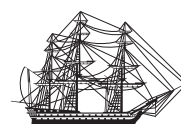


Oil, the Economy, and the Stock Market

Vanguard Investment Counseling & Research



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Executive summary. In the past, sharp rises in oil prices have coincided with bear equity markets, sparked higher inflation and government bond yields, and presaged economic recessions. Recently, as oil prices have leapt past \$100 a barrel, some analysts warn of a prolonged period of “stagflation,” or persistent inflation coupled with high unemployment rates. Other analysts are more sanguine, arguing that demand-driven oil-price shocks are less relevant for modern economies that have become less energy-intensive.

This paper addresses several related questions. First, what impact does a given oil-price shock have on economic growth, and have those effects changed over time? How should monetary policy respond to oil-price shocks, now and in the future? How has the stock market—across countries and sectors—reacted to changes in oil prices? Does this response vary depending upon the direction or source of oil-price movements? Finally, do fundamentals explain the rapid rise in oil prices to more than \$100 a barrel? We focus our analysis on the U.S. economy and financial markets, although our results are also applicable to the U.K. and broader European economies.

We find that the negative short-run impacts of oil-price shocks on U.S. economic growth since the early 1980s are similar to those in earlier decades. Indeed, oil-price shocks can still induce a U.S. recession, given the inherent lag between a change in monetary policy and its impact on real growth.

However, the negative “second-round” real GDP effects of oil-price shocks witnessed during the 1970s have been notably absent over the past 25 years. Our empirical analysis attributes this phenomenon primarily to the more

Authors¹

Joseph H. Davis, Ph.D.
Roger Aliaga-Díaz, Ph.D.

¹ We thank Clement Ogbomo for excellent research assistance.

-muted response of long-term inflation expectations and long-term interest rates to oil-price movements. This change enhances the present-day Federal Reserve Board's flexibility in addressing oil-price shocks that, in the past, presented a difficult policy trade-off with respect to stagflation.

Our simulations indicate that today it would be appropriate for the Federal Reserve to *lower* short-term interest rates in response to an oil-price shock, *as long as long-term inflation expectations do not rise from their desired level*. We provide rules-of-thumb for determining the proper change in the Federal funds rate for a given oil-price shock under alternative macroeconomic scenarios.

We find that global stock markets have responded fairly symmetrically and inversely to changes in oil prices since the 1970s, with a 10% increase in oil prices associated with a statistically significant 1.5% lower total return. However, when we decompose movements in oil prices, we find that the stock market's reaction to oil-price increases varies dramatically, depending on the source of the oil-price shock. Specifically, the stock market—particularly in the U.S. industrials and materials sectors—responds quite favorably to oil-price increases attributed to global-demand shocks. A key implication

of these stock regressions is that oil-price increases do not uniformly lead to lower stock returns.

Interestingly, our oil-price decomposition suggests that the recent surge cannot be fully explained by oil-supply disruptions, global-demand fundamentals, or the decline in the value of the U.S. dollar.

Do higher oil prices matter?

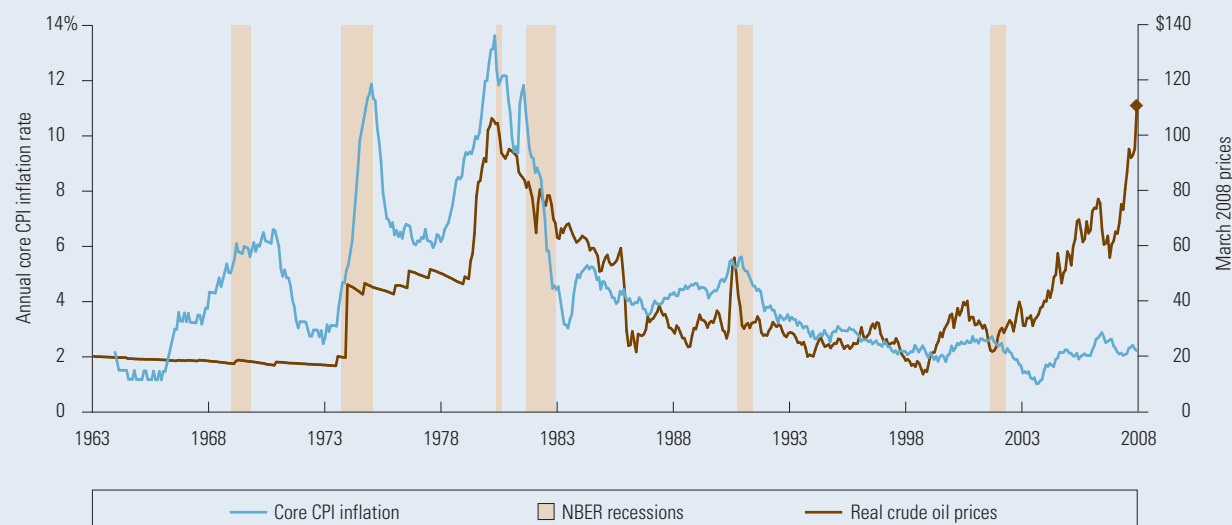
Throughout the 1990s, crude oil prices in the United States averaged roughly \$20 a barrel, with highs of \$35 a barrel set during the 1990–1991 Persian Gulf War and lows of approximately \$11 a barrel reached after the 1998 emerging-market crises.² Since that time, petroleum prices have skyrocketed to once-unimaginable levels. In early 2008, oil prices topped \$110 a barrel, breaking the inflation-adjusted highs established in April 1980 (see **Figure 1**). As oil spot prices have risen, so too has the futures market's perception of oil's long-run or "fair" value.

In the past, dramatic oil-price increases have often been caused by oil-supply disruptions centered in the Middle East. Notable oil-supply shocks include the 1956 Suez Crisis, the 1973 Arab–Israel War, the beginning of the Iranian Revolution in 1978, the onset of the Iran–Iraq War in 1980, and the 1990 Persian Gulf War. Today, some analysts point out that the dramatic rise in oil prices from \$20 a barrel in 2001 to more than \$100 in 2008 is primarily the result of the world's first global-demand shock. Throughout

Notes on risk: Investments are subject to market risk. Investments in bonds are subject to interest rate, inflation, and credit risk. Foreign investing involves additional risks including currency fluctuations and political uncertainty. Sector investments are subject to sector risks and nondiversification risks, which may result in performance fluctuations that are more extreme than fluctuations in the overall stock market.

² Throughout this paper, oil prices are measured using West Texas Intermediate (WTI) crude oil spot prices. For various reasons, WTI prices can differ at times from other crude oil prices, including spot prices for Arab Light Crude and Brent Crude.

Figure 1. Oil prices, recessions, and inflation trends in the United States, 1963–2008



Notes: WTI spot oil prices (in dollars per barrel) are expressed in March 2008 WTI prices and deflated by the core CPI, which excludes food and energy prices. Monthly WTI figures correspond to the highest daily price within each month. Shaded areas represent NBER (National Bureau of Economic Research) recessions.

Sources: Federal Reserve Bank of St. Louis, National Bureau of Economic Research, U.S. Bureau of Labor Statistics, and Vanguard.

this decade, the global economy has expanded robustly, and commodity demand has surged. As illustrated in **Table 1**, the emerging-market economies of China and India have more than doubled their combined share of world oil consumption since 1990, and have accounted for more than one-third of consumption growth since 2000.³ Many experts anticipate that China's demand for oil will double again in the next two decades.

In the past, sharp rises in oil prices have sparked higher inflation, as shown in Figure 1. More recently, as oil prices rapidly surpassed \$100 a barrel, some analysts have warned of a prolonged period of U.S. stagflation, with the economy's inflation and unemployment rates rising in tandem.

Table 1. Global demand for oil

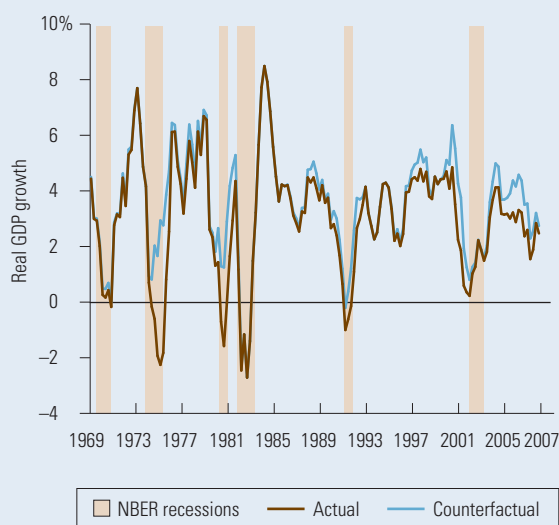
	Share of world consumption (%)				Contribution to world consumption growth (%) 2000–2006
	1980	1990	2000	2006	
Europe	25.4	22.0	20.7	19.3	6.3
United States	27.0	25.5	25.7	24.4	12.0
Japan	7.9	8.0	7.2	6.1	–4.1
China and India	3.8	5.2	9.0	11.6	35.9

Note: Percentages do not total 100% because other regions of the world have been omitted for clarity.

Source: Vanguard calculations from data provided by the Energy Information Agency (EIA).

3 Together, China's and India's total oil consumption grew 42.4% between 2000 and 2006, compared with 5.0% for the United States and 3.2% for Europe.

Figure 2. Rewriting history—a hypothetical world without oil shocks



Notes: Lines reflect year-over-year growth in real U.S. GDP. The counterfactual real U.S. GDP growth estimates are based on a linear regression model of annualized real GDP growth on its own four quarterly lags and four lags of oil-price shocks, as defined by Hamilton (2003). Shaded areas correspond to actual U.S. recession dates, as defined by the NBER.

Source: Authors' calculations.

Economists have long observed that oil-price shocks tend to precede U.S. recessions, as consumer discretionary spending declines and future investment plans are postponed.⁴ To demonstrate the powerful effect that oil-price shocks can have on the business cycle, **Figure 2** compares the year-over-year growth in actual U.S. real GDP with what it would have been under the counterfactual case of no oil-price increases.

According to this econometric exercise, the U.S. economy would have avoided five out of the past six recessions if oil prices had remained unchanged.⁵ In this hypothetical world, the mild 1990 and 2001 recessions would not have been recessions at all, but rather periods of below-trend growth.⁶ Figure 2 supports the work of Hamilton (1996, 2003) and others, who argue that spikes in oil prices are *the* primary cause of every U.S. recession since World War II. The results in Figure 2 would suggest to some that the recent marked rise in energy prices portends a prolonged period of economic weakness.

Of course, other analysts are more sanguine, arguing that oil-price shocks are less relevant for modern economies that have become less energy-intensive and even stagflation-proof. Many industrialized countries now use less energy per unit of output, thanks to technological advances, a more service-oriented economy, and improved living standards.

The U.S. economy—the world's largest consumer of oil—is 40% less oil-intensive per unit of output than it was in 1980. While petroleum remains a prominent input for the transportation industry, other sectors have become less oil-dependent since the 1970s. A good example is the electric utility industry. According to a 2004 report by the Energy Information Administration (EIA), today oil accounts for less than 2% of electric utility generation in the United States, compared with approximately 17% in the early 1980s. During that period, living standards and real wages increased for many U.S. households. Today American consumers dedicate approximately 6% of their personal expenditures to energy goods and services, down from a high of more than 9% in the early 1980s, but up from its nadir of 4% in 1999.

So, how concerned are the U.S. economy and the stock market about high oil prices?

4 Analysts estimate that every \$1-per-barrel increase in the price of crude oil translates into a rise of 3 cents per gallon of retail gasoline.

5 For our counterfactual GDP growth estimates, we use the unofficial (albeit popular) definition of recessions as two consecutive quarters of negative real GDP growth. It could also be argued that in this counterfactual world, the U.S. economy would have avoided the pernicious 1981–1982 recession. At that time, the Federal Reserve raised short-term interest rates sharply to rein in high and rising inflation expectations that many contemporary observers attributed to high energy prices.

6 Figure 1 also reveals that the long-running U.S. economic boom from 2002 through 2007 would have been even stronger without higher oil prices. In the counterfactual case, real GDP growth between 2002 and 2007 would have been 3.27% per annum, rather than 2.65% per year. This estimated “deadweight loss” in U.S. GDP is equivalent to the annual national output of Sweden or the annual output of the state of North Carolina.

We address this question on a number of fronts. In Section II, we model the impact of a given oil-price shock on economic growth and inflation, and explain why oil's macroeconomic impact has changed over time. We then show how the Federal Reserve has reacted to past oil-price shocks, and demonstrate how it might react in the future. In Section III, we investigate whether supply-and-demand fundamentals fully explain the rapid rise in oil prices, and consider whether more speculative forces have been at work in driving up oil prices. Finally, we examine the reaction of the stock market—across countries and sectors—to changes in oil prices and discuss why the stock market's correlation with oil prices depends critically upon the source of oil-price movements.

Oil-price shocks and the U.S. economy

We quantify how oil prices affect the U.S. economy by estimating a small-scale vector autoregressive (VAR) econometric model. Our VAR model is estimated using quarterly data with two-quarter lags on four variables: (1) annualized real GDP growth; (2) the annual inflation rate on the core Consumer Price Index (CPI), which excludes food and energy prices and is considered an effective measure of inflation expectations;⁷ (3) the real federal funds rate, which is deflated by our core inflation series; and (4) a nonlinear measure of oil-price shocks.

Following Hamilton (1996) and others, our oil-price shock series is equal to the percentage change between the current WTI oil price and the maximum price over the past 12 months or zero, whichever is greater.⁸ In this approach, each oil-price shock is modeled as a “deadweight loss” that affects the economy asymmetrically; that is, the effects of a given oil-price increase are greater than those of a similar-sized oil-price decrease. Our VAR model extends previous research by Bernanke et al. (1997), Hooker (2002), and Kilian (2006).

We estimate the VAR model for two sample periods: 1959:1–1982:4 and 1983:1–2007:4. We allow for potentially different oil-price impacts between the two sample periods, given the documented structural break in macroeconomic volatility and monetary-policy regimes before and after the early 1980s (McConnell and Perez-Quiros, 2000; Davis, 2007).

Figure 3, on page 6, presents the estimated effect of a 10% oil-price shock on the subsequent ten quarters of real U.S. growth, inflation expectations, and the real federal funds rate. The lines in the figures measure the percentage point deviation of the macroeconomic series from its long-term average.⁹

Oil-price shocks: Impact on U.S. growth

Broadly, the oil-price shocks in Figure 3 produce the expected “stagflationary” effect of increasing inflation expectations while depressing real growth.

The immediate or “first-round” impacts of oil-price shocks on U.S. economic growth for the following four quarters are similarly negative between the two periods. During the 1970s and early 1980s, a 10% oil-price shock led to a cumulative 0.4% decline in real GDP growth after four quarters.¹⁰ Over the 1983–2007 period, a 10% oil-price shock triggered a similar 0.4% cumulative drag on real GDP growth for the following year.

An important implication of these “first-round” effects is that a sufficiently large oil-price shock can still induce a U.S. recession, contrary to the suggestions made by Bernanke et al. (1997). Indeed, the current dynamics of the U.S. economy imply that a 60% increase in the price of crude oil would be sufficient to cause a recession, even if the economy was growing at its long-run average of nearly 3% before the oil-price shock.¹¹

7 The VAR model estimates are similar under alternative inflation expectation measures, such as those derived from a survey of economists by the Federal Reserve Bank of Philadelphia.

8 Our empirical results are robust to alternative oil-price shock measures. See also Kilian (2007).

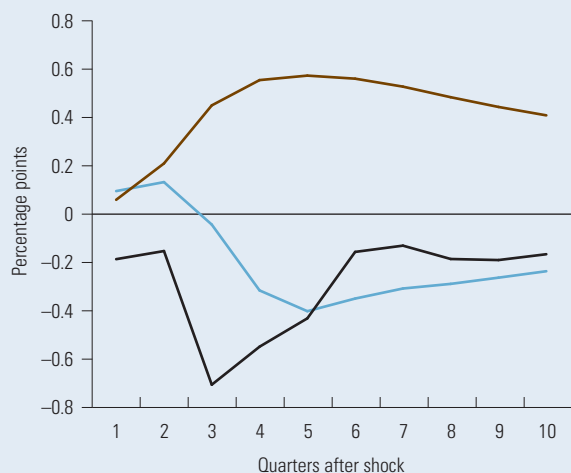
9 The impacts of a larger oil-price shock (e.g., a 100% shock that would double oil prices) can be gauged by simply multiplying the lines in the figure (e.g., by 10).

10 The *cumulative* impact on real GDP growth is simply the *average* estimated impulse response of annualized real GDP growth for the first four quarters. For the 1959–1982 sample, the VAR impulse response to a 10% oil shock in Figure 3 is –0.55% for the first quarter, –0.52% for the second quarter, –0.24% for the third quarter, and –0.22% for the fourth quarter, for an average impact on annualized real GDP growth of –0.38% (–0.4% rounded).

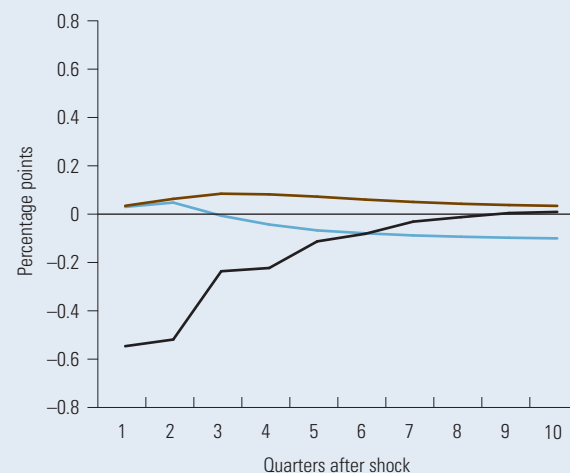
11 These calculations also suggest that the magnitude of the oil-price shocks in 2007 raises the odds of a U.S. recession in 2008.

Figure 3. VAR-based macroeconomic effects of a 10% oil-price shock

Economic effect of a 10% oil-price shock 1959–1982



Economic effect of a 10% oil-price shock 1983–2007



— Inflation expectations — Real federal funds rate — Real GDP growth

Note: Lines represent the impulse-response functions computed from a Cholesky decomposition of the quarterly VAR model. Impulse-response functions correspond to a 10% oil-price shock, or an increase of 10% in WTI crude oil prices over its trailing 1-year maximum price.

Source: Authors' calculations.

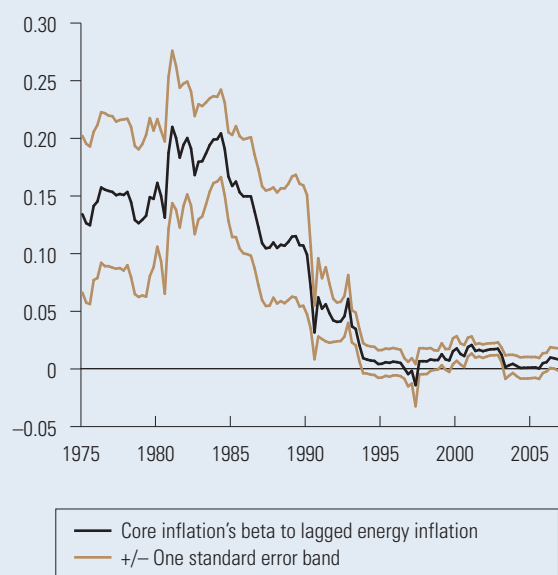
Figure 3 also reveals that oil-price shocks in the 1983–2007 period were shorter lived. Indeed, the observant reader will note that the negative “second-round” effects of oil-price shocks on real GDP growth witnessed during the 1960s and 1970s are notably absent over the 1983–2007 sample. This is striking, considering that the average response of the real federal funds rate is statistically zero between 1983 and today, compared with a reduction in real interest rates from an “accommodative Fed” between 1959 and 1982.

Oil-price shocks: Impact on inflation expectations

The disappearance of negative “second-round” real GDP effects can be linked to the more muted response of inflation expectations to oil-price shocks over the past 25 years. Higher energy prices translate into higher *headline* inflation because of the CPI’s weighting to gasoline and other energy products. Yet a 10% oil-price shock does *not* have a statistically significant impact on core inflation or other measures of inflation expectations, which Davis (2007) has shown to be the dominant driver of longer-term inflation trends over the past 25 years.¹²

12 In examining changes in U.S. inflation dynamics, Davis calculated that inflation expectations accounted for approximately 81% of the variance in core inflation since 1982, compared with only 38% in the pre-1979 period. At the same time, the influence of commodity prices, the business cycle, and the value of the U.S. dollar on core inflation has weakened considerably.

Figure 4. Core inflation responds less to energy-price shocks



Note: Betas were derived from estimating the VAR inflation equation over a rolling ten-year sample.

Source: Davis, 2007.

Our VAR model results are consistent with previous macroeconomic research that found that inflation expectations have become less responsive to commodity prices since the early 1980s (Hooker, 2002). For instance, **Figure 4** illustrates that the “pass-through” or “beta” from price changes for gasoline and other energy products to U.S. core inflation has declined considerably over time, even though the magnitude of oil-price fluctuations has not. Figure 4 implies that the average response of core inflation to energy-price shocks declined an astounding 94% in the period between the 1970s and the ten years ended December 31, 2006.

In essence, inflation expectations have become much more stable in the face of oil-price shocks. Consequently, long-term interest rates and other borrowing costs that can heavily influence business investment and consumer spending also remain anchored.

The close-to-zero correlation between higher oil prices and long-term inflation expectations is clearly evident in the U.S. Treasury Inflation-Protected Securities (TIPS) market. A good real-time measure of the U.S. bond market’s long-run inflation expectations is the TIPS five-year breakeven inflation rate, expected five years forward, commonly known as the 5-year 5-year-forward breakeven inflation rate.

Figure 5, on page 8, traces the rolling one-year correlation between the daily percentage change in WTI crude spot oil prices and the daily change in the 5-year 5-year-forward breakeven inflation rate. Since the U.S. TIPS market came into existence, there has only been a very slight positive correlation between the two measures.¹³ A similar pattern is found for a survey-based measure of long-run inflation expectations from the Federal Reserve Bank of Philadelphia’s *Survey of Professional Forecasters*. While oil prices since 1997 have risen five-fold, the survey’s consensus expectation for the average ten-year CPI inflation rate has remained well-anchored at 2.5%.

Oil-price shocks and the Federal Reserve

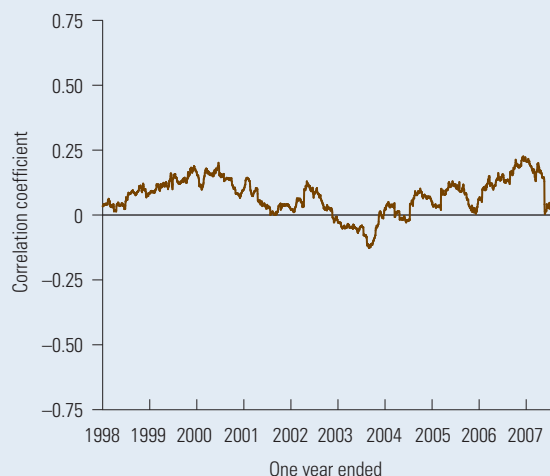
We attribute the improved anchoring of inflation expectations in the face of higher oil prices primarily to more credible and effective monetary policy.¹⁴ The Federal Reserve has been instrumental in helping to alter U.S. inflation dynamics by setting short-term interest rates more appropriately—i.e., at a level more likely to neutralize inflationary oil-price shocks and hence their negative second-round growth effects.

¹³ A simple average of the rolling one-year correlations in Figure 5 yields an average correlation coefficient of 7%.

¹⁴ See also Davis (2007) and citations therein.

Figure 5. Oil prices have not dramatically influenced the U.S. bond market's long-run inflation expectations

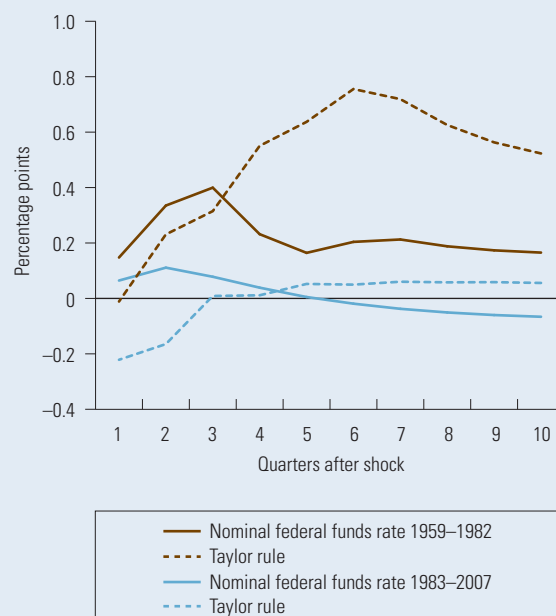
Rolling one-year correlations of daily data, July 10, 1997, through March 19, 2008



Note: Line represents rolling one-year correlation between daily percentage change in WTI crude spot oil prices and daily change in the 5-year 5-year-forward breakeven inflation rate derived from the TIPS market.

Sources: Bloomberg and Vanguard calculations.

Figure 6. Actual and optimal monetary policy response to a 10% oil-price shock



Note: Lines for nominal federal funds rate represent the sum of the impulse-response functions for inflation and the real federal funds rate, as computed from a Cholesky decomposition of the quarterly VAR model. The optimal Taylor rule response (ffr_t^{opt}) for each period is derived from a forward-looking Taylor rule suggested by Taylor (1999) and calibrated to the growth and inflation impulse responses, such that: $ffr_t^{opt} = ffr^* + 1.5 * (E_t \pi_{t+4} - \pi^*) + 0.5 * (Y_t - Y^*)$.

Source: Authors' calculations.

To better illustrate the changes in U.S. monetary policy, we can estimate so-called *Taylor rules* in the face of oil-price shocks. Taylor rules are simple monetary-policy guidelines that prescribe how the Fed should weigh the policy trade-offs of rising inflation expectations and lower real GDP growth in their joint pursuit of price stability and full employment.

Figure 6 compares the *actual* change in the nominal federal funds rate in response to an oil-price shock with what should have been the *optimal* monetary policy response over the same period using a Taylor rule.

In the pre-1983 period, the Fed's response to an oil-price shock was too accommodative, as indicated by the considerable gap between the actual and optimal paths for the federal funds rate during that period. Figure 6 illustrates that the Fed emphasized managing real GDP growth over inflation expectations. As a result, the *Federal funds rate was simply too low before the early 1980s to preserve low and stable inflation expectations in the wake of an oil-price shock*. The consequences of those policy decisions—namely, stagflation—were unfortunate.¹⁵

15 Our empirical results and interpretation are consistent with Clarida et al. (2000), Orphanides (2001), and Leduc and Sill (2004).

By contrast, the Fed since the early 1980s has not deviated significantly from the Taylor rule in the face of an oil-price shock.¹⁶ Given oil's estimated macroeconomic impacts, the central tendency has been for the nominal federal funds rate to remain unchanged, on average.

How should the Fed respond to *future* oil-price shocks?

Oil-price shocks can present a significant challenge for monetary policy. Going forward, how should the Federal Reserve respond if oil prices rise further, say from \$120 to \$150 a barrel? Should the Fed cut rates to prevent a recession, at the risk of higher inflation? Or should the Fed leave rates unchanged and perhaps facilitate a more significant downturn?

Table 2 calculates the appropriate change in the federal funds rate for a 25% oil-price shock under three alternative and hypothetical scenarios for inflation expectations. As is evident in Table 2, the “optimal” policy response to an oil-price shock depends critically on how inflation expectations respond to the energy news, all else being equal.

Our statistical analysis indicates that the appropriate Federal Reserve response to an oil-price shock will be to *lower* short-term interest rates, so long as long-term inflation expectations do not rise from their desired level. If future inflation expectations remain “anchored,” as they were during the 1983–2007 period (Case A), then a Taylor-based rule would suggest that the Fed should quickly cut short-term interest rates. Should long-term inflation expectations not move at all in response to higher energy prices (Case C), then the Fed could be more aggressive in easing the federal funds rate. Of course, should inflation expectations rise in response to higher energy prices, as they did in the 1970s (Case B), then the appropriate Federal Reserve response would be to raise the federal funds rate markedly above its initial level.

Overall, Table 2 underscores the fact that the present-day Federal Reserve has greater flexibility in addressing oil-price shocks than, in the past, presented a difficult policy trade-off with respect to stagflation. However, this flexibility is conditional on the Federal Reserve maintaining its credibility in fighting inflation.

Table 2. Hypothetical response of future federal funds rate to a 25% oil-price shock

Appropriate response depends on response of inflation expectations to higher oil prices

Appropriate federal funds rate scenarios	Case A: Inflation expectations anchored, as in 1983–2007	Case B: Inflation expectations eventually become unanchored, as they did in the 1970s	Case C: Inflation expectations completely anchored (<i>zero</i> response to oil prices)
Hypothetical rate before shock	4.00%	4.00%	4.00%
Rate <i>one quarter</i> following oil-price shock	3.50	4.00	3.25
Rate <i>one year</i> following oil-price shock	4.00	5.50	3.75
Rate <i>two years</i> following oil-price shock	4.25	5.50	4.00

Notes: Scenarios are based on the empirical estimates and methodology underlying Figures 3 and 6. Hypothetical federal funds rates have been rounded to the nearest 25-basis-point increment.

Source: Authors' calculations from VAR econometric model.

16 For the 1983–2007 sample in Figure 6, the gap between the actual and optimal federal funds rate paths is not statistically different from zero.

What explains the recent surge in oil prices?

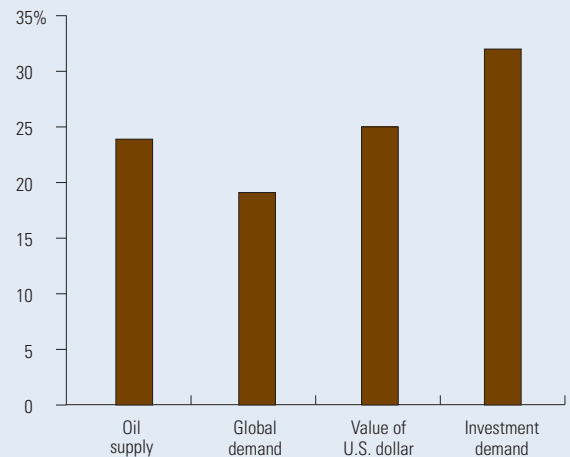
The price of crude oil is determined in global markets and typically quoted in U.S. dollars. Broadly speaking, changes in oil prices reflect a combination of five forces:

- **Oil-supply shocks**, which reflect the current physical availability of crude oil.
- **Global-demand shocks**, which reflect the global business cycle.
- **Relative U.S. demand shocks**, which are indicated by changes in the value of the U.S. dollar relative to other major currencies.
- **Precautionary demand shocks**, which arise from the desire to hedge uncertainty about *future* oil supplies.
- **Speculative shocks**, which influence oil futures prices and, through arbitrage, spot prices.

Kilian (2007) and others argue that the sharp rise in energy prices in the 1970s and early 1980s was the result of not only a marked drop in *current* oil production (an oil-supply shock), but also a higher “security premium” concerning *future* oil supplies (a precautionary demand shock).¹⁷ The recent surge in the investment demand for oil and other commodities could represent a precautionary demand shock, a speculative shock, or both.

Today, an important question among market participants is whether \$100-per-barrel oil reflects genuine supply and global-demand fundamentals, or some type of speculative overvaluation. The former would suggest that \$100 oil may persist, while the latter would indicate that the “fair value” of oil is much lower.

Figure 7. Factors most influential in explaining changes in oil prices since 2000



Note: Bars represent percentage of oil-price volatility attributed to each of the four structural shocks.

Source: Authors' calculations.

We attempt to explain the recent rise in energy prices by extending the structural VAR model of crude oil prices developed by Kilian (2007). By imposing certain identifying restrictions, this structural VAR model allows us to attribute changes in oil prices over time to four interrelated variables. Based on data availability, we estimate a quarterly structural VAR model beginning in 1995. Further details on the model can be found in the **Appendix**. We stress that the decomposition of oil-price changes into various sources is one of correlation; we cannot *prove* causality.

Figure 7 displays the average structural variance decomposition of oil prices over the 1995–2007 period attributed to the model's four factors: (1) oil supply, (2) global demand, (3) the value of the U.S. dollar, and (4) investment demand, which could reflect precautionary demand, speculation, or some percentage of both.

¹⁷ Precautionary demand shocks can reflect the “convenience yield” from having excess inventory holdings of oil that can serve as a “hedge” against some future change in oil supply, oil demand, or both.

As one would expect, the four types of shocks have been important influences on oil prices. The relative influence of each shock varies over time. For instance, the oil-supply shocks associated with Venezuelan production cuts are identified as the primary catalyst of higher oil prices in late 2002 through early 2003. In late 2005 and throughout 2006, the rise in oil prices from the high \$50s to more than \$75 a barrel are attributed to global demand shocks resulting from the surging emerging-market economies of China and others.

Further analysis reveals that neither oil-supply shocks nor global demand shocks have contributed significantly to oil prices since early 2007. Rather, oil's rapid rise since early 2007 from approximately \$60 to more than \$100 a barrel can be explained nearly entirely—and equally—by two sources: the decline in the value of the U.S. dollar, and the surge in investment demand. If the value of the U.S. dollar had not declined significantly over this period, crude oil prices would be closer to \$90 per barrel, a level that some energy analysts consider oil's long-run "fair value," given current estimates of the marginal cost of producing a barrel of oil.

Is \$100-per-barrel oil justified?

If oil's recent surge beyond \$90 a barrel cannot be adequately explained by oil-supply disruptions, global demand fundamentals, or the decline in the value of the U.S. dollar, then is \$100-per-barrel oil simply the result of a speculative bubble? The answer to that question depends critically on whether the "premium" derived from our model reflects *precautionary demand* or *speculation*. The distinction is important with respect to reasonable expectations of future oil prices.

Precautionary demand motives could reflect a genuine desire to hedge against future oil-supply uncertainty arising from either geopolitical concerns or from fears of an imminent and permanent shortage in world oil production (also known as "peak oil theory"). Speculative motives, on the other hand, would suggest that the recent upward momentum in oil prices should eventually reverse.

Unfortunately, available information is inconclusive as to whether our derived "premium" reflects precautionary demand or speculation. Energy market indicators—such as elevated oil and gasoline inventories—are not helpful, since they could support either view. Data on the net long positions of commercial (e.g., hedgers) and noncommercial (e.g., speculators) traders of crude oil futures contracts do show a moderate rise in the proportion of trading activity that can be considered "speculative," although analysis by the International Monetary Fund (2006) finds that such activity accounts for only a small percentage of oil-price movements. That data is also difficult to interpret, since it's debatable how commodity index traders should be classified. While commodity index traders are typically classified as commercial hedgers (since their goal is to replicate an index return) the increased interest among investors in commodity futures as an asset class and inflation hedge could be speculative.

Our intuition tells us that the derived "premium" of \$100-per-barrel oil above its estimated "fair value" likely reflects more speculation than precautionary demand. And even if one assigns this *entire* premium to precautionary demand motives, future oil prices could decline markedly if investor interest in commodities as an asset class wanes, the U.S. dollar appreciates, or the concerns over "peak oil" prove too pessimistic. (See our brief discussion of peak oil theory.)

On the theory of peak oil

Following the “peak oil theory” of Hubbert (1956), authors such as Deffeyes (2001) predict an imminent and permanent decline in world oil production that will be followed by cataclysmic oil shortages and dramatic further increases in oil prices.

Other well-respected authorities on energy prices discount this theory. The Energy Information Agency (EIA), for instance, stipulates in a 2004 report that world oil production will not peak until sometime around 2040. More pointedly, Crum (2008) concludes that an impending world oil

shortage is “a near zero probability event.” By estimating a general equilibrium model of oil prices that explicitly incorporates the endogenous response that higher oil prices can have on oil exploration and discovery, Crum predicts that real oil prices will fall significantly from their current highs and then gradually increase before leveling off in the long run at a real price of close to \$85 per barrel in constant dollars. Crum’s baseline oil production forecast is comparable to the findings of the EIA (2004), although Crum projects that world energy production will remain essentially at its peak 2045 level *for nearly two decades*.

Oil and the stock market

We examine how the stock market—across countries and sectors—has reacted historically to changes in oil prices by running simple regressions of monthly stock market total returns on changes in oil prices over the sample period of January 1972 through February 2008. The regressions allow for an asymmetric stock market response to oil-price increases and decreases, as well as for asymmetric responses to alternative types of oil-price increases. **Table 3** summarizes the stock market regressions. It should be stressed that oil-price fluctuations account for only a small percentage of the monthly volatility in stock prices; the R^2 on the S&P 500 return regression is 5%.

The first two columns in Table 3 indicate that the broad domestic and international stock markets have varied inversely—and somewhat symmetrically—to changes in oil prices. Since the early 1970s, a 10% decline in oil prices has been associated with a statistically significant 1.5% higher monthly total return compared to long-term averages. Conversely, a 10% increase in oil prices has been associated historically with a 1.1% lower monthly total return. The regression coefficients indicate that a *doubling* of oil prices would be associated with significant

stock market declines, as the global stock market would be expected to post returns 18 percentage points below its historical averages.

Table 3 also indicates that, on average, domestic and international stock markets respond very similarly to oil-price fluctuations. As expected, only the returns for the domestic energy sector are positively correlated with oil-price movements, although the statistical significance is somewhat weak.

However, further analysis confirms that the relationship between oil prices and the stock market is not quite that simple. Table 3 confirms our intuition that the equity markets respond very *differently* to supply-driven and demand-driven oil-price increases. Oil-supply shocks have strong negative effects on domestic and international stocks. Even the total returns on stocks in the domestic energy sector are not significantly boosted by oil-supply shocks, although their average *excess returns* to the broader U.S. equity market are positive when oil prices increase. Table 3 also shows that the stock market response to oil-price increases attributed to relative U.S. demand shocks and precautionary demand/“speculation” shocks is mixed and not statistically different from zero.

Table 3. Marginal impact of a 10% change in oil prices on monthly stock returns

Monthly total returns, January 1972 through February 2008

	Oil-price decrease	Oil-price increase	Oil-price increase (decomposed)				R ²
			Precaution/ speculation	Supply shock	Global demand	U.S. dollar	
S&P 500 Index	-1.48 (-3.13)	-1.07	0.36 (0.36)	-3.16 (-2.35)	1.82 (1.54)	-0.09 (-0.49)	5.5%
International stock market (excluding U.S.)	-1.44 (-2.81)	-2.52	-0.12 (-0.11)	-3.79 (-2.25)	1.47 (1.55)	-0.08 (0.04)	5.0%
<i>U.S. stock market sectors</i>							
Consumer discretionary	-2.24 (-3.84)	-3.53	0.33 (0.27)	-3.85 (-2.26)	1.20 (0.75)	-1.21 (-1.37)	7.9%
Energy	0.85 (1.47)	9.00	2.70 (2.20)	0.41 (-1.24)	4.65 (1.69)	1.24 (-1.30)	8.2%
Financials	-2.10 (-3.58)	-2.85	0.21 (0.17)	-3.74 (-2.12)	1.20 (0.84)	-0.52 (-0.64)	5.6%
Health care	-2.11 (-3.82)	0.83	0.61 (0.52)	-1.91 (-1.43)	1.81 (1.08)	0.31 (-0.28)	5.0%
Industrials	-1.63 (-2.87)	-4.58	-0.63 (-0.52)	-4.55 (-2.16)	1.60 (1.96)	-1.00 (-0.33)	5.7%
IT	-1.46 (-1.87)	-2.74	0.45 (0.27)	-5.13 (-2.24)	1.89 (0.92)	0.04 (-0.27)	3.1%
Materials	-1.64 (-2.77)	-3.47	-0.60 (-0.48)	-4.47 (-2.05)	1.97 (2.17)	-0.37 (0.21)	5.7%
Consumer staples	-1.75 (-3.70)	-2.36	-0.32 (-0.32)	-2.99 (-1.77)	0.99 (1.38)	-0.04 (0.30)	5.2%
Telecommunication services	-1.27 (-2.33)	-5.32	-0.54 (-0.47)	-5.20 (-2.70)	0.69 (1.13)	-0.27 (0.25)	4.9%
Utilities	-1.38 (-3.16)	-1.09	0.50 (0.54)	-4.18 (-3.36)	1.07 (0.66)	1.51 (1.19)	5.9%

Past performance is not a guarantee of future results. The performance of an index is not an exact representation of any particular investment, as you cannot invest directly in an index.

Notes: Regression coefficients are derived from an OLS regression of stock market total returns on a constant, oil price changes, and interaction terms for each source of price increases. Bolded coefficients are statistically different from zero at 10% level. Coefficient implied t-statistics are shown in parentheses.

Source: Authors' calculations.

Most notably, domestic and international stocks—in particular the energy, industrials, and materials sectors—respond quite favorably to oil-price increases attributed to global-demand shocks. This is not surprising, because the earnings of the companies in these sectors depend critically on the global business cycle; their profit margins may even expand with a *global* economic boom, despite cost pressures arising from higher energy prices. These results also help to explain why the stock market performed well through 2006 and the first half of 2007 as oil prices headed higher.

A key implication of these regressions is that oil-price increases do not uniformly lead to lower stock returns. Indeed, Table 3 on page 13 shows that the well-recognized negative correlation between oil-price increases and stock market declines arises primarily from oil-supply shocks, such as the ones that occurred in the 1970s and early 1980s. Other catalysts of oil-price increases are either ambiguous for stock returns, or even significantly positive.¹⁸

Conclusion

This paper has quantified the time-varying effects of oil-price shocks on the U.S. economy, Federal Reserve policy, and global equity markets. Our analysis showed that while the “first-round” impact of oil-price shocks on U.S. economic growth has not changed materially over time, their formerly negative “second-round” effects have been notably absent over the past 25 years, as illustrated by oil’s near-zero impact on long-term inflation expectations.

Since oil-price shocks now represent a less-stagflationary policy trade-off, we concluded that the Federal Reserve should *lower* short-term interest rates in response to an oil-price shock under certain (but not all) macroeconomic scenarios.

For domestic and international stocks, our simple regressions revealed the anticipated inverse relationship, with a 10% increase in oil prices associated with a statistically significant 1.5% lower total return. However, we have also shown that the stock market’s reaction varies dramatically, depending on the source of the oil-price shock, and that global stocks—particularly in the industrials and materials sectors—respond quite favorably to oil-price increases attributed to global-demand shocks. A key implication is that oil-price increases do not uniformly lead to lower stock returns.

Interestingly, our oil-price decomposition suggests that oil’s recent surge beyond \$90 per barrel cannot be explained by supply disruptions, global demand fundamentals, or the depreciation of the U.S. dollar.

18 Contrary to our VAR macroeconomic results, we do not observe any appreciable change in the coefficients when comparing pre- and post-1983 stock market regressions.

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Appendix

A structural VAR decomposition of oil-price shocks

By imposing certain identifying restrictions, a structural VAR model allows us to attribute changes in oil prices over time to several interrelated variables. Our structural VAR model is estimated with four lags using quarterly data between 1995Q2 and 2007Q4. The model includes five variables, all expressed in logarithmic first differences:

- WTI crude spot oil prices.
- World oil production.
- Baltic Exchange Dry Index, which measures world commodity demand and thus captures global-demand shocks.
- Broad U.S. dollar trade-weighted index, which captures relative U.S.-demand shocks.
- Total open interest in crude oil futures on the NYSE, which captures effective investment interest.

To parse out the relative impact that these fundamentals have on crude oil prices, we impose the following three assumptions regarding world oil markets in our structural VAR. First, as in Kilian (2006), we stipulate that unanticipated shocks to oil production are solely supply-driven and not a function of past oil prices or demand conditions. Since we estimate our model at a quarterly frequency, it seems reasonable that oil producers could not respond to higher oil prices by ramping up production on such short notice, even if they wanted to. Second, we assume that unanticipated changes in global demand in a given quarter are not caused by unexpected oil-price changes *in the same quarter*. It seems reasonable to assume that oil's impact on global demand operates with at least a one-quarter lag. We also assume that the unexpected movements in the dollar are not caused simultaneously by oil-price changes, at least at a quarterly frequency. Finally, we assume that investor demand for oil derivative contracts is not caused by within-quarter surprises in oil prices that are not already explained by the other fundamental factors.

Given these assumptions, the following matrix maps the unexpected shocks of the VAR model (or residuals ϵ) to their structural sources v , such that:

$$\begin{bmatrix} \epsilon_{production} \\ \epsilon_{g.demand} \\ \epsilon_{dollar} \\ \epsilon_{open_int} \\ \epsilon_{oil_price} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \times \begin{bmatrix} v_{oil_supply} \\ v_{oil_demand} \\ v_{dollar} \\ v_{speculation} \\ v_{other} \end{bmatrix}$$

In estimating the structural VAR, the resulting matrix enables us to empirically identify the sources of oil-price movements in a “cascade” manner, such that:

- **Oil-supply source** = unexpected oil production changes ($v_{oil_supply} = \epsilon_{production}$).
- **Global-demand source** = unexpected global-demand changes – oil-supply sources ($v_{oil_demand} = \epsilon_{g.demand} - a_{21} \times v_{oil_supply}$)
- **Relative U.S.-demand source** = unexpected dollar depreciation – oil-demand source – oil-supply source ($v_{dollar} = \epsilon_{dollar} - a_{31} \times v_{oil_supply} - a_{32} \times v_{oil_demand}$)
- **Precautionary demand/“speculation” source** = unexpected changes in open interest – oil dollar-demand source – oil-demand source – oil-supply source ($v_{speculation} = \epsilon_{open_int} - a_{41} \times v_{oil_supply} - a_{42} \times v_{oil_demand} - a_{43} \times v_{dollar}$)

Note, then, that the residual to the structural VAR model produces:

- **Other unexplained sources** = unexpected oil-price changes – speculation/precautionary demand – dollar source – oil-demand source – oil-supply source ($v_{other} = \epsilon_{oil_price} - a_{51} \times v_{oil_supply} - a_{52} \times v_{oil_demand} - a_{53} \times v_{dollar} - a_{54} \times v_{speculation}$)

Figure 7 plots the variance decomposition of quarterly oil-price changes, where the average oil-price volatility is attributed to each of the four structural shocks: $v_{speculation}$, v_{oil_supply} , v_{oil_demand} , and v_{dollar} . Taken together, the structural shocks to these four factors account for close to 38% of the total oil-price volatility observed during the sample period.



P.O. Box 2600
Valley Forge, PA 19482-2600

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Vanguard Investment Counseling & Research

E-mail > research@vanguard.com

John Ameriks, Ph.D./Principal/Department Head

Michael Hess

Karin Peterson LaBarge, Ph.D., CFP®

Liqian Ren, Ph.D.

Kimberly A. Stockton

Contributing authors

Joseph H. Davis, Ph.D./Principal

Francis M. Kinniry Jr., CFA/Principal

Roger Aliaga-Diaz, Ph.D.

Frank J. Ambrosio, CFA

Donald G. Bennyhoff, CFA

Maria Bruno, CFP®

Scott J. Donaldson, CFA, CFP®

Julian Jackson

Colleen M. Jaconetti, CPA, CFP®

Christopher B. Philips, CFA

David J. Walker, CFA

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