What Do We Know About Oil Prices and State Economic Performance?

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The persistent rise of oil and gasoline prices during the past few years raises the issue of the effect of oil prices on the aggregate economy. Recent research shows that oil prices have an asymmetric effect: Rising prices have a measurable negative impact on aggregate economic activity, but falling prices do not have a commensurate positive impact. This study examines the effect of oil price changes on the states of the Eighth Federal Reserve District, using various measures of oil price increases. The study finds that some states are more sensitive to oil price changes than others. The study also finds only limited support for the asymmetry hypothesis at the state level. (JEL R11, Q43)

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Recent gasoline price increases have caused significant economic heartburn for households, energy-sensitive businesses, and transportation-sensitive government agencies. Households that loaded up on gas-guzzling sport utility vehicles when gasoline prices were low are now especially feeling the pinch in their pocketbooks. Transportation-intensive businesses such as airlines, delivery, and trucking have been hit hard by fuel price increases, with limited ability to pass cost increases on to customers. School systems that transport large numbers of students to and from school have been hit hard, as have state and local highway departments that depend heavily on petroleum-derived asphalt for road construction and maintenance. Rising gasoline prices have forced households, businesses, and governments to adjust by consuming less energy or spending less on everything else. High gasoline prices have changed vehicle buying preferences, with sales of large SUVs down about 6 percent from last year.

Clearly, higher gasoline prices have changed household (and probably business and government) spending habits. The issue for this study is this: How has the increase in oil and gasoline prices affected the economies of states in the Eighth Federal Reserve District? The effect of higher oil prices on the national economy has received a fair degree of attention in the literature, but the impact on state economies has received much less attention.

LITERATURE

During the past two decades a number of studies have explored the effect of oil prices on the national economy, concluding that oil prices and aggregate measures such as output or employment are negatively related: that is, rising oil prices cause the economy to slow, while falling oil prices stimulate the economy.[1] More recent research on this matter, however, shows that since the mid-1980s the connection from oil prices to economic activity has changed; current thinking by economist is that rising oil prices generate a negative impact on aggregate economic activity, but falling prices have little effect (Hamilton, 2003). What is more, oil price

[1] Hamilton (2003) offers an overview of this scholarship.

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increases that simply average out recent price declines have little effect. The next section of this paper applies current thinking about the oil price–economy connection at the national level to the states in the district of the Federal Reserve Bank of St. Louis.

APPROACH AND DATA

The model for this study follows that outlined by Hamilton (2003) and Mehra and Petersen (2005). In brief, Hamilton measures the sensitivity of quarterly gross domestic product (GDP) growth to alternative measures of oil price changes; he finds that oil price increases matter while price declines do not, especially since the early 1980s. And rising oil prices matter more when the increase does not simply correct a recent decline. Drawing on Hamilton's work, Mehra and Petersen investigate the effect of various measures of oil price change on consumer spending at the national level. Similar to Hamilton, they find that oil price increases that follow a recent peak matter for consumer spending.

In the discussion below, I adapt and apply the model in Mehra and Petersen (2005) to show how state economic output is affected by changing oil prices, focusing just on the states of the Eighth Federal Reserve District. Autoregressive distributed lag (ARDL) models are estimated for each state, using various measures of oil price change. The models are autoregressive because previous values of real earnings help explain current real earnings.

Details of the model are shown in the following equation:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{4} \beta_{1i} \Delta y_{t-i} + \sum_{i=1}^{4} \beta_{2i} \Delta oilprices_{t-i} + \sum_{i=1}^{4} \beta_{3i} \Delta Fedfunds_{t-i}.$$

The equation shows how quarterly real output growth (Δy_t) depends on growth of real output in the previous four quarters (Δy_{t-i}), the change in oil prices from the previous four quarters ($\Delta oilprices_{t-i}$), and the change in the federal funds rate from the previous four quarters ($\Delta Fedfunds_{t-i}$). The coefficient

$$\sum_{i=1}^{4} \beta_i$$

is the sum of the coefficients for the four lagged values of real income, oil prices, and federal funds.

For the measure of oil prices, I use the oil and gasoline deflator published by the Bureau of Economic Analysis (BEA), deflated using the GDP deflator. By using national figures for oil and gasoline prices, I impose the restriction that oil prices in the various states fluctuate in the same pattern as they do nationally. Following Mehra and Petersen (2005), nominal short-term interest rates are also included in the state models, as measured by the federal funds rate adjusted for inflation using the GDP chain-weighted deflator. Measuring quarterly real output presents a problem, because state-level data for quarterly GDP do not exist. A proxy that mimics the growth rate of gross state product (GSP) on a quarterly basis is needed. Earned income (or just earnings) fits the bill well; the largest component of value-added, earned income includes all payroll for all hourly and salaried workers plus all income earned by the self-employed. Comparing annual earnings growth for the seven states with annual growth of GSP shows a close correspondence, with an R^2 of 0.8 or more.

As in Hamilton (2003) and Mehra and Petersen (2005), the effects of oil prices are tested using three different measures. First, the *oil price change* is simply the quarterly change of the inflation-adjusted oil and gasoline price index from the BEA. The second measure, *positive oil price change*, restricts price changes to positive changes only; otherwise, the measure is set equal to zero. Finally, the *net oil price change* measures a positive change from a recent previous maximum, thereby excluding price increases that simply correct a recent price decline. I use both four-quarter and eight-quarter horizons to determine the previous maximum; calculation details are provided in Appendix A. Depictions of the oil price change, positive oil price change, and net oil price change (four-quarter and eight-quarter horizons) are shown in Figures 1 through 4.

Using these measures of oil prices, the study will test the following propositions:

Figure 1

Quarterly Oil Price Change, 1960-2005 (first differences of logs)

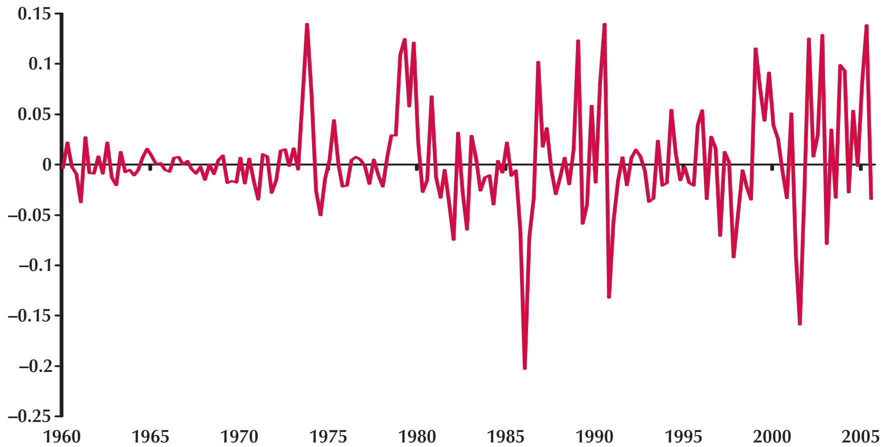

Figure 2

Positive Quarterly Oil Price Change, 1960-2005 (first differences of logs)

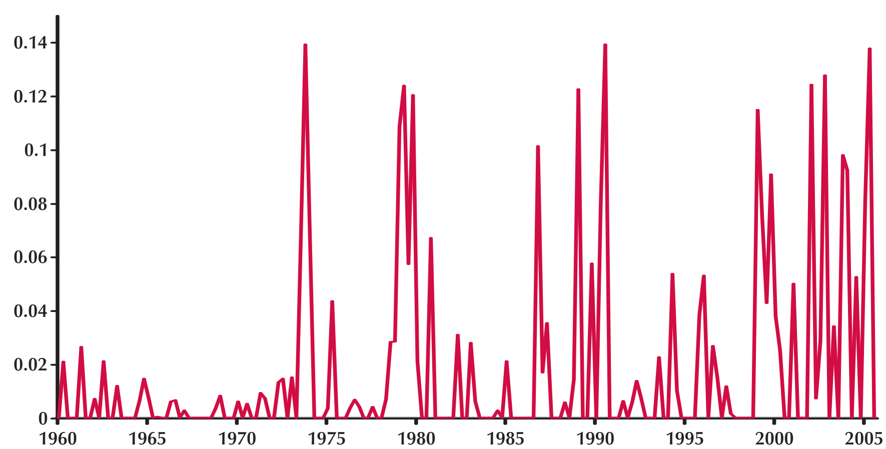

Figure 3

Net Quarterly Oil Price Change, Four-Quarter Horizon (first differences of logs)

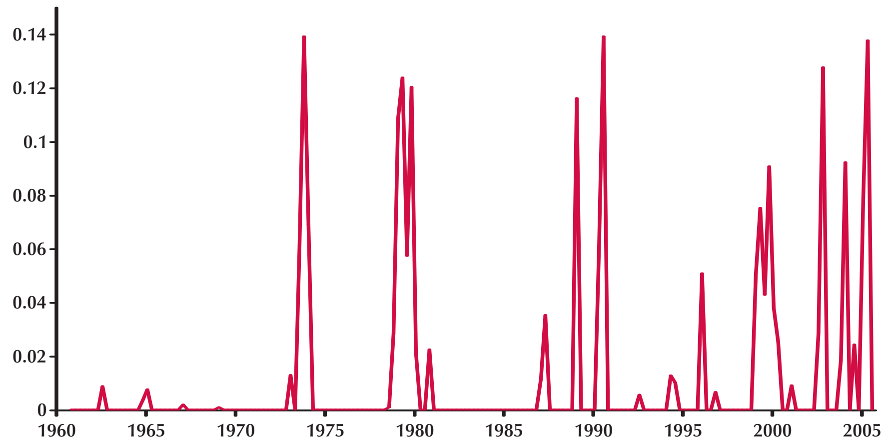

Figure 4

Net Quarterly Oil Price Change, Eight-Quarter Horizon (first differences of logs)

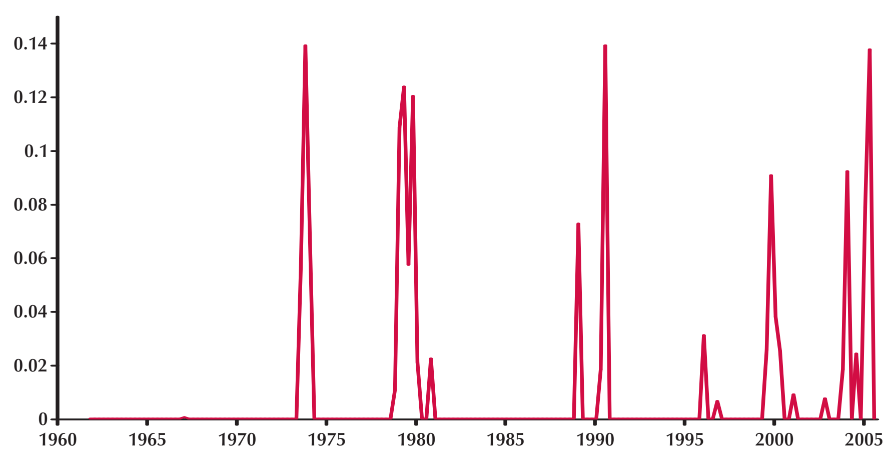

Table 1

Consumption of Gasoline, Distillates, and Jet Fuel per Dollar of GSP, 2002

State	BTU per dollar GSP	National rank
Arkansas	4.33	9
Illinois	1.95	48
Indiana	3.41	19
Kentucky	4.09	11
Mississippi	5.03	4
Missouri	3.26	24
Tennessee	3.26	23
U.S.	2.71	

SOURCE: Compiled from the Energy Information Administration and Bureau of Economic Analysis.

Table 2

Expenditures for Gasoline, Distillates, and Jet Fuel per Hundred Dollars of GSP, 2002

State	Spending	National rank
Arkansas	4.14	8
Illinois	1.99	48
Indiana	3.15	20
Kentucky	3.86	11
Mississippi	3.07	23
Missouri	4.55	4
Tennessee	2.96	26
U.S.	2.56	

SOURCE: Compiled from the Energy Information Administration and Bureau of Economic Analysis.

Proposition 1: Simple oil price changes (positive and negative) don't matter.

Proposition 2: Oil price increases matter.

Proposition 3: Net oil price increases matter more.

PETROLEUM CONSUMPTION IN THE EIGHTH FEDERAL RESERVE DISTRICT

Examining the pattern of petroleum consumption and expenditures may offer clues concerning the connection of oil prices and state economic activity. Using data from the Energy Information Agency and the BEA, a measure of the energy intensity of each state can be estimated by dividing the measure of energy usage by GSP, resulting in the amount of energy consumption or expenditure needed to produce one dollar of GSP. Table 1 shows consumption of gasoline, distillates (diesel), and jet fuel per dollar of GSP for 2002. Among the Eighth District states, Mississippi and Arkansas consume much more energy per dollar of GSP than most of the other states of the union. Kentucky and Indiana are clearly above the United States average, whereas Tennessee and Missouri are slightly above average. Only Illinois ranks below the national average in energy intensity—in fact, greatly below. Energy intensity varies considerably within the District, ranging from 1.95 British thermal units (BTU) per dollar of GSP for Illinois to 5.03 BTU for Mississippi.

Another view of energy intensity can be derived by examining spending for energy instead of units of energy consumed. Of course, if energy prices vary among the states, the pattern of energy expenditures may differ from energy consumption per unit of GSP. Table 2 shows spending for gasoline, distillates, and jet fuel per hundred dollars of GSP for 2002. National rankings are the same as for Table 1 except for Missouri and Mississippi; Missouri ranks high and Mississippi about average on this measure of energy intensity. One would expect a priori that the more energy-intensive states will be more sensitive to changes in energy prices. I shall test this proposition later in the paper.

Another important measure of energy intensity is gasoline spending per capita, providing evidence of the energy intensity for the transportation sector. In this regard the Eighth District states show wide divergence. Illinois ranks 46th lowest among the 50 states and Washington, D.C., in terms of spending per capita for gasoline, with $572 in 2002; this is substantially below the United States average of $623 per capita. The other six states in the District rank above the United States average: Indiana ranks 29th ($651 per capita), Tennessee 26th ($658), Arkansas 17th ($681), Kentucky 16th ($691), Mississippi 12th ($702), and Missouri 11th ($708).

Table 3

State Motor Gasoline Taxes (cents per gallon)

State	Tax
Tennessee	21.00
Kentucky	18.50
Indiana	18.00
Illinois	19.00
Mississippi	18.40
Missouri	17.00
Arkansas	21.50
Average of 50 states	21.17

NOTE: State rates are effective January 1, 2006. Additional taxes are levied by these states: Illinois (6.25 percent sales tax), Indiana (6 percent sales tax). Local sales taxes may also be applicable.

SOURCE: Energy Information Administration.

By comparison, Wyoming ranks highest for per capita spending for gasoline, at $875 in 2002. Judging from these spending figures, we may expect that, with the exception of Illinois, an increase in gasoline prices in the Eighth Federal Reserve District states will likely have a greater impact than in most other states.

Gasoline taxes can also have an impact on consumption. Table 3 shows current state government gasoline tax rates per gallon consumed. Only in Arkansas does the state gasoline tax rate exceed the 50-state average. For Illinois and Indiana, taxes are more complex; in addition to the state tax per gallon, additional state and local sales taxes apply.

Taking into account transportation costs and local taxes, retail gasoline prices may differ considerably, both within states and between states. However, given tax rates and transportation costs, it is reasonable to assume that *changes* in prices will be roughly equivalent across areas.

RESULTS

The model estimated in this study is dynamic; real earnings depend on oil prices and past values for real earnings. And past real earnings depend on past oil price changes. Thus, we can think of two channels for the impact of oil prices; the direct impact on current real earnings and an indirect impact by way of past earnings. The former channel is estimated by the oil price coefficient, whereas the latter channel is estimated by the oil price multiplier. Both will be discussed below.

Given the context of petroleum expenditures in Table 2, one would expect the largest effects of oil price hikes to occur in Missouri, Arkansas, and Kentucky, with more modest impacts in Indiana, Mississippi, and Tennessee. The smallest impact is expected for Illinois.

First I must make several assumptions about the suitability of the model variables and later will speculate about the sensitivity of the model estimates if the assumptions are incorrect. As discussed earlier, I assume that earned income is a good proxy for GSP. Earnings growth may not be a good proxy for growth in other GSP components, such as profits, interest income, and indirect taxes. Second, we assume that oil and gasoline prices change by the same proportion across the seven states and that these changes are accurately measured by the BEA oil and gasoline price deflator. Finally, we assume that changes in the general level of prices are the same across the states, so that we may apply the national GDP price deflator to the oil price index and to earned income to adjust for changes in the general price level. The dependent variable is the quarterly change of real earned income; specifically, the first difference (quarter-to-quarter change) of the natural log of real earned income. Oil price changes also enter the regressions as differences of logs, whereas the interest rate is the simple quarter-to-quarter difference. Earnings and oil prices are deflated using the consumer expenditure deflator and the GDP deflator, respectively. The structure of the model is this: Real earnings growth is believed to depend on the previous four quarters of oil price growth, interest rate changes, and changes in real earned income.

Oil price coefficients are presented in Table 4 for each of the four measures of oil prices,[2] using private sector real earnings growth as the dependent variable. The estimates are the sum of the four lagged coefficients from the regressions; *t*-values

[2] Complete results for Tennessee are presented in Appendix B. Complete results for other states are available on request.

Table 4

Oil Price Coefficients by State

State	Oil price change	Positive oil price change	Net oil price change (4)	Net oil price change (8)
Tennessee	–0.026 (0.83)	–0.115 (2.79)	–0.115 (2.36)	–0.119 (2.13)
Kentucky	–0.063 (1.74)	–0.129 (2.66)	–0.122 (2.18)	–0.141 (2.18)
Indiana	–0.011 (0.32)	–0.103 (2.12)	–0.108 (1.86)	–0.120 (1.63)
Illinois	–0.011 (0.32)	–0.063 (1.39)	–0.103 (2.20)	–0.151 (2.99)
Mississippi	0.002 (0.07)	–0.090 (2.04)	–0.071 (1.40)	–0.065 (1.12)
Missouri	–0.013 (0.40)	–0.095 (2.24)	–0.115 (2.38)	–0.135 (2.49)
Arkansas	–0.016 (0.49)	–0.101 (2.27)	–0.098 (1.96)	–0.114 (2.07)

NOTE: The *t*-values are in parentheses. Coefficients are the sum of values for four lags. Net oil price (*) is the net change of oil prices evaluated at four- and eight-quarter horizons. Values show the percent change in current real income from a 1 percent change in the price of oil sustained for four quarters.

are shown in parentheses. The coefficients show the negative impact on a state's current real earnings caused by a sustained four-quarter increase in oil prices. For example, if oil prices rose 10 percent per quarter for four quarters in Tennessee, the quarterly real earnings growth rate would be reduced by 1.15 percent.

Several things in the table are worth mentioning. First, none of the coefficients for the simple oil price change measure (first column) are significantly different from zero at the 5 percent level. This result is consistent with Hamilton (2003) and Mehra and Petersen (2005) for the national economy. Second, positive changes in oil prices matter for all but one state, Illinois. For the other six states, the positive oil price change coefficients range from –0.09 in Mississippi to –0.129 in Kentucky, with significance of 5 percent or better. Last, oil price increases do matter for Illinois, but only when measured as a net price increase. We may surmise from these results that the six states excluding Illinois show some sensitivity to simple oil price increases, regardless of whether they simply correct recent price decreases. Illinois appears to show more resilience to oil price increases.

In this regard, the results differ from the findings of Hamilton (2003) and Mehra and Petersen (2005) for the national economy in that net oil price changes do *not* matter more than positive price changes for three states: Tennessee, Mississippi, and Arkansas. For the other four states, net changes evaluated at either the four- or eight-quarter horizons do matter more than simple positive changes, especially for Illinois.

Given a 1 percent change in oil prices this quarter, how much will real earnings decline in the future? The long-term link between oil price changes and real earnings growth is the long-term multiplier. The multiplier shows the effect of an oil price increase on real earnings growth four quarters later, taking into account the direct effect of oil prices on earnings and the indirect effect as oil price increases ripple throughout the economy. Oil price multipliers are shown for the Eighth District states in Table 5 for private sector earnings. The positive oil price change multiplier for Tennessee is –0.222, which means that a 1 percent increase in the price of oil sustained for each of four quarters will cause real private sector earnings to grow 0.22 percent less than would have occurred in the absence of higher oil prices.

The relative size of the multipliers in this table are similar to the oil price coefficients in Table 3: Positive oil price changes matter for six states, and the net oil price change matters for Illinois. Only for Illinois do net oil price changes matter more than positive oil price changes, the result Hamilton found for the national economy. The correspondence of the Illinois result with the national economy may well be due to the relative size of the

Table 5

Long-Term Oil Price Multiplier

State	Positive oil price change	Net oil price change (4)
Tennessee	–0.222 (3.40)	–0.224 (2.98)
Kentucky	–0.189 (3.07)	–0.196 (2.59)
Indiana	–0.219 (2.26)	–0.255 (2.07)
Illinois	–0.150 (1.54)	–0.219 (2.55)
Mississippi	–0.151 (2.38)	–0.132 (1.60)
Missouri	–0.172 (2.77)	–0.200 (2.98)
Arkansas	–0.208 (2.59)	–0.209 (2.23)

NOTE: The *t*-values are in parentheses. Coefficients show the effect on private real earnings growth from a 1 percent four-quarter sustained rise in oil prices. The multiplier is calculated as the sum of the four lagged oil price coefficients divided by 1 minus the sum of the four lagged earnings coefficients.

state's economy; with a GSP of $521.9 billion in 2004, Illinois is fifth largest among the 50 states[3] and more than twice as large as the second state (Indiana) in the Eighth District. In Mississippi's case, the small size of the multiplier might be attributable to the substantial presence of oil production in the state, particularly offshore production. In 2004, Mississippi ranked 12th largest in terms of oil production, averaging 47,000 barrels per day, about 50 percent more than Illinois (30,000 barrels per day). While higher oil prices undoubtedly affect consumer spending and transportation-sensitive businesses in Mississippi, the oil and gas production sector in Mississippi benefits. The negatives are offset by the positives, and the state shows only a small net difference in real earnings due to oil price increases.[4]

CONCLUSIONS

We may conclude that for six of the seven states in the Eighth District, positive oil price changes matter, whereas simple oil price changes (positive and negative) do not, as Hamilton (2003) and Mehra and Petersen (2005) found for the national economy. However, net oil price changes matter only for Illinois, probably because of the size and similarity with the national economy.

Also, measures of energy intensity do a poor job predicting the sensitivity of state economies to oil price changes, with the exception of Illinois. Much more work is needed to explore the importance of oil prices and state economies. What factors more fully explain the differences between states in terms of oil price sensitivity? This and other questions, such as the stability of the oil price coefficients, need more attention by economists.

REFERENCES

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[3] Illinois ranks in size of GSP behind California, New York, Texas, and Florida.

[4] Although oil production for Illinois is substantial, the size of the sector relative to the state's GSP is small and has little relative impact.

APPENDIX A

Calculating the Net Oil Price Change

The net oil price change is computed by comparing the current value of the real oil and gas price index with its maximum over the previous four quarters. More specifically, let $Oilprice_i$ indicate the value of the oil and gas price index for the current period i, and let $Maxoilprice_{i-4}$ indicate the maximum of the index over the previous four quarters. Then the net oil price change ($\Delta Netoilprice_i$) is:

$$\Delta Netoilprice_i = (Oilprice_i - Maxoilprice_{i-4}) \text{ if } Oilprice_i > Maxoilprice_{i-4}, \ 0 \text{ if } Oilprice_i \leq Maxoilprice_{i-4}.$$

APPENDIX B

Detailed Model Estimates for Tennessee Using Quarterly Data, 1960-2005

Each model estimates a different measure of oil price change. The dependent variable is the log difference of quarterly real earned income.

	Model			
Variable	One	Two	Three	Four
Change in earnings$_{1-4}$	0.621 (5.77)	0.480 (4.26)	0.489 (4.10)	0.504 (4.09)
Change in federal funds$_{1-4}$	–0.008 (4.45)	–0.007 (4.32)	–0.007 (4.01)	–0.007 (3.90)
Oil price change$_{1-4}$	–0.026 (0.83)			
Positive oil price change$_{1-4}$		–0.115 (3.40)		
Net oil price change(4)$_{1-4}$			–0.115 (2.98)	
Net oil price change(8)$_{1-4}$				–0.119 (2.13)
Oil price multiplier	–0.069 (0.91)	–0.222 (3.40)	–0.224 (2.98)	–0.240 (2.73)
Adjusted R^2	0.340	0.370	0.357	0.358
Log likelihood	585.2	589.2	577.0	562.7

NOTE: The *t*-values are in parentheses. Coefficients are the sum of estimates for four lags. The oil price multiplier is the oil price coefficient divided by 1 minus the earnings coefficient.