of anticipated and unanticipated changes in the price of energy, as well as changes in the price of capital, the level of output, etc. This paper summarizes the results of using the model to stimulate the effects of a number of "events": (1) the price of energy unexpectedly increases by 10%, and is then expected to remain at this higher level; (2) the same 10% increase in the price of energy is anticipated by firms five years before it occurs; (3) the price of energy rises gradually at 2% per year; (4) the cost of capital unexpectedly declines by 5%.

The results of simulating these four hypothetical "events" with the model are shown graphically in Figures 1–4. Figures 1a–4a show percentage changes in capital, labor, energy, and materials inputs over time. These percentage changes are relative to a base year ("year 1"), which corresponds to 1971. At this time all factor inputs are taken to be in steady state equilibrium. Figures 1b–4b show the behavior over time of the ratio of net investment to the capital stock. For simplicity, inputs and output are assumed constant in steady state equilibrium, so that in the absence of an "event," net investment is zero.

Figures 1a and 1b show the effects of an unanticipated 10% increase in the price of energy. The major impact is a significant drop in the use of both capital and energy (which, in the model, are complements).[7] Because it is costly to change capital quickly, capital falls gradually, while energy, a flexible factor, falls by a significant amount in the first period, and continues to fall in subsequent periods in conjunction with the drop in the use of capital. The parameter estimates of our model indicate that adjustment is fairly rapid; about three-fourths of the total drop in capital occurs in seven years.

Suppose that same energy price increase is anticipated five years before it occurs. As can be seen in Figures 2a and 2b, the same steady state

6. *See* Pindyck & Rotemberg, *Dynamic Factor Demands and the Effects of Energy Price Shocks*, 73 AM. ECON. REV. 1066–79 (Dec. 1983).

7. Two inputs are complements if the rise in the price of either of them reduces the use of both of them. In contrast, they are substitutes if the use of the input whose price is constant rises.

FIGURE 1a. 10% unexpected increase in energy prices in year 2.

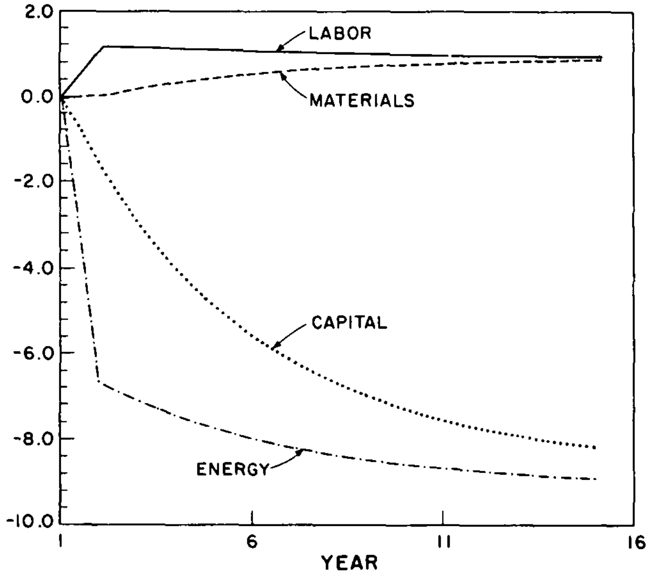


FIGURE 1b. I/K: 10% unexpected increase in energy prices in year 2.

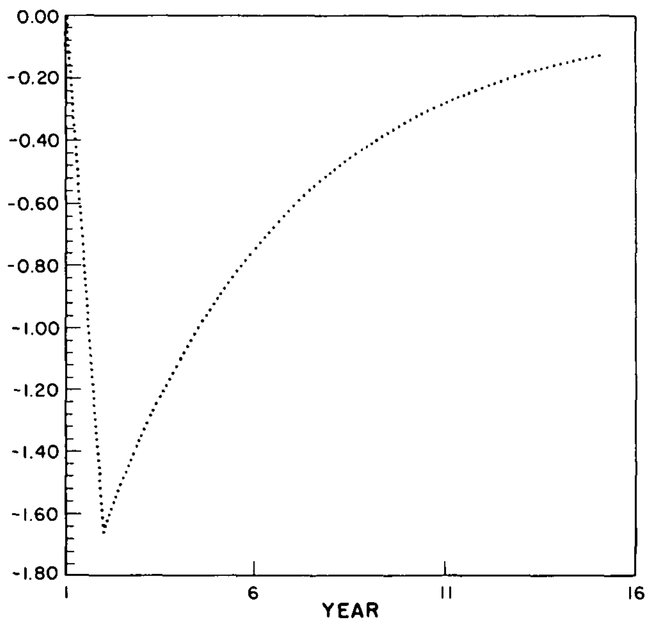


FIGURE 2a. 10% increase in energy prices beginning in year 7, anticipated as of year 2.

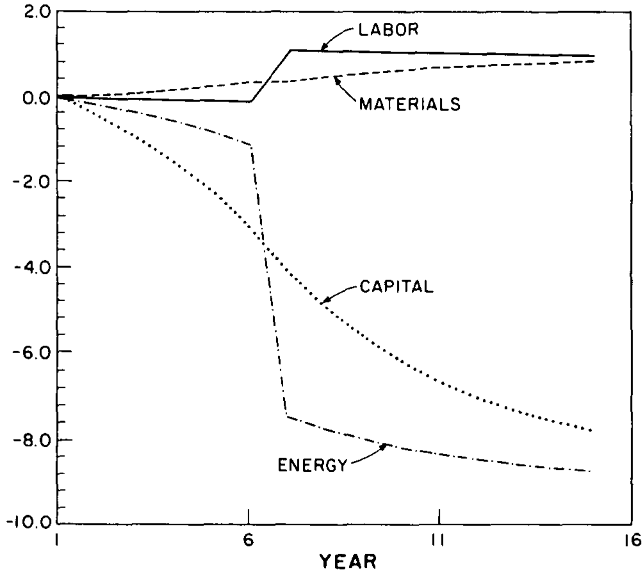


FIGURE 2b. I/K: 10% increase in energy prices beginning in year 7, anticipated as of year 2.

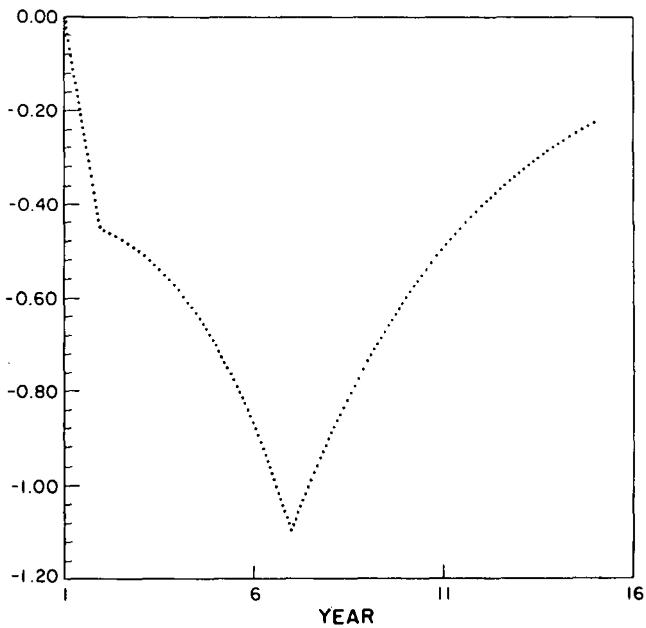


FIGURE 3a. 2% per year increase in energy prices beginning in year 3, expected as of year 2, and continuing for 15 years.

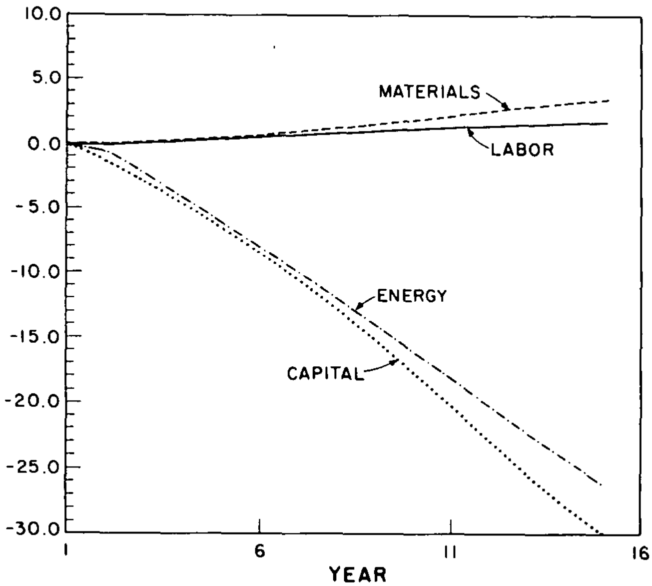


FIGURE 3b. I/K: 2% per year increase in energy prices beginning in year 3, expected as of year 2, and continuing for 15 years.

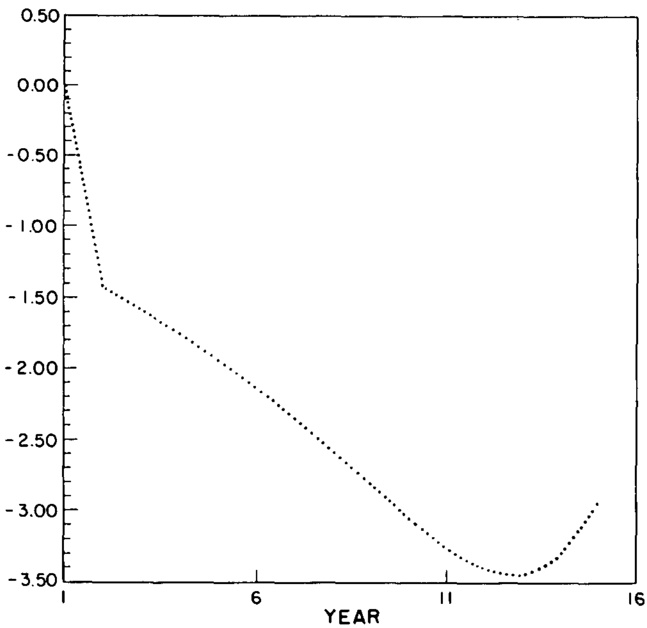


FIGURE 4a. 5% unexpected decrease in the cost of capital, beginning in year 2.

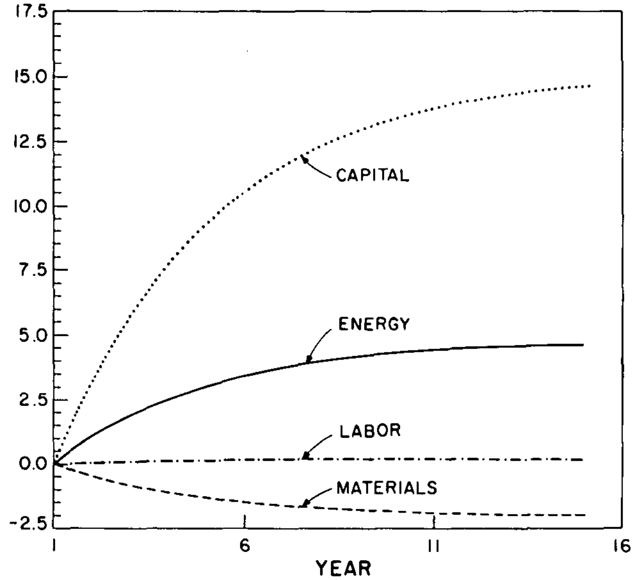
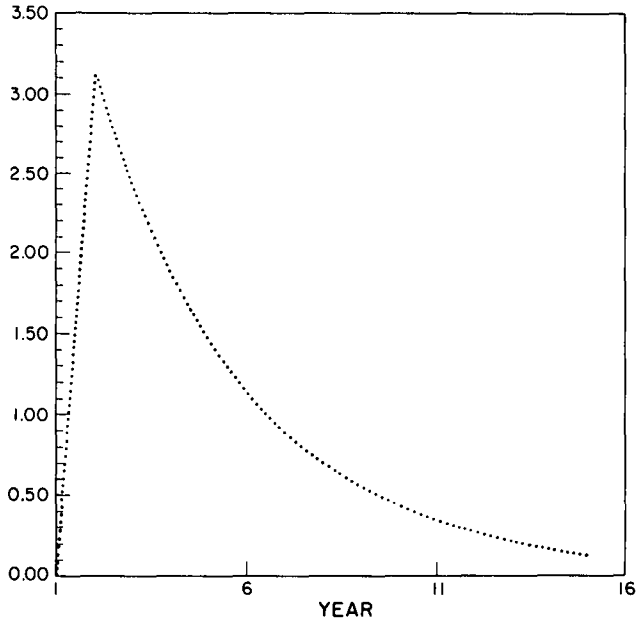


FIGURE 4b. I/K: 5% unexpected decrease in the cost of capital, beginning in year 2.



equilibrium eventually results, but the dynamics of adjustment are quite different. The demand for capital begins dropping immediately because of the presence of adjustment costs, but the major changes in the use of energy and labor occur after the price increase is realized. There is still a noticeable decline in the use of energy prior to the price increase, however, because energy and capital are complementary inputs. Note that simulations such as this one can be used to analyze the impact of the 1978 Natural Gas Policy Act in the United States and related legislated future changes in energy prices.

In Figures 3a and 3b, the price of energy increases steadily at 2% per year. Costs of adjustment are then negligible, and, as one would expect, the result is gradual changes in the values of all factor inputs.

One can also use a model such as this to examine the effects of changes in the prices of other factors. Figures 4a and 4b show the simulated effect of an unanticipated 5% decline in the cost of capital, resulting, say, from a change in the tax laws. The result is a substantial increase in the use of capital (in the model, the long-run price elasticity of capital is nearly -3), but also a significant increase in the use of energy (which, in the model, is complementary to capital).

General Equilibrium Effects

The model used for these simulations has an important limitation—it is a partial equilibrium model. In other words, when simulating the effect of an increase in the price of energy, the real wage rate and the level of output were taken to be fixed. In fact these variables will also change, leading to further changes in the use of labor and capital and, thus, in the use of energy.

Even if all real factor prices other than energy stay constant, an increase in the real price of energy leads to an increase in the marginal cost of production if output is unchanged. This induces firms to reduce their output, thus further reducing their demand for energy, and also reducing the demands for the other inputs to production.

While the real prices of capital and materials might be relatively unaffected by an increase in the price of energy, since they too are produced using capital, labor, energy, and materials, the real wage can be influenced in a number of ways. First, the demand for labor is likely to decline for any real wage. It is conceivable that the desire on the part of firms to substitute labor for energy may be so strong that the demand for labor actually rises in spite of the output effect mentioned above. However, this is unlikely because if the supply curve for labor were upwards sloping (or vertical) and unaffected by the change in energy prices, the real income of workers as a whole would increase in response to the higher price of energy. This would require a sharp drop in the income of the owners of capital to ensure that national income actually fell. Therefore, it is more plausible that the demand for labor falls. This in turn induces a fall in the real wage, if the supply of labor schedule is unchanged by the increase in the price of energy.

The supply of labor itself may fall for any given real wage measured in domestic goods.[8] As the real price of energy rises, the real compensation of a worker who consumes energy directly falls, even if the ratio of his wage to the price of domestic output is changed. This may induce some workers to substitute nonmarket activities (*e.g.*, leisure) for market activities. The resulting shift in the supply of labor raises real wages but lowers employment and is thus consistent with the fall in total real labor income. It must be noted that this shift in labor supply, while theoretically plausible, has not been isolated empirically, thus lending credence to the notion that real wages must fall in equilibrium. This fall in real wages induces a further fall in the demand for energy as firms substitute energy for labor. This is somewhat offset by an increase in the demands for all factors as the fall in real wages lowers marginal costs of production. The magnitude of these effects is a subject of ongoing research.

Finally, an increase in the relative price of energy can affect the level of nonenergy prices. The size and magnitude of this effect depends on the characteristics of the demand for money. As stated above, a direct effect of the increase in energy prices is a fall in real income. However, the demand for real money balances depends on the level of income. As real income falls, people demand a smaller quantity of real money balances. To maintain the demand for the existing level of nominal money balances, the price level must rise. The price level, however, is a composite of energy and nonenergy prices. Therefore, nonenergy prices will tend to rise if (a) the demand for money is more responsive to changes in income, (b) the fall in real income is sharper, and (c) the weight of energy prices in the price level is smaller.

This does not guarantee that nonenergy prices will rise; in theory, they could fall. If the demand for money were completely inelastic with respect to income, the increase in energy prices would have to be offset by a decrease in nonenergy prices in order to keep real money balances constant and equal to the constant money demand. In practice, money demand is expected to be sufficiently elastic so that nonenergy prices will indeed rise, as they did following the 1974 and 1979–80 oil price shocks.

ADJUSTMENT PROBLEMS

So far we have discussed the direct effects of energy price changes. If

8. *See* Branson & Rotemberg, *International Adjustment with Wage Rigidity,* 13 EUROPEAN ECON. REV. (May 1980).

those price changes are sharp and unexpected, as they were during the past decade, they will also cause significant adjustment effects, at least during the short run. These adjustment effects will come on top of the reductions in real income and output discussed earlier.

Adjustment effects are the result of rigidities in our economy—in particular, rigidities in prices and wages. For example, after an energy price increase, the prices of other goods may not adjust rapidly to their new steady state values. In addition, real wage rates may fail to fall quickly to the new lower equilibrium level which is likely to be required by higher energy prices. In this case labor prices itself out of the market; from the point of view of firms, full employment becomes uneconomical; and the unemployment rate rises and real output falls.

This problem is particularly acute in Europe where real wages tend to be rigid.[9] The problem is that most workers would rather not hear the message that real wages must fall. Because many European workers' wages are automatically linked to prices through explicit and implicit cost of living escalators, the message can be ignored to some extent. Wage setting processes based on cost of living escalators will cause wages to rise in the wake of an energy price shock, when instead they may well have to fall relative to the cost of living. This contributes to the inflationary spiral, lowers employment, and increases unemployment as workers price themselves out of the labor market. These changes in employment lead to a reduction in real output. The problem is that the economy is unable to come back to equilibrium quickly at a lower real wage level.

In the United States it is the nominal wage and not the real wage that is sticky.[10] This is due to the presence of long labor contracts which are signed in nominal terms and have only partial escalator clauses. Because (for the reasons discussed previously) there tends to be a burst of inflation following an energy price shock, this shock leads to a fall in the real wage, as an unchanging nominal wage is deflated by a higher price level. Indeed, as Table 1 illustrates, the real wage fell significantly in the United States during the 1974 and the 1979–80 shocks.

The question remains whether these declines in real wages were smaller or larger than those which would have prevailed in the absence of sticky nominal wages. This is an important empirical question. If in the short run real wages in fact fall *more* than they would in the absence of nominal wage rigidities, then output falls by *less*.[11] The opposite occurs if nominal

9. *See* Sachs, *Wages, Profits, and Macroeconomic Adjustment in the 1970s: A Comparative Study*, BROOKINGS PAPERS ON ECONOMIC ACTIVITY (1979), and Branson & Rotemberg, *supra* note 8.

10. *See* Sachs, *supra* note 9, and Branson & Rotemberg, *supra* note 8.

11. This is the case in the model of Blinder, *Monetary Accommodation of Supply Shocks Under Rational Expectations*, 13 J. OF MONEY, CREDIT, AND BANKING 425–38 (Nov. 1981).

TABLE 1

PERCENT CHANGE WITH RESPECT TO THE PREVIOUS YEAR OF REAL HOURLY EARNINGS OF NONAGRICULTURAL EMPLOYEES

Year	%
1972	3.0
1973	−0.1
1974	−2.8
1975	−0.7
1976	1.4
1977	1.0
1978	0.5
1979	−3.1
1980	−4.0

Source: *Economic Report of the President*, 1982.

wage rigidities prevent real wages from falling as much as they should.[12] These effects follow from the incentives firms have to lay off workers when real wages are high and to hire them when real wages are low.

Rigidities in nonenergy prices create further adjustment effects on output, and the direction of these effects is also ambiguous. As explained in the preceding section, in the absence of rigidities, the nonenergy component of the aggregate price level could go up or down depending on the characteristics of the demand for money and the extent to which real income changes. If, in the absence of rigidities, nonenergy prices would fall, then the presence of rigidities would delay this fall, real money balances would temporarily be lower thereby reducing people's purchasing power, and hence output would temporarily be lower. The opposite would be the case if nonenergy prices would rise in the absence of rigidities.[13]

Price rigidities can create a further effect on output. It is possible that

12. *See* Hall & Pindyck, *supra* note 3, and Hall & Pindyck, *What to do When Energy Prices Rise Again*, THE PUBLIC INTEREST 59–70 (Fall 1981). Hall and Pindyck assume this latter effect predominates. The ambiguity can be explained as follows. The change in nonenergy prices depends on the size of the fall in real income, on the sensitivity of the demand for real money balances to changes in real income, and on the weight of the price of energy in the price level. These factors are to some degree independent of those which determine the fall in real wages required by the direct effects discussed in Section 3. Therefore it is possible that the fall in real wages which stems from the rigidity of nominal wages accompanied by the rise in nonenergy prices is larger than the fall in real wages which would prevail in the absence of adjustment problems.

13. Rotemberg, *Supply Shocks, Sticky Prices, and Monetary Policy*, 15 J. OF MONEY, CREDIT AND BANKING 489–98 (Nov. 1983) shows conditions under which each of these cases will arise.

nonenergy firms will raise their prices too much by just "passing through" increases in energy costs without regard to demand conditions. Output would then be lower in the short run until firms finally adapt to depressed demand by lowering their prices.

The point here is that rigidities in nominal wages and nonenergy prices can lead to short run shifts in real output, beyond the direct reductions discussed earlier. Ongoing research hopefully will help to better establish the direction and magnitudes of these short run shifts, and the extent to which adjustment problems exacerbate the economic effects of energy price increases.

One last effect should be mentioned. Real output also can be reduced in the longer run because of the dampening effect that an energy price shock can have on investment. As stated earlier, one of the direct effects of an energy price increase is to alter the mix of factor inputs in industrial production, reducing investment to the extent that energy and capital are complementary. In addition, a sudden change in energy prices can create uncertainty about the profitability of private investment. Combined with the higher interest rates that can accompany the higher rate of inflation, this can bring about a slow-down in investment demand.[14]

IMPLICATIONS FOR ECONOMIC POLICY AND ENERGY POLICY

An energy price shock can result in a combination of higher inflation, higher unemployment, and lower real output, and this complicates the design of an economic policy response. Social and political pressures will on the one hand encourage the pursuit of contractionary policies in order to fight inflation, and on the other hand encourage expansionary policies in order to stimulate output and reduce unemployment.

Following the 1974 oil price shock, the goal of fighting inflation dominated. The Federal Reserve used a highly contractionary monetary policy as a means of "treating" the inflationary burst that followed the oil price shock, and this resulted in a recession that was probably worse than it needed to be.

On the other hand, an expansionary monetary policy is likely to postpone the fall in real income which is necessitated by the increase in energy prices. It is still an open empirical question, however, as to whether

14. For further discussions of the macroeconomic effects of rising energy prices, and the implications for macroeconomic policy, see Rotemberg, *id.*; Helliwell, *The Stagflationary Effects of Higher Energy Prices in an Open Economy* (Resources Paper No. 57, Department of Economics, University of British Columbia, Vancouver (Oct. 1980)); and Solow, *What To Do When OPEC Comes*, RATIONAL EXPECTATIONS AND ECONOMIC POLICY (S. Fischer, ed., 1980). For a discussion of the international differences in these effects, see Hall and Pindyck, *supra* note 12, and Fieleke, *Rising Oil Prices and the Industrial Countries*, NEW ENGLAND ECON. REV. 17–28 (Jan. 1981).

nominal rigidities in the United States tend to raise or lower output relative to what it would have been otherwise. Monetary policy, of course, can take advantage of these rigidities and temporarily increase output by following expansionary policies. Because the direction in which output should move in the short run is ambiguous, money growth simply ought to be smooth and predictable so as to provide a stable economic environment and to control inflation in the longer run.

An energy price shock also can create problems for fiscal policy. As we explained earlier, an energy price shock must be followed by an adjustment in real national income, and this means adjustments in the components of real national income, including the government sector. Unfortunately, if real income falls after a shock, there is a tendency for the share of government in the economy to rise. The role of government and the size of government's share in GNP should be determined by social and economic considerations. Any reductions in real national income following a price shock should be spread evenly across all sectors of the economy, including the government sector. Otherwise government budget deficits can grow out of control, leading to a more than proportionate drop in real income levels outside the government sector. Moreover, these deficits would lead to higher inflation in the future if they are monetized. Because of this, an energy price shock should not be followed by a cut in income taxes. In fact, if the government wants to keep expenditures in real terms at their pre-shock level, tax increases will be needed.

Some people have argued that a system should be put in place to "recycle" purchasing power back to consumers in the wake of an energy price shock. We see no need for such a scheme, because the government would have no additional revenue to "recycle" unless it imposed new taxes. An energy shock would increase revenues from the Windfall Profits Tax, but these are likely to be more than offset by the reduction in income tax receipts. Also, the recession that accompanies an energy shock would increase the "uncontrollable" outlays of the government (*e.g.*, unemployment compensation). "Recycling" schemes that have been proposed are simply methods of increasing government transfers. They have no rationale as part of economic policy or energy policy.

Incentives to stimulate investment are desirable following an energy price shock. Policies, such as investment tax credits and accelerated depreciation, can be used to help stimulate investment demand, which might otherwise be depressed. This can help to accelerate capital-energy substitution earlier and thereby reduce energy consumption, because new capital is likely to be more energy efficient.

Insofar as nonenergy prices rise too much, it is also desirable to utilize cost reducing tax policies, which lower prices and raise output by reducing costs of production. Such a policy provides a way for the government to compensate for the flexibility that the economy lacks in the short run. The best candidate for this kind of policy is a reduction in payroll taxes. A payroll tax increase has the same kind of effect as an energy price increase—it raises production costs, causing more inflation, which in turn feeds back into wages, and so on. It is unfortunate to note that the United States is moving in the opposite direction, with major payroll tax increases scheduled.

In summary, while it is impossible to eliminate the inflationary and recessionary impacts of an energy price shock, there are policies that can be used to ameliorate the impact and prevent it from becoming worse than necessary. Those policies include moderate growth of the money supply, restraint on fiscal expansion, investment incentives, and reductions in payroll taxes.

The macroeconomic impact of an energy price shock also has implications for energy policy. As the experience of 1973–74 proves, the imposition of price controls following a shock can be disastrous. Price controls can turn a price shock into a quantity shock—*i.e.*, they can result in significant shortages of energy. The macroeconomic impact of higher energy prices can be large, but not nearly as large as the economic impact of energy shortages.

The macroeconomic impact of an energy price shock should be viewed as a social cost, since no single firm or consumer can affect that impact. As such, it warrants a public policy response. In particular, our vulnerability to sharp increases in the price of oil adds a premium to the social value of every barrel of oil.

In addition to economic vulnerability, dependence on imported oil also creates an undesirable political and strategic vulnerability. Because of the economic and political consequences of a major cutoff of OPEC oil, the United States spends vast sums to develop a "Rapid Deployment Force." Also, oil-exporting countries subject the United States to political pressure. These political and strategic costs further raise the premium on the value of a barrel of oil.

Estimates of the size of the premium vary, depending in part on one's view of the political costs of import dependence, but a reasonable estimate would be in the range of $10 to $20 per barrel. Some people have argued that this premium justifies the subsidization of synthetic fuel development as an eventual substitute for oil. This is not the case, and those subsidies would be an extremely inefficient way to deal with our import dependence.[15] Rather, the premium implies the need for a tariff on imported oil.

Unlike a "Btu tax" or related excise tax, a tariff would raise the price

15. *See* Joskow & Pindyck, *Should the Government Subsidize Nonconventional Energy Supplies?*, REGULATION (Sept. 1979), and Pindyck, *Energy, Productivity, and the New U.S. Industrial Policy*, in TOWARD A NEW U.S. INDUSTRIAL POLICY (M. L. Wachter & S. M. Wachter, eds., 1981).

of all oil in the United States, affecting both the demand and supply sides of the market. The tariff gives consumers an added incentive to conserve, and gives producers an added incentive to produce—efficiently choosing those energy sources (oil or others) and those technologies that are most economical. At the time of an energy shock, the tariff would be reduced or temporarily removed, thereby insulating the economy from a sharp energy price change.

Unfortunately, in the short term a tariff—like an OPEC-induced increase in the price of oil—is inflationary and recessionary. This problem can be largely eliminated, however, if the tariff is phased in gradually over a two or three year period (remember that gradual increases in energy prices are much less damaging than rapid increases). Imposition of the tariff can also be combined with reductions in the payroll tax.

The present Windfall Profits Tax would tax away part of any increase in revenues accruing to oil producers as a result of the tariff. Whether that tax should be expanded or reduced as part of a tariff program is a question that has not been addressed in detail; it hinges on both equity and resource depletion considerations.

The "social premium" on oil may also justify the strategic oil reserve. A strategic reserve has two functions. First, in the event of a war that disrupted most shipping and trading of oil, shortages could occur in that imports might be unavailable at any price. Strategic reserves could be used to prevent such shortages. Second, a strategic reserve could be used to smooth out the price increases that follow a major production cutback, thereby reducing their economic impact.

But a strategic reserve works best when implemented as part of an international agreement. When a stockpile is released, wherever it happens to reside, it adds to the world supply of oil and thereby reduces the world price. As a result the benefits are enjoyed by all importing countries, even if they do not have stockpiles of their own, but the benefits to the country holding the stockpile are likewise reduced. If only the United States released a stockpile in the wake of a crisis, the impact on world oil prices—and prices faced by Americans—would be small. If most major OECD nations maintained and released large stockpiles, however, this would significantly limit price increases and the economic damage they cause.

As the experience of the International Energy Agency has shown, the likelihood of obtaining this type of international agreement is low. Meanwhile the costs of implementing the strategic reserve have risen. The program therefore should be carefully reassessed. It may be better to aim for a smaller stockpile, but impose a hefty tariff on imported oil.

TABLE 2
SUMMARY OF ENERGY PRICE SHOCK EFFECTS

Effects	Policy Implications
I. DIRECT EFFECTS	
1. Reduction in real National Income. Size depends on energy cost share and demand elasticities.	Economic policy cannot reduce this effect. However, to keep government share fixed, government spending must fall commensurately.
2. Short-run drop in investment spending. Behavior of factor demands over time depends on pattern of price change and on anticipations.	—
3. Real output unchanged if energy demand is price inelastic and home factors are supplied inelastically; otherwise real output falls.	—
4. In general, real wage will fall. Theoretically possible for real wage to rise if (a) factor substitution effect is very strong, or (b) large drop in labor supply as workers substitute leisure for labor.	—
II. ADJUSTMENT EFFECTS (Assumes real wage falls in (4).)	
5. Burst of inflation in short run. Inflationary burst is greater the greater the direct reduction in real income, and the more elastic the demand for money with respect to changes in real income.	Inflationary burst is largely unavoidable. Do *not* respond with a sharply contractionary monetary policy.
6. *If the real wage is rigid* (*e.g.*, Europe), output falls by more in short run, and employment falls.	Reduce payroll or value added taxes. Use tax incentives to stimulate investment.
7. *If the nominal wage is rigid* (U.S.), inflationary burst reduces real wages.	
(a) If real wage falls by *more* than it would in absence of rigidity, then output falls by less.	Contract money supply. } Since 7(a) vs. 7(b) and 8(a) vs. 8(b) are empirically unresolved issues, *money growth should remain stable*.
(b) If real wage falls by *less* than in absence of rigidity, output falls by more.	Expand money supply. }
8. *If nonenergy prices are rigid*, and they:	
(a) rise by *less* than they would in absence of rigidity, then output falls by less.	Contract money supply. }
(b) rise by *more* than in absence of rigidity, output falls by more.	Expand money supply. }
III. ENERGY MARKETS	
9. Price controls will turn a price shock into a *quantity* shock, which has much worse economic impact.	Avoid the use of price controls and/or "allocation" schemes.
10. Macroeconomic adjustment effects add a social premium to the value of a barrel of oil.	Impose a tariff on imported oil. Phase tariff in gradually over 2 or 3 years.

SUMMARY AND CONCLUSIONS

This paper explains how energy price shocks can affect macroeconomic variables through a variety of different channels. Some of these effects are the result of rigidities in wages or prices, and in some cases the direction of the effect is ambiguous. The paper also reviews the implications that these effects have for economic and energy policy.

A rather wide territory has been covered, and a brief summary of the main points and policy conclusions would be helpful. This summary is provided in Table 2.

Our understanding of the macroeconomic effects of an energy price shock is still incomplete. For example, the general equilibrium effects of an energy price increase on the real wage and on nonenergy prices is ambiguous and requires further empirical study. In addition, this paper has ignored exchange rate effects, which preliminary studies have shown could be important.[16] Nonetheless, our current understanding of these macroeconomic effects has strong and robust implications for economic and energy policy. The policies outlined in the preceding section would help limit the impact of any future shocks. That impact will still be significant, but it should be manageable. The United States and other energy-dependent countries must avoid exacerbating the effects of energy shocks with misguided policies.

16. For a discussion of exchange rate effects, *see* Krugman, *Oil and the Dollar* (NBER Working Paper, 1981).