The Macroeconomic Effects of the Recent Fall in Oil Prices

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BETWEEN the end of 1985 and the second quarter of 1986, oil prices fell by about half, the reverse of the near doubling of oil prices in both 1973–74 and in 1979–81.[1] This decline prompted a renewed debate about the effects of oil price changes and whether the effects of oil price declines are simply the reverse of oil price increases, that is, whether the effects are symmetric. This article examines these issues. A theoretical analysis of oil and energy price effects on the economy is presented first, along with some evidence on the actual effects of oil price increases on the United States and other countries. While the theory indicates symmetric effects, several arguments suggest the 1986 oil price decline will not have equal and opposite, or symmetric, effects on the economy.

THE THEORETICAL CHANNELS OF OIL PRICE EFFECTS

There are several channels through which an oil price "shock," an unanticipated change in the level of oil prices, could affect the economy. The first is through its effect on aggregate supply; this has come to be called a "price shock." In this view, an oil price increase results in an initial upward shift in the aggregate supply curve that will raise prices; output falls along a downward-sloping aggregate demand curve. Subsequent wage adjustments, however, can restore the initial level of output and price. This analysis can be found in many textbooks.[2]

The effect of oil price shocks on aggregate supply is more involved than simply a rise in the cost of output, however. Energy price shocks are changes in relative prices; to make such changes effective, the supply of energy must be altered.[3] To the extent that energy is a factor of production, the production possibilities and aggregate supply conditions of the economy are al-

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[1]This paper pays little attention to the rise in U.S. oil prices from about $13.40 per barrel in the fourth quarter of 1986 to about $17.00 per barrel in March of 1987. The adjustments in early 1987 are not large enough to affect the arguments below.

[2]See, for example, Hall and Taylor (1986, pp. 134–35). Despite the unique fit of past experience with the emerging "real business cycle theory" which emphasizes productivity shocks, such theorists tend to ignore oil price changes as a source of such shocks; for example, Prescott (1986) maintains that oil price shocks do not affect a country's production possibilities.

[3]Alternatively, many transitory price shocks occur from quantity shocks that are transmitted through transitory relative price changes. The characterization of price or quantity shocks is unimportant in theory. Quantity shocks, however, are typically transitory and associated with transitory relative price changes, while permanent macroeconomic shocks of a "cost-push" type tend to be associated with permanent changes in relative prices that also affect potential or natural output.

tered.[4] Energy price shocks alter the incentives for firms to employ energy resources and alter their optimal methods of production. Energy-using capital is rendered obsolete by an energy price increase, optimal usage of the existing stock is altered, labor resources are diverted to economize on energy use and production switches to less energy-intensive technologies.[5] Thus, existing capital and labor resources are *incapable* of producing as much output as before. The reduced capacity output of the economy is usually referred to as a decline in potential or natural output.

A second channel emphasizes an effect on aggregate demand. Analysts use a "tax analysis" in which domestic aggregate demand is affected due to a change in net imports of oil. In this analysis, the direction and extent of effects depend on the country's net oil export status. Countries that are self-sufficient in oil are unaffected by oil price shocks, while net exporting countries experience an increase (decrease) in aggregate demand when oil prices rise (fall). The effect on net oil importing countries is exactly the opposite.[6]

Such a simple characterization, however, ignores the effects of oil price changes on productivity, which tend to work in the same direction regardless of the oil trade status of the country. Thus, a focus on trade status would suggest that Canada, whose net oil exports equaled 0.4 percent of GDP in 1973, would have had a boost to aggregate demand, or output and employment, from the 1973–74 oil price rise, and that the United Kingdom, which became a net oil exporter in 1979, would have had a similar gain from the 1979–81 oil price hike. Neither conclusion is supported by evidence on real output, employment or productivity growth.[7] Similarly, while this argument suggests that output and employment in the United Kingdom would have been adversely affected by the 1986 decline in oil prices, the evidence again does not support the conclusion.

In most models of the economy, price shocks operating through aggregate supply have the dominant effect. Hickman (1984) examines 14 large and small scale econometric models and finds that aggregate prices respond quite similarly to an oil shock and that the models are linear and symmetric so that aggregate price level responses are proportional to the magnitude of the oil price shock.[8] The Hickman (1984) study also indicates that oil price shocks affect aggregate demand only minimally in several models of the U.S. economy because:

> incipient deterioration in the terms of trade from the increase in the price of oil imports is partly offset by the induced rise of export prices, and because the decline of world production does not impinge heavily on U.S. exports (p. 91).

The channels of influence on aggregate supply can be seen in figure 1, which shows the aggregate supply and demand for aggregate real output. Initially, the price level is P_0 and output is y_0. A higher oil price for an oil-importing country would reduce aggregate net exports and shift the aggregate demand curve, AD_0, to the left, according to the aggregate demand channel above. If this were the only effect, both output and the price level would fall. This effect is not included in the figure because of its dubious merit and to focus on the aggregate supply channel. The "price shock" raises the supply price of aggregate output for any level of output, thus, the aggregate supply curve, AS_0, shifts upward to AS_1. Figure 1 also incorporates the capacity output; thus, the aggregate supply curve, AS_0, shifts with a relatively steep slope at the initial level of real output (y_0) to reflect the notion that at y_0, existing supplies of domestic capital and labor resources are fully employed, and price level variations cannot induce larger use of energy, given the relative price of

[4]This is the emphasis in Rasche and Tatom (1977a, b, c and 1981). Hickman (1984) discusses this channel in a study of 14 macroeconomic models. He indicates that the participants in the study generally agreed there is such an effect, but that formal estimates of it were included in only six of the 14 models. Phelps (1978) and Gordon (1975) implicitly recognize the shift in production possibilities in models that treat a supply shock as a shift in a fixed supply of resources. Related theoretical and empirical analyses are discussed in Tatom (1987).

[5]Baily (1981) and (1982) emphasizes the capital obsolescence arguments. Fischer (1985) incorporates this effect in a model of aggregate supply. Wilcox (1983) successfully tested the interest rate implications of the energy-induced decline in the marginal productivity of capital.

[6]Hickman (1984) breaks this aggregate demand shift for an oil price increase into a domestic "terms of trade" effect that reduces domestic disposable income and a net export effect due to reduced foreign income. His argument for an aggregate demand shift also includes a shift due to a discretionary policy response in the face of an oil price shock.

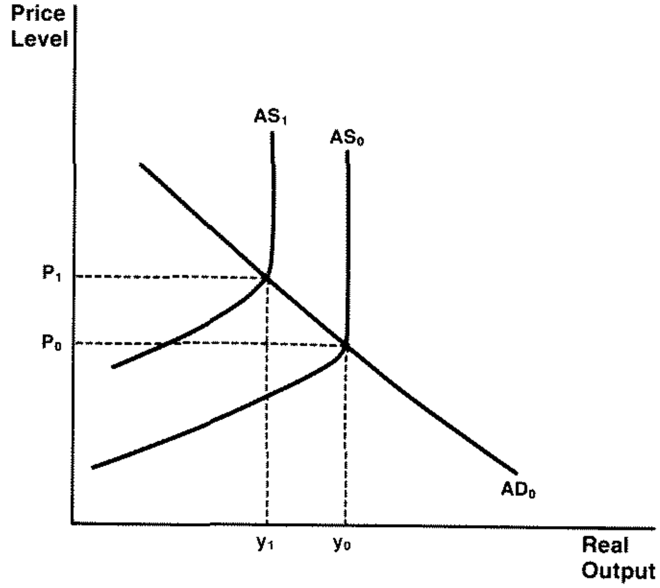
[7]See Rasche and Tatom (1981) and the evidence below.

[8]The linear and symmetric issues were addressed by comparing simulation outcomes for a number of energy shocks including a 20 percent increase or decrease in the price of oil and a 50 percent increase in the price. Hickman also notes that most models have unitary price elasticities of aggregate demand so that "the relative magnitude of the output and price responses to an oil shock is similar across models, with big output reductions accompanying large price increases and vice-versa" (p. 93).

energy, or increase supplies of other resources. When energy prices rise, the aggregate supply curve shifts upward, but the level of output corresponding to full utilization of existing labor and capital resources also shifts to the left, y_1.[9]

In capital and labor markets, this productivity loss is manifested in lower real wages and, over time, in a smaller capital stock relative to labor. The latter effect reinforces the initial productivity loss and shows up as a reduction in growth of the capital stock and economic capacity during the period of adjustment to a lowered desired capital-labor ratio. Since the theoretical channel is reversible, energy price reductions have equal and opposite effects to those of an energy price increase; in figure 1, an equal-sized energy price reduction shifts aggregate supply from AS_1 to AS_0.[10] Thus, this approach implies that energy price changes have symmetric influences on the economy.

Figure 1
The Aggregate Supply Effect of a Rise in Energy Prices



Some International Evidence From Earlier Oil Price Changes

The theory presented above suggests that energy price shocks should affect the productivity of capital and labor resources similarly across countries. Support for this view is provided by Rasche and Tatom (1981), using production function estimates for Canada, the United Kingdom, Germany, France and Japan. More recent evidence can be found using business sector data for these countries and Italy prepared by Helliwell, et al (1986) for the Organization for Economic Cooperation and Development (OECD).[11] This data can be used to demonstrate the significance of the general predictions of the theoretical analysis for earlier energy price increases.[12]

The top panel of table 1 presents the annual average growth rate of the relative price of energy from the OECD data set.[13] Table 1 also shows the growth rates of output per worker, capital per worker, and energy per worker in the seven countries. Two periods including

[9]Analyses like that in figure 1, but which ignore the shift in capacity, have upward sloping supply curves at (P_1, y_1) that suggest that the former output level, y_0, is achievable if government policy can raise aggregate demand sufficiently; viewed another way, these analyses suggest that the decline in output from y_0 to y_1, involves a reduction in employment of existing labor and capital resources.

[10]In Rasche and Tatom (1977a, b, c and 1981), aggregate demand shifts play no essential role. Shifts in oil imports or exports are presumably offset by corresponding changes in other imports or exports or by changes in other components of aggregate demand. This analysis also emphasizes that optimal policy responses are effectively limited or absent because economic capacity is changed, and the economy adjusts to energy price shocks relatively quickly. Output cannot be "restored" to its original level through short-run aggregate demand management. Moreover, such policies work slowly relative to the dynamics of adjustment to a supply shock, so that the effects of oil price shocks are largely completed before monetary and fiscal policy effects could have an impact on them.

[11]These data, updated and revised from the original article, were kindly provided by Mr. Peter Jarrett and Mr. G. Salou of the OECD.

[12]The OECD data on the business sector was prepared to develop the supply-side of the OECD's macroeconomic model for seven countries. Two important characteristics of this data are the consistency of measurement across countries and the development of the energy purchases series. Helliwell et al. (1986) do not directly address the symmetry issue or whether variations in energy purchases fully capture the effects of energy price shocks on aggregate supply. Energy price effects work through changes in the relative cost of capital and energy in their model, so the effects are implicitly symmetric.

[13]These data are available from 1963 for all countries but Japan and extend to 1983. The relative price of energy is constructed by deflating the nominal price of business energy purchases by the deflator for business sector gross output. Besides the United States, only Italy, Germany, and Japan show declines for this measure after 1981. The only decline for the latter three countries is in 1983 and ranges from a decline of only 3.1 percent (Japan) to 5.1 percent (Germany). The decline in the relative price of energy in the United States from 1980 to 1985 and rise in most other countries is one of the reasons given in Tatom (1986) for the improvement in productivity growth in the United States compared with other countries and, therefore, the improved U.S. competitiveness and associated rise in the value of the dollar in international exchange.

Table 1
Annual Growth Rates

Relative price of energy	1965–73	1973–79	1979–83
United States	−0.1%	8.2%	5.6%
Canada	−0.4	8.1	6.8
Japan	−3.7	5.3	15.5
United Kingdom	−2.9	4.7	3.8
France	−1.1	5.3	9.3
Germany	−2.0	6.8	5.7
Italy	−2.7	9.4	9.8
Output per worker			
United States	1.5%	0.1%	0.3%
Canada	3.0	0.8	−0.0
Japan	9.2	3.0	2.1
United Kingdom	3.7	0.9	1.4
France	5.5	3.5	1.5
Germany	5.0	3.3	1.3
Italy	6.9	2.2	−0.1
Capital per worker			
United States	2.5%	1.7%	2.1%
Canada	2.5	2.3	4.6
Japan	10.5[1]	6.5	5.1
United Kingdom	4.6	3.3	4.8
France	5.1	4.9	4.6
Germany	5.9	4.8	4.5
Italy	6.5	3.5	3.2
Energy per worker			
United States	1.8%	−0.4%	−4.3%
Canada	3.8	0.7	−1.8
Japan	10.9	−0.2	−6.4
United Kingdom	2.8	−1.4	−3.0
France	5.0	3.0	−3.3
Germany	6.8	1.8	−0.5
Italy	8.0	−1.9	−5.4

[1]1967 to 1973; 1967 is the earliest available data.
SOURCE: OECD data, except for the United States, where more recent U.S. data on output, employment, and capital are used.

the 1973–74 and 1979–81 oil price shocks and their aftermath are shown, along with the 1965–73 trend in each variable. The second panel shows the slowdown in labor productivity from the 1965–73 trend during each period. Japan and Italy had the sharpest reductions in the 1973–79 period. The slowdown in labor productivity growth is more pronounced in all countries, except the United States and United Kingdom, in the 1979–83 period when compared with 1965–73.

The capital-per-worker growth rates also declined in 1973–79 compared with those in 1965–73. Movements in the capital-labor ratio are not indicators of the desired capital-labor ratio when cyclical movements in employment depart from labor force growth. Nonetheless, over the 1979–83 period, four countries showed a further deceleration; the growth of capital per worker accelerated, however, in the United States, Canada and the United Kingdom.

As the bottom panel of table 1 shows, the growth rate of energy per worker slowed markedly in each country for each period. The largest reductions in 1973–79 were in Japan and Italy, the two countries in which the largest reductions in the growth of output per worker also occurred. All countries showed larger reductions in the growth of energy per worker in the 1979–83 period. The results in table 1 are consistent with the theoretical predictions that a rise in the relative price of energy reduces both energy and capital per worker and, therefore, lowers output.

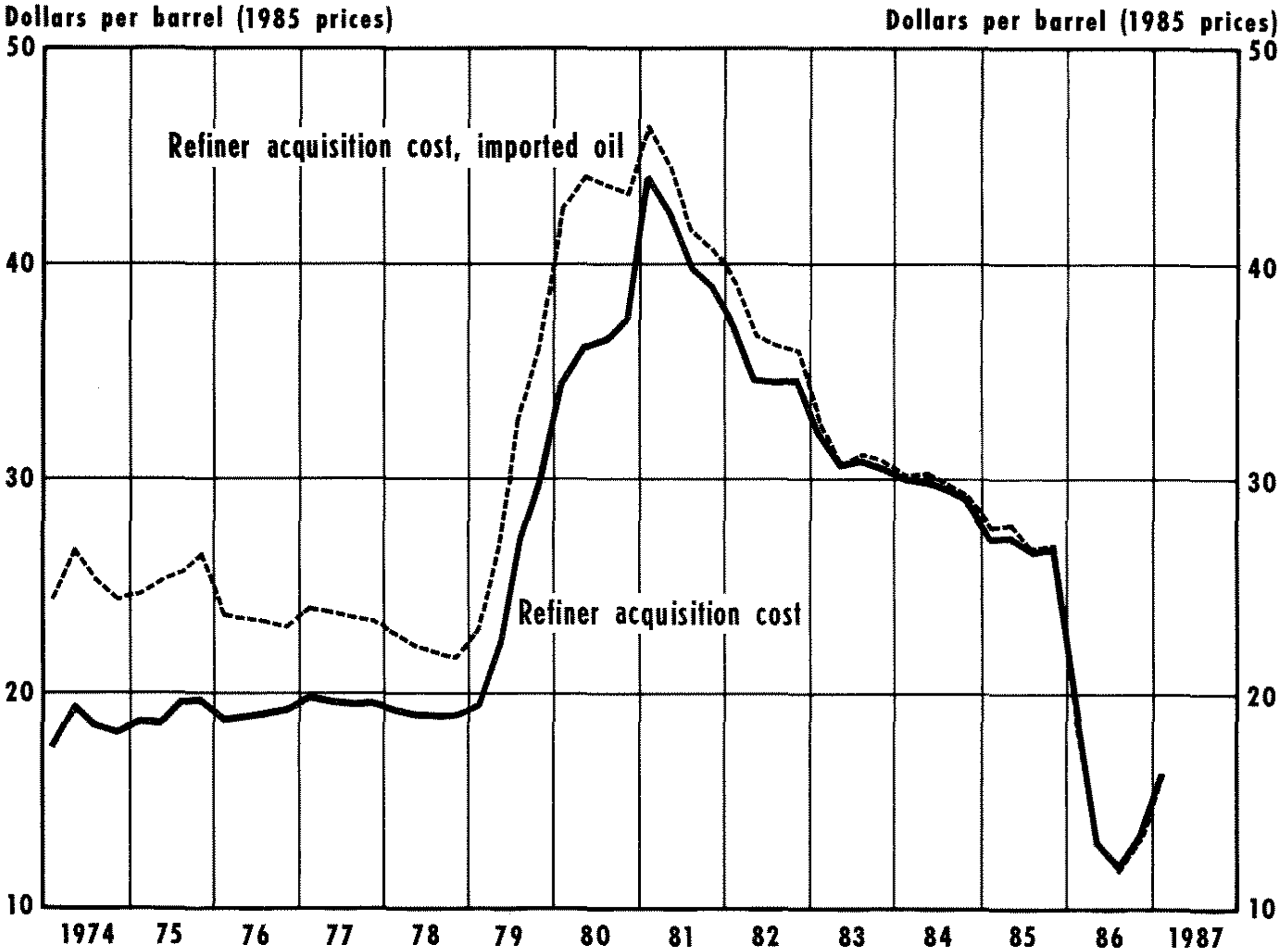
Over the period 1973–83, output per worker growth slowed substantially in the seven countries when compared to the 1965–73 period; reduced energy use alone accounted for a substantial share of these reductions without taking into account the energy price-induced reductions in capital per worker.[14] Some analysts have suggested that these developments will not be reversed, or at least not reversed in proportional magnitudes, by the recent decline in the relative price of oil and other energy resources. Some of these arguments are examined in the next section.

DO OIL PRICE INCREASES AND DECREASES HAVE EQUAL AND OPPOSITE EFFECTS?

Previous studies of the effects of oil price changes on the economy do not indicate that they are asymmetric. Existing models of oil price effects are not formulated in a manner that would reveal such asymmetric effects, however. Besides, empirical models rely heavily on the experience in the 1970s, when real oil and

[14]The reductions in energy use per worker together with "output elasticities of energy use," the percentage change in output associated with each percentage point change in energy use, can be used to estimate the direct effect of the energy use reductions on output. These elasticities, estimated in Tatom (1987), show that reduced energy use had a substantial negative effect on output and productivity growth in these seven countries.

Chart 1
The Relative Price of Oil



energy prices did not decline.[15] There are some arguments, however, that suggest the recent oil price decline will not yield equal and opposite effects.

The Asymmetric Effects of Transitory vs. Permanent Oil Price Declines

If the recent decline in oil prices is only temporary, there should be no long-run adjustments of methods of production, prices or employment. At least one perspective on the recent declines, however, suggests that they are not likely to be reversed. According to this view, the decontrol of the U.S. crude oil market in early 1981 lowered OPEC's optimal price of oil. This view also suggests that OPEC2 was due largely to output changes associated with the Iran-Iraq war; if correct, the OPEC2 price increase ultimately will be reversed.[16] Consequently, the 1986 oil price reduction is not a temporary aberration, but the continuation of a downward oil price adjustment that began five years earlier.

[15]Real oil prices and energy prices did decline through most of the post-war period included in the estimation of most models, but on a steady and moderate trend rather than abruptly. Hamilton (1983), however, indicates that there were cyclical movements induced by oil shocks before 1973.

[16]The analysis in Ott and Tatom (1982a and b) and several of the references cited there explain this argument.

Chart 1 shows the relative price of oil from 1974 to the end of 1986. The prices, measured relative to 1985 business sector prices, show the average U.S. refiner acquisition cost for oil and for imported oil. The imported price is included to indicate the world price of oil. The two prices differ until early-1981 because of the entitlement system that held the U.S. price paid for oil, whether domestic or foreign, below that in the world market. Subsequent differences reflect minor variations in the characteristics of domestic and imported oil. Note that the U.S. real price of oil in 1974–78 averaged about $19.50 per barrel (1985 prices) and varied little. OPEC2 sent the world price up from $22 per barrel at the end of 1978 to about $46 per barrel in the first quarter of 1981, when U.S. decontrol of the domestic oil market occurred. Subsequently, the world and domestic price of oil fell to about $27 per barrel by late 1985, a decline of $17 to $19 per barrel, then further declined to an average of about $14 per barrel (1985 prices) in 1986.

An examination of chart 1 reveals three central points: (1) the 1986 oil price decline is not unprecedented — the decline began in 1981; (2) the 1986 decline was exceeded by the larger reductions that occurred from 1981 to the end of 1985; and (3) not until early 1986 had U.S. real oil prices fallen to their 1974–78 levels. Thus, the recent shock makes the 1981–86 change comparable in magnitude to the 1979–81 increase, except for the timing. These results are consistent with the view that the 1986 shock is permanent and point to the fact that the United States has had at least five years of experience with declining real oil prices.[17]

Chart 2 shows the quarterly relative price of energy (measured by deflating the quarterly average producer price index for fuel, power and related products by the business sector price deflator from 1970 to the present); the price has been indexed to 1972. Energy prices show the same pattern as the real price of oil in chart 1, especially the relative magnitudes associated with the OPEC1 and OPEC2 increases and the 1981–86 decline. From the end of 1972 to the third quarter of 1974, the logarithm of the relative price of energy rose 45.8 percent; from the first quarter of 1979 to the first quarter of 1981, it rose 47.9 percent; finally, from the first quarter of 1981 to the second quarter of 1986, it fell 51.8 percent. These changes were largely due to the near doubling in real U.S. oil prices in each of the earlier periods and the decline since early 1981.

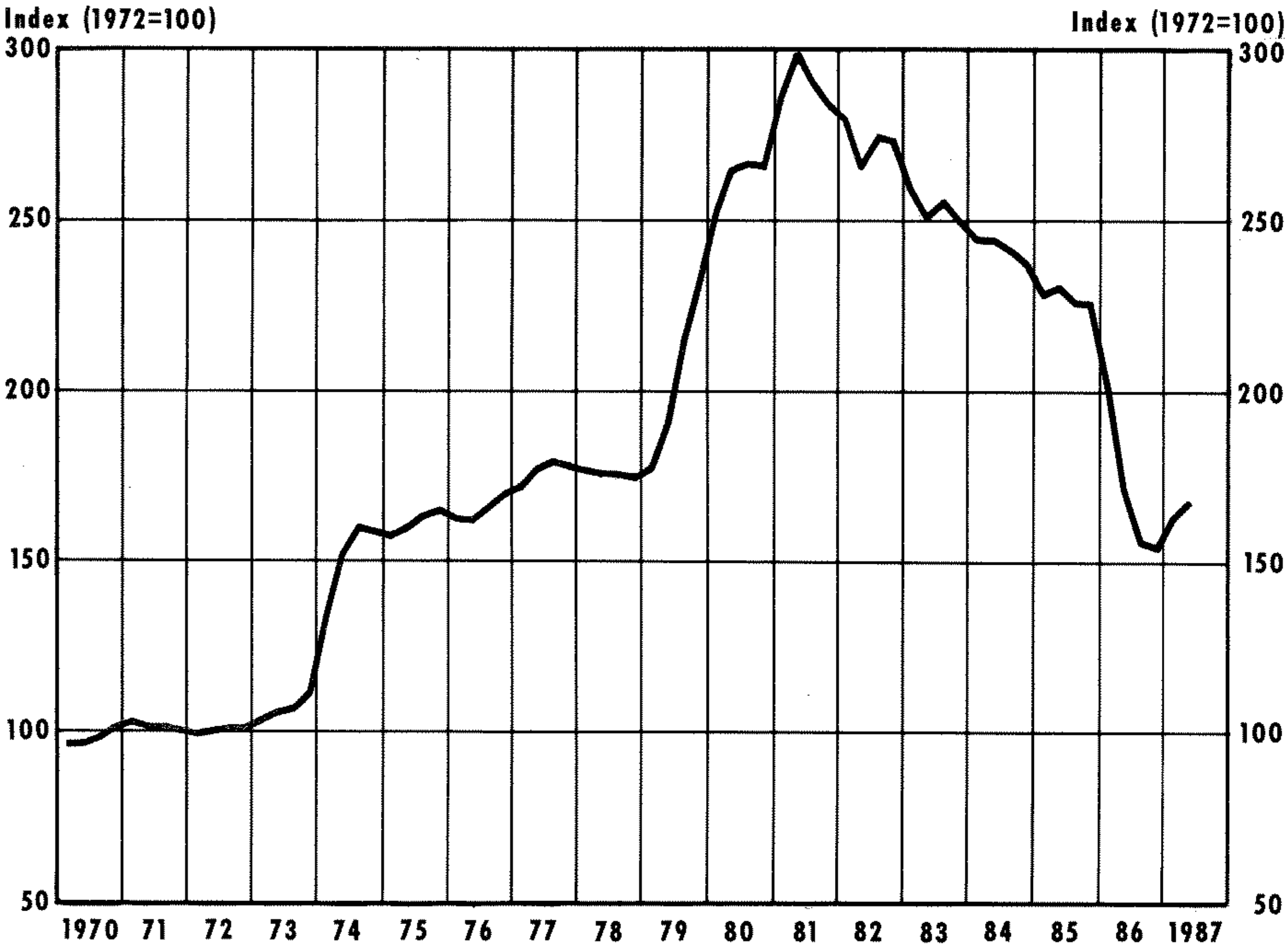
OPEC's incentive to maintain a lower price than prevailed as recently as 1985 can be seen from production and consumption developments since OPEC2. In 1973–79, world oil production (and, roughly, consumption) ranged from about 59.7 million to 62.5 million barrels per day, of which OPEC produced about 30.7 million (in 1973 and 1979, the figures were 31.0 and 30.9, respectively). OPEC output declined to 16.1 million barrels per day in 1985. World production also fell, to about 53 million barrels per day in 1982–83, and only recovered to about 54 million barrels per day in 1985. Thus, OPEC's market share plummeted from about 50 percent during 1973–79 to about 30 percent of a smaller market in 1985.

Comparing 1979 and 1985, world consumption fell about nine million barrels per day or about 14.5 percent, while non-OPEC production rose about six million barrels per day, or about 20 percent. The decline in the OPEC share arose from both a relatively large increase in rest-of-the-world production and a decrease in world consumption. OPEC, by late 1985, had not adjusted fully to its lowered optimal price. In 1985–86, Iran and Iraq's joint production level of about 3.6 million barrels per day, while 50 percent larger than in 1981, was well below their 1973–78 joint production level of 8 million barrels per day.

Since 1980, oil market developments have lowered OPEC's optimal price of oil. The actual price was reduced gradually in an attempt to increase the quantity of oil demanded and reduce competitors' supplies. By the end of 1985, such efforts had not been successful; moreover, even if the price reductions since then become somewhat successful, the rest of OPEC will face a future problem — a decline in market share and stronger incentive to lower prices — to the extent that Iran-Iraq production eventually rises further back toward pre-war levels. Thus, the recent decline in world oil prices is not likely to be temporary and its effects should not be asymmetric, at least not on this account.

[17]Since the initiating factor in OPEC2 has not totally disappeared, further downward movement can be expected. In 1978, Iran and Iraq produced 7.8 million barrels per day. This dropped to a low of 2.4 million barrels per day in 1981 and recovered to only about 4 million barrels per day at the end of 1985. Trehan (1986) presents an "alternative" view of nominal oil prices, arguing that they are driven by movements in the exchange value of the dollar. But Trehan's model only explains nominal price movements, given the relative price of oil, it does not account for the sharp nominal price changes associated with relative price disturbances.

Chart 2
U.S. Relative Price of Energy



Do Oil Price Changes Have Asymmetric Effects on Capital Obsolescence?

When oil prices rise, energy-using capital is rendered obsolete, unless (1) product prices adjust sufficiently, (2) product demand is unaffected, *and* (3) other lower-cost methods of production are unavailable. In the absence of these conditions, increased scrapping and/or alterations in the optimal employment of capital resources occurs. One approach to obsolescence emphasizes "putty-clay" technology, where the capital stock embodies a technology that is premised on expected factor and product prices and "fixed" relative factor proportions, for example, labor and energy employment per unit of capital. When factor prices change, the existing capital stock is no longer optimal; *any* relative factor price change can make the existing capital stock obsolete. Oil price shocks (or other factor price shocks) reduce productivity by effectively destroying capital resources regardless of the direction of change.

The concept of putty-clay capital suggests that short-run relative factor proportions are insensitive to factor price changes; it appears that output and employment can be altered only after sufficient time has passed so that capital can be changed. But inelastic factor proportions increase the short-run output loss associated with a rise in energy prices. Firm and industry output adjustments and industry product prices are larger when factor substitution cannot occur in the short run because of a change in the price of one resource.[18] The asymmetric result from a putty-clay perspective rests on the assumed relative ease of shutting down the use of existing plant and equipment compared with the adjustment cost of installing new capital or reemploying obsolete and idle capital. But this difference, if it actually exists, is one of the relative timing of effects. Thus, the putty-clay assumption does not yield differences in the response of the desired capital-labor or capital-energy ratios when the relative price of energy changes. These determinants of output and productivity respond similarly whether capital is putty-clay or not.

Are Firms' Responses to Cost Reductions and Cost Increases Asymmetric?

Another argument is that firms respond differently to factor price reductions than to increases. A factor price increase forces adjustments because profitability and survival are threatened. A factor price decline gives rise to less pressure to change production methods; profits rise for energy-using firms even if they don't alter their behavior. A related argument is that adjustments to energy price shocks depend on the state of the economy, especially the state of the business cycle. Capacity utilization was relatively high and unemployment rates were relatively low when OPEC1 and OPEC2 occurred. These conditions have not been observed since 1981. Thus, current incentives to expand production due to factor price reductions or even to reduce product prices could be viewed as weaker. Incentives to expand the employment of energy-using plant and equipment, especially through new purchases, could be more limited in light of supposed weak demand for output.

These views ignore maximizing behavior or even minimal interest in achieving efficiency in the pursuit of firms' goals. Moreover, they ignore the effects of competition from other firms. Again, this argument suggests, at best, a difference in the timing of adjustments to a lower energy price shock, not an asymmetry in the direction or magnitude of the effects of lower energy prices.

Do Inter-Industry Effects Result in Asymmetric Macroeconomic Effects of Oil Price Changes?

Another suggestion is that adverse effects on domestic oil-related industries dominate the positive developments for other industries when oil prices fall, despite a recognition that the reverse effects do not occur, or are not dominant, when oil prices rise. The importance of reductions in oil exploration and development activity and oil-related loan losses for the macroeconomy have been overstated, however. The effects are symmetric in that the domestic oil market boomed following both OPEC1 and OPEC2, while the dominant effects were on other producers.[19] More importantly, however, reductions in such activity in 1986 reflected short-run responses that reverse when factor prices in exploration adjust to the permanently lower oil price.

Part of the confusion over the dominance of domestic oil effects could arise from the apparent relatively slow growth of employment following the 1986 oil shock, especially early in the year. Yet this result is consistent with the earlier experience with oil price increases. In the initial period of a shock, the dominant effect is on productivity and supply, given product prices; with little price level adjustment, aggregate demand changes little. Thus, when oil prices rise sharply and unexpectedly, desired output falls more than sales, resulting in undesired inventory reductions that create upward pressure on prices and, initially, downward cyclical pressure on the unemployment rate.[20] Proponents of an asymmetric response in 1986 may be relying on an inaccurate comparison of the adverse cyclical experience that followed past oil price increases after a few quarters and the immediate cyclical developments that followed the 1986 oil price reduction.

[18]It is curious that some analysts appear to ignore the short-run pressure that the putty-clay assumption puts on reducing capacity utilization through shutting down, arguing instead that the effects of oil shocks work relatively slowly over extended periods of time as the capital stock is adjusted. How individual product prices or the price level can adjust relatively rapidly, as considerable evidence shows, in the face of the changes in "fixed" costs in the putty-clay case, is not typically addressed.

[19]Some analysts contend that the U.S. experience in 1973–74 was not comparable because of price controls on domestic crude oil. See Trehan (1987), for example. This ignores the 75.3 percent rise in domestic crude oil prices that occurred from III/1973 to III/1974, despite the existence of controls, or the 196 percent increase from January 1979 to January 1981, a period of similar controls.

[20]See the unemployment rate discussion in Tatom (1981, 1983b) and more recent evidence in Ott and Tatom (1986).

DO OIL PRICE REDUCTIONS HAVE ASYMMETRIC EFFECTS? THE EVIDENCE

Empirical macroeconomic models can provide evidence on the symmetry issue because real oil and energy prices have been falling for nearly six years. A simple reduced-form model is used [see Tatom (1981, 1983b), (1987)] to analyze the short-run effects of oil price shocks. In addition, evidence from production function estimates that have been used to assess the productivity effects of adverse oil shocks is examined. The evidence from these models on GNP, price and output effects of energy price changes is presented below. Finally, some evidence on symmetric temporary surges in inflation in seven countries is discussed.

The Model

The Andersen-Jordan GNP equation (1968) expressed in growth rates and augmented to account for effects of the energy price changes is used in the model. While such effects could be either permanent or transitory, estimates reveal that the statistically significant effects are only transitory. The price equation for the GNP deflator in this model is a reduced-form equation in which the principal determinant of inflation is the rate of growth of the money stock (M1); price controls and energy price changes, however, also influence the level of prices and, temporarily, the inflation rate. Since real GNP is the ratio of nominal GNP to the price deflator, the growth rate of real GNP is the difference between the growth rates of nominal GNP and the GNP deflator.

The GNP equation includes a strike measure (the change in the quarterly average of days lost due to strikes deflated by the civilian labor force), current and four lagged values of money (M1) and federal expenditure growth, and six previous quarter's changes in the relative price of energy, (the quarterly average producer price index for fuels, related products and power, deflated by the business sector price deflator). The price equation includes the current and 20 lagged growth rates of the money stock, dummy variables for wage-price control (for II/1971 to I/1973) and decontrol periods (I/1973 to I/1975), and changes in the relative price of energy for the past four quarters.

The model was estimated over the periods I/1955 to III/1980 and to III/1986, respectively, in Tatom (1987).[21] The model and energy price effects are stable and two tests rejected the hypothesis that energy price reductions since 1981 have had different effects, either in sign or size, on GNP, price, or indirectly, output growth. The two tests involved allowing post-1980 declines to have different effects on GNP or price growth and, second, allowing energy price declines throughout the sample to have different effects from increases in energy prices.[22]

Oil Price Shocks and Real GNP

The effect of an oil price shock on output is determined from those on nominal GNP and prices. Since the effect of an energy price shock on the growth rate and level of GNP is zero after six quarters, its effect on output after that time is the inverse of its effect on the price level. The model described above yields estimates that indicate the responsiveness of the price level to energy price changes has not changed since 1980; thus, the permanent responsiveness of output to such changes, has not changed. In addition, the timing and magnitude of the short-run output effect has remained unchanged as well. The elasticity of the price level with respect to an energy price change (that is, the percentage rise (fall) in the GNP deflator associated with each percentage point rise (fall) in the relative price of energy) is estimated to be 0.050 to 0.058.[23] Thus, a doubling in oil prices led to about a 40 percent energy price rise during OPEC1, OPEC2, that, in turn, resulted in a permanent increase in the price level and decrease in output of about 2 percent to 2.3 percent [(40)(.05) to (40)(.058)] in each instance; the same size

[21]Over the longer period, adjustments were made for systematic overpredictions of GNP and price growth. These overpredictions are uncorrelated with the right-hand-side variables or other factors that various analysts claim explain a fall in velocity since 1981; see Tatom (1983a). The intercept shift in each equation was chosen by finding the shift that minimized the standard error of each equation where the shift was allowed to occur in any quarter since 1978. Christiano (1986) has shown that a trend velocity shift of this type is supported by the stability of difference-stationary models. The shifts used here begin in II/1981 for the GNP equation and in III/1982 for the price equation.

[22]A third test involves testing an asymmetry hypothesis suggested by Neumann and von Hagen (1987). They argue that, given wages and prices, relative price uncertainty reduces aggregate supply. Thus, an energy price change can reduce output and raise the price level regardless of whether energy prices rise or fall if it also raises relative price uncertainty. For energy price increases, the direct effect on aggregate supply and the uncertainty effect would reinforce each other, but for energy price reductions, they work in opposite directions. This hypothesis was tested by introducing the standard deviation of the relative price of energy and its lags in the equation estimates; these measures are *not* significant in either equation.

[23]This elasticity is the sum of the coefficients on the rate of change in the relative price of energy in the inflation equation.

decline in oil prices from IV/1985 to III/1986 is estimated to result in the same size reduction in prices and rise in output as in these earlier instances.

Oil Price Shocks and Productivity

The effect of energy price changes on productivity can be evaluated by estimating an annual business sector production function in which business sector output, X, is regressed on business sector hours, h_t, the product of the lagged net capital stock (constant dollars) and Federal Reserve capacity utilization rate, k_t, the relative price of energy, p^e_t, a constant, a trend, t, and trend breaks in 1967, t67, and in 1977, t77.[24] The production function is "Cobb-Douglas," or linear in logarithms and estimated with a "constant returns to scale" restriction.

The estimate for the period 1948–80 is (t-statistics are given in parentheses):

$$\begin{array}{llllll} (1) & \ln X_t = & 0.299 & + 0.690 \ln h_t & + 0.310 \ln k_t & - 0.053\, p^e_t \\ & & (0.80) & (13.18) & (5.90) & (-2.49) \\ & & + 0.019\, t & - 0.006\, t67 & - 0.008\, t77 & \\ & & (10.97) & (-3.41) & (-1.96) & \end{array}$$

$\bar{R}^2 = 0.97 \quad SE = 0.90\% \quad DW = 1.88 \quad \hat{\rho} = 0.25$

The production function, estimated for the period 1948 to 1985, is:

$$\begin{array}{llllll} (2) & \ln X_t = & 0.377 & + 0.701 \ln h_t & + 0.299 \ln k_t & - 0.055\, p^e_t \\ & & (1.15) & (15.01) & (6.41) & (-3.40) \\ & & + 0.019\, t & - 0.006\, t67 & - 0.006\, t77 & \\ & & (11.57) & (-3.87) & (-3.09) & \end{array}$$

$\bar{R}^2 = 0.97 \quad SE = 0.86\% \quad DW = 1.84 \quad \hat{\rho} = 0.28$

There are no statistically significant differences between the estimates in equations 1 and 2. Hence, adding five additional years of data during which energy prices declined sharply produces no changes in the estimates. Such evidence is only suggestive, however. A more direct test is to allow the coefficient on the energy price to be different after 1980. When equation 2 is estimated permitting energy prices from 1981 to 1985 to have a different effect on output, the difference is 0.0016 ($t = 0.94$); while the change in the coefficient is positive, indicating a smaller impact on output, the difference is tiny and statistically insignificant. When equation 2 is used to predict business sector output in 1986, the error is 0.05 percent; that is, business sector output grew 3.31 percent from 1985 to 1986, nearly the same as the 3.36 percent predicted by equation 2.

The output elasticity of the energy price in equation 2 is −5.5 percent, smaller than earlier estimates where trend shifts were not statistically significant and, thus, were omitted. Without the trend shifts in first-difference estimates of equation 1 and 2, the short-run output elasticity of the energy price is 8 percent.[25] Over short periods, such as the past ten years, it is not possible to determine whether trend shifts represent truly permanent changes or whether they are simply capturing residual effects due to energy price shocks or other transitory effects on productivity trends. In either case, the estimated output elasticity is in line with the estimate from the reduced-form model above.[26]

Oil Price Shocks and The Rate of Price Increase

Price developments across the seven countries referred to earlier provide more casual evidence of a symmetric response to the recent decline in oil prices. The top panel of table 2 shows that, during the period of the previous two oil price increases, inflation rates temporarily surged upward from levels in the preceding year and subsequently fell back. Since the timing of the peak rate of increase for a four-quarter period varied among the countries, inflation measures for

[24]Rasche and Tatom (1977b, c and 1981) test a popular hypothesis that the trend growth of productivity declined in 1967. The hypothesis is rejected but, the results indicate a smaller size for the output elasticity of energy prices when the insignificant trend-shift is included. When recently revised NIPA data are used, however, the 1967 trend break cannot be rejected.

[25]Tatom (1987) reports the results of both of the tests used in the GNP and price equation above for the first-differenced production function. First, the energy price declines from 1981 to 1985 were allowed to have differential effects on business sector output growth. Second, energy price increases and decreases in the period 1948 to 1985 were treated as two separate variables. A test of whether the coefficients of these variables are equal and opposite in sign is a test of symmetry. Both of these tests fail to reject symmetry. Finally, the standard deviation of real energy price changes (measured over the current and previous two years) was added to the level equation 2 and its first-difference was added to the first-difference equation. It is not significant in either case and does not alter the other coefficients.

[26]The emphasis above is on the output elasticity of the relative price of energy, given capital and labor employment. Rasche and Tatom (1981, p. 13, and elsewhere) explain that the desired capital-labor ratio falls (rises) due to an energy price rise (decline), and that, given potential employment, the long-run response is larger by a percentage equal to s_k/s_l, where s_k and s_l are the shares of capital and labor in value added. In equations (1) and (2) this increment to the output elasticity is 44.9 percent and 42.6 percent, respectively.

Table 2
Oil Shocks and Rates of Increase of Consumer Prices

	Pre-OPEC1 III/1972–III/1973	OPEC1* III/1973–III/1975	Post-OPEC1 III/1975–III/1976	Pre-OPEC2 IV/1977–IV/1978	OPEC2* IV/1978–IV/1981	Post-OPEC2 IV/1981–IV/1982
Canada	8.1%	10.9% (12.0)	6.5%	8.7%	11.0% (12.7)	9.7%
France	7.6	12.7 (14.9)	9.5	9.5	13.0 (14.1)	9.5
Germany	6.9	6.6 (7.4)	3.9	2.4	5.9 (7.1)	4.7
Italy	10.8	18.3 (25.7)	16.5	12.0	19.4 (21.5)	16.8
Japan	16.9%**	16.8 (23.8)	9.1	4.4	5.2 (7.7)	2.8
United Kingdom	9.1	21.7 (26.6)	13.7	8.1	14.8 (21.6)	6.2
United States	6.8	10.1 (12.1)	5.5	8.9	11.6 (14.4)	4.5

	December/1984–85	December/1985–86	December–June 1987
United States	3.8%	1.2%	5.4%
France	4.7	2.1	5.4
Germany	1.8	–1.1	2.3
Italy	8.6	4.3	5.1
Japan	1.8	0.1	3.0
United Kingdom	5.6	3.8	6.8
Canada	4.4	4.2	5.0

*Peak four-quarter rate given in parentheses.
**I/1973–III/1973.

two- and three-year periods are given along with the peak increase over four quarters (in parentheses).

The bottom of table 2 illustrates the symmetric response associated with the 1986 oil price decline. Consumer price increases slowed sharply in each country, except Canada where the slowing was slight. During the first six months of 1987, however, the rate of price increase rose sharply in all seven countries. In all the countries except Italy, inflation was higher in early 1987 than it had been in 1985, the year prior to the oil shock.

CONCLUSION

The decline in oil prices in 1986 raised the question of whether oil price shocks have symmetric effects on macroeconomic variables. The analysis presented here indicates that energy price shocks matter because they affect economic capacity and hence productivity of labor and capital resources, or aggregate supply. Their specific effects on other macroeconomic variables follow from the effects presented here. This view suggests that oil price increases or decreases have symmetric effects on the economy.

The United States had experienced a relatively large decline in the relative prices of oil and energy from 1981 to 1985, a decline that exceeded the recent one in 1986. Thus, evidence on the adjustments of spending, prices, output and productivity is available and described here that bears on the symmetry question. The evidence suggests that energy price shocks have symmetric effects. Formal tests of changing energy price coefficients in reduced form equations and an aggregate production function reject the asymmetry hypothesis. Finally, consumer prices for the United States and six other countries exhibit symmetric temporary movements surrounding the 1986 oil price decline.

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