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INTRODUCTION

The purpose of this paper is to analyze the impact on the United States economy of higher energy prices resulting from the establishment of the OPEC oil cartel in late 1973 and early 1974. The year 1972 is the last year of the "old" regime of energy prices and provides the starting point for our study. The year 1976 is the most recent year for which detailed data on energy prices are available and it provides the termination point for our study. These years correspond to periods of vigorous expansion following the recessions of 1970 and 1974. However, they differ drastically with regard to the level of energy prices.

The main conclusions of our analysis of the impact of higher energy prices on the U.S. economy are the following:

1. GNP: Real GNP in 1976 was reduced by 3.2 percent because of the increase in energy prices from 1972 to 1976.
2. Energy: Total energy consumption in 1976 was reduced by 8.8 percent because of the increase in energy prices, resulting in a sizeable fall in the energy-GNP ratio.
3. Capital: The level of capital stock in 1976 was reduced by $103 billion in constant dollars of 1972 because of the increase in energy prices. This can be compared with 1976 gross investment of $165 billion in constant dollars.
4. Labor: Despite the reduction in GNP growth, employment in 1976 declined by only 0.5 million jobs as a result of higher energy prices. As a consequence, productivity growth fell substantially over the period 1972-1976.

Our overall conclusion is that higher energy prices have had a dramatic impact on the U.S. economy over the period 1972-1976. This impact is not limited to a reduction in the growth of energy consumption, but it has also resulted in a slowdown in economic growth, a weak recovery of capital spending, a substantial increase in employment and a decline in the growth of productivity. We now turn to a detailed examination of the mechanisms through which energy prices have affected the U.S. economy. We examine the shift

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in the composition of total spending away from energy and energy-intensive goods and services. We will next consider the impact of a reduction of energy and energy-intensive inputs into the production sectors of the economy. Finally, we will analyze the impacts of these changes on investment and capacity and on employment and labor productivity.

ANALYTICAL FRAMEWORK

Our analysis of the effects of higher energy prices is based upon a dynamic general equilibrium model of the U.S. economy. The original form of the model was developed for the Energy Policy Project of the Ford Foundation.[1] Subsequent development of the model is outlined by Hudson and Jorgenson.[2] Production activity in this model is divided among ten sectors: agriculture and construction, manufacturing, transportation, services, and six energy sectors. There are thirteen inputs into each sector–intermediate inputs consisting of output from the ten producing sectors, together with three primary factors of production, including capital services, labor services and imports. Each producing sector supplies output to each of the ten intermediate sectors and to the four categories of final demand: personal consumption, investment, government purchases and exports.

The technology of each producing sector is represented by an econometric model giving the supply price of output as a function of the prices of primary and intermediate inputs and the level of technology.[3] Also, technical coefficients giving the use of each type of primary and intermediate input per unit of output for each producing sector are derived as functions of prices and productivity from these models of technology. Consumer preferences are represented

1. The original form of the model was presented in E. HUDSON & D. JORGENSON, ENERGY RESOURCES AND ECONOMIC GROWTH, FINAL REPORT TO THE ENERGY POLICY PROJECT Ch. 5 (1973).

2. A comprehensive description of the current version of the model is given in E. HUDSON & D. JORGENSON, THE LONG TERM INTERINDUSTRY TRANSACTIONS MODEL: A SIMULATION MODEL FOR ENERGY AND ECONOMIC ANALYSIS, FINAL REPORT TO THE APPLIED ECONOMIC DIVISION, FEDERAL PREPAREDNESS AGENCY (1977). A related discussion of the model in the policy analysis context is given in D. BEHLING, E. DULLIEN & E. HUDSON, THE RELATIONSHIP OF ENERGY GROWTH TO ECONOMIC GROWTH UNDER ALTERNATIVE ENERGY POLICIES (1976).

3. The econometric model of production also is described in E. BERNDT & D. JORGENSON, ENERGY RESOURCES AND ECONOMIC GROWTH, FINAL REPORT TO THE ENERGY POLICY PROJECT Ch. 3 (1973) and in Christenson, Jorgenson & Lau, *Transcendental Logarithmic Utility Functions*, vol. 55, no. 2, 65 Rev. Econ. Statistics 3 (Feb. 1973). A related application of the production model is given in Berndt & Wood, *Technology, Prices, and the Derived Demand for Energy*, 57 Rev. Econ. Statistics 259-68 (Aug. 1975).

by an econometric model giving the allocation of personal consumption expenditures among goods and services as a function of prices and income.[4] Given the final demands and the technical coefficients, the level of output from each sector can be determined. Then, using the levels of output and the technical coefficients, each sector's demand for intermediate and primary inputs, including energy, can be calculated.

In each period, the relative prices of all commodities are determined by the balance between demand and supply. Technical input coefficients are determined simultaneously with the prices. Final demands are also functions of these prices. Final demands and input coefficients together determine sectoral output levels and input purchases from the condition that there is balance between total demand and supply for each type of output. The condition that demands for capital and labor equal their supplies yields the prices of these primary inputs.

The supply of capital in each period is fixed by past investment. Variations in demand for capital services affect the price but not the quantity of these services. Similarly, the supply of labor time in each period is fixed by past demographic developments. Variations in demand for labor time by the producing sectors and by the household sector for consumption in the form of leisure affect the price of labor and the allocation of labor time between these market and nonmarket activities. Finally, the supply of saving by the household sector must be balanced by final demand for investment by the producing sectors. Dynamic adjustment to higher energy prices is modeled by tracing through the impact of investment on capacity expansion.[5]

Our dynamic general equilibrium model was used to simulate two economic growth paths over the 1972-1976 period. In the first simulation, actual values of the exogenous variables, including world oil prices, were employed as the basis for model solution. This simulation provides an estimate of the actual development of the U.S. economy between 1972 and 1976. In the second simulation, 1972

4. The econometric model of consumption is described in D. Jorgenson, *Consumer Demand For Energy*, INTERNATIONAL STUDIES OF THE DEMAND FOR ENERGY 309-28 (W. Nordhaus ed. 1977). The theory of this model also is developed in Christensen & Jorgenson, *The Structure of Consumer Preferences* vol. 4, no. 1 ANNALS SOCIAL ECON. MEASUREMENT 49-101 (1975) and Christensen, Jorgenson & Lau, *Transcendental Logarithmic Utility Functions*, vol. 65, no. 3 Am. Econ. Rev. 367-83 (June 1975).

5. A theoretical analysis of the dynamic adjustment process, in a macroeconomic growth model context, is presented by HOGAN, *Capital Energy Complementarity in Aggregate Energy-Economic Analysis*, ENERGY MODELING FORUM, INSTITUTE FOR ENERGY STUDIES, STANFORD UNIVERSITY (Sept. 1977).

energy prices were employed over the whole 1972-1976 period; i.e., world oil prices were held at their 1972 real values. As world oil prices are the only set of exogenous variables to change between the two simulations, the differences in simulated economic activity can be attributed solely to the impact of the oil price increase. (Other energy prices are affected by the oil price change so all energy prices change between the simulations.) Therefore, comparison between the two simulations provides the basis for analyzing the impacts of the energy changes on energy use and on the level and structure of economic activity.

OVERALL ECONOMIC IMPACT

The energy price increases, and the associated changes in energy use, have significant impacts on both the quantity and the price aspects of overall economic activity. The level of real GNP is reduced, or the rate of economic growth is slowed as a result of the energy changes, while the structure of spending and production is also changed. The overall price level is increased, or the rate of inflation is raised from the energy changes, at the same time as the structure of relative prices is altered.

The rise in energy prices leads to a reduction in real GNP. The simulated level of real GNP for 1976 under actual energy price conditions was 3.2 percent lower than its simulated level under 1972 energy prices. There are two broad sets of reasons for this decline, one centering on input productivity and one centering on capital. Producers can economize on energy by substituting other inputs for energy. This substitution is not perfect, so that productivity is adversely affected. In addition, any additional input used as a substitute for energy must be taken from some other use, further detracting from overall productive potential. The result is that a given set of primary inputs can sustain a lower real GNP than would be possible without the restructuring of production patterns caused by the energy price increases.

A second result of the energy-induced changes is a reduction in the demand for capital services. The rise in energy prices leads to a decline in the rate of return on capital. This reduces the incentive for saving and investment, slowing the rate of capital formation. In addition, the energy price increase and the reduced level of real GNP lead to less saving and to a change in the allocation of income between consumption, on the one hand, and saving and investment on the other. This further slows the rate of capital formation. There is, then, a slowing of the rate of growth of productive capacity with the result that the level of potential GNP is lower than would have been the case at lower energy prices. The combination of substitution and capacity expansion effects results in an estimated reduction in 1976 real GNP of 3.2 percent.

The rate of economic growth, as well as the level of real GNP at any time, is affected by higher energy prices. The substitution or productivity changes affect the level of GNP; after the adjustment to the new spending and production patterns has been made there is no further pressure from this source tending to reduce GNP. This results in a shift to lower economic growth path but it does not depress the underlying growth rate. The capacity expansion effect, however, can have a longer lasting impact. At reduced GNP levels, under higher energy prices and with the reduced rate of return, savings and investment account for a smaller fraction of income. The resulting slowdown in the rate of capacity expansion works to reduce the rate of economic growth. Only in the long run will the rate of growth return to the underlying trend. Since this new economic growth path is, at every point, below the previous path, the loss of income or production resulting from higher energy prices is permanent.

Inflation will be accelerated by the higher energy prices, since the direct impact of higher energy prices is to raise the level of output prices as the energy prices are passed through the whole cost structure. In addition, the shift from energy towards other inputs results in some loss of productivity and some further increases in unit costs, adding to inflationary pressures. The inflationary effects can be complicated by the labor productivity changes. If wage and salary demands are based on past trends, and if they are granted, then the slowdown in labor productivity growth means that unit labor costs will rise more rapidly than previously, giving further impetus to inflation. All of these effects, however, correspond to a transition to a higher price level, not to a higher rate of price increase. They give inflation only a temporary increase. It is only if some additional feedback mechanism such as a price-wage-price spiral comes into operation that these short-run inflationary impacts can be translated into a permanent rise in the rate of inflation.

EFFECT ON ECONOMIC STRUCTURE

The structure of economic activity, as well as the level of output, changes as a result of the energy price increases. Higher energy prices raise the whole price structure. In addition, the pattern of relative prices is changed with the more energy intensive goods experiencing the largest price increases. These price changes induce a shift in the pattern of final demand spending away from the now more expensive energy intensive products. Similarly, the pattern of inputs into production is altered with the role of energy being reduced. Since both the mix of final demand and the way in which output is made are adjusted away from energy, the composition of total output shifts away from energy and energy-intensive sectors. Thus, the energy content of each dollar of GNP is reduced.

Final demand patterns alter as a result of the energy price rises, partly in response to the price increases themselves and partly as a result of the associated reduction in income levels. The essence of the final demand changes is a movement away from energy intensive, and now more expensive, products. Table 1 shows the change in the pattern of final demand between the high and low energy price simulations. This gives the allocation of real final demand–personal consumption expenditure, investment, government purchases and exports–over the four non-energy products and delivered energy. The principal change is the reduction in the relative importance of energy purchases.

TABLE 1

COMPOSITION OF REAL FINAL DEMAND IN 1976
(PERCENT OF TOTAL REAL FINAL SPENDING)

	Simulated with 1972 energy prices	*Simulated with actual energy prices*
Agriculture, Construction	12.3	12.0
Manufacturing	32.4	32.2
Transportation	2.6	2.5
Services, Trade, Communications	48.8	49.9
Energy	3.9	3.4
Total	100.0	100.0

The share of energy in total real final demand declines from 3.9 percent under low energy price conditions to 3.4 percent with higher energy prices. Purchases of transportation and of agriculture and construction show the next largest declines while the share of manufacturing is reduced slightly. Purchases of services are increased, absorbing the expenditure directed away from each other type of output. The services' share of total real final demand rises from 48.8 percent at the lower energy prices to 49.9 percent under the higher price conditions. In sum, final demand is redirected from energy to non-energy products and, within the non-energy group, it is redirected to the purchase of services.

Producers respond to higher energy prices in a way analogous to final demand. The motivation is to minimize unit costs in the face of the new price structure. The direction of adjustment is to economize on energy input and, given time to adjust, significant reductions in energy use are cost-effective under a regime of high energy prices. This reduction in energy use is not costless; it is achieved by increases in the use of labor services, capital services and other intermediate inputs. What is involved, therefore, is a redirection of input patterns away from energy, not a net reduction in input levels. The changes in input patterns can be represented by changes in input-output coefficients. These coefficients are given in Table 2 for four input categories—capital services, labor services, energy, and materials (all other intermediate inputs)—into each non-energy producing sector. Two sets of coefficients are given for each sector, one the simulated 1976 coefficients, the other the coefficients simulated for 1976 on the basis of the 1972 energy prices.

The result of the adjustment from lower to higher energy prices is that for every sector the energy input coefficient is reduced. Thus, considerable energy savings are achieved in production activities. The greatest proportionate energy reductions are estimated to occur in services and in manufacturing, where the energy input coefficient is reduced by about 15 percent. Agriculture, construction and transportation obtain energy savings of half this amount. There are also considerable differences among the sectors as to how the other inputs are adjusted to compensate for reduced energy use. Labor input is increased in all sectors and capital input is decreased in all sectors other than services. Manufacturing shows particularly noticeable adjustments: the 16 percent reduction in the energy coefficient is accompanied by a 4 percent reduction in the capital coefficient, with both of these reductions being offset by the 3 percent increase in labor intensity of production.

Patterns of input into production in each sector move toward less energy use. Final demand patterns are adjusted away from energy-intensive goods and services. These two changes in combination mean that the pattern of gross sectoral outputs is altered and that the nature of this change is a shift away from energy and energy-intensive products. Table 3 summarizes these changes. The relative importance of the energy sector is reduced substantially, from 5.9 percent to 5.0 percent of total output. Transportation shows the next largest relative decline while agriculture, construction and manufacturing show smaller reductions. The role of services increases significantly. There is, then, a redirection of production in the economy away from energy, and to a lesser extent away from goods and towards service activities.

TABLE 2

INPUT-OUTPUT COEFFICIENTS FOR INPUTS INTO PRODUCTION (SIMULATED COEFFICIENTS FOR 1976)

	Coefficient Corresponding to Energy Price For: 1972	1976	*Difference*[1] *(Percent)*
Agriculture:			
Capital	.2242	.2222	–0.9
Labor	.2532	.2591	2.3
Energy	.0219	.0204	–7.0
Materials	.5007	.4983	–0.5
Manufacturing:			
Capital	.1059	.1015	–4.1
Labor	.2822	.2909	3.1
Energy	.0215	.0181	–15.8
Materials	.5904	.5895	–0.2
Transportation:			
Capital	.1777	.1743	–1.9
Labor	.4102	.4135	0.8
Energy	.0415	.0380	–8.4
Materials	.3706	.3742	1.0
Services, Trade, Communications:			
Capital	.2962	.2995	1.1
Labor	.4262	.4347	2.0
Energy	.0176	.0143	–18.8
Materials	.2599	.2515	–3.2

1. Percentage difference of the coefficients corresponding to 1976 energy prices relative to those based on 1972 energy prices.

These changes in the structure of economic activity are significant. First, they imply that all aspects of the economy are affected by the energy price changes, despite the relatively small fraction that energy represents in total economic output. Thus the relative sizes of the different sectors of the economy are affected as well as spending patterns and production patterns. In addition, the use of capital and labor inputs will be affected throughout the economy. Second, these structural changes have the effect of reducing the energy content of spending and of production. This means that, under the higher energy prices, each dollar of GNP requires less energy input.

REDUCTIONS IN ENERGY USE

In 1972 the U.S. used 72.0 quadrillion Btu's of primary energy input to sustain a real GNP of $1171 billion in constant dollars of

TABLE 3

COMPOSITION OF REAL GROSS OUTPUT IN 1976
(PERCENT OF TOTAL REAL GROSS OUTPUT)

	Simulated with 1972 energy prices	*Simulated with actual energy prices*
Agriculture, Construction	10.2	10.1
Manufacturing	33.3	33.2
Transportation	4.0	3.9
Services, Trade, Communications	46.6	47.8
Energy	5.9	5.0
Total	100.0	100.0

1972. This corresponds to an energy-GNP ratio of 61.4 (million Btu's per dollar (1972)). In 1976, GNP had increased to $1275 billion in constant dollars but energy use had risen only to 73.7 quadrillion Btu's,[6] giving a significantly reduced energy-GNP ratio. If the 1972 energy-GNP ratio still applied in 1976, the primary energy input required to sustain the actual 1976 GNP would have been 78.3 quadrillion Btu's. Further, if GNP had not been reduced by 3.2 percent as a result of the energy changes, the required energy input would have been 80.8 quadrillion Btu's. In these very aggregative terms, therefore, the changes in energy use patterns and economic structure induced by the rise in energy prices are shown to have resulted in an annual energy reduction of 7.1 quadrillion Btu's by 1976. The mechanisms yielding this energy saving are now outlined.[7]

The composition of real final demand changed significantly between the high and low energy price simulations. These changes were presented above. They imply that the direct energy content of a given total of real final spending is reduced in response to the rise in energy prices. Between the two simulations there is a reduction of 0.45 percent in the share of spending going to energy. When applied to the simulated 1976 total real final spending of $1330 billion in constant dollars, this represents a reduction of $6.0 billion in constant dollars in the demand for energy.

The non-energy component of real final spending accounts for the larger proportion of total final spending in 1976 as a result of higher

6. U.S. primary energy input in 1976 is estimated to be 73.7 quadrillion Btu; *see*, II ENERGY INFORMATION ADMINISTRATION xx (1978).

7. The role of energy in the current recovery also is discussed in JORGENSON, *The Role of Energy in the U.S. Economy*, NAT'L TAX J. (forthcoming). The impact of energy policy on future U.S. economic growth is considered in HUDSON & JORGENSON, *Energy Policy and U.S. Economic Growth* vol. 68 AMER. ECON. REV. 2 (1978).

energy prices. This shift in itself implies that more energy will be absorbed in satisfying non-energy final demand. Also, composition of spending as between the non-energy types of goods and services is altered. Services absorb a greater part of this spending while the other sectors decline in relative importance. Since services are the least energy-intensive type of production, this corresonds to a shift away from energy-intensive purchases. This shift works to reduce the energy content of final demand. These two types of adjustment work in opposite directions as far as energy use is concerned. The net change in the energy content of non-energy final demand could, therefore, be either positive or negative.

The information needed to calculate the impact of the change in non-energy final demand on energy utilization is presented in Table 4. This table determines the direct energy requirements for 1976 non-energy final demand spending, as well as the energy requirements of the same total spending allocated over commodities in the pattern associated with 1972 energy prices. Under the higher energy prices, there is a reduced requirement for direct energy for agriculture and construction, manufacturing and transportation. In contrast, spending on services is increased and this additional energy demand is sufficient to offset the energy reduction in the other three sectors. The net effect is that the direct energy content of non-energy final spending increases as a consequence of the higher energy prices. The increase is small, about $0.4 billion in constant dollars,

TABLE 4

CHANGE IN DIRECT ENERGY CONTENT OF 1976 REAL NON-ENERGY FINAL DEMAND (REAL VARIABLES IN BILLION DOLLARS (1972))

	Real Final Demand in Pattern for Prices of:[1]		*Energy Input Coefficient:*[2]	*Energy Content for Spending in Pattern of:*[3]		*Change in Direct Energy Content:*[4]
	1976	*1972*		*1976*	*1972*	
Agriculture, Construction	159.0	163.6	.0219	3.48	3.58	−0.10
Manufacturing	428.4	431.0	.0215	9.21	9.27	−0.06
Transportation	33.1	34.5	.0415	1.37	1.43	−0.06
Services, Trade, Communications	663.5	649.0	.0176	11.68	11.42	0.26
				25.75	25.70	0.04

1. Total real final demand in the 1976 simulation allocated over sectors in the 1976 patterns and in the pattern simulated for 1976, based on 1972 energy prices.
2. Input-output coefficients for energy into each producing sector as simulated for 1976, based on 1972 energy prices.
3. Direct energy input into each of the two sets of final demand.
4. Direct energy content of 1976 non-energy final demand allocated in the pattern corresponding to 1976 energy prices, less direct energy content of this final demand allocated in the pattern corresponding to 1972 energy prices.

but it does work to counter the energy reductions achieved by fewer direct final purchases of energy.

The pattern of inputs into each production sector also changes as a result of the energy price increases; these changes have been analyzed above in terms of adjustments in input-output coefficients. This restructuring of inputs means that the energy content of any set of total sectoral outputs is reduced. The implications of this reduction caused by energy saving are developed in Table 5. This table gives the energy content of the 1976 gross sectoral outputs for input patterns simulated under the 1976 energy prices, as well as the energy content of this output given the input patterns simulated on the basis of the 1972 energy prices. The change in energy content is the energy saving achieved by producing a given set of outputs in a less energy-intensive way. These energy savings are substantial, corresponding to $6.4 billion in contant dollars of 1972. The greatest energy savings are achieved in the manufacturing and the services sectors, reflecting the large size of these sectors and the substantial reductions in unit energy requirements achieved in these sectors.

The final type of energy saving is that due to a reduction in the overall level of economic activity. The rise in energy prices led to a reduction in 1976 real GNP, relative to its simulated level based on 1972 energy prices, of 3.2 percent. This reduction implies a decline of approximately 3.2 percent in energy use, even with no changes in economic structure. This yields an estimated $4.0 billion in constant

TABLE 5

CHANGE IN ENERGY CONTENT OF
1976 PRODUCTION DUE TO INPUT RESTRUCTURING
(REAL VARIABLES IN BILLION DOLLARS (1972))

	Total Output:[1]	*Energy Input Coefficients for Energy Prices of:*[2]		*Energy Content with Coefficients of:*[3]		*Change in Energy Content:*[4]
		1976	*1972*	*1976*	*1972*	
Agriculture, Construction	221	.0204	.0219	4.51	4.84	−0.33
Manufacturing	719	.0181	.0215	13.01	15.46	−2.45
Transportation	86	.0380	.0415	3.27	3.57	−0.30
Services, Trade Communications	1004	.0143	.0176	14.36	17.67	−3.31
				35.15	41.54	−6.39

1. Total real sectoral outputs in the 1976 simulation.
2. Input-output coefficients for energy into the production sectors for the 1976 simulation, and for the simulation of 1976 under 1972 energy prices.
3. Energy content of the given sectoral outputs under the two sets of energy input coefficients.
4. Energy content of 1976 output, given input based on 1976 energy prices less energy content of this output under the coefficients based on 1972 energy prices.

dollars as energy saved from reducing the scale of economic activity.

These changes show the mechanism of economic adjustment to higher energy prices and the resulting energy saving. In brief, there are three general sources of energy saving: the scale of economic activity is reduced, final demand becomes less energy intensive, and methods of production become less energy intensive. Using the approximations that these three types of energy reduction add up to the total estimated 1976 energy saving of 7.1 quadrillion Btu's, and that each constant dollar of energy purchases is equal to the same number of Btu's, we can allocate the total energy saving over its sources. The results are presented in Table 6.

TABLE 6

SOURCES OF ENERGY SAVING IN 1976

	Energy Reduction, Percent of Total		*Energy Reduction Quadrillion Btu*	
Changes in Final Demand				
Reduction in energy purchases	37.5		2.7	
Restructuring of non-energy purchases	– 2.5		–0.2	
Total		35.0		2.5
Changes in Inputs to Production				
Agriculture, Construction	2.1		0.1	
Manufacturing	15.3		1.1	
Transportation	1.9		0.1	
Services, Trade, Communications	20.7		1.5	
Total		40.0		2.8
Reduction in Economic Activity		25.0		1.8
Total Energy Reduction		100.0		7.1

Final demand changes account for 35 percent of the total saving, and all of this saving is due to redirection of final demand away from energy purchases and towards purchases of non-energy goods and services. Changes in input patterns, as represented by the input-output coefficients, account for 40 percent of the total energy saving. Reductions in energy used in service-oriented activities are the greatest single source of saving, at 21 percent of the total, with energy savings in the manufacturing sector, at 15 percent of the total, also being significant. Energy reduction in agriculture, construction and transportation provides a much smaller volume of saving, about 4 percent of the total. Reduction in the scale of economic activity resulting from higher energy prices yields the final 25 percent of energy saving. In terms of physical units of energy, the total saving of over 7 quadrillion Btu's is achieved by a reduction of 2.5 quads in final demand energy use, a reduction of 1 quad in manufacturing, a decline of 1.5 quads in services, and a decrease of almost 2 quads due to the reduced level of economic activity.

REDUCTION IN CAPITAL STOCK

The adjustments in spending and production patterns that reduce energy utilization relative to GNP also affect capital, labor and other factors of production. Demand for capital is affected as a result of changes in the mix of final demand and changes in the pattern of inputs into each sector. In addition, any effect of the energy changes on the level of real GNP will affect the overall level of demand for capital services as an input to production. Each of these three sources of change in demand for capital services will now be examined and the implications of the energy changes for investment and capacity growth indicated.

The change in the composition of final demand will alter the demand for capital input. For example, a decline in the proportion of spending directed to energy and an increase in spending on services will result in a different overall level of demand for capital services, since the capital requirements of these two types of production are different. The magnitudes of these changes are calculated in Table 7. This table presents the direct capital requirements of the simulated total 1976 real final demand when allocated over sectors in the 1976 patterns, and when allocated over sectors in the patterns corresponding to the 1972 energy prices. As a result of the higher energy prices, spending is directed away from energy and goods and towards services. The capital content of each type of production is held constant at the levels given by the input-output coefficients corresponding to 1972 energy prices. Under these conditions, the change in final demand composition leads to an increase in the direct requirement of capital services input of $1.3 billion in constant 1972 dollars. The central reason for this increase is the shift of spending towards services, which are relatively capital-intensive.

The demand for capital services also changes as a result of adjustments in the pattern of inputs to each producing sector. Specifically, the energy changes are accompanied by shifts in the capital input-output coefficients. In some sectors, production becomes more capital intensive; in other sectors it becomes less intensive. The overall

TABLE 7

CHANGE IN DIRECT CAPITAL INPUT TO 1976 REAL FINAL DEMAND (REAL VARIABLES IN BILLION DOLLARS (1972))

	Real Final Demand Pattern for Prices of:[1]		*Capital Input Coefficient:*[2]	*Capital Content for Spending in Pattern of:*[3]		*Change in Direct Capital Content:*[4]
	1976	*1972*		*1976*	*1972*	
Agriculture, Construction	159.0	163.6	.2242	35.65	36.68	−1.03
Manufacturing	428.4	431.0	.1059	45.37	45.64	−0.28
Transportation	33.1	34.5	.1777	5.88	6.13	−0.25
Services, Trade Communications	663.5	649.0	.2962	196.53	192.23	4.29
Energy	45.7	51.6	.2396	10.95	12.36	−1.41
Total	1329.7	1329.7		294.38	293.04	1.33

1. Total real final demand in the 1976 simulation allocated over sectors in the 1976 pattern and in the pattern simulated for 1976, based on 1972 energy prices.
2. Input-output coefficients for capital into each producing sector as simulated for 1976, based on 1972 energy prices.
3. Direct capital input into each of the two sets of final demand.
4. Direct capital content of 1976 final demand allocated in the pattern corresponding to 1976 energy prices, less direct capital content of this final demand allocated in the patterns corresponding to 1972 energy prices.

change depends on the size of the shift in each sector and the magnitude of each sector. Estimates of the size of the overall change are presented in Table 8. This table gives the input of capital services needed to sustain the simulated 1976 set of sectoral outputs under two sets of conditions: the 1976 input patterns and the input patterns simulated for 1976 based on 1972 energy prices. The difference in total demand for capital services, a reduction of $0.3 billion in constant dollars of 1972, is due to a change in methods of production. Under higher energy prices manufacturing uses less capital services, while the services sector demands a higher input of capital. These are almost offsetting, resulting in a small overall decline in demand for capital.

In addition, the energy price increases lead to a reduction in the simulated 1976 real GNP below the level estimated on the basis of a continuation of 1972 energy prices. The 1976 real GNP was 3.2 percent less than the level estimated for lower prices. As an approximation, this corresponds to a 3.2 percent reduction in the demand for capital services input. In constant dollars of 1972 this results in a $15.5 billion reduction in demand for capital services purely because the overall level of economic activity has been reduced.

The three types of changes in demand for capital services can now be brought together. Under the first order approximation that these components can be added to find the total change in capital demand, this yields the result that total demand for the input of capital ser-

TABLE 8

CHANGE IN CAPITAL CONTENT OF 1976 PRODUCTION DUE TO INPUT RESTRUCTURING (REAL VARIABLES IN BILLION DOLLARS (1972))

	Total Output:[1]	*Capital Input Coefficients for Energy Prices of:*[2]		*Capital Content with Coefficients of:*[3]		*Change in Capital Content:*[4]
		1976	*1972*	*1976*	*1972*	
Agriculture, Construction	221	.2222	.2242	49.11	49.55	−0.44
Manufacturing	719	.1015	.1059	72.98	76.14	−3.16
Transportation	86	.1743	.1777	14.99	15.28	−0.29
Services, Trade, Communications	1004	.2995	.2962	300.70	297.38	3.32
Energy	128	.2418	.2396	30.95	30.67	0.28
Total				468.73	469.02	−0.29

1. Total real sectoral outputs in the 1976 simulation.
2. Input-output coefficients for capital services into the production sectors for the 1976 simulation and for the simulation of 1976 under 1972 energy prices.
3. Capital content of the given sectoral outputs under the two sets of input coefficients.
4. Capital content of 1976 output, given input coefficients based on 1976 energy prices less capital content of this output under the coefficents based on 1972 energy prices.

vices in 1976 is reduced by $14.5 billion in constant 1972 dollars, due to the increase in energy prices. Capital services are the effective input services, or the implicit rental value, of capital stock. In any year, each dollar of capital stock provides about $0.14 of capital services. Therefore, this reduction in demand for capital services corresponds to a reduction of $103.3 billion in constant dollars in the desired level of capital stock. The allocation of this reduction over its sources is given in Table 9. The principal sources of change in demand for capital are the restructuring of inputs into manufacturing, which has a $22.4 billion reduction in constant dollars in demand for capital stock, the restructuring of inputs into services, which increases demand for capital stock by $23.5 billion in constant dollars, and the decline in the level of economic activity, which reduces demand for capital stock by $110.7 billion in constant dollars.

These are significant changes in the demand for capital. The overall decrease in demand for capital stock will be reflected by investment levels being lower than they would otherwise have been. If, as an illustration, all the capital adjustments were made in 1976, investment would be $103 billion less in constant dollars than would normally be expected. When this is compared to actual 1976 gross investment of $165 billion in constant dollars, it can be seen that the relative magnitude of the investment adjustment can be substantial.

TABLE 9

SOURCES OF REDUCTION IN CAPITAL STOCK IN 1976

	Capital Reduction, Percent of Total:		*Capital Reduction, $(1972) billion:*	
Changes in Final Demand:		–9.2		–9.5
Changes in Inputs to Production:				
Agriculture, Construction	3.0		3.1	
Manufacturing	21.9		22.4	
Transportation	2.0		2.0	
Services, Trade, Communications	–23.0		–23.5	
Energy	– 1.9		– 2.0	
Total		2.0		2.1
Reduction in Economic Activity:		107.2		110.7
Total Reduction in Capital Stock:		100.0		103.3

CHANGE IN EMPLOYMENT

Demand for labor and employment is affected by the energy-induced adjustments through a restructuring of final demand spending, a restructuring of the pattern of inputs into production, and a reduction in the overall level of economic activity. Final demand is redirected, as a result of the higher energy prices, away from energy and energy-intensive products. The implications of this adjustment for labor demand are presented in Table 10. The 1976 total real final demand is allocated over sectors in two patterns, one based on the 1976 energy prices, the other based on the lower 1972 energy prices. The direct energy content of these demands is calculated using one set of input-output coefficients. The result of the rise in energy prices is a substantial increase in labor demand. This increase of $2.9 billion in constant dollars of 1972 reflects the shift of final demand towards services and away from energy and goods. Since service activities have a higher labor content than any of these other sectors, the result of the shift is an increase in the labor content of each dollar of real final demand.

A restructuring of input patterns occurs in the producing sectors of the economy. In each sector increased labor input per unit of output results from the higher energy prices, so that the labor input for any given set of production outputs is increased. Table 11 presents the information necessary to make an exact calculation of this change in labor demand. In each sector, the labor input coefficient

TABLE 10

CHANGE IN DIRECT LABOR CONTENT OF 1976 REAL FINAL DEMAND (REAL VARIABLES IN BILLION DOLLARS (1972))

	Real Final Demand in Pattern for Prices of:[1]		*Labor Input Coefficient:*[2]	*Labor Content for Spending in Pattern of:*[3]		*Change in Direct Labor Content:*[4]
	1976	*1972*		*1976*	*1972*	
Agriculture, Construction	159.0	163.6	.2532	40.26	41.42	−1.16
Manufacturing	428.4	431.0	.2822	120.89	121.63	−0.73
Transportation	33.1	34.5	.4102	13.58	14.15	−0.57
Services, Trade, Communications	663.5	649.0	.4262	282.78	276.60	6.18
Energy	45.7	51.6	.1329	6.07	6.86	−0.78
Total	1329.7	1329.7		463.58	460.66	2.92

1. Total real final demand in the 1976 simulation allocated over sector in the 1976 pattern and in the pattern simulated for 1976, based on 1972 energy prices.
2. Input-output coefficients for labor into each producing sector as simulated for 1976, based on 1972 energy prices.
3. Direct labor input into each of the two sets of final demands.
4. Direct labor content of 1976 final demand allocated in the pattern corresponding to 1976 energy prices, less direct labor content of this final demand allocated in the pattern corresponding to 1972 energy prices.

increases, leading to additional labor demand totaling $16.6 billion in constant dollars of 1972. The largest increases in labor demand occur in services and in manufacturing, although there is also a significant increase in the agriculture and construction sector.

These two structural shifts add substantially to the demand for labor. Together they amount to $19.5 billion in constant dollars of

TABLE 11

CHANGE IN LABOR CONTENT OF 1976 PRODUCTION DUE TO INPUT RESTRUCTING (REAL VARIABLES IN BILLION DOLLARS (1972))

	Total Output:[1]	*Labor Input Coefficients for Energy Prices of:*[2]		*Labor Content with Coefficients of:*[3]		*Change in Labor Content:*[4]
		1976	*1972*	*1976*	*1972*	
Agriculture, Construction	221	.2591	.2532	57.26	55.96	1.30
Manufacturing	719	.2909	.2822	209.16	202.90	6.26
Transportation	86	.4135	.4102	35.56	35.28	0.28
Services, Trade, Communications	1004	.4347	.4262	436.44	427.90	8.54
Energy	128	.1344	.1329	17.20	17.01	0.19
Total				755.62	739.05	16.57

1. Total real sectoral outputs in the 1976 simulation.
2. Input-output coefficients for labor services into the production sectors for the 1976 simulation and for the simulation for 1976 under 1972 energy prices.
3. Labor content of the given sectoral outputs under the two sets of input coefficients.
4. Labor content of 1976 output, given input coefficients based on 1976 energy prices less labor content of this output under the coefficients based on 1972 energy prices.

1972, or 2.64 percent of the total demand for labor at the lower energy prices. If there had been no change in real GNP as a result of higher energy prices, the adjustment to these higher prices would greatly stimulate the demand for labor. If all of this increase were reflected in an increase in employment, it would imply a 2.6 percent reduction in the rate of unemployment as a result of higher energy prices. In the absence of an increase in energy prices, the rate of unemployment would have been 10.3 percent rather than the actual rate of 7.7 percent. In fact, the increase in energy prices reduced the level of GNP. This decreased the demand for labor and worked against the employment expansion which was resulting from high energy prices.

The estimated real GNP impact of the higher energy prices in 1976 is a reduction of 3.2 percent. This reduces the demand for labor by approximately 3.2 percent. Therefore, the overall impact on labor of the higher energy prices is a decrease in effective demand of 0.6 percent. The GNP decline, then, more than affects the employment increase resulting from the changed economic structure, so the net result in 1976 of the higher energy prices is a slight decline in labor demand and in employment. The structural increase in employment is significant, however, in that it serves to minimize the loss of employment associated with the lower general level of economic activity.

This change represents a reduction of 0.5 million jobs. Table 12 shows the sources of this change in employment. The restructuring of the inputs into production, as labor substitutes for energy input, adds substantially to labor demand. In particular, there are large increases in the manufacturing and services sectors. The change in final demand patterns adds only slightly to labor demand. These increases are more than offset by the effects of the reduced level of economic activity. All told, restructuring of inputs provides about two million more jobs, changed final demand patterns lead to 0.3 million jobs, and the decline in real GNP causes a loss of 2.8 million jobs.

The adjustments of spending and input patterns in response to higher energy prices leads to a substantial increase in the demand for labor. This increase in labor input is beneficial for employment, reducing the loss of jobs in the face of the GNP reduction, but it has an adverse effect on productivity. More labor input per unit of output is equivalent to less output per unit of labor input. These adjustments, therefore, lead to a reduction in the average gross productivity of labor. Specifically, the economic restructuring that occurs between the high and low energy price simulations leads to a 2.57 percent

TABLE 12

SOURCES OF REDUCTION IN EMPLOYMENT IN 1976

	Employment Reduction, Percent of Total:		*Employment Reduction, Millions of Jobs:*	
Changes in Final Demand:		−71.1		0.3
Changes in Inputs to Production:				
Agriculture, Construction	−31.6		0.2	
Manufacturing	−152.3		0.8	
Transportation	−6.8		0.0	
Services, Trade, Communications	−207.8		1.0	
Energy	−4.6		0.0	
Total		−403.1		2.0
Reduction in Economic Activity:		574.2		−2.8
Total Increase in Employment:		100.0		−0.5

reduction in average labor productivity. To place this change in perspective, it can be noted that the average annual rate of labor productivity increase between 1950 and 1970 was 1.44 percent. Against this norm, the reduction of 2.57 percent corresponds to the loss of two years of productivity improvement.

The decline in productivity growth implies that the rate of growth in real wages will not be as rapid as would otherwise have occurred. To the extent that real wages outstrip the slower growth of productivity, unit labor costs will increase and inflation will be accelerated. Lower productivity leads to slower real growth, slower growth of real wages, and more rapid inflation. It should be noted that these are one-time effects rather than permanent trends. Once the economy has adjusted to the new labor and productivity conditions, there will be no further energy-induced pressures for further changes. Continued changes will occur only if there is a secondary wave of induced price responses.

CONCLUSIONS

The oil price increases beginning in 1973 have had a significant impact on the U.S. economy. One direct effect of the higher oil prices has been to raise all energy prices and to induce a reduction in the intensity of energy use throughout the economy. This change in energy use patterns is estimated to have reduced 1976 energy input from about 81 quadrillion Btu's, corresponding to historical energy use patterns, to the actual level of about 74 quadrillion Btu's. Analysis of the sources of this energy saving suggests that about one third of the savings came from a redirection of final demand–consumption, investment, government, and export purchases–away from energy and energy-intensive goods and services; that almost half came from a restructuring of patterns of input into production away from energy; and that one fourth came from the reduced scale of economic activity. Four particular facets of these changes stand out: a substantial reduction in direct final demand purchases of energy, an increase in final purchases of services, substantial reductions in energy input to manufacturing, and substantial reductions in energy input to the service industries.

The effects of the energy changes have spread throughout the entire economy. Demand for capital input is reduced as a result of the higher energy prices. This leads to a reduction in investment levels and to a slowing in the rate of growth of capital stock and productive capacity. Equally important is the change in demand for labor input. The adjustment in economic structure, with final spending shifted towards labor intensive services and with labor substituting for energy as an input into production, results in an increase in the demand for labor, largely offsetting the adverse employment impacts of the reduced level of economic activity resulting from the higher energy prices. It is estimated that in 1976 employment under the higher energy price conditions was only 0.6 percent, or 0.5 million jobs less than would have been the case if 1972 energy prices were still in effect.

These structural effects are of interest in themselves, but they are also of great importance in interpreting recent economic developments. Two features of the current economic recovery stand out sharply from the pattern of virtually all previous business cycle upswings. The first feature is that employment has expanded much more rapidly, and unemployment has declined to a greater extent, than would have been anticipated from past cyclical upturns. The second feature is that investment has picked up more slowly than would have been anticipated. But both of these developments tie in closely with the predicted effects of the energy changes. This suggests that the observed changes are due at least in part to structural shifts, permitting adjustment to lower energy use, being superimposed on the normal cyclical patterns of recovery from recession. A related feature of the present economic situation that is at variance with the pattern of previous recoveries is the low level of advance in productivity. But again, at least part of the reason for this result lies in the structural shifts, in particular the greater intensity of labor use, resulting from the energy changes.

Finally, the energy price increases have significant impacts on the level and growth of real GNP. The estimated decline in 1976 real GNP between a situation characterized by 1972 energy prices and the actual present energy price situation is 3.2 percent. This means that the oil price increase amounted for part, though certainly not all, of the recession of the mid-1970's. Further, the entire future economic growth path has been shifted down as a result of the energy changes so that, even if long-term future growth rates are not affected, the level of real GNP will always be less than it would have been in the absence of the oil price increase. The oil price rise has, therefore, imposed a significant and continuing cost on the U.S. economy.