The Sensitivity of the General Price Level to Changes in the Price of Crude Oil

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Between January 2004 and May 2005, the U.S. refiner acquisition cost of a composite of imported and domestic crude oil rose at an annual rate of almost 30 percent in nominal terms (Energy Information Administration, 2005). This increase connects to an upward trend in the price of oil that started in 1999 and picked up steam in 2003. Given the price increases that have occurred since May, one wonders whether the trend is again accelerating, and what the economic impacts are likely to be. Since there are many direct and indirect effects of changing crude oil prices on the inflation rate, it is not surprising that there are different views about the resulting effects on the general price level and also on other aspects of the general economy.

Empirical studies conducted since the late 1990s generally conclude that the relationship between the price of oil and the economy has weakened over time (Leblanc and Chinn, 2004; Jones et al, 2004; and Federal Reserve Bank of Dallas, 2000). A Congressional Research Service report to Congress (Labonte, 2004) notes: “Oil prices no longer Granger-cause economic growth in straightforward ways. The effect of oil price changes on the economy was statistically insignificant in many studies.” One often hears that the greater efficiency in the use of energy has dampened the macroeconomic impacts of rising oil prices. Indeed, Alan Greenspan has noted that the energy intensity of the U.S. economy has been reduced by about half since the early 1970s (Greenspan, 2005). In recent remarks (Elliott, 2005), he said, “flexibility of our market-driven economy has allowed us, thus far, to weather reasonably well the steep rise in spot and future prices for crude oil and natural gas that we have experienced over the past two years.” Lynn Reaser, chief economist at Bank of America’s investment strategy group has argued that rising oil prices have had only a small impact on the economy because gasoline accounts for only about four percent of consumer spending (Bajaj, 2005). Jonathan Fuerbringer (2005) could not discern the effect of the price of crude on overall prices. Yet, we are beginning to see cost increases, as well as reductions in consumer confidence and spending, start to enter the conversation (Reuters, 2005). This is superbly exemplified by Wal-Mart. Earlier this year Wal-Mart officials were bemoaning their increased transportation costs for their trucking fleet (Bhatnagar, 2005). More recently they have pointed to a decline in profits due to decreased consumer spending (New York Times, 2005): “Just when it was starting to seem as if consumers..... were really shaking off high energy prices, Wal-Mart announces this week that its profits stumbled in the second quarter, rising at their slowest rate in four years. Forced to choose between their clos- ets and their gasoline tanks, Americans unsurprisingly chose their tanks.”

A quick judgment that is frequently made is that since energy usage is a smaller fraction of total GDP than it was during the oil shocks of the 1970s, the effect of rapidly rising oil prices on the present economy’s performance is not as serious as before. To substantiate this judgment, it is often noted that the impact of oil price changes on the core rate of inflation—estimated by excluding food and fuel prices from the Consumer Price Index (CPI) or the Producer Price Index (PPI) — is much smaller than the inflation rate computed from the total indexes, without excluding food and fuel prices. However, this approach seems to omit the consideration of many indirect effects. In this study, we estimate the direct and indirect effects of oil price changes on the economy-wide rate of inflation, which then has effects on spending and producing decisions. However, in this forum, we do not try to estimate the full indirect effects on the level of economic activity, such as effects on real GDP.

Almost sixty years ago, Wassily Leontief (1946) showed how input-output tables could be used to show the relation between sector outputs and sector final demands or between sector prices and sector values added. If F represents a column vector of final demand values, sector-by-sector, while X represents a column vector of output values, sector-by-sector, a fundamental relationship of input-output analysis is

\[ X = (I - A)^{-1} F \]

This equation shows how a column vector of final demand values can be transformed into estimates of gross output values. The matrix I is the identity matrix with “ones” on the diagonal and “zeros” off the diagonal. The elements of the matrix A...
are constants that show the relationship of inputs of one sector to gross outputs of another. Leontief also constructed a corresponding relationship of the form

\[(2) \, P = (I - A')^{-1} VA\]

Where \(P\) is a column vector of prices, sector-by-sector, and \(VA\) is a column vector of values added per unit of gross output, sector-by-sector. \(A'\) is the transpose matrix of \(A\), in which rows of \(A\) are changed into columns of \(A'\).\(^1\) Conceptually, the price indexes for the economy as a whole that are determined in this way are like producer price indexes.

A basic problem confronting the application of input-output analysis to a dynamic economy is that the elements of \(A\) are not necessarily constant. For studying change that is very close in the time dimension to the base case from which \(A\) is computed, as the ratio of individual flows between sector pairs to gross output values, there should not be unduly large changes in \(A\). The analysis of “neighborhood” change is then based on useable approximations from (an assumed) constant matrix \(A\).

The Bureau of Economic Analysis has fortunately provided a series of input-output tables between 1972, the year before the first oil shock (October 1973) and the early years of the 21st century.\(^2\) In the 1970s and 1980s, the input-output tables are not available for every year, but after 1997 there are annual benchmarks or extrapolated annual tables with similar degrees of sectoral display. Although the classification is somewhat different, these still provide a basis for studying price sensitivities from one year to the next.

The recent run up of crude oil prices can be analyzed on a dynamic basis from the sequence of benchmark tables during the period. For the benchmark years 1972-1997, the price of Sector 08, entitled “crude petroleum and natural gas” is exogenously changed by 10 percent. The corresponding sector in the 2003 input-output table is 211, entitled “oil and gas extraction.” The solution values for the price vector \(P\) in equation 2 with the exogenous change for each benchmark or interpolated year gives us the impact on each sector’s price. Table 1 summarizes the effect of this exogenous change on the overall price level, which is calculated by weighting the sectoral price effects by each sector’s contribution to total GDP. This weighted price would be comparable to the domestic GDP deflator, where GDP is determined from the supply side of the total economy.

\[
\begin{array}{|c|c|}
\hline
\text{Year} & \text{Percent Change in Price} \\
\hline
1972 & 0.316 \\
1977 & 0.700 \\
1982 & 1.049 \\
1987 & 0.380 \\
1992 & 0.375 \\
1997 & 0.334 \\
2003 & 0.365 \\
\hline
\end{array}
\]

These calculations illustrate that before the oil price shocks that started in 1973, the simulated effect on the overall price based on the 1972 input-output table is .316—an elasticity of approximately 0.03.\(^3\) The hoarding and the panic effect of the oil price shocks raises the price elasticity to be 0.07 in 1977 and 0.1 percent in 1982. The sensitivity of the general price level settles down to values slightly in excess of the estimated elasticity of .0316 that prevailed in 1972, prior to the first oil shock. It seems that the sensitivity of present inflation tendencies to oil price changes is no less than it was before October 1973 and is probably somewhat greater. This is contrary to much of the current conventional wisdom implicit in the conclusions that are cited above by Alan Greenspan, Lynn Reaser, and Jonathan Fuerbringer. Our calculations with moving input-output tables indicate that one should not assume that the economy, at least as far as inflation pressures are concerned, is now less sensitive to fluctuations in crude oil prices.\(^4\)

For a historical perspective, Figure 1 graphs the actual percent changes in the chained GDP deflator, PPI, and the price of intermediate crude. The swings in the GDP deflator and in PPI caused by the changing price of crude oil are clearly discernible.

Table 2 shows the sectors that are most affected over the period 1972 and 1997 if price changes are estimated according to our input-output analysis.\(^5\) These sectors are “petrole-

\(^{1}\) For a basic exposition of input-output analysis, see Leontief (1946).

\(^{2}\) These tables are discussed further in Klein, Saltzman and Duggal (2003).

\(^{3}\) The measure of elasticity used is the standard percent-change-in-X-relative-to-a-one-percent change-in-Y. Therefore, the entries in Table 1 and those that follow are simply divided by ten to derive elasticities.

\(^{4}\) It may be pointed out that similar calculations from a single input-output table of China, by Deming Wu (2004, pp. 23-26) quite independently came to the conclusion that a change in the crude oil price of 1.0 percent led to a general price increase of 0.06 percent in China’s general price level in 1997, This is larger than the US elasticity for the same period, which is plausible within the context of an energy inefficiency phase during the early years of the reform process. His results could also be extended year-by-year for China, using updated input-output tables.

\(^{5}\) Readers who are interested in the detailed calculations for individual sectors in the series of input–output tables can see the com-