Who's Afraid of a Big Bad Oil Shock?

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When the U.S. invaded Iraq in March 2003, many economists feared that the war would lead to a sharp decline in Iraqi oil production, a spike in oil prices, and a woeful economy that would follow the scripts of the oil shocks of 1973, 1978, and 1990. There was in fact a moderate decline in world oil production, and real oil prices increased from $20 in 2001:4 to $62 in 2006:3. But the ailments associated with earlier oil-price increases did not appear. Instead, output continued to grow rapidly, inflation was moderate, unemployment fell, consumers remained happy, and productivity grew at close to its postwar norm.[1]

Macroeconomists would be out of business were there no surprises. The business of this paper is to inquire into the explanations for the surprising oil non-crisis of the early 2000s. The robustness of the economy following the latest oil shock can perhaps be seen in the context of one of the most important developments in all of macroeconomics, the Great Moderation. This little-noticed theory holds that the economy has shown much less volatility of inflation, unemployment, and output growth since World War II. (See particularly Stock

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[1] The data and sources as well as elaboration of the quantitative statements in the text are contained in a set of accompanying notes, "Notes on Data and Methods for 'Who's Afraid of the Big Bad Oil Shock?'," August 27, 2007, available on the web at http://www.econ.yale.edu/~nordhaus/homepage/Data_BPEA_20072_v2.pdf. (Version is Big_Bad_Oil_Shock_Meeting.doc.)

and Watson [2002].) Perhaps the moderated response of the economy to the latest oil shock is part of the declining volatility of the overall economy.

While much has been written about the macroeconomic impacts of price shocks, little analysis is available on the impact of the most recent shock. The most comprehensive study is a preliminary paper by Blanchard and Gali [2007]. Most research focuses on the role of monetary policy and inflation dynamics in the post-shock periods. There seems to be no consensus as to whether the macroeconomic fear of oil-price shocks continues to be warranted.

Shocks past and present

It will be useful to present the basic data on oil shocks past and present, shown in Table 1. This table shows the major data on the behavior of the economy following the four oil-price shocks after the 1973 Arab-Israeli war, the 1978 Iranian revolution, the 1990 Iraqi invasion of Kuwait, and the 2002 run-up to the American war in Iraq. The first date shown is the dating of the oil shock, while the second date is period when oil prices peaked.

The first numerical column shows the percentage increase in the real price of oil. (The oil price shown here is the average refiner acquisition cost of crude oil, except during the period of price controls, when it is the import cost. The price is deflated by the price index of personal consumption expenditures.) The most recent shock involved a real oil-price increase of 125 percent, which about as large as the average of the 1970s oil-price increases. The 1990 increase was smaller and short-lived, while the most recent increase was more gradual and therefore perhaps less of a pure shock.

We next examine the macroeconomic reactions to the oil shocks. This is at this point a simple before-and-after look at the data and clearly cannot establish causality. It does provide an initial look at the economic conditions after the oil shocks.

The next two columns show the macroeconomic response in terms of the unemployment rate and the percentage output gap. (The gap, or perhaps more accurately the capacity utilization ratio, is the ratio of actual to potential output.) This illustrates that latest shock did not have the accustomed recessionary impact on the economy. The unemployment rate fell by slightly more than 1 percentage point, while the output gap increased slightly. The most recent episode contrasts sharply with the shocks of the 1970s, when the unemployment rate rose between 2 and 4 percentage points, and the output gap declined sharply.

While the latest oil shock did not lead to a recession, the impacts on inflation and productivity were similar to those in the shocks of the 1970s. Inflation measured by either the PCE price index or the CPI rose about 1½ percentage points, which is, we will see shortly, pretty much what is in line with the direct impact of the rise in energy prices. The most recent spurt in inflation was much less than the sharp rise in the 1970s. Additionally, the recent oil-price increase was followed by a significant decline in productivity growth of 1.5 percentage points. In this respect, the experience following the recent oil shock parallels that of the 1970s, where the decline in productivity was only marginally larger.

The summary message of Table 1 is that the most recent oil shock is more similar to earlier shocks than might first appear. Inflation and productivity behaved similarly to earlier shocks. The major difference is that the oil shock was followed by a continued economic expansion rather than a recession.

Why Are Oil-price Shocks Contractionary?

The first challenge in studying oil-price shocks is to understand why they might reduce real output in the first place. There are basically two sets of reasons: effects on productivity and effects on aggregate demand.

The effect of energy-price shocks on productivity involves substitution of other factors for energy in response to higher energy prices. In a world with exogenous technological change, there will actually be *no* response of multifactor productivity to price changes, for the response is only substitution along a given technological frontier. However, if we examine partial productivity measures, such as labor productivity, then there might be a response, such as when labor is substituted for energy.

It is easy to forget how small the substitution response would be. To begin with, in a full-employment world, there would be no productivity response in the short run until substitution occurs. None, as in zero. If people continue driving and flying and using the old capital equipment at the same rate as before the price shock, all inputs and outputs would be identical, and there would consequently be no productivity impact.

In a simplified one-product neoclassical world, the productivity response to an oil-price change is approximately proportional to (the elasticity of output with respect to oil) times (the price-elasticity of demand for oil) times (the logarithmic change in the price of oil). (You can substitute energy for oil in this equation to get the energy-price impact.) An illustrative calculation will indicate how small the substitution-productivity effect would be. We estimate that the one-year price-elasticity of demand for crude oil in the U.S. for the period 1970:Q1 to 1995:Q4 was -0.04 ($\pm$ 0.01) while the ten-year elasticity was -0.24. Taking the average share of oil in GDP for this period of 3 percent, the productivity effect of a doubling of real oil prices would be a decrease of 0.11 percent per year and 0.046 percent per year for a one-year and ten-year horizon, respectively. This is at least ten times smaller than the productivity impact shown in Table 1.

These calculations indicate that we should not look to impacts on productivity and potential output as the mechanism for understanding output responses to energy-price shocks. They also remind us that there is no fundamental economic reason why energy-price shocks should lead to recession and unemployment.

A more likely mechanism is that price shocks work through aggregate demand. There are actually two important ways that price shocks can affect aggregate demand. A first is through monetary policy: Higher energy prices produce inflation, which may lead the Federal Reserve to tighten money and slow the economy. (This is the mechanism that is argued for in Bernanke, Gertler, and Watson [1997].) We can think of this process in terms of the Taylor Rule, which holds that the Federal funds rate is a function of the deviation of inflation and unemployment from their targets. As energy-price increases boost consumer-price inflation, this would trigger a monetary tightening and thereby lead to a contractionary impact of higher energy prices.

The contractionary effect of monetary policy will clearly depend upon whether and how closely the Fed follows some variant of the Taylor Rule. In the late 1970s, the Fed, like Molière's character who spoke prose without knowing it, reacted powerfully to energy-price driven inflation, and this is one cogent explanation of the depth of the recession following the 1978 oil shock.

However, in recent years, the Fed has emphasized core PCE inflation, which excludes the direct effect of energy-price (as well as food-price) increases – call this the "core Taylor Rule." If the Fed follows the core Taylor rule, then this second contractionary mechanism would not operate until and unless energy prices get transmitted into a further round of price or wage increases. (As a technical aside, core inflation excludes energy-price increases that get into consumer goods and services indirectly through business purchases of energy; examples are airfares and apartment rents. So the total impact of energy prices on consumer prices with 100 percent pass-through will exceed the direct impacts that are removed in calculating the core inflation rates. A rough estimate is that the total impact on consumer prices is about 1.8 times the direct effect.)

There is some evidence that the Fed behaves as it speaks. If we estimate a rolling regression Taylor Rule with separate terms for core PCE inflation and energy PCE inflation, we see that the coefficient on energy inflation was essentially zero in the 1990-2007 period. By contrast, in earlier periods, particularly in the 1970s, the reaction of the Federal funds rate to energy inflation was very sharp. This would suggest that oil prices are less contractionary today because monetary policy accommodates one-time shocks to energy prices.

The second mechanism, and one that was emphasized in the 1970s by members of the Brookings Panel, is "oil price as tax increase." The idea is that an increase in oil prices, through the income effect, lowers real disposable income of consumers and thereby lowers real consumption. The logic is that the marginal propensity to consumer of energy buyers is much higher than that of energy sellers. Buyers tend to be consumers, perhaps even low-income consumers because of the regressive nature of energy spending, and therefore have high MPCs.

The seller side is more complex. An increase in oil prices leads to higher profits. The domestic profits would flow largely to corporations, which (at least in the old days when capital was taxed) had a high marginal tax rate. A substantial fraction of the post-tax corporate profits would either be saved in higher retained earnings or flow to high-income households, both of which would have low MPCs. Similarly, higher foreign revenues flowing to OPEC tend to be saved, and any additional spending would only marginally be on U.S. production. Going through this chain of spending, it would be plausible to argue that the marginal expenditure on U.S. production from oil profits might be close to zero in the short run. The net effect of a permanent oil-price increase might therefore be almost as powerful as a permanent tax increase.

Measuring Oil Shocks

The second challenge in studying oil-price shocks is to determine an appropriate shock variable. The standard approach in studies of oil prices and the macroeconomy has been to use either nominal or real oil prices (see Hamilton [1983] and Blanchard and Gali [2007] as examples). This approach is clearly defective, as it does not scale oil prices for their economic importance.

It is useful to go back to first principles in defining a shock variable. All three of the mechanisms discussed in the last section would point to the overall share of oil or energy as the relevant variable for measuring the effect of a price shock. In the production function approach, the share of oil or energy in income (or the production elasticity) will be the key variable.

Similarly, in the oil-price-as tax-increase theory, the impact of changing prices will come through the effect on real income – that is, through the standard income effect. We follow this route in defining our shock variable. This would be measured by the value of purchases times the change in the price. That is, the income effect = (PX) ΔP, where P = price, X= quantity, PX = value of consumption, and the change is over θ periods. If we want to consider the importance relative to the economy, we might then divide by nominal GDP, which provides a first definition of the "oil-shock variable" at time t:

(1) $$OilShock(t; \theta) = \{P(t)X(t) \ln[P(t)/P(t-\theta)]\}/GDP(t)$$

For this definition, P is the nominal price of crude oil and X is the total domestic consumption of crude oil.

This definition is limited because it considers only oil. We therefore define a second variable which is an "energy-shock variable." This is conceptually the same as the oil-shock variable but uses the price and quantity of personal consumption expenditures on energy products (primarily gasoline, electricity, and heating fuels). For this second shock variable, we use personal consumption expenditures as the denominator. The advantage of the energy-shock variable is that it is more inclusive and considers the impact on consumers. The disadvantage is that it omits second-round effects, such as the effect of oil prices on jet fuel and thence on air fares.

Figure 1 shows cumulative measures of the energy- and oil-shock variables. We show the cumulative totals because the shock variable will differ depending upon the length of the differencing period. Table 2 shows the changes in the scaled shock variables over the shock periods for each episode. These are calculated as a rate per year to reflect the fact that the period of shock varied across shock periods.

In terms of the total size of the shock, the 2002-2006 shock was close to the average of the 1970 shocks. However, the oil shocks of the 1970s had a completely different shape than that of 2002-2006 period in that the earlier ones were very sharp, while that of the 2000s was much more gradual. If we consider the oil-shock variable at an annual rate, then the shock per year was 2.1% for 1973-75, 2.4% for 1978-80, but only 0.7% for 2002-2006. The rates were roughly similarly proportioned for the energy-shock variables.

The historical context and shape of the energy and oil shocks suggest that those of the 1970s might have a far more powerful economic impact. The 1970s shocks were dislocations that changed our view of energy and resources in a fundamental way. Given the historical stability of oil prices before the fall of 1973, the changes that ensued were large-sigma events, similar in psychological effect to the collapse of the World Trade Towers or Hurricane Katrina. For example, the largest four-quarter change in the real oil price between 1950 and 1973 was 10 percent. In the next two years, the change was as high as 160 percent. My recollection is that no serious forecaster in 1972 foresaw anything approaching a five-fold increase in the real price of oil by the end of the decade.

By contrast, the oil-price increase of the 2000s was large, but not outside the range of reasonable pessimism. Indeed, George Perry's study of the economic effects of terrorist events indicated that $75 per barrel oil was a "worse case" and not even the "worst case" (Perry [2001]). My study of the economic effects of the war in Iraq also suggested an oil-price spike of $75 per barrel for my high case, declining as the war wound down (Nordhaus [2002]).

To summarize, when we construct a scaled oil-shock and energy-shock variable, we see that the oil and energy shock of the 2000 has a cumulative economic effect that is similar to that of the 1970s shocks. However, the latest shock was much more gradual and was not unthinkably large to market participants.

Mechanisms for declining impact of oil shocks

It is worth pausing to consider why oil shocks might have a smaller impact on the economy today than in earlier periods. We can preliminarily consider three reasons: smaller shocks, smaller multipliers, and other forces. (Many of these issues were originally investigated in Hamilton [1983].)

A first reason why oil-price shocks might have a smaller impact is that the shocks are smaller. As earlier sections indicated, this can account for a smaller macroeconomic response but not for an economic expansion during the 2002-2006 period.

A second reason for a smaller impact is that the transmission mechanism has progressively tended to moderate the macroeconomic impact of shocks. Under the classical Frischian view of the economy, we distinguish exogenous and policy shocks (in which category the first reason lies) from the complicated non-linear stochastic dynamic system which takes shocks and generates endogenous variables like unemployment, prices, and output. In this second approach, a given variability of exogenous or policy variables such as oil prices would lead to lower variability of output. In the simplest macroeconomic framework, the oil-price multiplier on output is smaller.

A third reason for a smaller impact is that other variables might have reinforced the contractionary and inflationary impacts of oil prices in the 1970s while they tended to offset those impacts in the 2000s. Economic histories of the 1970s point to other shocks such as commodity shortages, poor grain harvests, political business cycles, collapse of the Bretton Woods system, disappearing anchovies, and an army of plagues that reinforced the inflationary impact of the 1973 shock, while the anti-inflation wars of the 1979-82 period (in part motivated by the 1978 shock) surely reinforced the contractionary impact of the 1978 shock.

Note again that the story of the oil-price shocks runs parallel to the explanation of the Great Moderation. In explaining the declining volatility of output and inflation, we would look to some combination of these three factors.

<u>The trajectory of shocks and responses</u>

I next take a closer look at the pattern of shocks and responses for the three major episodes. For this, I examine the time series of inflation and output along with the cumulative energy and oil shocks. For these comparisons, I plot the cumulative oil and energy-shock variables just described along with the trajectories of output or inflation.

Figure 2 shows the time series on the price shock variables along with output. For this purpose, we use as the output variable the ratio of real output to potential real output as defined by the Congressional Budget Office. I have normalized the variables to be zero on the shock date. Therefore, the plot shows the cumulative change since the shock date. For example, output declined relative to potential by 7.7 percent in 1975:2, while the size of the cumulative energy and oil shocks were 1.2 and 3.7 percent of PCE and GDP in that period.

Figure 2 shows the anomaly for the 2000s. Whereas output paralleled the (negative) shocks of the 1970s, the relationship reversed in the 2000s. The sample size of shocks is obviously pathetically small, but it is clear that the earlier relationships did not hold.

Figure 3 shows the same graph for the energy shocks and inflation. For this graph, we use both the CPI (which policymakers tended to follow in the 1970s) and the PCE price index. The relationship between inflation and the price shocks is clearly positive for each of the three periods.

Looking closer, however, we see some interesting factors. Perhaps the most interesting relationship is between the energy-price shock and PCE inflation. By construction, if the only factor changing during the period was energy-price inflation, the two lines would coincide (almost) exactly. This is because the PCE price index is a superlative index that uses virtually the same construction as our energy-price shock variable. (There is actually a small third-order difference because the PCE is a Fisher index while our construction is a Törnqvist index, but the difference is trivially small.)

In the first period, the PCE shock was about three times the energy-price shock. This indicates that other factors (imports, other commodities, and wages) operated to reinforce the energy-price shock in the 1973-75 period. Note as well that the CPI bias was small in this period. In the second period, virtually all of the rise in PCE inflation can be accounted for by energy-price inflation. Note however that the CPI in the 1978-81 period rose much more rapidly than the PCE price index, partially because of flawed construction from housing and the Laspeyres structure.

In the third period, the contribution of the energy-price shock was about one-half times larger than PCE inflation. During the 2002-2006 period, therefore, other factors were retarding inflation by about 1 percent over the four years. During this period, wage inflation was stable as the rise in price inflation was not passed through into wages. This may have been due to the relatively high unemployment rate when the third shock occurred as compared particularly to the unemployment rate when the first shock occurred.

Summing up the evidence on the trajectories of inflation and output, the major points are that the 2000 episode was completely anomalous for output, while the major news on recent inflation is that there appears to have been no pass-through of higher energy prices into wages.

Offsetting forces?

It seems clear that the disappearing energy crisis is not primarily due to lack of energy shocks. This would leave the second and third potential causes. The lack of a response might be due to smaller amplifiers in the macroeconomic transmission mechanism, or it might be due to offsetting forces of macroeconomic policy or exogenous events. Sorting out these two forces is clearly a major task, but I will provide a few suggestions on the question.

We first examine the question of offsetting forces. Here, we simply look at the question of whether other major forces affecting aggregate demand were moving with or against the shock variables. For this purpose, I examine two variables. The first is the ratio of exogenous spending to potential GDP ("Exog"); for this calculation, I define exogenous spending as government current purchases and investment plus exports. A second variable is the nominal interest rate on the three-month Treasury bill rate (the real interest rate gives slightly different results).

I then examine the correlation structure of these two aggregate demand variables with the oil- and energy-shock variables. The results for the three major shock periods are shown in Table 3 (the periods are two quarters longer than the shock period to allow for lags). Exogenous spending was negatively correlated with the first price shocks, indicating that the contractionary drag of the energy shock was reinforced by the contractionary force of export and government purchases. By contrast, exogenous forces were positively correlated with the price shock in the second and third periods, indicating that they were offsetting the price shock.

The effect of interest rates was also mixed. Interest rates were negatively correlated with the price shock in the first shock period, but positively correlated in the second and third period. This indicates that monetary policy (to the extent that policy determines real interest rates) reinforced the price shock in the second and third periods. In no period were both forces operating to buffer the price shock.

Declining impact of shocks?

The big question remains whether the macroeconomy has become less sensitive to exogenous or policy shocks in recent years, with insensitivity to oil prices being the primary question raised in this paper. Investigating this issue requires taking a firm stance on the structure of the macroeconomy. In this section, I take a modest step by examining a small equation for aggregate demand and looking at the trend in variability and coefficients.

For this purpose, I take a very simple one-equation representation of the macroeconomy:

(2) $CU(t) = \alpha_0 + \alpha_1{*}Exog(t) + \alpha_2{*}CU(t\text{-}2) + \alpha_3 TB3(t\text{-}2) + \alpha_4\, Oilshock(t) + AR1$

where CU = ratio of output to potential output, Exog = ratio of exports plus government spending to potential output, TB3 is the nominal three-month Treasury bill rate, and Oilshock is the oil-shock variable. The α_i are estimated coefficients. Estimating this equation over the period 1950:Q1 to 2007:Q2 gives coefficients with the appropriate sign and size.

The question is whether the coefficients have changed over time. For this exercise, I estimate equation (2) for four subperiods, 1950:1-1970:1, 1960:1-1980:1, 1970:1-1990:1, and 1987.2-2007:2. I then show the coefficients in Table 4. (A similar approach with a different structure was undertaken by Blanchard and Gali [2007].)

While the results will be sensitive to different specifications and sample periods, they suggest strongly that the impact of exogenous spending continues to be relatively strong, perhaps even increasing slightly over the period. On the other hand, the impact of the oil-shock variable declines sharply over time and is close to zero in the last two decades – a period that excludes the earlier price shocks and includes only the shocks after 1987.

We can get another view of the contribution of different factors by examining rolling estimates of volatility over time. Figure 4 shows the sub-period standard deviations of changes in four policy or shock factors along with inflation and output. These volatility measures compute the standard deviation of the four-quarter changes for each of the five subperiods shown in the accompanying legend.

Beginning with energy prices, this graph shows the increase and then decrease in the volatility of oil- and energy shocks over the postwar period. The increase in volatility from the 1950-70 period to later periods is extremely dramatic. There has been only a modest decline in volatility, particularly of the oil-shock, since its peak in the 1970-1990 period. In terms of macroeconomic impact, the decreasing macroeconomic sensitivity of output to oil-price shocks has accompanied declining shocks over the period since 1970. This unambiguously leads to a smaller impact of oil and energy-price shocks on the economy since the 1970s.

What of exogenous spending shocks? The stunning point is that the variability of the exogenous component has declined by a factor of five since the first period. This sharp decline in variability of the exogenous factors is fighting against a constant or even perhaps increasing multiplier, with the likely outcome being a lower volatility of output. The endogeneity and changing structure of monetary policy requires a much more complicated economic and statistical structure than the model used here, but it is worth noting that the volatility of interest rates first increased and then decreased over the period. The interpretation of this is ambiguous, however, because it would involve assessing whether the movements in the different periods were pro- or anti-cyclical.

The last two sets of bars show the variability of output and inflation. Both of these show a decline in variability – as suggested by the theory of the Great Moderation. Over the range of observations, the variability of output has declined by almost two-thirds while that of inflation declined by more than half.

The net assessment is that the declining impact of oil and energy-price shocks on the economy results from a combination of both declining sensitivity of the economy to energy-price shocks and from a decline in the variability of energy and oil prices since the 1970s. The declining sensitivity appears quantitatively more important, but the estimates of the sensitivity parameter are hardly well-determined.

Conclusion

So what should we conclude? To begin with, the oil shock of 2002-2006 was different from those of earlier period. If we measure the shock as the income effect per year of the price increases, the shock was substantially smaller than the shocks of the 1970s. It occurred more gradually, and the change was much less of a surprise in the context of past experience. Roughly speaking, the shock was about one-third as large as the shocks of the 1970s.

In terms of effects, the impact of the shock on inflation was qualitatively similar although quantitatively different from the earlier shocks. The rise in PCE inflation in the recent shock was consistent with less than full pass-through of the energy-price increase. Unlike the shocks of the 1970s, there appears to have been no substantial pass-through of the energy-price increases into wages or other prices.

The impact of the shock on output was completely different from earlier episodes – indeed the sign was opposite. Output continued to grow relative to potential output after the shock, and unemployment continued to fall. The reason for the anomalous output impact is unclear. One possible reason is that the shock was too small to affect the overall pace of economic growth.

Additionally, there is modest evidence that the transmission mechanism from energy prices to output has changed from negative to neutral over the last three decades. The reasons for the declining sensitivity are not completely understood, but two underlying causes seem plausible. First, there is evidence that the Federal Reserve reacted more sensibly to energy prices in the 2000s, looking more at core inflation than total inflation and paying more attention to the superlative PCE price index than the flawed CPI of the 1970s and early 1980s. Perhaps experienced hands at the Fed remembered history and decided not to repeat it. Perhaps they correctly judged (correctly in my view) that the energy-price shock was a one-time shock to the price level that would not be passed through into wage inflation.

A second and more speculative reason for the muted macroeconomic reaction is that consumers, businesses, and workers may see oil-price increases as volatile and temporary movements rather than the earth-shaking changes of the 1970s. Returning to the oil-price-as-tax-increase theory, consumers might view oil-price increases as temporary rather than permanent tax increases, and their reactions would therefore be correspondingly smaller. Similarly, businesses today might build energy-price volatility into their plans and investments, and large price changes would not upset operations as much as in earlier periods. A similar set of factors might lead workers and unions to absorb declines in real wages induced by energy prices rather than go on strike in an attempt to recapture losses that might turn out to be transitory. All of these factors would tend to reduce the impact of energy-price shocks on the macroeconomy.

In the end, this suggests that much of what we should fear from oil-price shocks is the fearful overreactions of the monetary authority, consumers, businesses, and workers. A cautious reading today suggests that policymakers should not be afraid of a Big Bad Oil Shock. The most recent evidence suggests that the economy is robust in the face of major energy shocks. The economy weathered an increase in real oil prices of 125 percent from 2002 to 2006 without any major strain. This suggests that policymakers should focus on fundamentals such as employment, real output, and containment of inflation as well as the instabilities caused by financial innovations and risk-taking. Oil-price shocks are neither so big nor as bad as in the 1970s.

Oil-price-shock date	Oil-price-peak date	Change in real oil price (%)	Change in unemploy-ment rate (% points)	Change in output gap (% points)	Change in PCE inflation (% points)	Change in CPI inflation (% points)	Change in labor product-ivity growth (% points)
1973Q3	1975Q2	155	4.1	-7.5	2.5	2.5	-1.8
1978Q4	1980Q3	97	1.8	-6.3	2.7	3.6	-2.1
1990Q3	1990Q4	27	0.4	-1.5	0.5	0.7	-0.5
2002Q4	2006Q2	125	-1.2	2.1	1.4	1.7	-1.5

Table 1. Macroeconomic data for major oil shocks

The change in the real oil price is the arithmetic percentage change from the shock date to the oil-price-peak date. The other columns show the difference between the series at the oil-price-peak date and the series at the oil-price-shock date. For example, the unemployment rate change of 4.1 percentage points for the first shock equals the unemployment rate of 8.9 percent in 1975:Q2 minus 4.8 percent in 1973:Q3. Productivity and inflation growth are four-quarter logarithmic changes in percent per year.

Period	Oil shock*	Energy shock**
	[Percent per year***]	
1973:Q3-75:Q2	2.1%	0.7%
1978:Q4-1980:Q3	2.4%	1.4%
1990:Q3-90:Q4	3.0%	1.9%
2002Q4-2006:Q2	0.7%	0.6%

* Percent of national oil consumption
** Percent of personal consumption expenditures
*** Shock from beginning to end divided by number of years

Table 2. Scaled energy and oil shocks

The table shows the total scaled oil and energy shocks for the four major oil-shock periods. This measure annualizes the variables by taking the total change from beginning to end divided by the number of years.

Period and shock	Aggregate demand variable	
	Exogenous spending	Nominal interest rate
1973:2 to 1975:2		
Energy	-0.18	-0.15
Oil	-0.18	-0.17
1978.2 to 1980.3		
Energy	0.46	0.67
Oil	0.46	0.67
2002.2 to 2006.2		
Energy	0.65	0.89
Oil	0.69	0.91

Table 3. Correlation coefficients of shocks with aggregate demand variables

The table shows the correlation coefficients of the energy- and oil-shock variables with two major variables affecting aggregate demand. Positive changes in the shock variables and the real interest rate are contractionary, while a positive change in the exogenous-spending variable is expansionary.

Estimated coefficient	1950-70	1960-70	1970-90	1987-2007
Exogenous spending				
Coefficient	0.24	0.67	1.13	0.97
Standard error	(0.19)	(0.29)	(0.34)	(0.21)
Oil-price shock				
Coefficient	-4.48	-0.54	-0.19	-0.11
Standard error	(3.92)	(0.32)	(0.26)	(0.18)

Table 4. Coefficients on exogenous spending and oil-price shock in aggregate demand equation, various periods

The table shows the estimated coefficients for equation (2) in the text for different subperiods. The exogenous spending coefficient is α_1 while the oil-price shock variable is α_4 .

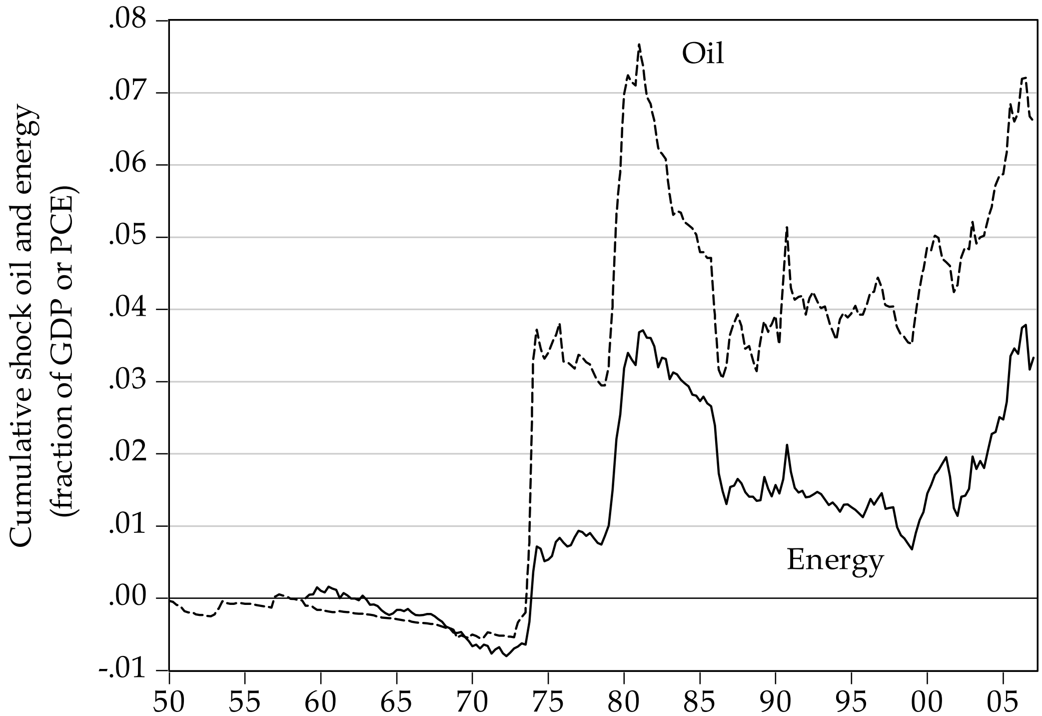

Figure 1. Cumulative energy and oil shocks

Figure shows the cumulative total shocks for each concept. The oil-shock variable is scaled by GDP while the energy-shock variable is scaled by personal consumption expenditures.

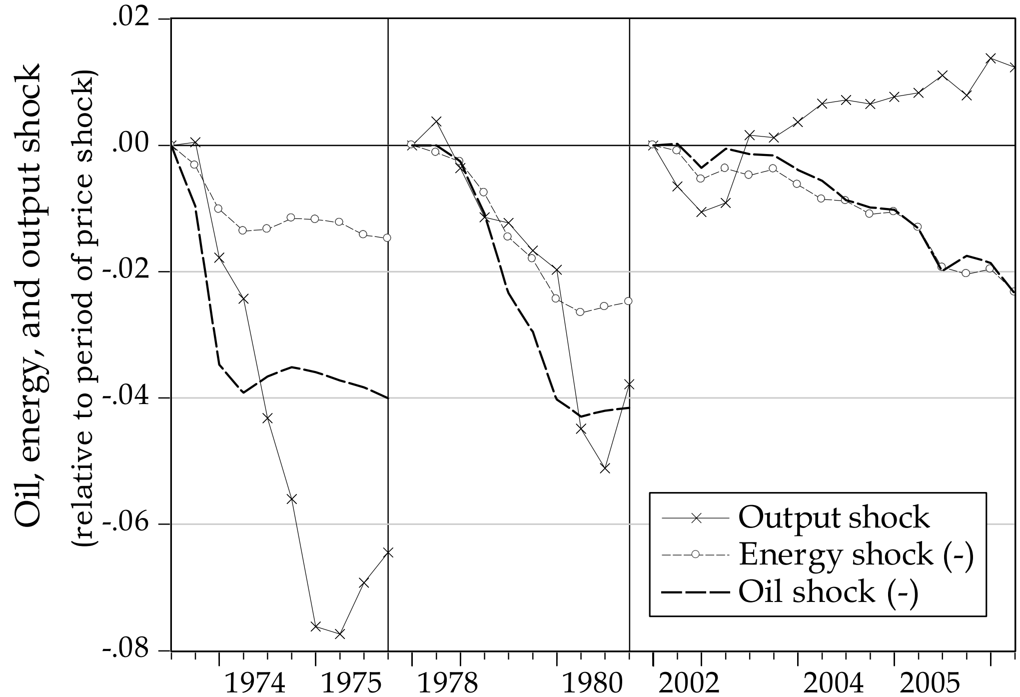

Figure 2. Price shocks and output

Figure shows the trajectory of GDP (as a fraction of potential GDP) and the energy and oil-shock variables for the three major price shock periods. Note that the shock variables are associated with declining output in the first two periods but not in the third period. Each variable is normalized to equal 0 in the shock period.

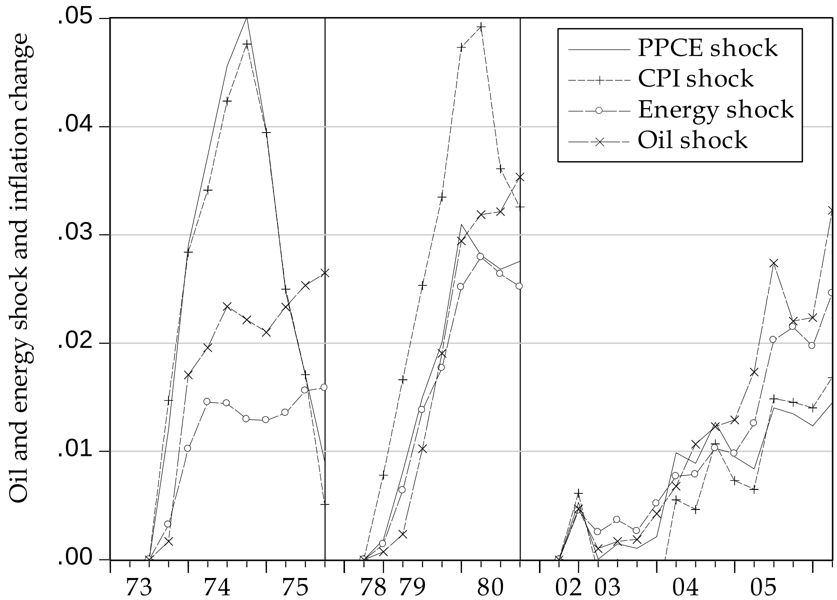

Figure 3. Price shocks and inflation

Figure shows the trajectory of two inflation rates (CPI and PCE price index) and the energy and oil shocks. Each variable is normalized to equal 0 in the shock period.

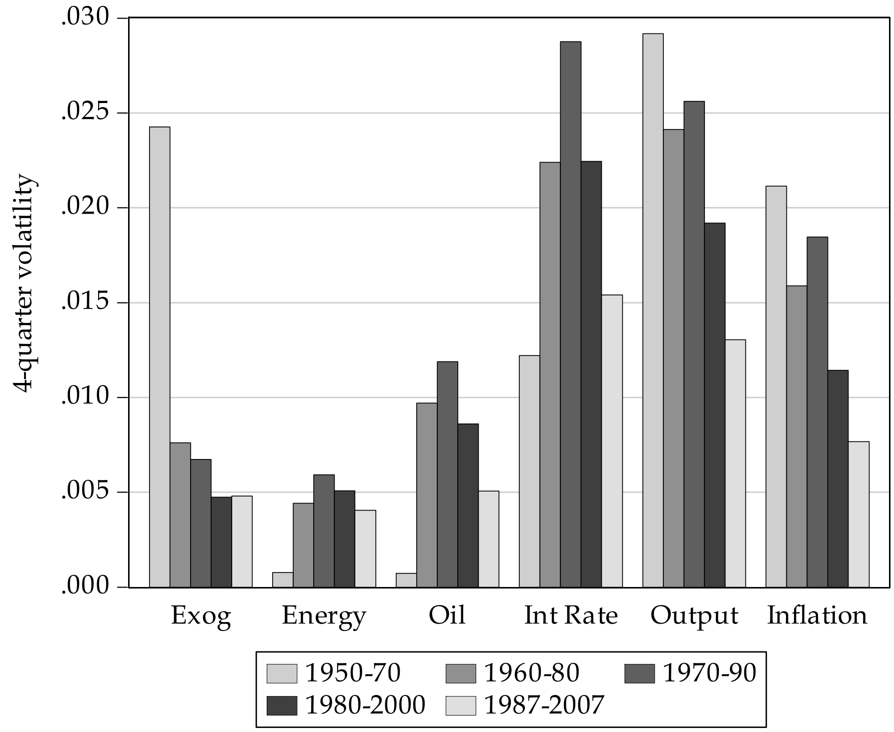

Figure 4. Variability of shocks, subperiods

Figure shows the standard deviation of the four-quarter change in each variable for different subperiods. The variables are "Exog" for the ratio of exports and government purchases to potential output, "Energy" and "Oil" for the scaled energy-price and oil-price shock variables shown in Figure 1, and "Int rate" for the Federal funds rate. "Output" is the ratio of output to potential output while "Inflation" is the PCE price index.

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