Petroleum Prices and their Impact on Aggregate Economic Activity: Greasing the Skids?

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Introduction

The United States is a major consumer of petroleum products, and as a result economists have paid particular attention to the impact of oil prices on the macroeconomy (i.e., Sauter and Awerbuch, 2003; Hondroyiannis and Papapetrou, 2001; Hamilton, 1996; and Hamilton, 1983). Politicians have also decried the absence of a national energy policy, particularly in period when oil prices are spiking. Unfortunately politicians' interest seem to wain as oil prices decline from their highs. The poplar and financial press, in recent years, have picked up on the theme that high oil prices have a direct and detrimental effect on economic aggregates:

> Dow component Wal-Mart Stores, Inc. Sounded a warning Thursday that high gasoline prices were starting to eat into consumers' spending money. The retailer said it would not meet Wall Street's forecasts for the second quarter. (Martinez, 2005).

Such attention, both by academics and the popular press, suggest that the relationship between oil prices and the health of the U.S. economy is to be taken seriously. The effect of oil price changes have been examined with respect to various economic aggregates. Chaudhuri (2000) has found that oil prices have a direct influence on the price of other industrial commodities, even if oil is not a substantial component of the cost of those commodities. As pricing power for oil is obtained by producers there are spill-over effects into other industrial commodities. In other words, ***oil prices grease the skids for the pricing of other industrial commodities***. Hooker (1996) found that GDP growth was restrained by oil price increases after the initial price shocks in the 1970s, but that neither unemployment or GDP could be predicted by price levels for the period 1973-1994. There have even been tests of the hypothetical relationships between the price of oil, and the performance of major stock market indices, both abroad and in the United States over time (Jones and Kaul, 1996; and Ciner, 2001).

The preponderance of studies published concerning the influence of oil prices appear to have focused on overall performance of the Gross Domestic Product (Hamilton, 1983) or related issues such as the unemployment rate (Lee, Ni and Ratti, 1995). Hooker (1999) even applied Granger causal models to determine if oil prices "Granger caused" unemployment for data in the 1990s, similar to studies reported by Hamilton (1983) and Mork (1989). While Hamilton found evidence of causality running from oil prices to unemployment, Hooker's evidence sheds doubt that the relationship of the 1970s was still identifiable in the 1990s. Bernanke, Getler, Watson *et al* (1997) review the literature to date, and suggest that the evidence of the unemployment which was associated with oil price shocks was simply due to monetary policy over-reactions, and the operation of Okun's Law.

What has been missing in these studies is the influence of oil prices on specific components of the Gross Domestic Product. It is presumed in each of the published papers, to date, that changes in oil prices impacts Gross Domestic Product in some aggregate fashion such that it results in diminished growth or higher unemployment. The quote, above, from the Associated Press suggests that there are very specific ways in which oil prices operate on the aggregate level of economic activity.

The purpose of this paper is to examine the impact of oil prices on the four major components of Gross Domestic Product to determine if the variations in these components of Gross Domestic Product can be systematically explained, by oil prices, together with other known influences on macroeconomic activity. This study examines the period 1986 through 2006 to determine if oil prices impact, Consumption, Government Spending, Investment and Net Exports in the same way.

Model and Data

The studies reported to date have focused on a particular dependent variable thought to be determinate of the performance of the aggregate economy. Unemployment, inflation and Gross Domestic Product have been the sorts of variables specified for the left hand side of the equation. However, there is a limitation to this approach. Using a single continuous variable suggests that the price of oil will impact Gross Domestic Product in a specific way regardless of the component of GDP, and that these component parts of GDP are not of particular interest. In fact, it is the component parts of Gross Domestic Products that are of interest, and may very well react differently to changes in oil prices.

To be able to test the effects of oil prices on the component parts of Gross Domestic Product requires a method whereby multiple dependent (VAR Variables) and multiple independent variables (WITH Variables) may be specified. Canonical correlation permits the specification of multiple variable on each side of the equation to allow examination of the impact of explanatory variables (WITH Variables), including oil prices on each component of GDP (VAR Varibles). Equation 1 specifies the model to be estimated here:

$$(C + I + G + XN) = (UR + FFR + M2 + Oil) \quad (1)$$

where:

C = Consumption, I = Gross Domestic Investment, G = Government Expenditures, XN = Net Exports, UR = Unemployment Rate, FFR = Federal Funds Rate, M2 = M2 Money Supply, and Oil = WTI Cummings Oklahoma, Spot oil prices last day of the quarter.

Consistent with the results reported in the literature, the variables identified as being functionally related to Gross Domestic Product are included in the right hand side vector, and the components of Gross Domestic Product are included in vector on the left hand side of the equation. Canonical correlation is then used to determine a significant statistical relation exists between the vectors and their individual components. The component parts of each vector will then be analyzed to determine what the nature of the relations are between the predictor variables and each component of GDP.

The data used to estimate the relevant equations are from standard published sources. The GDP data is from the U.S. Department of Commerce website, and is quarterly data. The Bureau of Labor Statistics website is the source of the quarterly average unemployment data, and the M2 Money Supply and the Federal Funds Rate come from the Federal Reserve Board of Governors site, and are quarterly averages. Because these values change rather slowly over time during this period, quarterly averages do no great violence to what we are attempting to measure. The oil price data is for WTI at Cummings, Oklahoma and are spot prices for the last day of the quarter, which produces less of a smoothing effect than using quarterly average data for oil prices.

Results and Discussion

Canonical correlation analysis was applied to the data. The overall test statistics, canonical R-squared are reported, as well as the weights and loading from which inference can be made concerning the nature of the relationship between the individual components of each of the vectors (VAR Variables and WITH Variables).

The results of this analysis, including the weightings and loadings are reported in Table 1 below.

(TABLE 1 HERE)

There are several test statistics generated by the SAS program as standard output for canonical correlation analysis. The multivariate test statistics, Wilks' Lambda, Pillai's Trace, Hotelling-Lawley Trace and Roy's Greatest Root test are all significant at .0001, and confirm. Each of these statistics confirm that the canonical vectors are statistically significant.[1] The canonical R-squared is for the canonical vector with the best fit is reported at .997, with an Eigenvalue of just over 437.00. The cumulative variation and proportions of the VAR vector explained by the WITH vector variables are each nearly 99 percent. In other words, the canonical correlation is robust with respect to the goodness of fit criterion for the WITH Variables to the VAR vector of variables.

The VAR vector with the maximized correlation with the WITH vector is reported as V1, the second best correlation is reported as V2 and so on. The best fit of the WITH vector with the VAR vector of variables is reported as W1 and the next best is reported as W2. From inspection of Table 1 it is clear that the best fit of W1 with V1 explains more than 97 percent of the variation of the variables within the VAR vector.

The product of the canonical weightings and loadings are the typical method used to interpret the results of a canonical correlation analysis. To determine the nature of the relationship between the variables which comprise the VAR and WITH vectors respectively, those vector components in each vector of like sign are positively associated, while those of opposite sign are negatively associated. The appropriate comparison for purposes of determining the proper sign is the Standardized Canonical Coefficients for the WITH Variables (Weightings), with Correlations Between the VAR variables (Loadings).

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[1] See Hair *et al* (1984) for further discussion of the test statistics reported here and their equivalence in statistical tests of significant in multivariate methods such as the canonical correlation reported here, in various chapters, Wilks Lambda is defined and discussed on pp. 158-159.

(TABLE 2 HERE)

The products of the loadings and weighting result in a sign that may be interpreted as equivalent the β in an Ordinary Least Squares equation.[2] Table 2 reports sign for the components of the vectors which are, for the most part, consistent with the predictions of standard macroeconomic theory. As the M2 money supply increases (decreases), *ceteris paribus,* we would expect the Fed Funds Rate (FFR) to decrease (increase). As interest rates decline it is well documented, in the macroeconomics literature, that investment and consumption both increase. The sign for these two variables M2 (positive) and FFR (negative) are thus consistent with the common predictions of marcoeconomic theory. As the M2 Money Supply decreases (increases) the interest rate increases (decreases) which results in the dollar appreciating. As the dollar appreciates then imports become cheaper and exports more expensive, and the expected negative sign for the M2 Money Supply and expected positive sign for FFR are obtained for their relation with Net Exports.

The unemployment variable is more troublesome. As Hooker (1996) reports, during the late 1980s and early 1990s he found a disconnect between unemployment and the Gross Domestic Product – in other words, Okun's Law, seems to have been repealed. This controversial finding has not persuaded all informed observers that such a disconnect is in evidence (Bernanke, *et al,* 1997), however, there is an interesting observation which explains this positive sign for unemployment with respect to C, I, and G. That explanation has to do with what many observers referred to as the jobless recovery. That is, the stock market boom from 1987 through 2001 resulted in significant increases in income for the upper ends of the income distribution, in turn, resulting in increased consumption at high end retailers, increased investment, and the apparent economic boom dampened fiscal conservatives zeal for decreased government expenditures. At the same time this was going on at one end of the income distribution, the picture was more bleak for those at the other end. As American jobs disappeared, unionized jobs gave way to lower paying service sector and retail trade employment, and those at the lower end of the income distribution did experience bouts of unemployment (Samavati and Stump, 2006).

The oil prices mirror the results for the unemployment rate. As oil prices increase (decrease) so too did consumption, investment, and government expenditures. As oil prices increased, however, net exports decreased. In the case of net exports we would have expected this result. As the cost of imported oil increased, *ceteris paribus,* the value of imports increased, thereby adding negative numbers to our current accounts, and thereby driving net exports further into the negative column.

The positive sign for consumption should also not come as any great surprise. As oil prices

[2] For example, a minus times a minus yield a positive number, hence the sign of the β is positive, a minus times a positive yields a negative number and hence the sign of the β is properly interpreted as negative. The equations were re-estimated using four OLS equations, one for each component of GDP. The DW (d) for these equations indicated moderate positive serial correlation. The Cochrane-Orcutt transformation was used and the equations re-estimated. The estimated coefficients from the OLS models were consistent with those reported here, and they appeared to be stable.

increase, not only does the price of fuel go up, but the cost of transporting goods, and the cost of goods for which oil is an intermediate good (i.e., plastics, synthetic fibre, chemicals, and pharmaceuticals, etc.). The inflation experienced in consumer goods and fuels is consistent with increased consumption. What is not so intuitively obvious is why investment and government expenditures would increase.

In the case of investment, the period in which oil prices were increasing was also a period of unprecedented economic growth. The underlying data show that there was considerable investment undertaken in the energy producing sectors of the economy which in large measure is a function of the expectations of those firm's whose operate in those sectors. However, this increase alone does not seem to be sufficient to fuel this finding. During this period of time there were two significant boom periods. The technology boom in the dot com era, followed quickly by the construction boom clearly overwhelmed any negative influences increased oil prices may have had in transportation or manufacturing. Which is precisely why examination of the influence oil prices, by component of the GDP is important.

Government expenditures is also of interest. There is a positive association of oil prices with government expenditures. This result is clearly evident from American foreign policy, and also comes as no surprise. As instability in the oil producing regions of the world created a need or opportunity for American military intervention, that intervention required large expenditures of money. The first and second Iraq Wars were significant spikes in government expenditures. Lest we focus too narrowly on military adventures, there is another issue. The government is a large consumer of oil. Ships, planes, and vehicles (from the military to the Postal Service) makes the U.S. government the single largest consumer of motor fuels. As the price of oil increases, so too must government expenditures to keep the military on the move, and the mail delivered.

Finally, it should also be clear that the negative sign for oil price with net exports should be expected. As oil prices increase, so too do the costs of imports, and the value of all imports increase, net exports decrease, *ceteris paribus*. However, there are other issues involved. As the dollar becomes larger proportions of oil exporting countries foreign reserves, the value of the dollar should be expected to decline as the demand for those dollars declines in favor of other currencies from areas in which these exporting nations may wish to do business. This will have a lagged effect on the value of net exports, which may become more significant over time as those reserves of dollars build in the treasuries of Iran, Saudi Arabia, Nigeria, and other such countries.

Conclusions

The canonical correlation analysis produced results which were fully anticipated for the relationship between the M2 Money Supply and the components of GDP as well as for the Fed Funds Rate and the components of GDP. The unemployment rate variable, as was the case in the study reported by Hooker (1996), seems to reflect the jobless recovery of the period examined in this paper. The repeal of Okun's Law may not yet have occurred, because the 1980s, and 1990s were rather unique periods for income distribution, fiscal policies, and globalization, reflecting more these issues than anything involved with oil prices.

What this evidence does is to clearly demonstrate is that oil prices are not uniformly a negative influence on economic growth. As oil prices increased over the period examined, it is clear that consumption, investment and government expenditures were positively associated with oil prices. In other words, contrary to popular laments, increased oil prices are associated with increased consumer and government expenditures. With cold, rational thought, these conclusions are not surprising. Oil prices are negatively associated with net exports. Again, this should not surprise anyone. The United States is the world's largest importer of oil, as oil prices go up, *ceteris paribus*, net exports are going to decrease. What is perhaps the most surprising result is that oil prices are positively associated with investment. The period of time examined was a unique period of time in which a housing and technology boom occurred – this is at least a partial explanation. However, looking more deeply into the components of investment it is very clear that alternative fuel companies start up as prices of oil increase, and that energy companies themselves are given the incentive of higher prices for their commodities to explore for fossil fuels, and exploit more marginal sources that would not otherwise be profitable. In either case, energy companies will invest more the higher the price of oil.

There has been significant published research concerning the influence of oil prices on the aggregate performance of the U.S. economy. However, to date, little attempt has been made to disaggregate the GDP data to identify specific structural influences of oil prices on various segments of the economy. Far more research along these lines is necessary before we can lay these issues to rest.

References

Bernanke, B. S., M. Gertler, M. Watson, C. A. Sims, and B. M. Friedman, "Systematic Monetary Policy and the Effects of Oil Price Shocks," *Brookings Papers on Economic Activity,* (1997) No. 1, pp. 91-157.

Chaudhuri, K., "Long Run Prices of Primary Commodities and Oil Prices," *Working Papers, the University of Sydney,* 2000.

Ciner, C., "Energy shocks and Financial Markets: Nonlinear Linkages," *Studies in Nonlinear Dynamics and Econometrics,* (October, 2001) Vol. 5, No. 3, pp. 203-212.

Hamilton, J. D., "Oil and the Macroeconomy since World War II," *Journal of Political Economy*, (1983) Vol. 92, No. 2, pp. 228-248.

Hamilton, J. D., "This is What Happened to the Oil Price-Macroeconomy Relationship? *Journal of Monetary Economics,* (1996) Vol. 38, No. 1, pp. 215-220.

Hair, J. F., R. E. Anderson, and R. L. Tatham, *Multivariate Data Analysis with Readings, econd edition.* New York: Macmillan Publishing Company, 1984, Chapter 5.

Hondroyiannis, George, and Evangelia Papapetrou, "Macroeconomic Influences on the Stock Market," *Journal of Economics and Finance*, (2001) Vol. 25, No. 1, pp. 33-49.

Hooker, M. A., "What Happened to the Oil Price-Macroeconomy Relationship?" *Journal of Monetary Economics,* (1996) Vol. 38, No. 1, pp. 195-213.

Hooker, M. A. "Oil and the Macroeconomy Revisited," *Federal Reserve Board Working Papers,* Washington, D.C.: GPO, (August 1999).

Jones, C. M. And G. Kaul, "Oil and the Stock Markets," *The Journal of Finance.* (1996) Vol. LI, No. 2, pp. 463-491.

Lee, K., S. Ni, and R. A. Ratti, "Oil Shocks and the Macroeconomy: The Role of Price Varibility," *Energy Journal.* (1995) Vol. 16, No. 1, pp. 39-56.

Martinenz, M. J., "Wall Street Fears Oil Prices to Cut into Consumer Spending," Associated Press, May 16, 2005.

Mork, K. A., "Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamilton's Results," *Journal of Political Economy.* (June 1989) Vol. 97, No. 3, pp. 740-744.

Samavati, H. and C. F. Stumph, "Unions, Women, and the Consequences of the Jobless Recovery," *Journal of Collective Negotiations.* (2006) Vol. 31, No. 1, pp. 71-83
.

Sauter, Raphael and Shimon Awerbuch, "Oil Price Volatility and Economic Activity: A Survey and Literature Review," *IEA Research Paper,* IEA Paris, 2003.

Table 1: CANONICAL CORRELATION RESULTS GDP Components, Oil Prices, Unemployment, Federal Funds Rate, and Money Supply					
V	Canonical Correlation	Canonical R-Squared	Eigenvalue	Proportion	Cumulative
1	.998	.997	437.236	.988	.988
2	.902	.814	4.378	.010	.998
3	.690	.476	0.685	.002	.999
4	.288	.083	0.090	.000	1.000
		Value	F-Statistic	D.F.	Probability
Wilks' Lamda		.0002	214.67	16	.0001
Pillai's Trace		2.3711	28.02	16	.0001
Hoteling-Lawley Trace		442.6149	2020.20	16	.0001
Roy's Greatest Root		437.2359	8416.79	4	.0001
	Correlation between VAR Variables & their own Canonicals			Correlations between VAR Variables & Canonicals of the WITH Variables	
	V1	V2		W1	W2
C	.997	-.194		.976	-.175
I	.933	-.350		.932	-.315
G	.996	-.060		.996	-.054
NX	-.947	-.032		-.946	-.029
	Correlation between VAR Variables & their own Canonicals			Correlations between WITH Variables & Canonicals of the VAR Variables	
	W1	W2		V1	V2
M2	.997	-.058		.996	-.052
UR	-.391	.837		.391	.755
FFR	-.700	-.186		.699	-.168
OILP	.841	.218		.84	.197
	Standardized Canonical Coefficients for the VAR Variables			Standardized Canonical Coefficients for the WITH Variables	
	V1	V2		W1	W2
C	.095	-2.564		.881	1.017
I	-.191	-2.143		.021	1.413
G	.914	4.306		-.029	.771
NX	-.184	-.229		.130	.092

Table 2: Products of VAR Loadings WITH Weightings Signs of β				
	M2	UR	FFR	OILP
C	+	+	-	+
I	+	+	-	+
G	+	+	-	+
NX	-	-	+	-