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THE IMPACT OF OIL PRICE SHOCKS ON THE U.S. STOCK MARKET*

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It is shown that the reaction of U.S. real stock returns to an oil price shock differs greatly depending on whether the change in the price of oil is driven by demand or supply shocks in the oil market. The demand and supply shocks driving the global crude oil market jointly account for 22% of the long-run variation in U.S. real stock returns. The responses of industry-specific U.S. stock returns to demand and supply shocks in the crude oil market are consistent with accounts of the transmission of oil price shocks that emphasize the reduction in domestic final demand.

1. INTRODUCTION

Although changes in the price of crude oil are often considered an important factor for understanding fluctuations in stock prices, there is no consensus about the relation between stock prices and the price of oil among economists.[2] Kling (1985), for example, concluded that crude oil price increases are associated with stock market declines. Chen et al. (1986), in contrast, suggested that oil price changes have no effect on asset prices. Jones and Kaul (1996) reported a stable negative relationship between oil price changes and aggregate stock returns. Huang et al. (1996), however, found no negative relationship between stock returns and changes in the price of oil futures, and Wei (2003) concluded that the decline in U.S. stock prices in 1974 cannot be explained by the 1973–1974 oil price increase.

In this article, we take a fresh look at this question. One limitation of existing work on the link between oil prices and stock prices is that the price of crude oil is often treated as exogenous with respect to the U.S. economy. It has become widely accepted in recent years that the price of crude oil since the 1970s has responded to some of the same economic forces that drive stock prices, making it necessary to control for reverse causality (see Barsky and Kilian, 2002, 2004; Hamilton, 2003, 2008; Kilian, 2008a,b). This means that cause and effect are not well defined in regressions of stock returns on oil price changes. A second limitation of the existing literature is the presumption that it is possible to assess the impact of higher crude oil prices without knowing the underlying causes of the oil price increase. To the extent that demand and supply shocks in the crude oil market differ in their effects on the U.S. economy and on the real price of oil, as has been documented in Kilian (2008c, 2009), and to the extent that the relative importance of these shocks evolves over time, regressions relating stock returns to innovations in the price of oil will be biased toward finding no significant statistical relationships and/or statistical relationships that are unstable over time (see, e.g., Sadorsky, 1999).

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[2] For example, the *Financial Times* on August 21, 2006, attributed the decline of the U.S. stock market to an increase in crude oil prices caused by concerns about the political stability in the Middle East (including the Iranian nuclear program, the fragility of the ceasefire in Lebanon, and terrorist attacks by Islamic militants). The same newspaper on October 12, 2006, argued that the strong rallies in global equity markets were due to a slide in crude oil prices that same day.

We address both of these limitations by relating U.S. stock returns to measures of demand and supply shocks in the global crude oil market, building on a structural decomposition of fluctuations in the real price of oil. We find that the response of aggregate stock returns may differ greatly depending on the cause of the oil price shock. The negative response of stock prices to oil price shocks, often referred to in the financial press, is found only when the price of oil rises due to an oil-market specific demand shock such as an increase in precautionary demand driven by concerns about future crude oil supply shortfalls. In contrast, crude oil production disruptions have no significant effect on cumulative stock returns. Finally, higher oil prices driven by an unanticipated global economic expansion have persistent positive effects on cumulative stock returns within the first year of the expansionary shock. This result arises because a positive innovation to the global business cycle will stimulate the U.S. economy directly, while at the same time driving up the price of oil, thereby indirectly slowing U.S. economic activity. Because the stimulating effect dominates in the short run, the U.S. stock market may indeed thrive despite unexpectedly high oil prices. Because recent increases in the price of crude oil have been driven primarily by strong global demand for industrial commodities, as shown below, this fact helps explain why the U.S. stock market so far has proved resilient to higher oil prices. In contrast, conventional VAR models based on unanticipated oil price changes would have predicted a significant stock market correction in response to the recent oil price surge.

Our aggregate analysis implies that, on average, in the long run, 22% of the variation in aggregate stock returns during 1975–2006 can be attributed to the shocks that drive the crude oil market, making oil market fundamentals an important determinant of U.S. stock returns. More than two-thirds of that contribution is driven by shocks to the demand for crude oil. Regardless of the shock, the impact response of stock returns appears to be driven both by fluctuations in expected real dividend growth and by fluctuations in expected returns associated with a time-varying risk premium. We also show that only shocks to the precautionary demand for crude oil provide an explanation for the negative association between stock returns and inflation found in previous studies of the postwar period (see, e.g., Kaul and Seyhun, 1990).

Of additional interest from an investor's point of view is the response of industry-specific stock returns to demand and supply shocks in the crude oil market. We document considerably stronger and often more significant responses at the industry level to oil demand shocks than to oil supply shocks, although the degree of sensitivity varies across industries. Our analysis suggests that the appropriate portfolio adjustments in response to oil price shocks will depend on the underlying cause of the oil price increase. For example, shares for the gold and silver mining industry appreciate significantly in response to a positive oil-market specific demand shock, whereas shares for the petroleum and natural gas stocks remain largely unaffected, and automobile and retail sector stocks depreciate persistently and significantly. In contrast, if the same increase in oil prices is driven by innovations to global real economic activity, the share prices of all four industries increase within the first year, albeit to a different degree.

The responses of industry-level stock returns also shed light on the transmission of oil demand and oil supply shocks to the U.S. economy. We find evidence that the transmission is driven not by domestic cost or productivity shocks, but by shifts in the final demand for goods and services. Our results suggest that the total cost share of energy is not an important factor in explaining differences in the responses of real stock returns across manufacturing industries, which casts doubt on the interpretation of oil price shocks as aggregate cost shocks. Moreover, outside of the energy sector, some of the strongest responses to oil demand shocks are found in the automotive industry, in the retail industry, in consumer goods, and in tourism-related sectors such as restaurants and lodging, consistent with the view that oil price shocks are primarily shocks to the demand for goods and services instead of supply shocks for the U.S. economy (also see, e.g., Hamilton, 1988; Dhawan and Jeske, 2006; Edelstein and Kilian, 2007, 2009).

The remainder of the article is organized as follows. Section 2 describes the empirical methodology. Section 3 contains the empirical results for aggregate stock market data. Section 4 focuses on industry-level stock returns and the nature of the transmission of shocks in the crude oil market to the U.S. stock market. Section 5 contains concluding remarks.

2. DYNAMICS OF AGGREGATE STOCK RETURN RESPONSES TO OIL DEMAND AND SUPPLY SHOCKS

2.1. *Data Description.* Our data include a measure of the percent change in world crude oil production, the real price of crude oil imported by the United States, an indicator of global real activity, and selected U.S. stock market variables. All data used in this article are monthly. The sample period is 1973.1–2006.12. The aggregate U.S. real stock return is constructed by subtracting the consumer price index (CPI) inflation rate from the log returns on the Center for Research in Security Prices (CRSP) value-weighted market portfolio.[3] The aggregate U.S. dividend-growth rate is constructed from monthly returns on the CRSP value-weighted market portfolio with and without dividends following Torous et al. (2004).

We construct the percent change in the global production of crude oil based on production data from the U.S. Department of Energy. Our measure of the real price of oil is based on U.S. refiner's acquisition cost of crude oil, as reported by the U.S. Department of Energy for the period starting in 1974.1, and has been extrapolated back to 1973.1 following Barsky and Kilian (2002). The nominal price of oil was deflated by the U.S. CPI available from the Bureau of Labor Statistics. Finally, we rely on a measure of monthly global real economic activity designed to capture across-the-board shifts in the global demand for industrial commodities. That measure is constructed from an equal-weighted index of the percent growth rates obtained from a panel of single voyage bulk dry cargo ocean shipping freight rates measured in dollars per metric ton. The rationale of using this index is that increases in dry cargo ocean shipping rates, given a largely inelastic supply of suitable ships, will be indicative of higher demand for shipping services arising from increases in global real activity (see Kilian, 2009 for further discussion).[4]

One of the chief advantages of this monthly index based on bulk dry cargo ocean freight rates is that it automatically incorporates the effects of increased real activity in newly emerging economies such as China or India, for which monthly industrial production data are not available. In contrast, more conventional measures of monthly global real activity such as the OECD industrial production index exclude real activity in China and India. Because much of the recent surge in demand for industrial commodities (including crude oil) is thought to be driven by increased demand from India and China, the use of a truly global measure of real activity and one specifically geared toward industrial commodity markets is essential, although for other time periods the choice of the index typically makes little difference, as discussed in Kilian (2009).

2.2. *Empirical Methodology.* Existing studies of the relationship between oil prices and real stock returns suffer from two limitations. First, many previous empirical and theoretical models of the link between oil prices and stock prices have been constructed under the premise that one can think of varying the price of crude oil while holding all other variables in the model constant (see, e.g., Wei, 2003). In other words, oil prices are treated as strictly exogenous with respect to the global economy. This premise is not credible (see, e.g., Barsky and Kilian, 2002, 2004; Hamilton, 2003). There are good theoretical reasons and there is strong empirical evidence that global macroeconomic fluctuations have influenced the price of crude oil since the 1970s (see Kilian, 2008a, 2009). For example, it is widely accepted that a global business cycle expansion (as in recent years) tends to raise the price of crude oil.[5] The fact that the same economic shocks that drive macroeconomic aggregates (and thus stock returns) may also drive the price of crude oil makes it difficult to separate cause and effect in studying the relationship between oil prices and stock returns.

[3] The CRSP data were obtained from http://wrds.wharton.upenn.edu.

[4] The underlying panel data set of shipping rates is based on *Drewry's Shipping Monthly, Ltd.* It includes shipping rates for dry cargoes such as iron ore, coal, grains, fertilizer, and scrap metal for all major shipping routes in the world. The construction of the index controls for fixed effects associated with shipping routes, ship sizes, and types of cargo. The nominal index is deflated using the U.S. CPI and subsequently linearly detrended to remove a secular trend in the cost of shipping, resulting in a stationary index of fluctuations in global real activity.

[5] As noted by Hamilton (2008), "it is clear ... that demand increases rather than supply reductions have been the primary factor driving oil prices over the last several years."

Second, even if we were to control for reverse causality, existing models postulate that the effect of an exogenous increase in the price of oil is the same, regardless of which underlying shock in the oil market is responsible for driving up the price of crude oil. Recent work by Kilian (2009) has shown that the effects of demand and supply shocks in the crude oil market on U.S. macroeconomic aggregates are qualitatively and quantitatively different, depending on whether the oil price increase is driven by oil production shortfalls, by a booming world economy, or by shifts in precautionary demand for crude oil that reflect increased concerns about future oil supply shortfalls. It is quite natural to expect similar differences in the effect of these shocks on stock returns. Because major oil price shocks historically have been driven by varying combinations of these demand and supply shocks, their effect on stock returns is bound to be different from one episode to the next. Moreover, to the extent that exogenous demand shocks in the crude oil market have direct effects on the U.S. economy in addition to their indirect effects through the real price of oil, and to the extent that they affect other industrial commodity prices, it is misleading to think of an innovation to the real price of oil while holding everything else constant.

In this article, we address both of these limitations with the help of a structural VAR model that relates U.S. stock market variables to measures of demand and supply shocks in the global crude oil market. This model builds on a structural VAR decomposition of the real price of crude oil proposed in Kilian (2009). Specifically, we estimate a structural VAR model based on monthly data for the vector time series z_t, consisting of the percent change in global crude oil production, the measure of real activity in global industrial commodity markets discussed above, the real price of crude oil, and the U.S. stock market variable of interest (say, real stock returns) in the order given. The structural representation of this VAR model is

$$A_0 z_t = \alpha + \sum_{i=1}^{24} A_i z_{t-i} + \varepsilon_t, \tag{1}$$

where ε_t denotes the vector of serially and mutually uncorrelated structural innovations. Let e_t denote the reduced-form VAR innovations such that $e_t = A_0^{-1}\varepsilon_t$. The structural innovations are derived from the reduced-form innovations by imposing exclusion restrictions on A_0^{-1}. Our model imposes a block-recursive structure on the contemporaneous relationship between the reduced-form disturbances and the underlying structural disturbances. The first block constitutes a model of the global crude oil market. The second block consists of U.S. real stock returns.

2.2.1. *Structural shocks.* In the oil market block, we attribute fluctuations in the real price of oil to three structural shocks: ε_{1t} denotes shocks to the global supply of crude oil (henceforth "oil supply shock"); ε_{2t} captures shocks to the global demand for all industrial commodities (including crude oil) that are driven by global real economic activity ("aggregate demand shock"); and ε_{3t} denotes an oil-market specific demand shock. The latter shock is designed to capture shifts in precautionary demand for crude oil in response to increased uncertainty about future oil supply shortfalls ("oil-specific demand shock").

Below we will use the terms *oil-market specific demand shock* and *precautionary demand shock* interchangeably. Precautionary demand arises from the uncertainty about shortfalls of expected supply relative to expected demand. It reflects the convenience yield from having access to inventory holdings of oil that can serve as insurance against an interruption of oil supplies (see Alquist and Kilian, 2009, for a formal analysis). Such an interruption could arise because of unexpected growth of demand, because of unexpected declines of supply or because of both. One can interpret precautionary demand shocks as arising from a shift in the conditional variance, as opposed to the conditional mean, of oil supply shortfalls. Such shifts in uncertainty may arise even controlling for the global business cycle and the global supply of crude oil.

Although fluctuations in ε_{3t} potentially could reflect other oil-market specific demand shocks, as discussed in Kilian (2009) there are strong reasons to believe that this shock effectively represents exogenous shifts in a precautionary demand. First, there are no other plausible candidates for exogenous oil-market specific demand shocks. Second, the large impact effect of oil-market specific shocks documented in Section 3.1 is difficult to reconcile with shocks not driven by expectation shifts. Third, as documented below, the timing of these shocks and the direction of their effects are consistent with the timing of exogenous events such as the outbreak of the Persian Gulf War that would be expected to affect uncertainty about future oil supply shortfalls on a priori grounds. Fourth, the overshooting of the price of oil in response to oil-market specific demand shocks documented in Section 3.1 coincides with the predictions of theoretical models of precautionary demand shocks driven by increased uncertainty about future oil supply shortfalls (see Alquist and Kilian, 2009). Finally, the movements in the real price of oil induced by this shock are highly correlated with independent measures of the precautionary demand component of the real price of oil based on crude oil futures prices. Using oil futures market data since 1989, Alquist and Kilian (2009) show that this correlation may be as high as 80% notwithstanding the use of a completely different data set and methodology.

In the U.S. stock market block, there is only one structural innovation. Whereas $\varepsilon_{1t}, \varepsilon_{2t}$, and ε_{3t} may be viewed as fully structural, ε_{4t} is not a truly structural shock. We refer to the latter shock as an innovation to real stock returns not driven by global crude oil demand or crude oil supply shocks. We do not attempt to disentangle further the structural shocks driving stock returns, because in this article we are solely concerned with the impact of structural shocks in the crude oil market on the U.S. stock market.

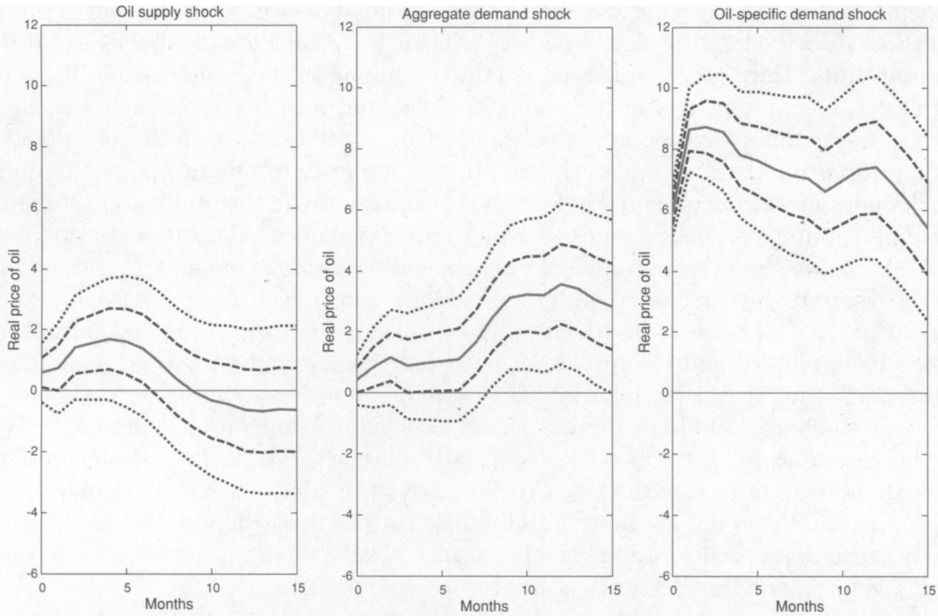
2.2.2. *Identifying assumptions.* The model imposes the following identifying assumptions resulting in a recursively identified structural model of the form

$$(2) \qquad e_t \equiv \begin{pmatrix} e_{1t}^{\Delta global\ oil\ production} \\ e_{2t}^{global\ real\ activity} \\ e_{3t}^{real\ price\ of\ oil} \\ e_{4t}^{U.S.\ stock\ returns} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{pmatrix} \varepsilon_{1t}^{oil\ supply\ shock} \\ \varepsilon_{2t}^{aggregate\ demand\ shock} \\ \varepsilon_{3t}^{oil-specific\ demand\ shock} \\ \varepsilon_{4t}^{other\ shocks\ to\ stock\ returns} \end{pmatrix}.$$

The nature and origin of the identifying assumptions is discussed in more detail below.

Global Oil Market Block. The three exclusion restrictions in the first block of Equation (2) are consistent with a vertical short-run global supply curve of crude oil and a downward sloping demand curve. Shifts of the demand curve driven by either of the two oil demand shocks result in an instantaneous change in the real price of oil, as do unanticipated oil supply shocks that shift the vertical supply curve. Following Kilian (2009), these identifying restrictions may be motivated as follows: (1) crude oil supply will not respond to oil demand shocks within the month, given the costs of adjusting oil production and the uncertainty about the state of the crude oil market; (2) increases in the real price of oil driven by shocks that are specific to the oil market will not lower global real economic activity within the month, given the sluggishness of global real activity; and (3) innovations to the real price of oil that cannot be explained by oil supply shocks or shocks to the aggregate demand for industrial commodities must be demand shocks that are specific to the oil market.

U.S Stock Market Block. The second block consists of only one equation. The block-recursive structure of the model implies that global crude oil production, global real activity, and the real price of oil are treated as predetermined with respect to U.S. real stock returns. Whereas U.S. real stock returns are allowed to respond to all three oil demand and oil supply shocks on impact, the maintained assumption is that ε_{4t} does not affect global crude oil production, global real activity, and the real price of oil within a given month, but only with a delay of at least one month. This assumption is implied by the standard approach of treating innovations to the price of oil as predetermined with respect to the U.S. economy (see, e.g., Lee and Ni, 2002). It implies the three exclusion restrictions in the last column of A_0^{-1}.



NOTES: Estimates based on the VAR model described in text. The confidence intervals were constructed using a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004).

FIGURE 1

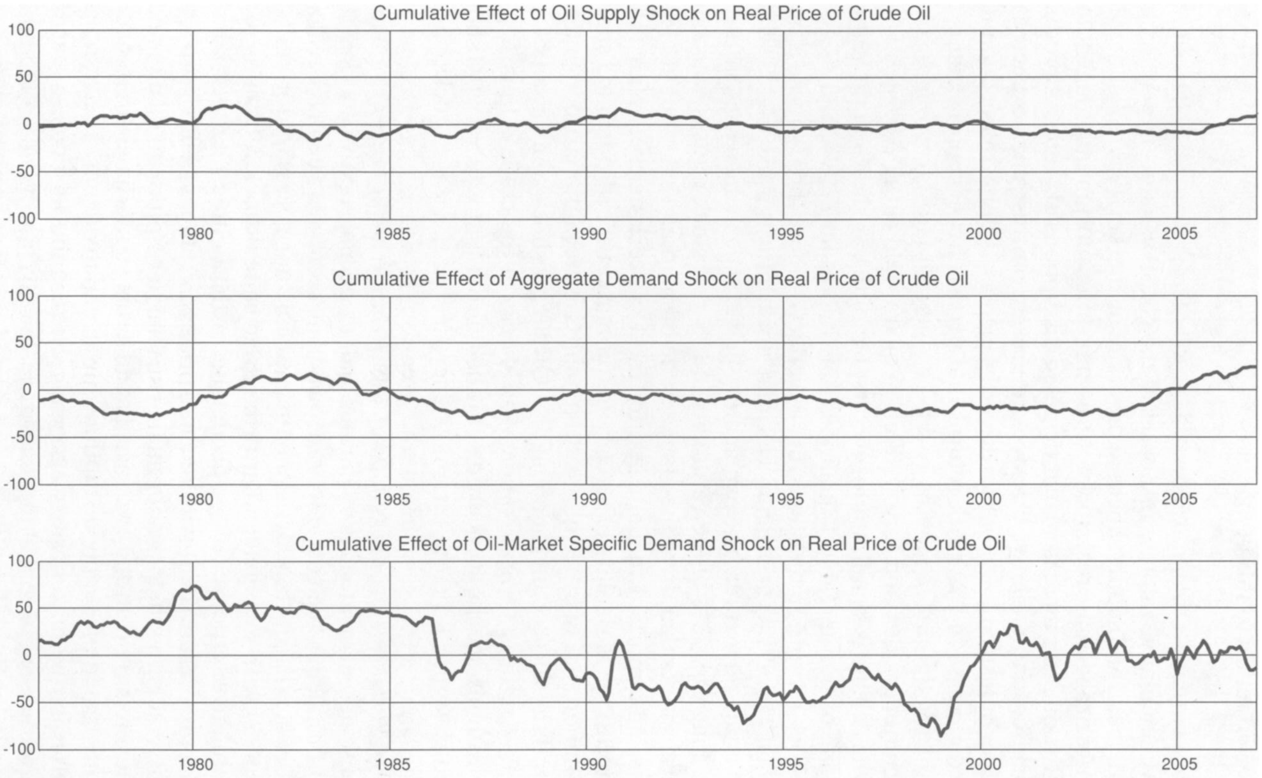
RESPONSES OF THE REAL PRICE OF CRUDE OIL TO ONE-STANDARD DEVIATION STRUCTURAL SHOCKS: POINT ESTIMATES WITH ONE- AND TWO-STANDARD ERROR BANDS

3. STRUCTURAL VAR ESTIMATES

3.1. *The Effects of Crude Oil Demand and Supply Shocks on the Real Price of Oil.* It is useful to review the responses of the real price of crude oil to the three structural shocks ε_{jt}, $j = 1, 2, 3$, as reported in Figure 1, before turning to the effect of the same shocks on U.S. real stock returns. The oil supply shock has been normalized to represent a negative one standard deviation shock, whereas the aggregate demand shock and oil-market specific demand shock have been normalized to represent positive shocks such that all three shocks would tend to raise the real price of oil. One-standard error and two-standard error bands are indicated by dashed and dotted lines. All intervals have been computed based on appropriate bootstrap methods. The central result in Figure 1 is that these three shocks have very different effects on the real price of oil. For example, an unexpected increase in precautionary demand for oil causes an immediate and persistent increase in the real price of oil, followed by a gradual decline; an unexpected increase in global demand for all industrial commodities causes a delayed, but sustained increase in the real price of oil; whereas an unanticipated oil production disruption causes a transitory increase in the real price of oil within the first year.

Although impulse responses help us assess the timing and magnitude of the responses to one-time demand or supply shocks in the crude oil market, historical episodes of oil price shocks are not limited to a one-time shock. Rather they involve a vector sequence of shocks, often with different signs at different points in time. If we want to understand the cumulative effect of such a sequence of shocks, it becomes necessary to construct a historical decomposition of the effect of each of these shocks on the real price of oil.[6] The historical decomposition of fluctuations in the real price of oil in Figure 2 suggests that oil price shocks historically have been driven mainly

[6] This may be accomplished by simulating the path of the real price of oil from model (1) under the counterfactual assumption that a given shock is zero throughout the sample period. The difference between this counterfactual path and the actual path of the real price of oil measures the cumulative effect of the shock at each point in time.



NOTES: Estimates based on VAR model described in text.

FIGURE 2

HISTORICAL DECOMPOSITION OF REAL PRICE OF OIL: 1975.1–2006.12

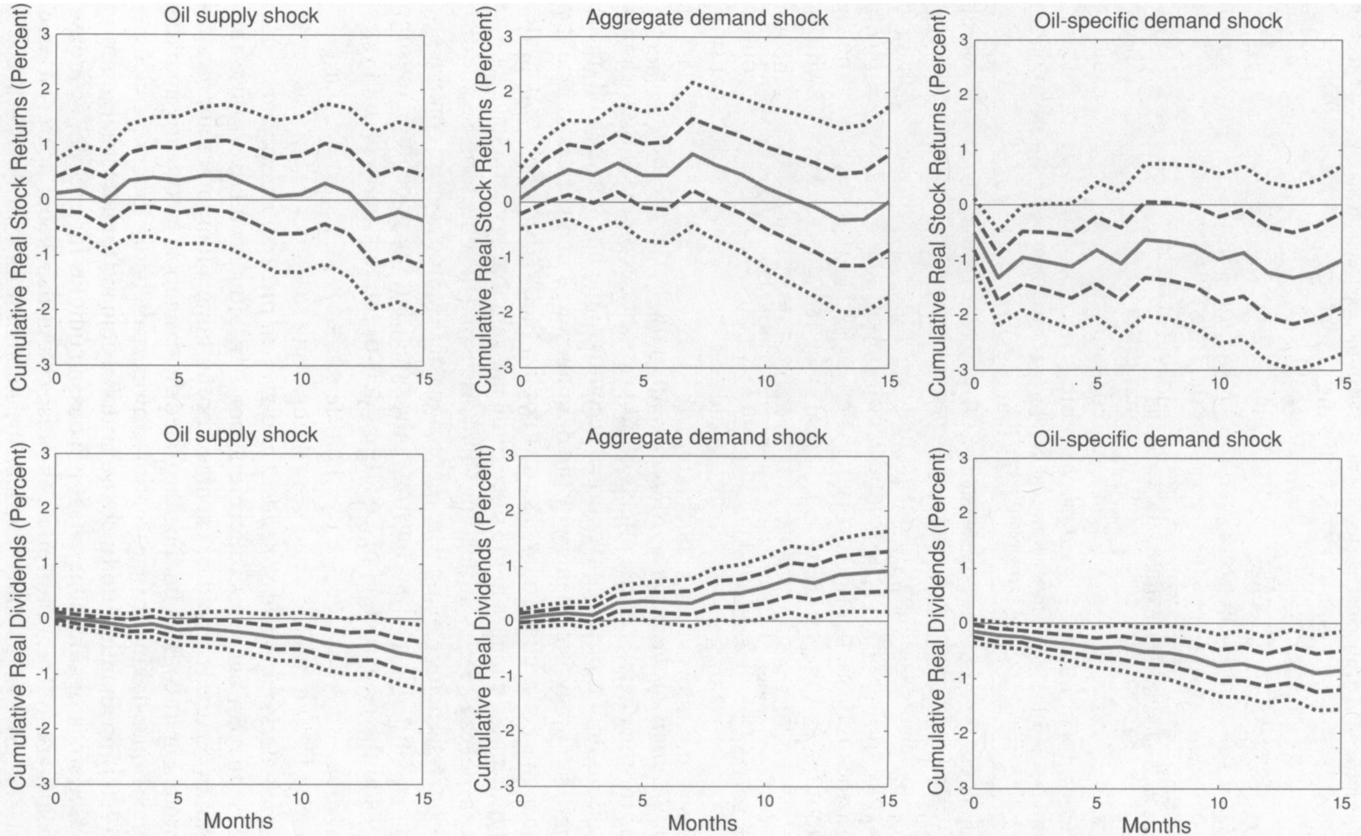
by a combination of aggregate demand shocks and precautionary demand shocks, instead of oil supply shocks. For example, the increase in the real price of oil after 1978 was primarily driven by the superimposition of strong global demand and a sharp increase in precautionary demand in 1979 with only minor contributions from oil supply shocks. Likewise the buildup in the real price of oil after 2003 was driven almost entirely by the cumulative effects of positive global demand shocks.[7] We will return to this point below.

3.2. *Responses and Variance Decomposition of U.S. Real Stock Returns.* The upper panel of Figure 3 shows the cumulative impulse responses of the CRSP value-weighted stock returns to each of the three demand and supply shocks in the crude oil market. Figure 3 underscores the point that the responses of aggregate real stock returns may differ substantially, depending on the underlying cause of the oil price increase. Unanticipated disruptions of crude oil production do not have a significant effect on cumulative U.S. stock returns. In contrast, an unexpected increase in the global demand for industrial commodities driven by increased global real economic activity will cause a sustained increase in U.S. stock returns that persists for 11 months and is partially statistically significant for the first 7 months based on one-standard error bands. Finally, an increase in the precautionary demand for oil all else equal would cause persistently negative U.S. stock returns. The decline is significant for the first 6 months, as shown in the right panel.

The variance decomposition in Table 1 quantifies how important $\varepsilon_{1t}, \varepsilon_{2t}$, and ε_{3t} have been on average for U.S. stock returns. In the short-run, the effect of these three shocks is negligible. On impact, only about 1% of the variation in U.S. real stock returns is associated with shocks that drive the global crude oil market. The explanatory power quickly increases, as the horizon is lengthened. In the long run, 22% of the variability in U.S. real stock returns is accounted for by the three structural shocks that drive the global crude oil market, suggesting that shocks in global oil markets are an important fundamental for the U.S. stock market. With 11% by far the largest contributor to the variability of returns are oil-market specific demand shocks. This estimate reflects the importance of expectations-driven shifts in precautionary demand for crude oil. Aggregate demand shocks account for about 5%. Oil supply shocks only account for about 6% of the variability of returns. Overall, oil demand shocks in the crude oil market account for 16%, whereas oil supply shocks account for only 6% of the long-run variation in the U.S. aggregate real stock returns.

3.3. *Responses and Variance Decompositions of U.S. Real Dividend Growth.* We also investigated the response of real dividend growth rates to demand and supply shocks in the crude oil market. Instead of modeling the contemporaneous relationship between U.S. real stock returns and U.S. real dividend growth, which is neither feasible nor necessary for our purposes, we re-estimate model (1) with real dividend growth replacing real stock returns as the last element of z_t. The cumulative responses of the dividend-growth rate to each shock are shown in the lower panel of Figure 3. Consistent with recent work by Lettau and Ludvigson (2005), we find that expected dividend growth does not remain constant in response to oil demand and oil supply shocks. Moreover, there is strong evidence that different shocks have different effects on real dividends. Unanticipated oil supply disruptions lower real dividends. The response is significantly negative after five months. Positive aggregate demand shocks increase real dividends persistently. The response is significant at most horizons. Finally, positive shocks to precautionary demand persistently lower real dividends. The response is significant at all horizons. The variance decomposition in Table 2 shows that, in the long run, 23% of the variation in real dividend growth can be accounted for by shocks that drive the crude oil market, more than two-thirds of which is associated with oil demand shocks. In contrast, the combined explanatory power of these shocks on impact is only 2%. These results are broadly similar to the earlier findings for real stock returns.

[7] These results are broadly consistent with other evidence and theoretical accounts of the history of the crude oil market. For further discussion see Barsky and Kilian (2002, 2004) and Kilian (2008a, 2009).



NOTES: Estimates based on the VAR model described in text. The confidence intervals were constructed using a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004).

FIGURE 3

CUMULATIVE REPONSES OF U.S. REAL STOCK RETURNS AND REAL DIVIDEND GROWTH: POINT ESTIMATES WITH ONE- AND TWO-STANDARD ERROR BANDS

TABLE 1
PERCENT CONTRIBUTION OF DEMAND AND SUPPLY SHOCKS IN THE CRUDE OIL MARKET TO THE OVERALL VARIABILITY OF U.S. REAL STOCK RETURNS

Horizon	Oil Supply Shock	Aggregate Demand Shock	Oil-specific Demand Shock	Other Shocks
1	0.06	0.02	1.37	98.55
2	0.08	0.50	4.66	94.76
3	0.30	0.72	5.26	93.72
12	1.53	2.60	6.81	89.07
∞	6.40	5.13	10.51	77.96

NOTES: Based on variance decomposition of the structural VAR model (1).

TABLE 2
PERCENT CONTRIBUTION OF DEMAND AND SUPPLY SHOCKS IN THE CRUDE OIL MARKET TO THE OVERALL VARIABILITY OF U.S. REAL DIVIDEND GROWTH

Horizon	Oil Supply Shock	Aggregate Demand Shock	Oil-specific Demand Shock	Other Shocks
1	0.20	0.16	1.69	97.95
2	0.55	0.36	2.09	97.00
3	0.76	0.48	2.12	96.64
12	2.80	6.83	4.53	85.84
∞	6.63	8.38	7.93	77.06

NOTES: Based on variance decomposition of the structural VAR model (1) with U.S. real dividend growth included instead of U.S. real stock returns.

3.4. *Broader Implications of the Impulse Response Analysis.* The preceding analysis has several implications for the analysis of the effects of oil price shocks on the U.S. stock market. First, it highlights serious limitations in conventional accounts of the link between oil prices and stock returns. Second, our analysis explains why the dramatic surge in oil prices in recent years has not caused a stock market decline so far. Third, it implies that VAR models that relate U.S. stock returns to unanticipated changes in the price of oil are valuable in characterizing average tendencies in the data, but can be very misleading when discussing the effects of specific oil price shocks. Fourth, our analysis helps explain why regressions of U.S. stock returns on the price of oil tend to be unstable. Fifth, our analysis illustrates the point that the price of oil must not be treated as exogenous in the construction of DSGE models of the link between oil prices and stock prices.

3.4.1. *Why the stock market has proved resilient to higher oil prices in recent years.* It may seem puzzling at first that an aggregate demand shock that after all tends to raise the real price of oil (as shown in Figure 1) would be capable of generating a temporary appreciation of U.S. stocks (as shown in Figure 3). This finding illustrates the dangers of incorrectly invoking the ceteris parabus assumption in linking changes in the real price of oil to stock market outcomes. As discussed in Kilian (2009), an unanticipated increase in global demand for industrial commodities has two effects on U.S. stock returns. One effect is a direct stimulus for the U.S. economy and hence the U.S. stock market. The other effect is indirect. As the global aggregate demand expansion raises the real price of oil (and other industrial commodities), it slows U.S. economic activity and depresses the U.S. stock market. The response estimate shown in Figure 3 shows that the stimulating effect tends to dominate in the first year following this shock, whereas the depressing effect reaches its full strength only with a delay.

Our model provides a direct answer to the question of why the stock market in recent years has proved surprisingly resilient to higher oil prices. The surge in the price of oil after 2003 was driven primarily by unanticipated strong global demand for industrial commodities, reflecting mainly strong economic growth in Asia. Given the response estimates for global aggregate demand shocks in Figure 3, we know that a series of positive aggregate demand shocks could sustain the U.S. stock market for several years. Thus, the absence of a stock market correction only seems puzzling when ignoring the direct stimulating effect of positive aggregate demand shocks in global industrial commodity markets. As long as that stimulus persists and there are no major precautionary demand shocks or adverse supply shocks, oil price increases do not necessarily constitute a reason for stock prices to fall. Only in the long run would one expect stock prices to decline.

3.4.2. *The limitations of VAR models of the responses to unanticipated oil price changes.* The standard approach in the literature is to estimate the responses of macroeconomic aggregates to an unanticipated innovation in the price of crude oil (see, e.g., Lee and Ni, 2002, for an application to U.S. industrial production). In its simplest form, this approach involves a recursively identified VAR model for $z_t \equiv [real\,price\,of\,oil_t, U.S.\,stock\,returns_t]$ of the form

$$A_0 z_t = \alpha + \sum_{i=1}^{24} A_i z_{t-i} + \varepsilon_t, \tag{3}$$

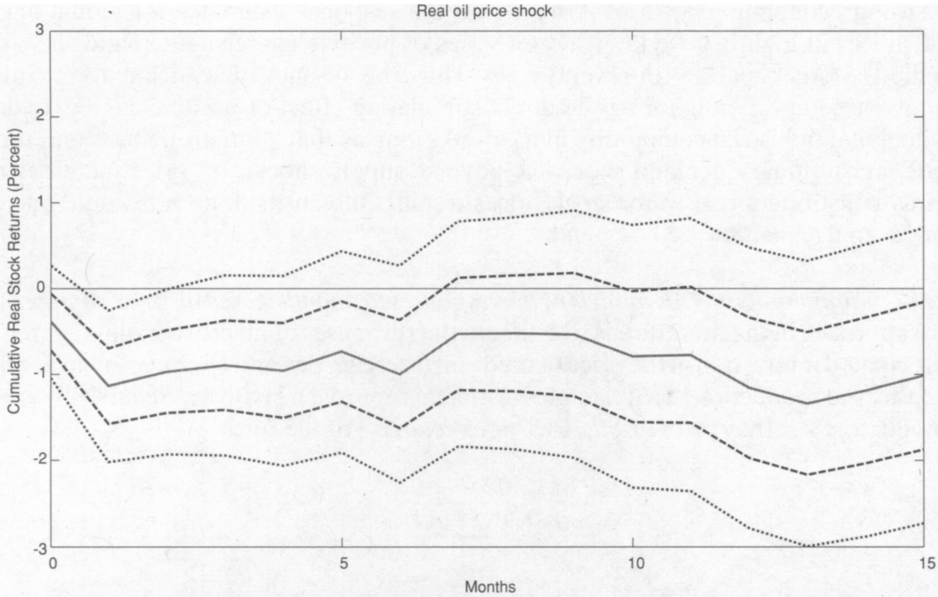
where

$$e_t \equiv \begin{pmatrix} e_{1t}^{real\ price\ of\ oil} \\ e_{2t}^{U.S.\ stock\ returns} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{bmatrix} \begin{pmatrix} \varepsilon_{1t}^{real\ oil\ price\ shock} \\ \varepsilon_{2t}^{other\ shocks\ to\ stock\ returns} \end{pmatrix}.$$

The exclusion restriction reflects the fact that innovations to the price of oil are treated as predetermined with respect to stock returns (and other domestic macroeconomic variables). For our purposes, it is immaterial whether this model is augmented to include additional variables, as long as the real price of oil is ordered first. Although this approach is valuable in characterizing average tendencies in the data (and indeed is logically consistent with our approach given that innovations to the real price of oil can be expressed as a weighted average of predetermined oil demand and oil supply shocks), it can be very misleading when discussing the effects of specific oil price shock episodes. A case in point is the surge in oil prices in 2003–2006. A researcher following the conventional approach and relying on model (3) would have concluded that the stock price should unambiguously fall in response to an unanticipated increase in the price of oil, as shown in Figure 4.[8] As we know, contrary to this result, the stock market has proved quite resilient to the surge in oil prices in 2003–2006. This example illustrates that it is important to understand why oil prices have increased when assessing the likely consequences of that increase. The same unanticipated increase in oil prices can be consistent with a sharp decline or a temporary increase in stock prices, depending on the composition of the underlying oil demand and oil supply shocks. Our methodology allows that distinction, whereas the conventional approach used by Lee and Ni (2002) and others does not.

3.4.3. *The instability of reduced-form regressions of stock returns on oil price changes.* The results in Figure 3 also suggest caution in interpreting empirical results based on reduced-form regressions of real stock returns on oil price changes. Figure 2 shows that the relative importance of any one shock in the crude oil market for the real price of oil tends to vary over time. Clearly, if over a given sample period one of the three shocks is more prevalent, it will dominate the average responses to the oil price increase estimated for that period. Whether or not one finds a stable negative relationship in the data then really becomes a question of how important

[8] The qualitative results reported for the bivariate VAR model are not sensitive to the lag order.



NOTES: Estimates based on the VAR model described in text. The confidence intervals were constructed using a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004).

FIGURE 4

CUMULATIVE RESPONSES OF U.S. REAL STOCK RETURNS TO REAL OIL PRICE INNOVATION: POINT ESTIMATES WITH ONE- AND TWO-STANDARD ERROR BANDS

aggregate demand shocks are for that period relative to precautionary demand shocks. This fact helps explain in part why existing empirical evidence using reduced-form regressions has been mixed, as noted in the introduction.

3.4.4. *Implications for DSGE models of the link from oil prices to stock prices.* Our analysis also has important implications for the construction of DSGE models of the effect of oil price shocks on stock markets. The standard approach in the DSGE literature, exemplified by Wei (2003), is to postulate that oil prices follow an exogenous ARMA(1,1) process. That assumption not only rules out feedback from the U.S. economy to the oil market, which seems implausible in light of recent research, but it also specifically rules out direct effects from unanticipated aggregate demand shocks on the U.S. economy. This fact makes it difficult to interpret the theoretical results in Wei (2003), for example.[9]

Quite apart from these methodological differences, our analysis provides a potential explanation for the difficulties Wei encountered in linking the stock market decline of 1974 to the oil price increase of 1973–1974. Because unanticipated aggregate demand shocks played a major role in driving up the price of oil in 1973–1974, as documented in Barsky and Kilian (2002) and in Kilian (2008a), the empirical finding in Wei (2003) that higher oil prices apparently seem to have had little impact on the stock market following the oil price shock of 1973–1974 is not surprising. This is what one would expect if positive aggregate demand shocks in global industrial commodity markets offset the effects of negative oil supply shocks and positive precautionary demand shocks. Thus, we tend to agree with the substance of Wei's findings. In fact, Barsky and Kilian (2002) made the case that the recession of 1974–1975 (and the associated decline in the stock prices) had little to do with the 1973–1974 oil price shock and was driven primarily by

[9] Recent DSGE models by Bodenstein et al. (2008) and Nakov and Pescatori (2007), building on the analysis in Kilian (2008c, 2009), have partially endogenized the price of oil, but to date no such DSGE model exists for the U.S. stock market.

domestic economic policies. On the other hand, our analysis suggests that, contrary to Wei's finding, as a general matter, oil price shocks may indeed be associated with a sharp decline in stock market values, provided the oil price shock is driven primarily by positive precautionary demand shocks, even if that was not the case in 1973–1974.

3.5. *What Is Driving the Response of U.S. Real Stock Returns?* The cumulative return responses shown in the upper panel of Figure 3 imply that not all of the adjustment of real stock returns in response to oil demand and oil supply shocks occurs on impact. This finding, although at odds with early models of market efficiency based on the counterfactual premise of constant expected returns, is fully consistent with modern models of time-varying expected returns (see, e.g., Campbell et al., 1997; Cochrane, 2005). Building on the analysis in Campbell (1991), by construction, the impact response of stock returns to a given oil demand or oil supply shock must reflect either variation in expected real dividend growth or variation in expected returns (reflecting the evolution of the risk premium) suitably discounted to the date of the shock. This fact allows us to construct a formal statistical test of whether the impact response of stock returns is fully accounted for by either expected returns or expected dividend growth. Following Campbell (1991), unexpected changes in log real stock returns can be approximated by

$$
\begin{aligned}
(4) \qquad r_t - E_{t-1}(r_t) = {} & E_t\left(\sum_{i=0}^{\infty} \rho^i \Delta d_{t+i}\right) - E_{t-1}\left(\sum_{i=0}^{\infty} \rho^i \Delta d_{t+i}\right) \\
& - \left[E_t\left(\sum_{i=1}^{\infty} \rho^i r_{t+i}\right) - E_{t-1}\left(\sum_{i=1}^{\infty} \rho^i r_{t+i}\right)\right],
\end{aligned}
$$

where Δd_t is the dividend-growth rate at time t, $\rho \equiv 1/(\log(1+\exp(\overline{d-p}))$, and $\overline{d-p}$ is the average log dividend-price ratio. Equation (4) states that unanticipated changes in real stock return from period $t-1$ to period t must be due to revised expectations about future dividend growth and/or revised expectations about future returns. Using reduced-form VAR methods, Campbell (1991) concluded that real stock returns were more closely related to fluctuations in expected returns than to fluctuations in expected dividend growth. In this article, we focus on the related, but different and more specific question of whether the responses of stock returns to specific demand and supply shocks in the crude oil market are driven by fluctuations in expected returns or by fluctuations in expected dividend growth.

This requires a reinterpretation of Equation (4) in terms of the responses to unanticipated disturbances in the crude oil market. Without loss of generality, suppose that we normalize all expectations as of period $t-1$ in Equation (4) to zero. Let ψ_i and δ_i denote the responses of real stock returns and real dividend growth, respectively, at horizon i to a given structural shock in the crude oil market. These responses may be obtained from the two VAR models described earlier. The response coefficients represent departures from the baseline induced by a given shock. Hence, changes in expected returns and changes in expected dividend growth relative to the baseline in response to an unexpected disturbance in the crude oil market can be written as

$$r_t - E_{t-1}(r_t) = E_t(r_t) - E_{t-1}(r_t) = \psi_0 - 0 = \psi_0,$$

$$E_t(\rho^i \Delta d_{t+i}) - E_{t-1}(\rho^i \Delta d_{t+i}) = \rho^i \delta_i - 0 = \rho^i \delta_i,$$

$$E_t(\rho^i r_{t+i}) - E_{t-1}(\rho^i r_{t+i}) = \rho^i \psi_i - 0 = \rho^i \psi_i.$$

Recall that ψ_0 denotes the response of r_t to a shock in the oil market in month t, as measured by the first element of the impulse response function of real stock returns. Similarly, the revisions

TABLE 3

TESTS OF THE IMPACT RESPONSE OF U.S. REAL STOCK RETURNS

	Wald Test Statistic $H_0 : \psi_{0j} = \sum_{i=0}^{36} \rho^i \delta_{ij}, \quad j = 1, 2, 3$	P-value
Oil supply shocks	2.5017	0.1137
Aggregate demand shocks	1.6678	0.1966
Oil-market specific demand shocks	0.8888	0.3458
	Wald Test Statistic $H_0 : \psi_{0j} = -\sum_{i=1}^{36} \rho^i \psi_{ij}, \quad j = 1, 2, 3$	P-value
Oil supply shocks	0.0150	0.9024
Aggregate demand shocks	0.0935	0.7598 .
Oil-market specific demand shocks	1.2840	0.2572

NOTES: ψ_{ij} denotes the response of real stock returns i periods after shock $j = 1, 2, 3$ occurred. δ_{ij} denotes the corresponding response of real dividend growth. The first test is for the null hypothesis that the contemporaneous return response is fully explained by changes in expected dividend growth; the second test is for the null hypothesis that the contemporaneous return response is fully explained by fluctuations in expected returns. All P-values were computed based on a recursive-design wild bootstrap.

of the expected values of future real dividend growth and real stock returns are given by the additional elements of the impulse response functions already estimated in Sections 3.2 and 3.3. This allows us to test formally whether the impact change in real stock returns arising from a given demand or supply shock in the global crude oil market can be attributed in its entirety to revisions of expected real dividend growth. This null hypothesis can be stated as

$$H_0 : \psi_{0j} = \sum_{i=0}^{\infty} \rho^i \delta_{ij} \approx \sum_{i=0}^{36} \rho^i \delta_{ij},$$

where δ_{ij} denotes the response of real dividend growth to shock j in period i, and ψ_{ij} is the corresponding response of real returns. The discount factor $\rho \equiv 1/(\log(1 + \exp(\overline{d - p}))$ may be estimated from the data. The infinite sum is truncated at horizon 36.[10] In addition, we may test the null hypothesis

$$H_0 : \psi_{0j} = -\sum_{i=1}^{\infty} \rho^i \psi_{ij} \approx -\sum_{i=1}^{36} \rho^i \psi_{ij},$$

which states that the impact response of real stock returns is fully explained by changes in expected returns. Because time-varying expected returns are the consequence of a time-varying risk premium in consumption-based asset pricing models such as Campbell and Cochrane (1999), this test may also be viewed as a test of the hypothesis that fluctuations in the risk premium alone explain the impact response.

Table 3 shows that neither null hypothesis is rejected at the 10% significance levels for any of the three shocks. These test results are consistent with the view that the response of stock returns to disturbances in the crude oil market reflects in part changes in expected returns and in part changes in expected dividend growth. That result differs sharply from the conclusion of Jones and Kaul (1996) that the reaction of U.S. stock prices to oil shocks can be completely accounted for by the impact of these shocks on real cash flows alone.[11]

[10] The qualitative results are insensitive to increasing the horizon.

[11] Analogous tests could be conducted for excess returns relative to the risk-free rate (which is commonly approximated by the short-term U.S. Treasury bill rate). In that case the impact response of excess returns may be due to variation in expected real dividend growth, expected excess returns, or the expected real interest rate. Because the test results are very similar to the baseline results for real stock returns in Table 3, we do not report them.

Our inability to reject the null hypothesis that fluctuations in expected returns alone are responsible for the impact response of real stock returns suggests that fluctuations in the risk premium are an important driving force for the responses of real stock returns to oil demand and oil supply shocks. Although no previous studies have examined the response of stock returns to oil demand and oil supply shocks, our findings are broadly consistent with Cochrane's (2005) assessment that most asset return and price variation comes from variation in risk premia, not variation in expected cash flows or interest rates. On the other hand, our inability to reject the null hypothesis that fluctuations in expected dividend growth alone are responsible for the impact response of real stock returns is consistent with the conclusion of Lettau and Ludvigson (2005) that expected dividend growth is time varying and that both expectations of real dividend growth and of returns matter for predicting stock returns.[12]

3.6. *Does the Oil Market Drive the Negative Relationship between Real Stock Returns and Inflation?* It may seem natural to think that real stock returns should have no relation with inflation. However, many studies have found a negative relation between real stock returns and inflation in the postwar period (see, e.g., Jaffe and Mandelker, 1976; Fama and Schwert, 1977). In order to explain this finding, it is common to appeal to real output shocks (see Fama, 1981; Kaul, 1987; Hess and Lee, 1999). Thus, a leading candidate for explaining this relationship is provided by disturbances in the crude oil market (see Kaul and Seyhun, 1990). In this subsection, we examine which—if any—of the demand and supply shocks in the crude oil market cause negative comovement between stock returns and inflation. We employ a statistical measure of the conditional covariance based on Den Haan (2000) and Den Haan and Summer (2004),

$$C(h) = r_h^{\text{imp}} \pi_h^{\text{imp}},$$

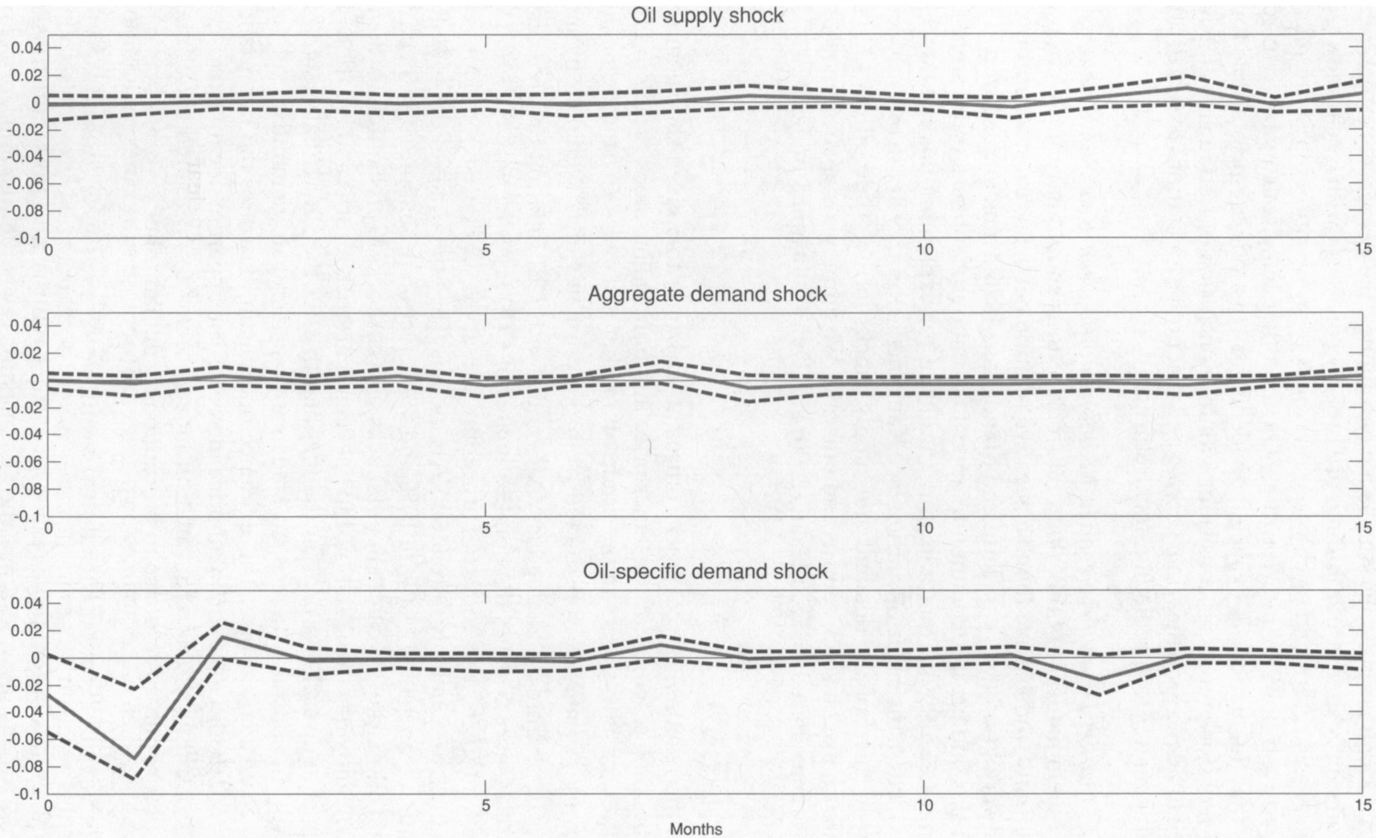
where r_h^{imp} denotes the response of real stock returns at horizon h to a given shock, and π_h^{imp} denotes the corresponding response of consumer price inflation. Falling stock prices and rising consumer prices in response to shocks in the crude oil market will cause $C(h)$ to be negative. The conditional covariance may be constructed from the estimates of r_h^{imp} implied by model (1) and estimates of π_h^{imp} from an analogous VAR model with CPI inflation ordered last instead of stock returns. Figure 5 shows the point estimates of $C(h)$ together with 80% and 90% bootstrap confidence intervals. The bootstrap procedure preserves the contemporaneous error correlations across the two seemingly unrelated VAR models. The upper tails of the confidence intervals correspond to a one-sided test with 10% and 5% rejection probabilities, respectively.

Figure 5 shows that oil-market specific demand shocks such as shocks to precautionary demand will generate a significantly negative relationship between real stock returns and inflation. That effect starts on impact and reaches a peak in the first month after the shock that is significant even at the 5% level. In contrast, there is no evidence that aggregate demand or oil supply shocks generate a negative covariance. This evidence once again illustrates the importance of understanding the underlying causes of an oil price increase. The apparent negative correlation between U.S. real stock returns and U.S. inflation indeed seems to be related to oil market developments, but occurs only in response to precautionary demand shocks.

4. DIFFERENCES IN U.S. REAL STOCK RETURN RESPONSES ACROSS INDUSTRIES

This section examines how different the responses of stock returns are across industries. This analysis helps address two distinct questions. The first question is whether the appropriate portfolio adjustment of an investor depends on the nature of the disturbance in the crude oil market. The second question is whether oil shocks act as adverse aggregate supply shocks (or aggregate

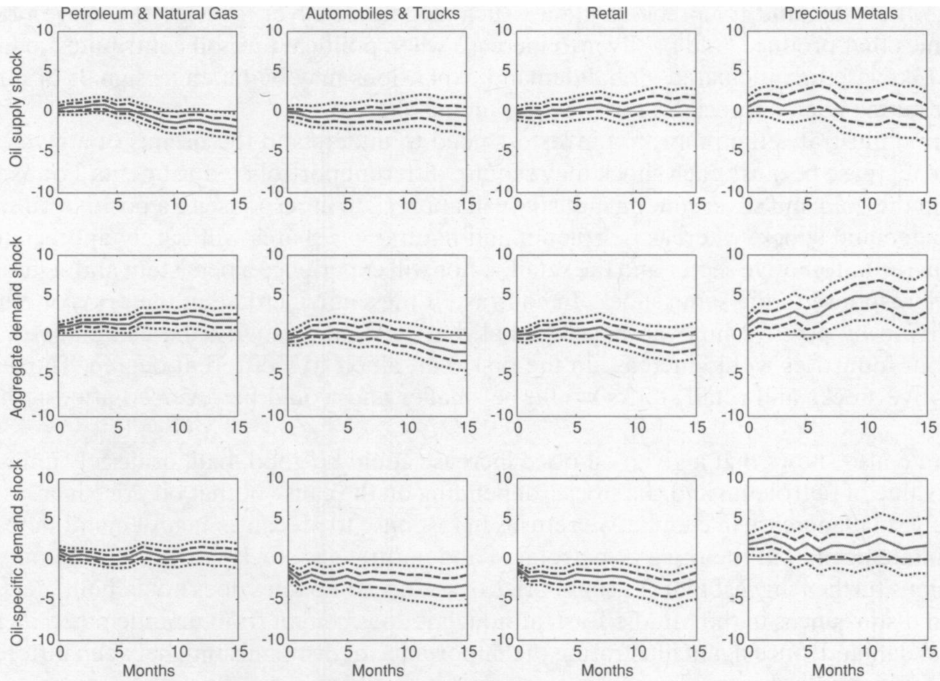
[12] Lettau and Ludvigson (2005) observe that dividend growth forecasts covary with forecasts of excess stock returns over business cycle frequencies. This covariation is important because positively correlated fluctuations in expected dividend growth and expected returns have offsetting effects on the log dividend–price ratio. Our methodology allows us to disentangle each of these effects because we estimate the impulse responses using separate VAR models.



NOTES: Estimates based on VAR models described in text. The confidence intervals were constructed using a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004).

FIGURE 5

CONDITIONAL COVARIANCE BETWEEN RESPONSES OF U.S. REAL STOCK RETURNS AND INFLATION: POINT ESTIMATES WITH 90% CONFIDENCE BANDS



NOTES: Estimates based on VAR models described in text. The confidence intervals were constructed using a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004).

FIGURE 6

CUMULATIVE REPONSES OF U.S. REAL STOCK RETURNS BY INDUSTRY WITH ONE- AND TWO-STANDARD ERROR BANDS

productivity shocks) or whether they are best viewed as adverse aggregate demand shocks for an oil importing economy (for related work see, e.g., Lee and Ni, 2002). This is a long-standing problem in macroeconomics with immediate implications for the design of macroeconomic models of the transmission of oil price shocks. We address both of these questions below. Our analysis is based on the industry-level data made available by Kenneth French.[13] These data are constructed from the CRSP database and hence are consistent with our aggregate stock return data. The sample period is 1975.1–2006.12. Instead of reviewing all 49 industries listed by French, we focus on industries that a priori are most likely to respond to disturbances in the crude oil market. The results below are based on running regression model (1) on selected industry-level stock returns.

4.1. *Implications for Investors' Portfolio Choice.* Figure 6 focuses on four industries. A natural starting point is the petroleum and natural gas industry. It is not clear a priori whether this industry would gain or lose from disturbances in the oil market. In part, the answer will depend on the extent to which oil companies own crude oil (or close substitutes) in addition to their other activities. In column 2, we consider the automotive industry, which is widely thought to be highly susceptible to disturbances in the crude oil market. We include the retail industry in column 3 because of a common perception that higher oil prices hurt the retail sector. In this view, falling oil prices cause stronger retail sales, as consumers have more money to spend on other items, because they will be paying less for gasoline. Finally, we include the precious metals sector, given the widespread perception that investors in times of political uncertainty

[13] See http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html. We use the file containing 49 industry portfolios. A detailed definition of the industries in terms of their Standard Industry Classification Code (SIC) is provided in the working paper version of this article.

increase their demand for precious metals such as gold or silver, causing the share prices of companies that produce gold or silver to increase when political turmoil contributes to high oil prices. Likewise unanticipated global demand expansions may be taken as signals of inflation risks, resulting in an appreciation of precious metals shares.

Figure 6 illustrates the point that investors need to understand the origins of a given crude oil price increase because each shock may require different portfolio adjustments. For example, shares in the gold and silver mining industry will appreciate in response to a positive oil-market specific demand shock, whereas petroleum and natural gas shares will barely appreciate, and shares in the automotive sector and the retail sector will experience a persistent and significantly negative response to the same shock. In contrast, if the same increase in the price of crude oil were driven by positive innovations to global real economic activity, the cumulative returns of all four industries would increase in the first year, albeit to a different degree. The gains in automotive stocks and retail stocks would be smaller and would be reversed after about one year.

Figure 6 also shows that a given oil price increase could be good, bad, or largely immaterial for the value of petroleum and gas stocks, depending on the cause of that oil price increase. The relatively small increase in cumulative returns in response to precautionary demand shocks and the ultimate decline in the price of petroleum and natural gas stocks in response to oil supply disruptions further suggest that the share price of energy companies does not benefit much from political disturbances in the Middle East, although it does benefit from unanticipated increases in global demand, once again illustrating the importance of distinguishing between different oil demand and supply shocks.

4.2. *Do Global Oil Market Shocks Represent Demand Shocks or Supply Shocks for the U.S. Economy?* An important question is how oil demand and oil supply shocks are transmitted to the U.S. economy in general and to the U.S. stock market in particular. A common (albeit by no means universal) view in the literature is that oil price increases matter for the U.S. economy and hence the U.S. stock market through their effect on the cost of producing energy-intensive goods. It is for this reason that stock returns of companies in the chemical industry, for example, are often expected to be particularly sensitive to disturbances in the crude oil market because they heavily rely on oil products as raw materials. Based on input–output table data from the Survey of Current Business, the chemical industry ranks second only to petroleum refineries both in terms of their direct and total energy cost share. The paper industry ranks third, rubber and plastics ranks fourth, and steel ranks only sixth (see Table 2 of Lee and Ni, 2002). Although typically there is little overlap between the industry classification in input–output tables and the classification of stock returns used by Fama and French, we were able to match approximately these four high energy-intensity industries. This allows us to assess the evidence in favor of the cost shock view based on industry-level stock return data. Below we focus on industry-level responses to precautionary demand shocks. This avoids the difficulty that global aggregate demand shocks may stimulate industries to a different degree and thus helps isolate the effect of higher oil prices. Moreover, unlike oil supply shocks, precautionary demand shocks tend to cause large and statistically significant responses in cumulative stock returns, making it easier to discriminate the hypotheses of interest.

We find that the aggregate supply or cost shock interpretation is not supported by our data. There are three pieces of evidence. First, there is no sign that the magnitude of the cumulative return responses among the four high-energy industries listed above is increasing in the industry's energy intensity. For example, returns for the rubber and plastic industry are more sensitive to precautionary demand shocks than returns for the paper industry or the chemical industry, although rubber and plastic producers have roughly the same energy intensity as paper producers and much lower energy intensity than the chemical industry. Second, the magnitude of the cumulative return responses for the four high-energy cost industries does not differ systematically from those for industries with low total energy cost shares such as electrical equipment or machinery. Third, we find that industries such as motor vehicles, retail trade, consumer goods, and travel and tourism that are particularly vulnerable to a reduction in final demand are more susceptible to precautionary demand shocks than other industries. The resulting declines are both large and precisely estimated.

In short, the industry-level response patterns are consistent with the view that shocks in oil markets are primarily shocks to the demand for industries' products instead of industry cost shocks. This finding is consistent with informal evidence in Lee and Ni (2002) that firms in most U.S. industries perceive oil price shocks to be shocks to the final demand for their products instead of shocks to their costs of production.[14] It is also consistent with related evidence based on the responses of consumption and investment expenditures in Edelstein and Kilian (2007, 2009) and with evidence in Barsky and Kilian (2004) against the interpretation of oil price shocks as aggregate supply or aggregate productivity shocks. Our evidence against the cost or supply shock interpretation has direct implications for DSGE models of oil price shocks. If oil price shocks are transmitted through the demand side of the economy instead, a different class of theoretical models will be required for understanding the effects of these shocks than the model used by Wei (2003), for example. Such a model would treat the price of oil as endogenous, would allow for demand as well as supply shocks in the global crude oil market, would allow for direct as well as indirect effects of these shocks on the U.S. economy, and would formalize the channels by which higher oil prices reduce final demand.

4.3. *The Role of Monetary Policy Responses.* An interesting question is to what extent the direct effects of oil demand and oil supply shocks on U.S. stock returns are amplified by endogenous monetary policy responses. Similar channels of transmission have been studied by Bernanke et al. (1997) and Herrera and Pesavento (2009), among others. A VAR model similar to model (2) with the change in the Federal Fund rate in place of U.S. real stock returns, suggests that there indeed is evidence that the Federal Reserve lowers interest rates in response to oil supply disruptions and raises interest rates in response to positive oil demand shocks, but historical decompositions show that these responses account only for a tiny fraction of the observed changes in interest rates.[15] This is particularly true for the large shifts in monetary policy in 1979–1980 under Paul Volcker. Thus, endogenous monetary policy responses do not play an important role in the transmission of global oil demand and supply shocks to the U.S. stock market.

5. CONCLUSION

We developed a new methodology for understanding stock market fluctuations associated with oil price shocks. This methodology has implications for aggregate stock market behavior as well as portfolio choices and is consistent with the modern finance literature. Instead of focusing on the average effect of unanticipated changes in the price of oil, we identified the fundamental supply and demand shocks underlying the innovations to the real price of oil. Jointly, these shocks explain one-fifth of the long-run variation in U.S. real stock returns.

We documented that the response of U.S. real stock returns to oil price shocks differs substantially, depending on the underlying causes of the oil price increase. Shocks to the production

[14] Not all results line up perfectly, however. Lee and Ni (2002) reported that positive oil price shocks act as adverse supply shocks for the petroleum industry and the chemical industry, but act as adverse demand shocks for most other U.S. industries. The fact that we find a decline in the cumulative returns of the chemical industry in response to a positive precautionary demand shock, yet a slight increase in the much more energy-intensive petroleum industry, argues against a supply shock interpretation for those industries.

[15] The positive response to an unanticipated aggregate demand expansion is consistent with the Federal Reserve's responding to demand-driven increases in industrial commodity prices. The negative response to oil supply shocks is consistent with evidence in Kilian (2009) that oil supply shocks do not appreciably increase the price level, but cause a temporary decline in the U.S. real GDP. In contrast, oil-specific demand shocks tend to be both recessionary and inflationary. The response estimates suggest that the Fed attaches greater importance to the inflation objective than to the output objective, when faced with a trade-off.

of crude oil are less important for understanding changes in stock prices than shocks to the global aggregate demand for industrial commodities or shocks to the precautionary demand for oil that reflect uncertainty about future oil supply shortfalls. Precautionary demand shocks, in particular, can account for the anecdotal evidence of large declines in stock prices in the wake of major political disturbances in the Middle East. As shifts in precautionary demand are ultimately driven by growing uncertainty about future oil supply shortfalls and such expectations can change almost instantaneously in response to political events in the Middle East, exogenous political disturbances may trigger an immediate and sharp increase in precautionary demand that is reflected in an immediate jump in the real price of oil as well as an immediate drop in stock prices. In contrast, if higher oil prices are driven by an unanticipated global economic expansion, there will be persistent positive effects on cumulative stock returns within the first year, as the stimulus emanating from a global business cycle expansion initially outweighs the drag on the economy induced by higher oil prices. Our findings both complement and reinforce the evidence in Kilian (2009) about the response of U.S. real GDP growth and consumer price inflation to demand and supply shocks in the crude oil market.

Our analysis suggests that the traditional approach to thinking about oil price changes and stock prices must be rethought. An immediate implication of our analysis is that researchers have to move beyond empirical and theoretical models that vary the price of oil while holding everything else fixed. Relaxing this counterfactual ceteris parabus assumption helps resolve two main puzzles in the related literature. First, it helps explain the apparent resilience of the U.S. stock market to higher oil prices to date, given the evidence that recent increases in the price of crude oil have been driven primarily by strong global demand for all industrial commodities. In contrast, conventional VAR models based on unanticipated changes in the price of oil would have mistakenly predicted a decline in the equity market in response to the most recent surge in the price of oil. Second, our approach helps explain the apparent instability of regressions of stock market variables on oil price changes. Such instabilities arise by construction from changes in the composition of oil demand and oil supply shocks over time.

Finally, our analysis has direct implications for the construction of DSGE models of the link between oil prices and stock prices. We highlighted the importance of, first, integrating the crude oil market into general equilibrium models and, second, of modeling the U.S. and foreign demand for crude oil explicitly. This contrasts sharply with the current generation of DSGE models such as Wei (2003) that postulate an exogenous ARMA(1,1) process for oil prices and stress the effect of higher oil prices on aggregate productivity. We also provided new evidence based on industry-level stock returns that the primary channel of transmission of oil price shocks is a reduction in the final demand for goods and services. This evidence is consistent with a growing body of evidence on the importance of the demand channel.

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