Understanding the effects of exogenous oil supply shocks

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How do shortfalls in crude oil production caused by wars and other political events in the Middle East affect economic growth and inflation in major industrialized countries? Public discussion of this question has been shaped by the economic experience of the 1970s and early 1980s. The conventional wisdom leaves little doubt that oil supply shocks abroad were to blame for the economic malaise of the 1970s. This has led to the concern that history might repeat itself if a new oil supply shock were to occur, say in the form of a cutback of Iranian oil production and exports, as recently discussed in the media. Thus, understanding the effects of such politically motivated shortfalls in crude oil production is more important than ever.

Compared to two decades ago, we are now in a much better position to separate systematic from idiosyncratic features of oil supply crises, as the number of such events has steadily increased over time. Of particular interest are oil supply shocks associated with political turmoil in OPEC countries. Table 1 lists important political events that are thought to have triggered shortfalls of OPEC crude oil production. These events are typically treated as exogenous with respect to global macroeconomic conditions, which means that these events are believed to have evolved independently of the state of the business cycle in industrialized countries, and of variables such as exchange rates, interest rates, and inflation rates. This interpretation is not obvious in all cases.

For example, the decision to launch the Arab oil embargo of 1973/74 could also be viewed as an endogenous response to macroeconomic conditions, as detailed in Barsky and Kilian (2002, 2004). Nevertheless, for the purpose of this article we will follow the conventional view that the embargo was an exogenous political event.

Alternative approaches to identifying the effects of exogenous oil supply disruptions

How much are economic outcomes in industrialized countries affected by crude oil production shortfalls triggered by exogenous events in OPEC countries? A common feature of all methodologies designed to learn about the dynamic effects of exogenous oil supply shocks is that they relate changes in macroeconomic aggregates to some measure of the exogenous oil supply shock.

Oil prices are endogenous to global macroeconomic conditions

Early studies sometimes treated increases in the price of oil as the measure of the exogenous oil supply disruption. This approach is misleading in general, as the price of oil like all commodity prices tends to respond to the global business cycle and fluctuations in interest rates and exchange rates. It is widely understood today that at least since late 1973 the price of oil has been fully endogenous to global macroeconomic conditions and cannot be treated as exogenous (see Rotemberg and Wood-

Oil supply shocks are usually considered to be the result of exogenous political events

Table 1

Important Political Events in OPEC Countries

Date	Political Event
October 1973	Yom-Kippur War/ Arab Oil Embargo
October 1978	Iranian Revolution
September 1980	Iran-Iraq War
August 1990	Persian Gulf War
December 2002	Civil Unrest in Venezuela
March 2003	Iraq War

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ford 1996; Barsky and Kilian 2002, 2004; Hamilton 2003).

This seemingly trivial point has far-reaching implications. It is tempting, for example, for a policymaker to pose the question of what the effects of higher oil prices are on macroeconomic performance; yet this question is not well posed because it postulates a thought experiment, in which the price of oil changes, while holding all other variables constant. If in reality, the price of oil increases due to strong demand for oil from a booming world economy, then by construction not all other variables are held constant, invalidating the thought experiment. Thus, it is essential to decompose movements in the price of oil into well identified components that can be attributed to mutually uncorrelated structural shocks. Much of the recent literature on oil prices has attempted to address this problem one way or another.

Are at least the major oil price increases driven by exogenous political events?

Some studies have noted that at least the major oil price fluctuations in the 1970s and 1980s were arguably driven by exogenous political events in the Middle East (see, e.g., Shapiro and Watson 1988). This insight was subsequently formalized by Hamilton (1996, 2003) who proposed a statistical measure of the net oil price increase relative to the recent past designed to capture those major oil price increases presumably caused by exogenous political events. That measure also produces a time series very similar to fitted values from more sophisticated nonlinear models of the price of oil (see, e.g., Lee, Ni and Ratti 1995, Hamilton 2003).

Such measures are problematic, however. First, although three of the largest oil price increases since the early 1970s occurred near periods of large exogenous shocks to oil production, not all exogenous oil supply shocks have been associated with net oil price increases. For example, the 2002/03 twin shocks associated with civil unrest in Venezuela and the Iraq War were not associated with a net oil price increase in real terms (see Kilian 2005). Second, there have been instances of oil price shocks, most notably the sharp increase in crude oil prices since 2003, that were apparently not related to any specific exogenous shock to OPEC oil supply. Thus, exogenous oil supply shocks are neither necessary nor sufficient for the occurrence of oil price shocks

and we need to look for other possible explanations of oil price shocks.

How shifts in the demand for oil may cause oil price shocks

There is widespread agreement that the bulk of crude oil price increases since 2003 can be attributed to strong global demand for oil, driven in part by robust growth in many industrialized countries and in part by the increased appetite for oil of newly industrializing economies. It may seem puzzling at first that a shift in global demand for crude oil could be responsible for a large and rapid increase in the price of oil. The reason why even gradual shifts in demand may cause sharp increases in the price of crude oil, is that at times the production of crude oil is subject to capacity constraints. If the supply of crude oil is effectively limited, a steady increase in the global demand for oil may translate into large increases in the price of oil, before supply responds. Given the long lags in expanding productive capacity in the oil industry and the reluctance of oil companies to invest in new capacity, lest the increase in the price of oil prove temporary, the resulting oil price increases may persist for several years before corrective forces come into play. For example, it took about five years for significant increases in productive capacity to take place following the 1973/74 oil price shock.

Capacity constraints may be amplified by the fact that crude oil is not a homogenous commodity. For example, Saudi Arabia in recent years could have increased its output of crude oil, but only by producing more so-called "sour" varieties of crude oil rather than the "light sweet" crude oil most oil refineries are prepared to process. In this sense, part of the bottleneck may not be on the production side, but on the processing side of the oil market. While refineries may be adapted to different types of crude oil or new refineries may be built, this process is slow and costly. Thus, it is not surprising that in the short run the price of light sweet crude oil increased sharply in recent years.

The striking fact that oil price shocks may occur even in the absence of exogenous shocks to crude oil production also sheds new light on earlier oil price shock episodes. It is widely accepted that the oil price increases of 1973/74 and 1979/80, for example, were mainly caused by crude oil production cuts associated with the Yom Kippur war and the Arab

Not all oil price shocks result from supply shortages but also from shifts in global demand

oil embargo in one case and with the Iranian revolution in the other. What has often been ignored is the possibility that the observed oil price increases may also have reflected increased demand for oil and other industrial commodities.

How important are shifts in the global demand for industrial commodities?

One way of gauging the importance of increased demand for industrial commodities is to focus on price increases for non-oil industrial commodities. The period leading up to the 1973 oil price increase, for example, coincided with strong global growth for industrial commodities, as Europe, Japan and the United States were all nearing the peak of their business cycles. In 1972–74, the prices of ordinary industrial commodities increased across the board. The price of scrap metal nearly quadrupled between late 1972 and early 1974, not unlike the price of crude oil (see Barsky and Kilian 2002), yet the National Commission on Supplies and Shortages (1976) found no evidence that these industrial commodity price increases were driven by exogenous supply shocks in commodity markets. Similarly, 1979/80 was a period of strong global growth that continued until the Volcker recession, and of rising industrial commodity prices.

It is also possible to construct measures of global demand for industrial commodities based on freight shipping rates (see Kilian 2006b). Again these measures suggest large and across the board increases in the demand for industrial commodities in 1973 and 1979 (as well as in the period since 2002), which one would expect to be mirrored by a surge in the demand for crude oil.

Quantity-based approaches to measuring exogenous oil supply shocks

Since observed movements in the price of crude oil reflect shifts in the demand for oil driven by macroeconomic conditions, one cannot simply assume that major oil price increases are driven by events such as wars and political conflicts in the Middle East. Hence, the fact that exogenous oil supply shocks are neither necessary nor sufficient for oil price shocks is not a puzzle.

An alternative, more promising approach is to identify the exogenous fluctuations in the supply of crude oil from quantity data rather than price data. Monthly data on crude oil production by country are available from the US Department of Energy. These data can be used to construct a time series of the exogenous fluctuations in OPEC crude oil production based on explicit assumptions about how OPEC oil production would have evolved in the absence of political turmoil in the Middle East. Such a direct measure of exogenous oil production shortfalls has recently been proposed by Kilian (2006a). This measure can be thought of as a refinement of traditional quantitative dummy approaches to measuring exogenous oil supply shocks (see Hamilton 2003). It allows us to have a fresh look at the historical experience of the industrialized countries during previous oil supply shocks.

The next exogenous oil supply shock: A thought experiment

Using linear regression analysis one can estimate the effects of previous exogenous oil supply shocks on real GDP growth and consumer price inflation in industrialized countries. If we take these estimates as our guide in assessing the likely impact of future oil supply shocks, we can construct a benchmark for discussions of energy security. It is instructive to consider the expected outcomes for the largest European economies of a permanent elimination of Iranian oil supplies. Iranian crude oil production accounts for approximately 5 percent of world crude oil production. The Iranian case is a natural example, given recent discussions of an embargo and possible military action. Table 2 suggests that this shock would have considerable effects on real GDP growth

In 1972/74, price increases of non-oil industrial commodities were not due to supply shocks but to cyclical demand growth

Table 2

Estimated Effects of a 5% Permanent Reduction in Oil Supply

	Expected Effect on Annual Real GDP Growth (%)		
	1st Year	2nd Year	3rd Year
Italy	0.2	– 1.9	– 0.2
France	0.0	– 1.4	– 0.4
Germany	0.3	– 2.6	– 0.6

	Expected Effect on Annual Consumer Price Inflation (%)		
	1st Year	2nd Year	3rd Year
Italy	1.2	0.2	– 0.0
France	1.2	0.6	0.2
Germany	1.6	1.4	1.0

and to a lesser extent on consumer price inflation in France, Italy and Germany. Table 2 does not include the U.K., since that country was a substantial crude oil producer during much of our sample period.

While there is essentially no response of real growth in year 1 following the shock, there is a substantial decline in real growth in year 2. Real growth per annum drops by about 2 percentage points in most countries. The projected declines in real growth in year 2 after the shock range from – 2.6 percentage points for Germany to – 1.4 percentage points for France. This reduction would be enough to induce a real contraction in many countries. In year 3, the effect on real growth remains negative, but is much smaller, as real growth reverts back to normal levels.

Table 2 also shows that all three countries would experience a one-time increase in consumer price inflation in the first year after the shock. The increase varies between 1.2 and 1.6 percentage points at annual rates. For France and Italy, there is no evidence that an exogenous oil supply shock would lead to sustained inflation. For Germany, the increase in inflation appears much more persistent. Hence, with the exception of Germany, there is no evidence that an exogenous oil supply shock would be stagflationary. Unlike the responses predicted for other European economies, the German response includes both a reduction in growth and an increase in inflation in year 2 after the shock. This evidence is suggestive of additional wage-price dynamics being triggered by the exogenous oil supply shock.

Other considerations

Table 2 provides a useful baseline that represents our best guess of the effects of an exogenous cutback of Iranian oil production based on the evidence available since 1971. It is important to keep in mind, however, that there are a number of additional factors that could lower or raise the impact of such a shock.

Permanent versus temporary shocks

One important assumption in the thought experiment underlying the results in Table 2 has been that the reduction in Iranian oil supplies is permanent. While this is one possible outcome, it is not likely. There is a tendency to think of exogenous oil supply

shocks as one-time adverse shocks. This need not be the case. Historically, exogenous production shortfalls have tended to be temporary. For example, the production cutbacks during the 1973/74 Arab oil embargo were quickly reversed in 1974. Similarly, crude oil production in Kuwait today has completely recovered from the effects of the invasion. When the exogenous production shortfall is temporary, by construction, negative shocks to oil production are followed by positive shocks, as the initial production shortfall is at least partially reversed over time. A complete assessment of a given oil supply shock episode therefore must involve the full sequence of exogenous oil supply shocks, as a given episode unfolds. The cumulative effect of such a sequence of shocks (some negative and some positive) may differ greatly from that of a one-time permanent shock.

Rather than speculate about the likely form that this sequence might take in the case of Iran, we illustrate this point using as examples the five historical episodes listed in Table 1. We treat the Venezuelan crisis and the 2003 Iraq War as one event, given their close proximity. The cumulative effect of these five exogenous oil supply shock sequences are shown in Table 3 by episode and country. Table 3a shows the average value of the annualized rate of consumer price inflation for each subsample and country (normalized relative to its long-run average such that a zero value would indicate average performance in that country and a positive value abnormally high inflation). In addition, the table also shows the average of the estimated cumulative effect of the exogenous oil supply shock on inflation for the same period, obtained from counterfactual historical simulations based on the same linear regression estimates used in constructing Table 2. The corresponding results for real GDP growth are shown in Table 3b.

Table 3a suggests the following findings: First, in the absence of the exogenous oil supply shocks that took place during 1973/74, 1978/79, 1980, 1990/91, and 2002/2003 the evolution of consumer price inflation in France, Germany and Italy would have been remarkably similar overall to its actual path. There is no evidence that the 1973/74, 1978/80 and 2002/03 oil supply shocks had more than a negligible impact on consumer price inflation in France, Germany or Italy. Nor is there evidence of such an effect in 1980–83 or 1990–93. Only for Germany is there some evidence that oil supply shocks can account for a

Table 3a

**CPI Inflation Rates Relative to Long-Run Average and
Average Estimated Effect of Exogenous Oil Supply Shocks**

		Episodes of Exogenous Oil Supply Shocks				
		1973.IV to 1975.II	1978.IV to 1980.III	1980.IV to 1983.I	1990.III to 1993.III	2002.IV to 2004.III
Italy	Inflation	9.84	8.92	8.08	− 2.96	− 5.68
	Effect	0.01	0.40	0.20	0.52	0.44
France	Inflation	7.24	6.40	5.92	− 2.60	− 3.08
	Effect	0.16	0.64	0.40	0.84	0.60
Germany	Inflation	4.32	2.00	2.28	1.40	− 1.48
	Effect	0.24	0.84	1.28	1.36	0.44

substantial fraction of the observed rate of inflation after the outbreak of the Iran-Iraq War and again after the outbreak of the Persian Gulf War. The extent of the observed increase in inflation, however, is small by the standards of the 1970s.

This evidence is consistent with the view that the high inflation of the 1970s was caused by domestic policies rather than external shocks. Indeed, one of the striking features of the data is that the period of global economic stagnation and excessive inflation in the 1970s (also known as the Great Stagflation) in the wake of the first two major oil crises has never been repeated after subsequent oil supply shocks.

Second, as Table 3b shows, there is no evidence that the 1973/74, 1978/79 and 2002/03 oil supply shocks had a substantial impact on real GDP growth in France, Germany or Italy. This finding is consistent with an important role for demand-led oil price increases during these episodes. Although for some countries the 1980 and 1990/91 shocks did contribute to subsequent lower real growth, these effects were typically small. For example, only about one half of the abnormally low growth observed in Italy and France after the invasion of Kuwait can be attributed to exogenous oil production shocks. In the case of Germany, the stimulating effect of German re-unifi-

cation more than offset the effect of the exogenous oil production shock, resulting in abnormally high growth for the same period.

These results drive home the point that in discussing the likely effects of future exogenous OPEC oil production shortfalls, one must examine the entire path of exogenous fluctuations in crude oil production rather than the initial shock only. In this sense, the standard analysis of dynamic multipliers as shown in Table 2 can be misleading.

The limitations of extrapolating from the past

A second important assumption underlying Table 2 has been that the responses of policy-makers and of the oil industry to the Iranian crisis will resemble their average responses in the past. To the extent that today's policymakers have more experience with and a better understanding of exogenous oil supply shocks (as well as more credibility with the public), one might conjecture that these shocks will have less of an effect than on average in the past. A perhaps more important factor is the ability of the oil industry to overcome supply constraints. It seems safe to assume that the structural increase in energy demand due to the newly industrializing economies will persist, making it important to exploit alterna-

The negative effects of past temporary oil supply shocks were largely offset by positive effects

Table 3b

**Real GDP Growth Rates Relative to Long-Run Average and
Average Estimated Effect of Exogenous Oil Supply Shocks**

		Episodes of Exogenous Oil Supply Shocks				
		1973.IV to 1975.II	1978.IV to 1980.III	1980.IV to 1983.I	1990.III to 1993.III	2002.IV to 2004.III
Italy	Growth	− 2.00	2.08	− 1.68	− 1.96	− 1.52
	Effect	− 0.28	− 0.36	− 1.00	− 0.96	− 0.32
France	Growth	− 1.08	− 0.24	− 0.36	− 1.72	− 0.88
	Effect	− 0.08	− 0.20	− 0.88	− 0.84	− 0.20
Germany	Growth	− 3.36	0.16	− 2.00	2.32	− 1.36
	Effect	− 0.24	− 0.24	− 1.52	− 1.36	− 0.52

tive sources of oil or alternative energies. Certainly, the ability of the oil industry to expand greatly its global productive capacity in the early 1980s helped cushion the impact of subsequent exogenous oil supply shocks. In 2006, it is not clear to what extent additional oil supplies will be forthcoming in response to the current high price of crude oil. The constraint is less geological than geopolitical. On the other hand, compared to the 1970s and early 1980s, there have been important technological advances (such as the introduction of alternative fuels, wind and solar technology, energy conservation and higher fuel efficiency) that should help mitigate the consequences of future exogenous oil supply shocks. On balance, it is not clear which of these effects will dominate.

The role of shifts in precautionary demand

The third and most important qualification relates to the fact that exogenous production shortfalls, while important, capture only one aspect of an oil crisis. Another potentially important channel is associated with increased or decreased fears about future oil supplies. The latter channel actually is best thought of not as an oil supply shock but rather as a shock to the demand for oil in that increased uncertainty about future oil supplies will trigger increased precautionary demand for oil. The latter effect is captured by our analysis only to the extent that precautionary demand shifts in proportion to exogenous changes in actual crude oil production. Of course, it is easy to imagine that shifts in uncertainty could arise independently of actual oil production.

These shifts and their effect on the price of oil can be large. While there are no good measures of precautionary demand in the oil market in general, there are episodes for which we can gauge these effects using price data. A good example is the Persian Gulf War episode. The invasion of Kuwait in August 1990 created an imminent and unprecedented military threat to the Saudi oil fields, which was not reflected in Saudi oil production that continued unabated. Thus, one would expect a sharp rise in the price of crude oil on this date, driven by increased fears about future Saudi oil supplies. The military threat to the Saudi oil fields was only averted in late 1990, as the Allies had moved enough troops to the region to forestall an invasion. Since there were no other important shifts in the global demand for oil at the time and since measures of exogenous oil supply shocks do not explain the sharp swing in oil prices, we may feel reasonably certain that the observed

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sharp increase in the price of oil in August 1990 and its decline half a year later were indeed driven by fluctuations in precautionary demand. By that metric we can attribute a price increase of about $15/barrel to precautionary demand.

Most other episodes do not involve well-defined dates on which uncertainty suddenly increased or declined. Nevertheless, one can speculate that the increase of $5 or $6 in the price of crude oil/barrel between the summer of 2002, when the possibility of another Iraq War became more concrete, and March 2003, right before hostilities broke out, represents the "war premium" associated with shifts in precautionary demand. This also is roughly the amount by which the price of oil fell after large-scale military action in Iraq ceased in mid-2003.

Of course, these crude estimates of the importance of shifts in precautionary demand are not independent of the state of the world economy. There have been substantial shifts in uncertainty in the past such as the surges in the tanker war in the Gulf region in 1984 and 1987, when at times more than 30 oil tankers per month were damaged or sunk in the Persian Gulf by Iranian and Iraqi naval and air force attacks. Those shifts seem to have had no perceptible effect on the price of crude oil, given the slack demand for crude oil in the world at the time. Nevertheless, it is clear that in the present economic climate an Iranian crisis could conceivably trigger an unprecedented "run" on crude oil, resulting in price increases as high as those in August 1990 or even higher if buyers expect strong global demand for oil to persist. This effect is not captured by the dynamic multipliers in Table 2. The extent of such a shift in precautionary demand and its persistence will depend, for example, on the likelihood of a prolonged regional conflict that could undermine oil production or shipping, on the perceived stability of the Arab Gulf states in such a conflict, and on whether Iran threatens to use nuclear weapons on Saudi oil fields.

Conclusion

This article provided a baseline for discussing the effects of oil production shortfalls triggered by political events in OPEC countries on macroeconomic aggregates in major European countries. This baseline was based on a careful analysis of exogenous shifts in crude oil production in OPEC countries

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Effects of shifts in precautionary demand depend on the state of the world economy

since the 1970s. The article also outlined some additional factors that must be taken into account in assessing the likely effect of future oil supply disruptions. While considerable progress has been made in recent years in understanding the nature of exogenous oil supply shocks and their effects on macroeconomic aggregates in industrialized countries, a central message of the article is that one cannot fully understand the effects of exogenous political events in the Middle East without a better understanding of the role of precautionary demand and the impact of shifts in expectations about future oil supplies on oil prices.

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