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The Anatomy of an Oil Price Shock

by Eric O'N. Fisher and Kathryn G. Marshall

The price of a barrel of crude oil doubled within a few months last year. Although prices have been easing lately, for those who paid more than $3 for a gallon of gas, the memory is not likely to fade quickly. But worries about higher gas prices don't end at the pump. Oil price shocks—sudden and sharp increases in the price of oil and its derivatives like gasoline—are associated in the popular mindset with an unavoidable descent into inflation. Ask just about anyone about the inflation of the 1970s, for example, and they're likely to associate it with the oil crisis that occurred early in the decade.

Many economists have also held the view that oil shocks can lead to inflation—although not directly or inevitably, but because of the way monetary policy responds when there is a shock.

What do the latest round of oil-price increases bode for inflation? We trace the path of an oil shock through all sectors of the U.S. economy and demonstrate that such shocks do not cause inflation. They can, however, cause other unpleasant economic repercussions. We identify the sectors that suffer the highest long-run price increases after an oil shock and find that they are among the most capital-intensive in the economy, suggesting that an oil shock may actually increase the relative profitability of capital in a few sectors that can pass increased costs onto consumers. One reassuring result of our analysis is that it seems likely that our economy may now be less dependent on oil, so that this time around, the consequences of an oil shock may be less severe.

Guilt by Association

Figure 1 presents some historical data on oil prices and inflation in the United States. A cursory glance at the figure suggests that a doubling of oil prices leads to double-digit price increases. It's no wonder people associate oil shocks with inflation.

But an oil price shock is an increase in the real price of a commodity that will be passed on to other sectors of the economy. Since the shock is a one-time increase in the price of oil, by definition it cannot be considered inflationary. Inflation, instead, is a persistent rise in prices, sustained year after year. Such a persistent rise can only be caused by the monetary authority, when it creates too much money.

It is possible that the Fed has responded to past oil shocks by creating inflation—intentionally, to ease the blow of the oil shock—or accidentally, because the oil shock distorted information about how much money the economy needed. Some economists argue that is the case. But that oil price shocks have been viewed as inflationary is really guilt by association.

To be sure, even if an oil price shock doesn't cause inflation, the consequences of one can be severe. Because so many other commodities depend on oil for their manufacture or distribution, an oil shock can ripple through the economy, raising the prices of many goods and services. Those higher prices, in turn, can cause people hardship and force adjustments elsewhere in the economy.

Oil price shocks do not cause inflation, no matter how close the connection seems to be in our practical experience. But they can cause significant price increases throughout the economy. Tracing the way a sharp increase in the price of crude oil affects prices in various industrial sectors of the U.S. economy suggests how big these increases are. Fortunately, our economy seems better prepared now to weather such shocks than in the 1970s and 1980s.

Commodity Price Effects

What are the aggregate price effects of an oil shock, isolated from the monetary policy response? To answer that question, we follow the price effects of a shock as it moves through individual sectors of the U.S. economy, using a detailed input–output table. In principle, this table shows how much input various industry sectors require from other sectors to produce their output. The automobile sector, for example, might require material from the steel sector amounting to 30 percent of the total cost of producing a car, material from the plastics sector amounting to 20 percent of the total, and so on.

We base our analysis on the 2003 input–output table for the U.S. economy. It is compiled by the Commerce Department's Bureau of Economic Analysis and based on detailed benchmark data from 1997 and updated annually. The version we use divides the American economy into 61 sectors,

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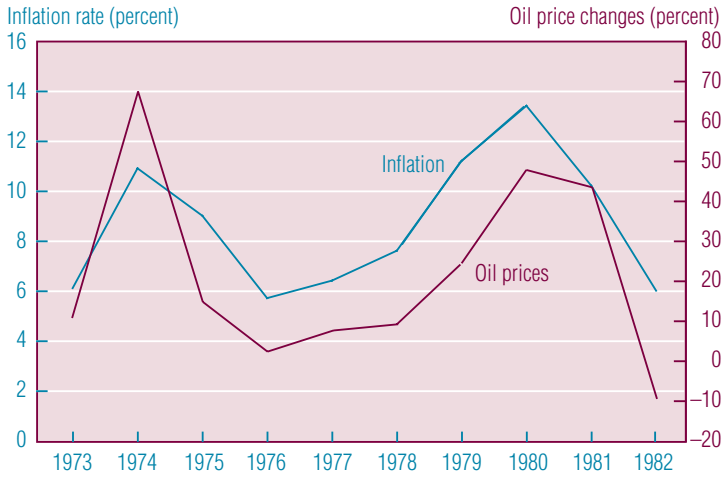
FIGURE 1 HISTORICAL OIL PRICES AND INFLATION



Note: Inflation and oil price changes are measured as annual percentage rates, using the difference between current data and data from the corresponding month one year before.
Source: N. Gregory Mankiw. 2006. *Macroeconomics (6th Edition)*. New York: Worth Publishers.

disaggregating it into 19 manufacturing sectors and 35 service sectors. The remaining 7 sectors include agriculture, mining, utilities, and construction. For each sector, the data give the cost of the inputs from each of the 61 sectors needed to produce a dollar's worth of output.

We consider the effect of a 100 percent increase in the price of oil, equivalent to the price of a barrel of crude going from $30 to $60. We trace the effect of this price increase through the 61 sectors, calculating the resulting price increases at two points in time, in all of the sectors that use oil.

We designated the two points in time round 1 and round 2. A round is the time it takes for the typical firm to set a new price in response to the rise in the world price of crude; we think of a round as the time it takes for increased costs to be passed on to consumers. Different industries have different patterns of posting prices. In those sectors where there is a strong direct link between output and oil input, such as gasoline at the pump, we would expect this response to be almost immediate. In other sectors, the increases would be more gradual. As a rough gauge, we would expect the full long-run price increases to materialize in one year. Some industries change posted prices every day, and other do so very infrequently. A conservative assumption is that prices change once a quarter; in our numerical analysis, the full effects of a price shock pass through the economy almost completely within four rounds.

An oil price increase means higher costs for sectors that use this commodity as an input. These costs are passed on to other sectors that may not use oil directly. To keep our analysis simple, we concentrate on price effects only. Thus we assume output and employment stay the same, and by doing so don't consider the effect an oil shock might have on either. We also assume the shock will have no effect on personal incomes.

In reality, output would likely decline in those sectors whose prices have risen substantially, because demand will fall as people find substitutes that cost less. If labor markets do not adjust quickly to sector-specific shifts in production, or if the income effects of an oil shock are strong, then aggregate output and employment will be affected.

Economists don't yet know for sure which sectors could find substitutes for oil or how quickly. Some suggest capital is a general substitute for oil in the production processes of many sectors of the economy. In other words, firms can invest in energy-efficient equipment to reduce their dependence on oil, but changing established techniques of production may take many years (see Atkeson and Kehoe, 1999). Our empirical analysis—using input–output tables with benchmarks two decades apart—is consistent with their model.

Table 1 reports the eight sectors that have the highest long-run price increases. Here we see the concentration in the transportation sector. However, since fuel costs are directly or indirectly a small part of almost every economic activity, in the long run all sectors show some price increase.

To understand the long-run effects, it is useful to review the logic of an input–output matrix. When the economy produces a final good, it uses many intermediate inputs. Each of these inputs in turn uses many other inputs, and those inputs must also be produced. An input–output table gives precise measures of this iterative process, and the long-run effect summarizes the full cost increases. These cost increases summarize the long-run effects of the oil shock in an economy that uses existing production techniques—in 2025, it is likely that the future economy will be even less dependent on energy and will be able to weather coming oil price shocks even more readily.

The iterative process that leads from the oil shock to overall higher prices in the long run is not inflationary; it represents a rise in the relative price of commodities, holding factor prices constant. The price of oil-dependent sectors is rising relative to those sectors which are less reliant on oil, either directly or indirectly. For example, the sectors with the lowest price increase in 2003 include insurance and financial services and computer systems design. Goods and services produced in these sectors are now relatively cheaper.

To summarize the overall effect, we construct a weighted average of the individual sectors based on the share of each sector's output in final consumption. This aggregate effect is shown in the final row of table 1. A 100 percent increase in the price of crude oil, holding factor prices constant, translates into only a 3.2 percent price increase in the typical basket of consumption goods. Since unrefined oil itself is not a consumer good, the oil price shock is passed through indirectly in the prices of many other goods and services. Of course, an important consumption good is refined oil in the form of gasoline, which has a long-run price increase of over 83 percent, but has a weight of only 1.3 percent in the national consumption basket. (Since our weights are based on the input–output matrix, they do not

FIGURE 1 COMMODITY PRICE EFFECTS

Sector	First round	Long run
Utilities	22.0%	29.1%
Pipeline transportation	11.9%	26.8%
Air transportation	0.0%	10.2%
Waste management and remediation services	0.0%	8.3%
Chemical products	1.6%	6.4%
Mining, except oil and gas	1.2%	5.8%
Truck transportation	0.0%	5.3%
Farms	0.0%	5.0%
Aggregate price increase	**1.4%**	**3.2%**

correspond exactly to those used in the well-publicized Consumer Price Index constructed by the Bureau of Labor Statistics and based on household spending. For example, the weight of gasoline in the CPI is about 4 percent.)

Our approach amounts to a worst-case scenario. Since we assume perfect competition in every sector, higher costs are passed on completely as higher prices. In the long run, one way the economy adjusts to a permanently higher real price of oil is by adopting less oil-intensive production techniques.

Certainly, this has happened before. In 1982, the same oil price shock modeled here would have resulted in an overall price increase of about 7 percent. The U.S. economy has certainly become less oil dependent by this measure. Sharp price increases in sectors that were heavily dependent on oil in 1982 no doubt contributed to a shift of production into less oil-intensive activities. By 2003, the economy could sustain an oil price shock with a lower overall impact on prices.

■ Factor Price Effects

The analysis so far has held fixed the combinations of intermediate goods and also the factors of production that go into producing final output in each sector. This amounts to assuming that producers will continue to use the same intermediate inputs no matter how expensive they get. But a permanent increase in the price of crude oil will no doubt change how the economy produces many goods. It will also change the mix of factors of production that are used in each sector.

What effect will an oil price shock have on the amount of input various industry sectors require from other sectors? To answer that question, we analyzed how the "factor prices" in the input–output table changed over time.

Gross domestic product is measured as the total value of output produced for final demand or as the total value added by all the factors of production in the economy. The input–output table shows spending on intermediate inputs and also factor payments in each sector. Value added is just the value of total output net of the costs of intermediate inputs. In the input–output data, value added consists of compensation of employees, indirect taxes, and gross operating surplus. We will refer to compensation of employees as wages, and gross operating surplus as payments to capital. Payments to capital determine the rate of return of capital, or what economists often refer to as the real interest rate.

Using new statistical techniques (described in detail in Fisher and May 2006), we estimate with regression analysis the factor-price changes that best explain the pattern of price changes observed in the input–output tables after an oil shock. Our analysis indicates that an oil price shock tends to raise the real return on capital, lower the real wage, and raise receipts from indirect businesses taxes. The effect that an oil price shock has on wages explains an important aspect of a real price change: Not every single price in the economy can increase in real terms. Thus some prices must be pushed down. We are not accustomed to thinking about real wages as a price, but the real wage is indeed the opportunity cost of one's free time. Thus the owners of capital—people in the national economy who have positive net wealth—will find solace in the fact that an oil price shock tends to increase the income from their portfolios. But the same oil price shock puts downward pressure on real wages.

We also analyzed how the economy in 1982 would have reacted to the same kind of long-run price changes. In that case, the real wage falls and the real interest rate rises, but the effects were less pronounced in the data from the table benchmarked in 1982.

■ It Still Hurts, but Maybe Less So

Oil price shocks often take the blame for stagflation. While we have chosen not to examine the output effects of such a shock, we are adamant that the shock in itself is not inflationary. Since price increases vary substantially across sectors, a more accurate description of an oil price shock is that it causes a change in relative prices, with those industries that use oil intensively experiencing the highest relative price increases. Because the sectors that experience the highest long-run price increases are among the most capital-intensive in the economy, the rate of return to capital tends to rise and economywide wages are liable to fall.

Even under the worst-case scenario, though, the economy seems to be in a better position to accommodate an oil price shock than before 2000. If the price of oil doubles, the one-time increase in commodity prices due to the oil increase alone averages around 3 percent, which is substantially less than what would have occurred in 1982.

■ Recommended Reading

Andrew Atkeson, and Patrick J. Kehoe. 1999. "Models of Energy Use: Putty-Putty versus Putty-Clay." *American Economic Review*, vol. 89, pp. 1028–43.

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The important distinction between inflation and the real cost of living effects is explored in depth in:

Michael F. Bryan. 2002. "Is It More Expensive, or Does It Just Cost More Money?" Federal Reserve Bank of Cleveland, *Economic Commentary* (May 15).

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