Business Cycles: The Role of Energy Prices

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Working Paper 0304

FEDERAL RESERVE BANK OF DALLAS

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by
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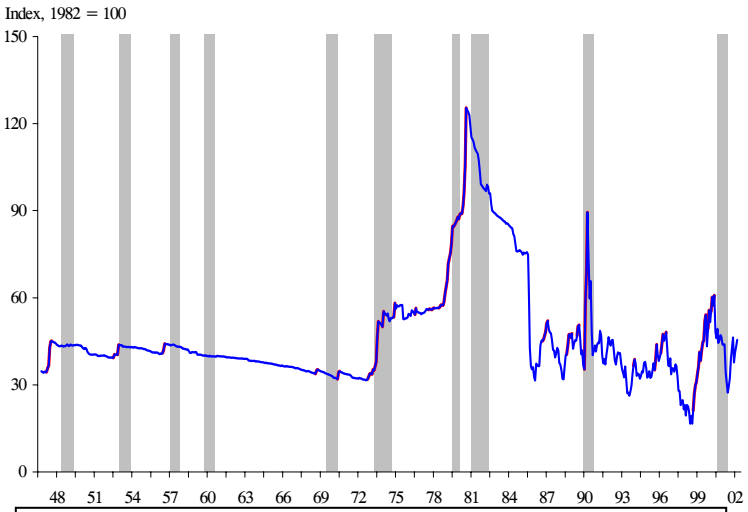
Overview/Abstract:
Oil price shocks have figured prominently U.S. business cycles since the end of World War II—although the relationship seems to have weakened during the 1990s. In addition the economy appears to respond asymmetrically to oil price shocks, rising oil prices hurt economic activity more than falling oil prices help it. This section of the *Encyclopedia of Energy* sorts through an extensive economics literature that relates oil price shocks to aggregate economic activity. It examines how oil price shocks create business cycles, why they seem to have a disproportionate effect on economic activity, why the economy responds asymmetrically to oil prices, and why the relationship between oil prices and economic activity may have weakened. It also addresses the issue of developing energy policy to mitigate the economic effects of oil price shocks.

I. Business Cycles and the Role of Energy Prices

Despite occasional periods of notable recession, the U.S. economy has generally traveled an expansionary path throughout its history. In fact, U.S. gross domestic product (GDP) has averaged a 3.6 percent annual rate of increase since 1929. Population increases account for some of the growth, but productivity gains have also been essential to long-term national economic growth.

Although the U.S. economy has generally expanded over time, its upward trend has not been free of interruption. Shocks have occasionally hit the U.S. economy disrupting the expansionary forces and creating business cycles. Since World War II, oil price shocks have played a significant role in U.S. business cycles. In fact, rising oil prices preceded nine of the ten recessions that occurred from the end of World War II through 2002 (Figure 1). Research conducted by James Hamilton (University of California, San Diego) strongly suggests that the recessions that followed sharply rising oil prices were not the result of other business cycle variables, such as aggregate demand shocks or contractionary monetary policy.

Figure 1: Real Oil Prices and U.S. Recessions



Episodes of sharply rising oil prices (shown as the highlighted portions of oil prices) have preceded nine of the ten post-World-War II recessions in the United States (shown as bars).

In examining the influence of oil price shocks on U.S. economic activity in the six decades since the end of World War II, economists have found that oil price shocks seem to have a disproportionate effect on economic activity. In addition, the economy appears to responds asymmetrically to oil price movements—that is, the gains in economic activity that follow oil price declines are not commensurate with the losses in economic activity that follow oil price increases. In addition, oil price shocks seem to have had less effect on economic activity during the 1990s than in previous decades.

These observations suggest a number of questions. What basic factors account for the negative influence that sharply rising oil prices have on U.S. economic activity? Why do sharply rising oil prices have disproportionate effect in weakening reducing economic activity? Why doesn't the economy respond as favorably to falling oil prices as it responds unfavorably to rising oil prices? Why has the economy become less sensitive to oil price shocks? And, how does our understanding of the effect of oil price shocks on economic activity shape desired energy policies?

II. Understanding the Basic Response

The oil price shock of 1973 and the subsequent recession, which (at the time) was the longest of the post-WWII recessions, gave rise to many studies about the effects of oil price increases on the economy. The early research documented and sought to explain the inverse relationship between oil price increases and aggregate economic activity. Subsequent empirical studies confirmed an inverse relationship between oil prices and aggregate economic activity for the United States and other countries. The latter research included James Hamilton's findings (published in the *Journal of Political Economy*) that other economic forces could not account for the negative effect that rising oil prices had on U.S. economic activity.

Economists have offered a number of explanations for why rising oil prices hurt aggregate U.S. economic activity. The most basic explanation is the classic supply shock in which rising oil prices are indicative of the reduced availability of an important input to production. Another explanation is that rising oil prices result in income transfers from oil-importing nations to oil-exporting nations which reduces U.S. aggregate demand and slows economic activity.

The remaining explanations sought to attribute the effects of oil price shocks to developments in the financial markets. One is simply that the monetary authorities responded to rising oil prices with a contractionary monetary policy that boosted interest rates. Another is that rising oil prices led to increased money demand as people sought to rebalance their portfolios toward liquidity. A failure of the monetary authority to meet growing money demand with an increased money supply boosted interest rates. In either case, rising interest rates retarded economic activity.

Sorting through the explanations that economists have offered for the inverse relationship between oil prices and economic activity requires a comparison between how

the economy has responded to oil price shocks historically, and how the various explanations would suggest the economy should respond. In the United States past episodes of rising oil prices have generally resulted in falling GDP, a higher price level, and higher interest rates (Table 1). As is shown below, of the various explanations that have been offered for why rising oil prices hurt economic activity, only the classic supply-side effect can account for falling GDP, a rising price level and higher interest rates.

Table 1
Expected Responses to Rising Oil Price

	Real GDP	Price Level	Interest Rate
Historical Record	**Down**	**Up**	**Up**
Classic Supply Shock	**Down**	**Up**	**Up**
Aggregate Demand Shock	**Down**	Down	Down
Monetary Shock	**Down**	Down	**Up**
Real Balance Effect	**Down**	Down	**Up**

A Classic Supply Shock

Many economists consider an oil price shock to be illustrative of a classic supply shock that reduces output. Elevated energy prices are a manifestation of increased scarcity of energy, which is a basic input to production. With reduced inputs with which to work, output and labor productivity are reduced. (In more mild cases, the growth of output and productivity are slowed.) In turn, the decline in productivity growth reduces real wage growth and increases the unemployment rate.

If consumers expect such a rise in oil prices to be temporary, or if they expect the near-term effects of output to be greater than the long-term effects, they will attempt to smooth their consumption by saving less or borrowing more. These actions boost the real interest rate. With reduced output and a higher real interest rate, the demand for real cash balances falls and the price level increases (for a given rate of growth in the monetary aggregate). Therefore, higher oil prices reduce real GDP, boost real interest rates and increase the price level (Table 1). The expected consequences of a classic supply shock are consistent with the historical record.

Income Transfers and Reduced Aggregate Demand

When oil prices rise, there is a shift in purchasing power from the oil-importing nations to the oil-exporting nations. Such a shift is another avenue through which oil price shocks could affect U.S. economic activity. Rising oil prices can be thought of as being similar to a tax that is collected from oil-importing nations by oil-exporting nations. The rise in oil prices reduces purchasing power and consumer demand in the oil-importing nations. At the same time, rising oil prices increases purchasing power and consumer demand in the oil-exporting nations. Historically, however, the increase in consumer demand occurring in oil exporting nations has been less than the reduction in consumer demand in the oil-importing nations. On net, world consumer demand for goods produced in the oil-importing nations is reduced.

Reduced consumer demand for goods produced in the oil importing nations increases the world supply of savings, which puts downward pressure on interest rates. Lower interest rates could stimulate investment, partially offsetting the lost consumption spending, and partially restoring aggregate demand. The net result, however, is a reduction in aggregate demand.

The reduction in aggregate demand puts downward pressure on the price level. Economic theory suggests that real prices will continue falling until aggregate demand and GDP are restored to pre-shock levels. If nominal prices are sticky downward, as most economists believe they are however, the process of adjustment will not take place, and aggregate demand and GDP will not be restored—unless unexpected inflation increases as much as GDP growth falls.

The reduction in aggregate demand necessitates a lower real price level to yield a new equilibrium. If the real price level cannot fall, consumption spending will fall by more than investment spending increases. Consequently, aggregate demand and output are reduced. With nominal prices downward sticky, the only mechanism through which the necessary reduction in real prices can occur is through unexpected inflation that is at least as great as the reduction in GDP growth. Domestically, the necessary change in inflation can be accomplished through a monetary policy that holds the growth of nominal GDP constant. A monetary policy that allows nominal GDP to fall will not generate enough unexpected inflation to restore aggregate demand and output.

To the extent that income transfers and reduced aggregate demand account for the aggregate effects of oil price shocks, monetary policy would have to allow nominal GDP to fall. The aggregate effects would be lower interest rates, reduced real GDP, and inflation that fell or increased by by less than the reduction in real GDP growth (Table 1). These effects are *in*consistent with the historical record for the United States, which shows that interest rates rise, real GDP falls, and the price level increases by as much as real GDP falls. Such a record seems to indicate that the effects of income transfers are negligible at best.

Monetary Policy

Monetary policy was prominent among the early explanations of how oil price shocks affected aggregate economic activity, but it was gradually supplanted by real business cycle theory, which attributed the effects to a classic supply shocks rather than monetary policy. Nevertheless, an apparent breakdown in the relationship between oil and the economy during the 1980s and 1990s led researchers to question the pure supply shock theory of real business cycle models and to revisit other channels through which oil could affect the economy, such as changes in monetary policy.

Nonetheless, monetary policy is a difficult way to explain the basic effects of oil price shocks on aggregate economic activity. Restrictive monetary policy will result in rising interest rates, reduced GDP growth, reduced inflation, and reduced nominal GDP growth (Table 1). That is *in*consistent with the historical record.

The Real Balance Effect

The real balance effect was one of the first explanations that economists offered for the aggregate economic effects of an oil price. Under this theory, an increase in oil prices led to increased money demand as people sought to rebalance their portfolios toward liquidity. The failure of the monetary authority to meet growing money demand with an increased money supply would boost interest rates and retard economic growth, just like a reduction in the money supply. Adjustment would put downward pressure on the price level. The effects would be higher interest rates, lower GDP, and a reduced price level, which is *in*consistent with the historical record (Table 1).

Sorting Through the Basic Theories

Of the explanations offered for the inverse relationship between oil price shocks and GDP growth, the classic supply-side shock argument best explains the historical record (Table 1). The classic supply shock explains the inverse relationship between oil prices and real GDP and the positive relationship between oil price shocks and measured increases in inflation and interest rates. Income transfers that reduce aggregate demand can explain reduced GDP, but cannot explain rising interest rates. Neither monetary policy or the real balance effect can explain both slowing GDP growth *and* increased inflationary pressure.

III. Amplification of the Basic Response

A number of economists have recognized that basic supply shock effects can account for only a portion of the intense effect that oil price shocks have on aggregate economic activity. Consequently, additional explanations for the intensity of the response are important. Among the possible explanations are restrictive monetary policy, adjustment costs, coordination externalities, and financial stress.

Monetary Policy

Monetary policy can shape how an oil price shock is experienced. When the monetary authorities hold the growth of nominal GDP constant, the inflation rate will accelerate at the same rate at which real GDP growth slows. To the extent that the market is slow to adjust to monetary surprises, a more accommodative monetary policy, which is accomplished by reducing interest rates, would temporarily offset or partially offset the losses in real GDP while it increased inflationary pressure. A counter-inflationary (restrictive) monetary policy, which is accomplished by increasing interest rates, would temporarily intensify the losses in real GDP while it reduced inflationary pressure.

In the case of counter-inflationary monetary policy, adjustment could be lengthy. If nominal wages and prices are sticky downward, real wages and prices would fail to fall as is necessary to clear the markets. Consequently, unemployment would rise, aggregate

consumption would fall, and GDP growth would be slowed beyond that which would arise directly from the supply shock.

If wages are nominally sticky downward, the reduction in GDP growth will lead to increased unemployment and a further reduction in GDP growth—unless unexpected inflation increases as much as GDP growth falls. The initial reduction in GDP growth is accompanied by a reduction in labor productivity. Unless real wages fall by as much as the reduction in labor productivity, firms will lay off workers, which will generate increased unemployment and exacerbate GDP losses. Therefore, if nominal wages are sticky downward, the only mechanism through which the necessary wage reduction can occur is through unexpected inflation that is at least as great as the reduction in GDP growth.

Several lines of research assert that restrictive monetary policy accounts for much of the decline in aggregate economic activity following an oil price increase. In two related pieces of research, Douglas Bohi (Resources for the Future) reasoned that energy-intensive industries should be most affected if a classic supply shock explains the principal effects of oil price shocks. Using industry data for four countries, Bohi found no relationship between the industries affected and their energy intensity. He also found inconsistent effects of oil price shocks across countries and time. Asserting that monetary policy was tightened in each of the countries he examined, Bohi concluded that much of the negative impact of higher oil prices on output must be restrictive monetary policy.

Similarly, Ben Bernanke, Mark Gertler and Mark Watson (Princeton, New York University, and Princeton, respectively) had an article published in the *Brookings Papers on Economic Activity* that shows the U.S. economy responds differently to an oil price shock when the federal funds rate is constrained to be constant than in the case in which it is unconstrained. In their unconstrained case, a sharp increase in oil prices leads to a higher federal funds rate and a reduction in real GDP. With the federal funds rate held constant, Bernanke, Gertler and Watson (hereafter BGW) find that an oil price increase leads to an increase in real GDP. Defining neutral monetary policy as holding the federal funds rate constant, BGW find that monetary policy has tightened in response to increased oil prices, and they conclude that this monetary tightening accounts for the fluctuations in aggregate economic activity.

Despite some findings to the contrary, other research casts doubt on the idea that monetary policy accounts for much of the response of aggregate economic activity to oil price shocks. In an article that is forthcoming in the *Journal of Money Credit and Banking*, James Hamilton and Ana Maria Herrera (University of California, San Diego and Michigan State University, respectively) show the BGW findings are sensitive to specification. Using a longer lag length, Hamilton and Herrera find oil price shocks have a substantially larger direct effect on the real economy. Furthermore, with the longer lag lengths, Hamilton and Herrera find that even when the federal funds rate is kept constant, an oil price shock still yields a sizable reduction in output, which implies that monetary policy has little effect in easing the real consequences of an oil price shock.

Hamilton and Herrera's findings are consistent with previous research conducted by others that shows counter-inflationary monetary policy was only partly responsible for the real effects of oil price shocks from 1970 to 1990. Some researchers agree that monetary policy has become more restrictive following an oil price shock, but conclude oil price shocks had a stronger and more significant impact on real activity than monetary policy.

Writing in the Federal Reserve Bank of Dallas' *Economic and Financial Review*, Stephen Brown and Mine Yücel go farther by arguing that U.S. monetary policy likely has had no role in aggravating the effects of past oil price shocks. Using a specification similar to BGW's, Brown and Yücel find that oil price shocks lead to an increased federal funds rate, reduced real GDP, and an increased price level. The increase in the price level is about the same as the reduction in real GDP, which means nominal GDP is unchanged. Such a finding conforms to Robert Gordon's definition of monetary neutrality, which is achieved when monetary policy is adjusted to hold nominal GDP constant.

Brown and Yücel also criticize the assertion that an unchanged federal funds rate *necessarily* represents a neutral monetary policy. They find that holding the federal funds rate constant (in a counterfactual experiment) after an oil price shock boosts real GDP, the price level, and nominal GDP, which is consistent with Gordon's definition of accommodative monetary policy. In short, monetary policy can cushion the real effects of an oil price shock, but at the expense of accelerating inflation.

The use of the fed-funds rate to gauge the stance monetary policy can be faulty when the economy is adjusting to a supply shock. As explained above, the attempt by consumers to smooth consumption in response to a basic supply shock accounts for the higher interest rates. In a market with rising interest rates, a policy of holding the fed-funds rate constant will accelerate money growth, contributing to short term gains in real GDP and increased inflationary pressure.

In summation, oil price shocks create the potential for a monetary policy response that exacerbates the basic effects of an oil supply shock. The research assessing whether monetary policy has amplified the basic effects of a supply shock is contradictory, but the most compelling evidence suggests monetary policy has had a relatively small or no role in amplifying the basic effects in the United States. Furthermore, interest rates are not a good way to assess the stance of monetary policy when there is a supply shock, and measured in other ways, monetary policy has remained neutral in response to past oil price shocks.

Adjustment Costs

Adjustment costs are another way in which the basic response to rising oil prices might be amplified. Adjustment costs could arise from either captial stock that embodies energy technology or sectoral imbalances. In either case, adjustment costs could further retard economic activity.

To a great extent, the technology a firm chooses for its production is embedded in the capital equipment it purchases. (Economists refer to this characteristic of technology and capital as "putty-clay" because the firm can vary its energy-to-output, capital-to-output, and labor-to-output ratios over the long run as it purchases capital, but not in the short run.) With production technology embedded in the capital stock, a firm must change its capital stock to respond to rising energy prices. The consequence is slow adjustment and a disruption to economic organization when energy prices rise, with stronger effects in the near term than the long term.

In a similar way, changes in oil prices could also create sectoral imbalances by changing the equilibrium relationship between the sectors. For example, rising oil prices would require a contraction of energy-intensive sectors and an expansion of the energy-efficient sectors. These realignments in production require adjustments that cannot be achieved quickly. The result is increased unemployment and the underutilization of resources.

Coordination Problems

Coordination problems are a potential outgrowth of sectoral imbalances. Coordination problems arise when individual firms understands how changing oil prices affect their own output and pricing decisions, but lack enough information about how other firms will respond to changes in oil prices. As a consequence, firms experience difficulty adjusting to each other's actions and economic activity is further disrupted when oil prices rise.

Uncertainty and Financial Stress

Uncertainty about future oil prices increases when oil prices are volatile, and such uncertainty reduces investment. When firms are uncertain about future oil prices, they will find it increasingly desirable to postpone irreversible investment decisions. When technology is embedded in the capital, the firm must irreversibly choose the energy-intensity of its production process when purchasing its capital. As uncertainty about future oil prices increases, the value of postponing the investment decision increases, and the net incentive to invest decreases. In addition, uncertainty about how firms might fare in an environment of higher energy prices is likely to reduce investor confidence and increase the interest rates that firms must pay for capital. Together, these two effects work to reduce investment spending and weaken economic activity.

Sorting through the explanations

The currently available research has not reached a consensus about why the effects of rising oil prices are so strong. The most recent research casts doubt on the idea that monetary policy is the primary factor amplifying the aggregate economic effects of oil price shocks. No empirical research has attempted to sort through the other effects—adjustment costs, coordination problems, and financial stress. In fact, these effects are

consistent with observed facts and are mutually reinforcing, rather than mutually exclusive. All three effects may be at work.

IV. The Asymmetry of the Response

Prior to the 1980s, the large shocks in oil prices were increases. The 1980s brought the first big decrease in oil prices, and it gradually became evident that U.S. economic activity responded asymmetrically to oil price shocks. That is, rising oil prices hurt U.S. economic activity by more than falling oil prices helped it. Although all but one of the post-World-War-II recessions followed sharp rises in oil prices, accelerated economic activity did not follow the sharp price declines of the 1980s and 1990s.

The Discovery of Asymmetry

Initially, the weak response of economic activity to oil price decreases was seen as a breakdown in the relationship between oil price movements and the economy, and researchers began to examine different oil-price specifications in their empirical work to reestablish the relationship between oil price shocks and economic activity. In research published in *The Energy Journal*, Knut Mork found that when he separated oil price changes into negative and positive oil price changes, oil price increases had more effect on economic activity than oil price decreases. Later research conducted by others found that oil price increases had a significant effect on economic activity while oil prices decreases did not. Similar asymmetry was also found at a more detailed industry level, and further research established that economic activity in seven industrialized countries responded asymmetrically to oil price movements.

Writing for the *Journal of Monetary Economics*, James Hamilton (University of California, San Diego) further refined the analysis by creating what he called a "net oil price." This measure of oil prices attempts to capture episodes of oil price increases that are outside normal market fluctuations. This measure reflects only those increases in oil prices that take the price higher than it has been in the past 12 months. (Technically, the net oil price series is the price of oil for all periods in which the price of oil is higher than it has been during the past 12 months, and zero in all other months.) Hamilton's own research and subsequent research by others find a statistically significant and stable negative relationship between the net oil price series and output, while various series constructed to reflect episodes of sharp oil price declines do not seem to have any explanatory power. In a related vein, Steven Davis (University of Chicago) and John Haltiwanger (University of Maryland) constructed an oil price series that combined asymmetry with persistence and also found an asymmetric relationship between oil price shocks and economic activity.

Understanding Asymmetry

Classic supply-side effects cannot explain asymmetry. Operating through supply-side effects, reductions in oil prices should help output and productivity as increases in

oil prices hurt economic output and productivity. Accordingly, economists have begun to explore the channels through which oil prices affect economic activity. Monetary policy, adjustment costs, coordination problems, uncertainty and financial stress, and asymmetry in the petroleum product markets have been offered as explanations. Of these explanations, adjustment costs, coordination problems and financial stress seem the most consistent with the historical record.

Monetary Policy and Asymmetry

Monetary policy could contribute to an asymmetric response in aggregate economic activity to oil price shocks in two different ways. Monetary policy itself could respond to oil price shocks asymmetrically. Another possibility is that nominal wages are sticky downward but not upward, and monetary policy is conducted in such a way that nominal GDP falls when oil prices are rising and nominal GDP rises when oil prices are falling.

When oil prices rise, real wages must fall to clear markets and restore equilibrium. If real wages do not fall, the economic displacement will be greater. When oil prices fall, real wages must rise to clear markets and restore equilibrium. If real wages do not rise, the gains in economic activity will be greater.

If nominal wages are sticky downward, an increase in unexpected inflation that is at least as great as the decline in real GDP is necessary to yield the necessary reduction in real wages. If the monetary authority maintains a neutral monetary policy, nominal GDP is unchanged, prices will rise as much as real GDP falls, and real wages will adjust sufficiently. If the monetary authority conducts policy such that nominal GDP falls, however, prices will rise by less than real GDP falls, and because nominal wages are sticky downward, real wages will not adjust by enough to restore equilibrium.

Because nominal wages can adjust upward freely, however, unexpected disinflation is not required for adjustments in real wages to occur, and the conduct of monetary policy is not as important. If the monetary authority conducts policy such that nominal GDP rises, prices will rise by more than real GDP falls, but because nominal wages adjust freely upward, real wages will rise enough to restore equilibrium. Consequently, a monetary policy that results in nominal GDP rising in response to lower oil prices will not be as stimulative as a policy that results in nominal GDP falling in response to higher oil prices will be contractionary.

John Tatom (Federal Reserve Bank of St. Louis) provided some early evidence that monetary policy responded asymmetrically to oil price shocks by showing that the economy responded symmetrically to oil price shocks if the stance of monetary policy is taken into account. In a later contribution, Peter Ferderer (Clark University) showed that monetary policy cannot account for the asymmetry in the response of real activity to oil price shocks in his model. More recently, Nathan Balke, Stephen Brown and Mine Yücel (Federal Reserve Bank of Dallas) found that the Federal Reserve's response to oil price shocks does not cause asymmetry in real economic activity. In their model, the

asymmetry does not go away—and is in fact is enhanced—when monetary policy (as measured by either the fed funds rate or the fed funds rate plus expectations of the fed funds rate) is held constant.

Adjustment Costs and Coordination Problems

James Hamilton (University of California, San Diego) contributed the idea that adjustment costs could lead to an asymmetric response to changing oil prices. Rising oil prices would retard economic activity directly, and falling oil prices would stimulate economic activity directly. The costs of adjusting to changing oil prices retard economic activity whether oil prices are rising or falling. Consequently, rising oil prices result in two negative effects on economic activity that reinforce each other. In the other direction, falling oil prices result in both positive and negative effects, which tend to be offsetting.

As described above, these adjustment costs can be the result of the energy-to-output ratio being embedded in the capital or the result of sectoral imbalances. Coordination problems could reinforce adjustment costs whether oil prices are rising or falling.

Uncertainty and Financial Stress

Uncertainty and financial stress also could contribute to an asymmetric response in aggregate economic activity to oil price shocks. As explained by Peter Ferderer (Clark University), uncertainty about future oil prices is reflected in increased interest rates and reduced investment demand, which adversely affects aggregate economic activity. In addition if the energy-to-output ratio is embedded in the capital stock, firms will find it increasingly desirable to postpone irreversible investment decisions until they are more certain about future oil prices.

Volatile oil prices contribute to oil price uncertainty and weaker economic activity whether oil prices are rising or falling. As is the case for adjustment costs, therefore, uncertainty and financial stress augment the basic supply-side effect when oil prices are rising, and offset the basic supply side effect when oil prices are falling. The result is that aggregate economic activity responds to oil price shocks asymmetrically.

Asymmetry in Petroleum Product Prices

Petroleum product prices are another avenue through which the economy may respond asymmetrically to fluctuation in crude oil prices. A considerable body of research shows that petroleum product prices themselves respond asymmetrically to fluctuations in oil prices, and most of the price volatility originates in crude oil prices rather than product prices. It is a relatively short leap to suggest that asymmetry in the response of product prices could account for the asymmetry between crude oil prices and aggregate economic activity.

Hillard Huntington (Stanford University) has found the economy responds symmetrically to changes in petroleum product prices, but that petroleum product prices respond asymmetrically to crude oil prices. The consequence is an asymmetric relationship between crude oil prices and aggregate economic activity. These findings need further examination, but substantial research shows the asymmetric response of aggregate economic activity to oil price shocks arises through channels that cannot be explained by the asymmetric response of product prices alone.

Sorting through the Explanations of Asymmetry

Although asymmetry is now fairly well accepted, relatively few studies have attempted to distinguish empirically through what channels oil price shocks might yield an asymmetric response in aggregate economic activity. The available research seems to rule out the likelihood that asymmetry is the result of monetary policy, but the findings are consistent with explanations of asymmetry that rely on adjustment costs, coordination problems, or uncertainty and financial risk.

In empirical work published in the *Review of Economics and Statistics*, Prakash Loungani (World Bank) found that oil price shocks lead to a reallocation of labor across sectors, which increases the unemployment rate, whether oil prices are rising or falling. These sectoral shifts are consistent with adjustment costs and coordination problems, but they do not preclude uncertainty and financial risk.

Research by Steven Davis and John Haltiwanger (University of Chicago and University of Maryland, respectively) assesses the channels through which oil price shocks affect economic activity. Looking at job destruction and creation in firm level data they find that allocative channels (such as, changes in the desired distributions of labor and capital) contribute to the asymmetric response of aggregate economic activity to oil price shocks. Again, sectoral shifts are consistent with adjustment costs and coordination problems, but they do not preclude uncertainty and financial risk. In addition, Davis and Haltiwanger show that the allocative effects are relatively strong, and reinforce the basic supply side effect when oil prices are rising and cancel the basic supply side effect when prices are falling.

In research recently published in *The Energy Journal*, Nathan Balke, Stephen Brown and Mine Yücel (Federal Reserve Bank of Dallas) found that monetary policy responds asymmetrically because the economy has responded asymmetrically to oil price shocks and that monetary policy cannot account for the asymmetry. They also found that output and interest rates respond asymmetrically to oil price shocks—with the shocks transmitted through asymmetric movements in market interest rates. Such interest rate movements are consistent with several explanations for asymmetry. Asymmetric movements in the interest rates may be indicative of the increased uncertainty and financial risk that result from oil price shocks. Alternatively, movements in market interest rates may be a reflection of expectations that oil price shocks will necessitate costly adjustments in the future.

V. A Weakening Relationship

By the mid-1990s, the quantitative relationship between oil prices and economic activity seemed fairly robust and reasonably well understood—even if the exact channels through which the effects operated were not known with certainty. During the latter half of the 1990s, however, the relationship seemed to weaken. In the late 1990s and early 2000s, rising in oil prices had less effect on economic activity than previous research suggest might have been expected.

Rising oil prices led increases in the unemployment rate from the early 1970s through the early 1990s, and unemployment fell with oil prices from 1982 through 1990 and in the late 1990s (Figure 2). Nonetheless, the relationship began weakening in the late 1990s. Although oil prices were relatively strong, the unemployment rate continued to fall. One explanation is that high world oil prices were a result of a strong world economy, and strong demand rather than a supply shock accounted for rising oil prices.

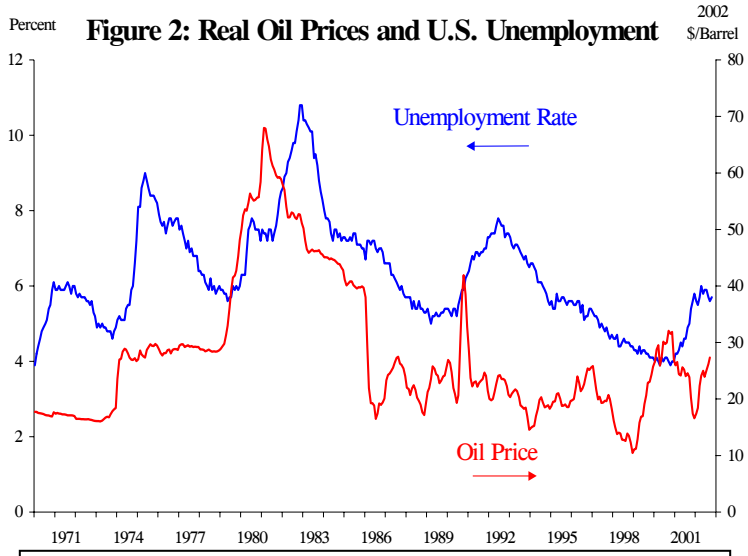


Figure 2: Real Oil Prices and U.S. Unemployment

Unemployment fell with oil prices from 1982 through 1990 and in the late 1990s, but the relationship weakened in the late 1990s.

The data also show a weaker relationship between rising oil prices and core inflation in the late 1990s (Figure 3). Mark Hooker (Federal Reserve System, Board of Governors) reevaluated the oil price-inflation relationship and found that since about 1980, oil price changes did not seem to affect core measures of inflation. Prior to 1980, however, oil price shocks contributed substantially to core inflation in the United States. One possibility is that U.S. monetary policy in the Volcker and Greenspan eras was significantly less accommodative to oil price shocks than it had been with under their predecessors, and so monetary policy no longer contributed to high inflation.

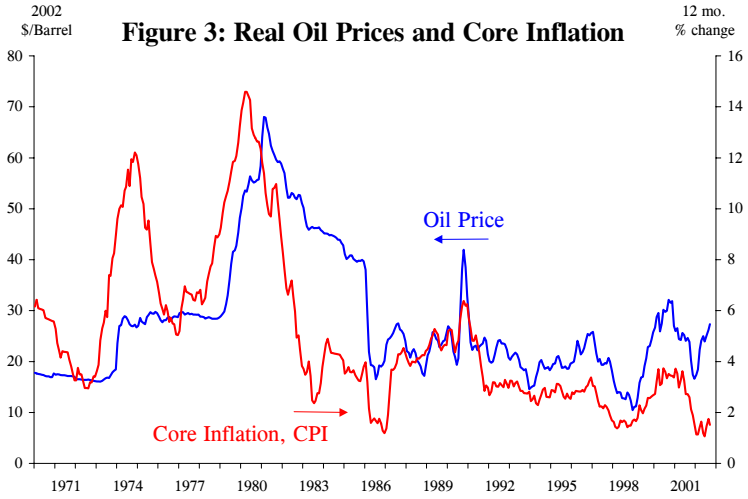


Figure 3: Real Oil Prices and Core Inflation

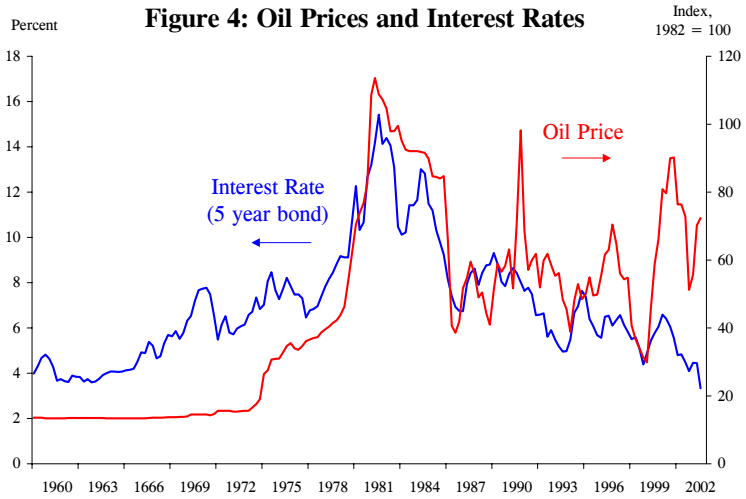
Prior to 1980, real oil prices and core inflation were more closely related.

Nonetheless, the relationship between oil prices and interest rates was relatively unchanged through the 1990s. Rising oil prices led to higher interest rates, which is the

expected consequence of supply shocks that have greater near-term effects than long-term effects (Figure 4). Stephen Brown and Mine Yücel (Federal Reserve Bank of Dallas) show that some of the increases in the U.S. federal funds rate that occurred in 1999 and 2000 may have been part of a general increase in market interest rates that resulted from higher oil prices.

Since about mid-2000, however, interest rates have not risen with oil prices. This changing relationship may be further evidence of an economy that is becoming less sensitive to oil price shocks.

Figure 4: Oil Prices and Interest Rates

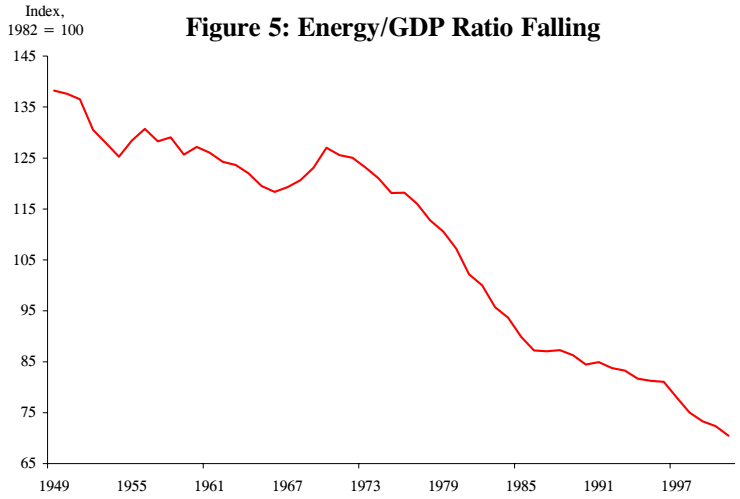


Oil prices and U.S. interest rates moved closely together until mid-2000.

Factors Contributing to a Weakening Relationship

Several factors likely have contributed to a weakening relationship between oil prices and economic activity over the past three decades. Among the possibilities are a reduced energy-to-GDP ratio, the fact that oil price increases were the result of increased demand rather than oil supply shocks, and prior experience with oil price shocks. In addition, the 1990s boom was marked by strong productivity gains that may have simply obscured the relationship between oil prices and aggregate economic activity.

Figure 5: Energy/GDP Ratio Falling



The U.S. energy-to-GDP ratio has declined since the end of World War II. Higher energy prices contributed to strong reductions in the energy-to-GDP ratio from the mid-1970s

A Reduced Energy-to-GDP Ratio

Although it represents a continuing trend, the energy-consumption-to-GDP ratio declined from the 1970s through the early 2000s (Figure 5). On the basis of this decline, Brown and Yücel estimate that the U.S. economy could have been about one-third less sensitive to oil price fluctuations in 2000 than it was in the early 1980s, and about one-half as sensitive as it was in the early 1970s.

Increased Demand Rather than a Supply Shock

Another factor that could have contributed to a weakening relationship between oil prices and economic activity was the fact that rising oil prices in the late 1990s were

largely the result of economic expansion. Price increases that are the result of increased demand increases rather than supply shocks may be less disruptive to economic activity.

As the result of increased energy efficiency, U.S. oil consumption only grew moderately during the 1990s, but oil consumption in the industrialized nations grew steadily during the 1990s (Figure 6). World oil consumption was further boosted by the dramatic gains in oil consumption outside the OECD, with the strongest gains in consumption occurring in the newly industrializing Asian countries such as China and Korea.

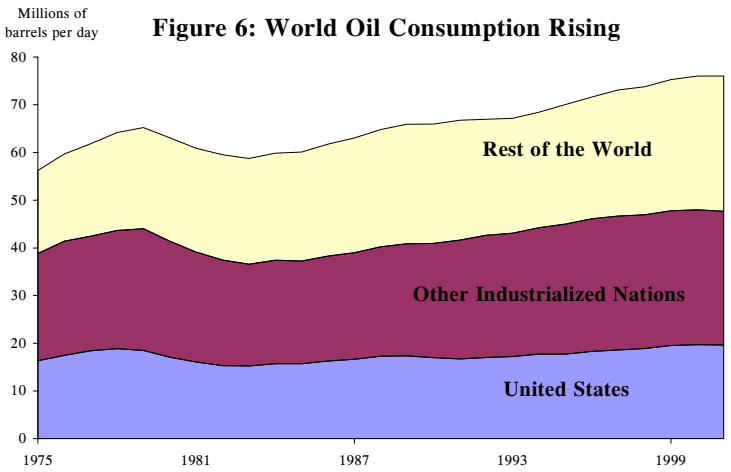


Figure 6: World Oil Consumption Rising

U.S. oil consumption rose moderately in the 1990s. Oil consumption in the industrialized countries combined rose steadily through the 1990s. The biggest gains in oil consumption occurred in the newly industrializing

In addition, world capacity to produce oil did not keep pace with growing consumption throughout much of the 1990s. Consequently, the gap between OPEC capacity and production was relatively small throughout most of the 1990s (Figure 7). With demand growing faster than supply, oil prices increased in the latter part of the decade—though the real increase was relatively small by 1980s standards (Figure 8, next page). In 2000, world oil demand rose sharply (Figure 9, next page), which led to greater consumption and a jump in prices. Because the rise in oil prices was the result of strong demand from economic expansion, the usual decline in economic activity did not follow.

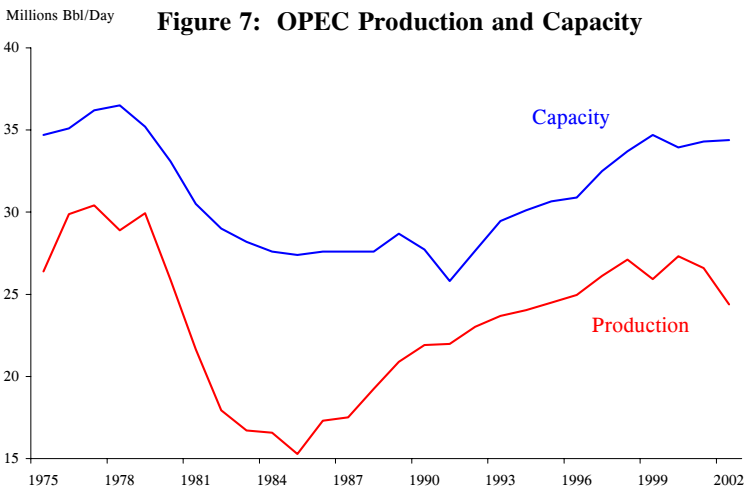


Figure 7: OPEC Production and Capacity

OPEC operated fairly close to full capacity in the 1990s.

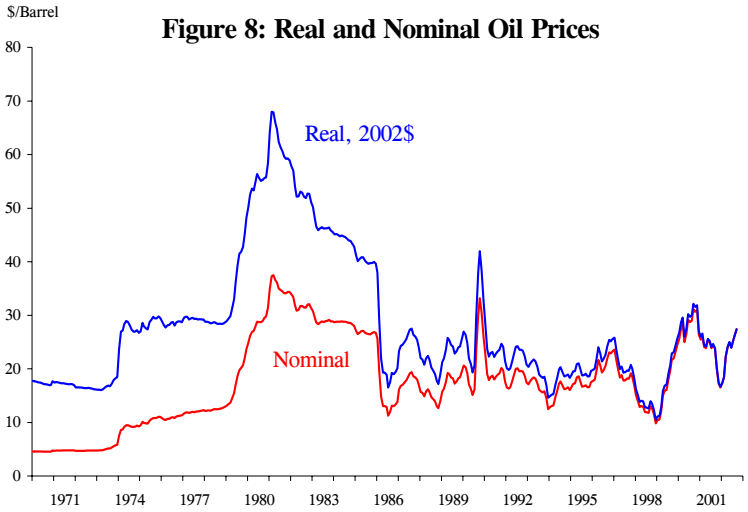
Prior Experience with Energy Price Shocks

Prior experience with oil-price shocks may also have contributed to the muted response of U.S. economic activity to oil price shocks. Such experience may have reduced adjustment costs, coordination problems, and uncertainty and financial stress. In addition, monetary authorities have increased experience with oil price shocks, which may have reduced the inflationary pressure resulting from oil price shocks.

VI. Conclusions and Implications for Policy

Economic research provides considerable evidence that rising oil prices contribute to real GDP losses. Economic theory suggests a number of channels could account for this phenomenon. The most basic is a classic supply-side effect in which rising oil prices are indicative of the reduced availability of a basic input to production. Other channels include reduced aggregate demand and contractionary monetary policy. Of these channels, the empirical evidence is most consistent with a classic supply-side effect. This effect best explains reduced aggregate output, an increased price level and higher interest rates.

Figure 8: Real and Nominal Oil Prices

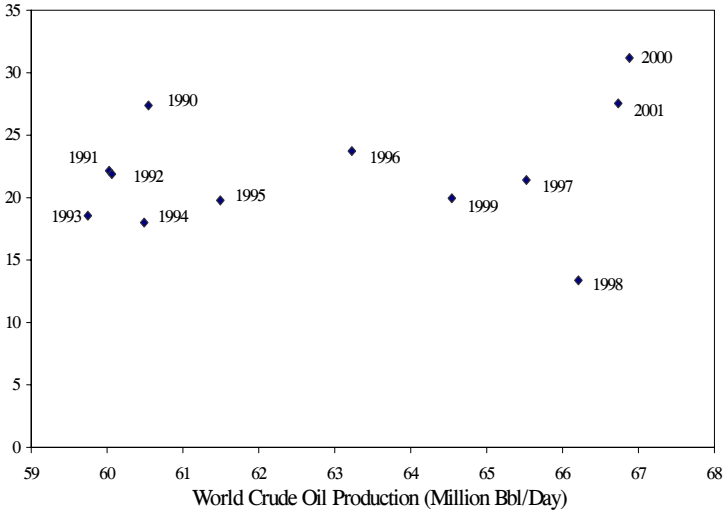


The real oil price shows that the oil price gains in 2000 were moderate by historical standards.

Given the current understanding of the way oil price shocks affect economic activity, analysts are relatively well positioned to prescribe the proper fiscal and monetary policy responses to oil price shocks. Given that rising oil prices reduces potential GDP and the reductions in aggregate demand are likely to be negligible, a fiscal policy response seems unnecessary. As far as monetary policy is concerned, a neutral response to rising oil prices, which consists of holding nominal GDP constant, will neither aggravate the GDP losses nor offset them. Such a policy will also lead to an increase in the price level that is the same as the loss in real GDP.

Beyond taking a neutral stance, monetary policy can shape the aggregate effects of an oil price shock. If the monetary authority is willing to accept higher inflation, it can temporarily boost real GDP through an expansionary policy. If the monetary authority wants to lessen the inflationary consequences of rising oil prices, it can tighten policy, which will temporarily aggravate the losses in real GDP.

Figure 9: Oil Demand Rose Sharply in 2000



The plotted points show the market-clearing prices and quantities of oil, 1991-2001. Increases in quantity and price are indicative of increased demand.

Economists have variously suggested that monetary policy, adjustment costs, coordination problems, and increased uncertainty and financial stress account for an

amplification of the basic supply-side effect when oil prices are rising and a lessening of the aggregate response when oil prices are falling. Although recent research seems to show that the conduct of U.S. monetary policy has not resulted in such effects, monetary policy *could* have such effects, and the issue is not completely resolved. Researchers have provided evidence that adjustment costs, coordination problems, or increased uncertainty and financial stress amplify basic supply-side effects when oil prices are rising. They have not been able to reliably distinguish between these effects.

Because economic research has not been able to distinguish between the contributions of adjustment costs, coordination problems, and uncertainty and financial stress, analysts are less able to prescribe the best course of action for energy policy. In particular, research has not yet determined whether the private sector is capable of providing the optimal level of insurance against price shocks. Given the possibility of coordination problems across industries and the asymmetric response of aggregate economic activity to oil price shocks, an energy policy that leans against movements in international oil prices would seem justified. Nonetheless, considerably more research needs to be conducted before economists can provide sound guidance as to how far policymakers should go to reduce an economy's vulnerability to oil price shocks.

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Glossary of Terms:

Aggregate Channels – changes in economic activity that work through changes in aggregate supply or demand.
Aggregate Economic Activity – the sum total of economic activity in a country, which is commonly measured by gross domestic product (GDP).
Allocative Channels – changes in economic activity that work through changes in the composition of output.
Asymmetry – a process in which aggregate economic activity is reduced by more by an oil price increase than it is increased by an oil price decrease.
Business Cycles – fluctuations in aggregate economic activity.
Consumption Smoothing – the process of adjusting consumption spending to lifetime income by holding consumption relatively constant when there are short-term fluctuations in income.
Core Inflation – a measure of inflation that is thought to provide a better signal of underlying inflationary pressure because it excludes food and energy prices, which are quite volatile.
Federal Funds Rate – The interest rate at which commercial banks borrow from each other reserves that are on deposit with the Federal Reserve System.
Net Oil Price – an oil price series that captures no price decreases and only those increases that take the price of oil higher than it has been during the past year.
Neutral Monetary Policy – is the conduct of monetary policy in such a way that it has no effect on economic activity. According to Robert Gordon of Northwestern University, a neutral monetary policy leaves nominal GDP unchanged. According to Milton Friedman, who is retired from the University of Chicago, a neutral monetary policy requires that the money supply be unchanged. Many other economists regard a constant federal funds rate as neutral monetary policy. In the absence of aggregate supply shocks, all three definitions of neutrality are consistent with each other. Aggregate supply shocks can cause a divergence between these three measures of monetary neutrality.
Oil Price Shock – a sharp change in the price of oil.
Putty-Clay Technology – is technology in which the energy-to-output, capital-to-output, and labor-to-output ratios can be varied over the long run as capital is purchased and installed but cannot be changed in the short run because they are embedded in the capital stock.
Real Interest Rate – the market interest rate minus expected inflation.
Sticky Wages and Prices – the inability of market forces to change wages and prices. This stickiness usually occurs when market forces would reduce nominal wages and prices.