<u>Oil and the Macroeconomy</u>

Prepared for the Shadow Open Market Committee Meeting, November 13th, 2000.

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<u>Summary</u>

Two empirical relationships about the effect of oil prices on the U.S. economy are well accepted. The first is that while oil price increases lowered real GDP growth in the 1970's, since then changes in oil prices have had no significant effect on U.S. economic activity. Second, while oil price changes continue to change core inflation in the U.S. based only on their expenditure share of price indices, since the 1980's they have no longer had an additional impact on core inflation.

The Fed's reaction to oil price has also shifted. During the 1970's, prior to Paul Volcker's chairmanship, the Fed <u>tightened</u> monetary policy in response to rising oil prices. This policy response can be justified since, as pointed above, oil prices led core inflation during this time period. Of course, history suggests that the Fed's responsiveness during this period was also insufficiently aggressive to keep inflation from accelerating.

While oil prices changes do not seem to have played a direct role in Chairman Volcker's implementation of monetary policy, during Chairman Greenspan's tenure the Fed has acted to keep monetary policy <u>looser</u> in response to an oil price rise. Indeed, I calculate that the recent 50 percent rise in oil prices may account for the federal funds rate being 50 to 100 basis points below where it would be otherwise.

This is not to say that Greenspan has taken his eye off inflation. He has managed to keep inflation low and he has acted aggressively against increases in inflation expectations. Nevertheless, the wisdom of this new accommodative response to oil price changes is unclear. Oil price spikes (both up and down) are short lived and may not even have a direct effect on U.S. economic activity, as recent evidence seems to indicate. A policy that responds to oil prices may foster a monetary policy environment of "fine tuning", rather than one based on maintaining low inflation.

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We all remember the 1970's. Disco. Unemployment. Inflation. Obviously things were not good. While we shouldn't blame disco on the "oil shocks" of the 1970's, macroeconomic textbooks and policymaking were substantially revised in light of the stagflation that was experienced during this time period.

Were oil prices the real culprit responsible for causing such economic turmoil? Quite remarkably, the economics profession largely agrees that substantial declines in real output growth and surges in core measures of inflation in the 1970's were directly affected by these "oil shocks". In a recent set of papers, former Federal Reserve economist Mark Hooker (1996) establishes the following scenario for the oil-macroeconomy relationship in the U.S. First, that real GDP growth prior to 1980 was negatively affected by oil price changes (where oil prices are measured by producer price index for crude inflation less the overall rate of inflation). Second, that oil prices changes affected core measures of inflation far in of oil's expenditure share in domestic spending and price indices.[1] Third and most importantly, however, he finds that after 1980 this relationship between oil prices and growth and inflation has disappeared statistically. Namely, oil price changes have not had a statistically significant effect on real GDP growth, the unemployment rate, or the rate of overall inflation since 1980.

In Figure 1 I plot real GDP growth and the oil price variable from 1959:Q2 to 2000:Q2. The scale for GDP growth is on the left-hand side (from –12% to +16%), while the scale for the oil price variable is on the right hand side (from –200% to +200%). The data are quarterly, but expressed as annualized growth rates. There are three striking aspects about the oil-real growth relationship: first, oil prices have become much <u>**more**</u> volatile in the 1980's and 1990's (i.e. lots of upward spikes <u>**and**</u> downward spikes) at the same time that real GDP growth has become much <u>**less**</u> volatile. Second, while the early oil spikes in 1973 and 1979 did precipitate downturns in the

[1] Mark Hooker, "What happened to the oil price-macroeconomy relationship?" <u>Journal of Monetary Economics</u>, 1996, p. 195—213. Mark Hooker, "Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime," Board of Governors of the Federal Reserve System, <u>Finance and Economics Discussion</u> Series #99-66 http://www.bog.frb.fed.us/pubs/feds/1999/199965/199965pap.pdf

economy, the evidence since 1980 is much weaker. From 1959:Q2 to 1979:Q oil prices have grown by more than 40% (on an annual basis) in a quarter 3 times and have never fallen by 25% (on an annual basis) in a quarter. Indeed, each time the oil price measure rose above 40%, a recession soon followed. In contrast, from 1980:Q1 to 2000:Q2, oil prices have grown by more than 40% (on an annual basis) in a quarter 16 times since 1980 and fallen by 25% (on an annual basis) 14 times. Obviously, oil's reliability to predict GDP growth has dramatically lessened. Finally, the up and down swings in the oil price suggests that much of its movement is temporary. Indeed, over the entire sample, the statistical evidence suggest that there has been no change in the relative price of oil since 1959, and that one can comfortably reject the hypothesis that the relative price of oil has experienced permanent shifts.

So why hasn't the recent spike in oil prices lead to a fundamental disruption of the U.S.? First, the rise in oil prices partly reflects an increase in world demand for oil that is due to a pick-up in world wide economic activity. This pick-up is good news for the U.S. and its exports. Second, Alan Greenspan's recent talk at the Cato Institute made several fundamental points about the "new" oil-macroeconomy relationship.[2] He argues that the oil industry has been greatly affected by new technology, which has lowered the long run marginal cost of exploration. Indeed, he points to the fact that the prices for the very longest futures contracts for oil lay well below the current spot price as supporting evidence of this declining marginal cost. Moreover, he argues that due to earlier energy price rises, "*the energy intensity of advanced industrial economies has been reduced by half from the levels of the early 1970s*." He concludes that, baring unforeseen political disturbances, the price of oil should return to a lower level consistent with the declining marginal cost of oil, after inventory levels are restored.

Does the Federal Reserve Board take a position as to how oil price changes affect output and inflation? In the January 1999 edition of the Federal Reserve Bulletin, economists David Reifschneider, Robert Tetlow and John Williams as part of a study on the on the Federal Reserve Board's large-scale model (FRB/US), simulated the effects of a rise in oil prices.[3] They simulated the effect on the U.S. economy from a $10 permanent increase in the price of a barrel of oil relative to the price of all other goods, that gradually builds up over 1 year. They report that if the Fed were to keep the real federal funds rate constant, the level of GDP would be below its baseline trend by 0.2 percentage points after 1 year and by 0.4 percentage points after two years. In ten years, the level of GDP would be 0.3 percentage points below its baseline trend, and

[2] http://www.bog.frb.fed.us/boarddocs/speeches/2000/200010192.htm
[3] David Reifschneider, Robert Tetlow and John Williams, "Aggregate disturbances, monetary policy and the Macroeconomy: the FRB/US perspective," Federal Reserve Bulletin, January 1999, p. 1-19. http://www.bog.frb.fed.us/pubs/bulletin/1999/0199lead.pdf

inflation would be higher by 0.4 percentage points. Indeed, over a two-

similar response by GDP and inflation to the oil price change even if the Fed were to use an

[4] Indeed, after 10 years the response of the level of GDP to the oil price shock is

-1.1 percentage points below the baseline, although the effect

inflation after ten years is virtually zero. This finding reflects one of the proposed benefits of using a Taylor rule: namely, a stronger connection to maintaining low inflation.

The important lesson to see here is that even with a large permanent shock

oil relative to all other goods, the magnitudes reported in this Fed study are not large enough to warrant even remote fears of a severe slowdown brought about by higher oil prices. Moreover,

temporary rather than permanent, the true response of the FRB/US macroeconomy to these shocks would be much smaller than those reported by the

cited above.

So how has the Fed responded to oil price shocks in the past? There are a number of

rise (decline) in inflation, then the Fed may wish to use this information when determining the

lead to a decline (rise) in real growth rates, then the Fed may also wish to take this into account when setting monetary policy if they

examining the influences of inflation and output on the setting of monetary policy is to estimate a "Taylor rule". As discussed above, a Taylor Rule simply sets the federal funds rate in order to

lize output while still targeting and maintaining low inflation. There are a number of ways to specify a Taylor rule, but they all have three things in common. First, the nominal federal funds

-for one to expected inflation, as the Fed must raise the real fed

above it's long run level. Second, to conduct counter-

respond to increases (decreases) in output above its long run potential level by raising (lowering) the federal funds rate. Finally, the Fed may want to take a gradualist approach to monetary policy

me. The generic presentation of the Taylor rule is thus:

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where i_t is the nominal federal funds rate, $(Y_t - \bar{Y}_t)$ is the current output gap measured as the log-level of real GDP relative to its potential (as published by the Congressional Budget Office), and $E_t(\pi_{t+k})$ is the time t expectation of inflation k periods from now. The error term reflects both lagged interest rate effects as well as unexplained changes in federal funds rate.[5] The coefficient on b should be positive, while the coefficient on c should be greater than one. Again, the latter is argued as follows: The Fed must raise real interest in response to a rise in inflation expectations (i.e. the nominal federal funds rate must over-respond to changes in inflation expectations) to dampen interest rate sensitive spending in order to obtain its inflation target.

So how do we make the Taylor rule operational? The problem is that when the Fed sets the federal funds rate it neither observes the current output gap nor the expected level of inflation. Therefore a backward looking Taylor rule is often specified such as:

$$i_t = a + b *(Y_{t-1} - \bar{Y}_{t-1}) + c* (1/4) (\Sigma^4_{j=1} \pi_{t-j} /4) + \text{error} \qquad (2).$$

so that last period's gap is used for the current period gap and a lagged four quarter moving average of inflation is used as a proxy for future inflation. Of course, these shortcuts could be quite imprecise and could actually allow for an oil price variable to help predict interest rates, especially if oil prices help to predict future inflation and the strength of the economy. Hence a backward looking Taylor rule, though not a forward looking one, may pick up an effect of oil prices on federal reserve policy such as:

$$i_t = a + b * (Y_{t-1} - \bar{Y}_{t-1}) + c* (1/4) (\Sigma^4_{j=1} \pi_{t-j} /4) + e* OIL_{t-1} + \text{error}. \qquad (3).$$

OIL is measured, as in Hooker's work, as the growth of the producer price index for crude less the overall rate of inflation.

Table 1 presents estimates of the backward looking Taylor over a number of different regimes and both with and without OIL. The estimates presented in columns (I)-(III) present the results for the backward looking Taylor rule, equation (2). The last three columns include an oil price variable to help pick up information about future inflation that may be omitted in the simple backward looking rule, equation (3). Columns (I) and (IV) present estimates for the Fed's

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more below.

[5] More precisely, I estimate using non-linear least squares with robust standard errors:
$i_t = (1-\rho_1-\rho_2) *[a + b * (Y_{t-1} - \bar{Y}_{t-1}) + c* (\Sigma^4_{j=1} \pi_{t-j} /4) + e* OIL_{t-1}] + \rho_1 i_{t-1} + \rho_2 i_{t-2} + \text{error}.$
The coefficient "a" is a combination of the Fed's long run inflation target, the parameter "c" and the long run real interest rate.

interest rate rule during the 1970's prior to Volcker's arrival in 1979:Q3, while columns (II) and (V) do so for the Volcker Chairmanship (1979:Q3 to 1987:Q2), and (III) the third and sixth does so for the Greenspan Chairmanship (1987:Q3-2000:Q2).

The findings reported in this table can be summarized in four key points. First, the interest rate rule has a good fit over all three time-periods. As suggested by the R^2, the actual and predicted interest rates are more than 85% correlated. Second, the results in columns (I)-(III) when lagged oil prices are excluded from the Taylor rule, suggest that the funds rate responds positively to lagged inflation, although the responses are not significantly greater than one. Recall that a coefficient greater than one is needed to stabilize inflation, as the rise in real interest in response to inflation dampens interest rate sensitive spending which reinforce a low inflation environment. Third, whether the OIL variable is included or not in these backward looking Taylor rules, Volcker responds more aggressively against inflation and the least to the output gap.

Finally, the effect of oil prices on the federal funds rate has changed over time. In the pre-Volcker period (column (IV)), oil price increases suggested an extra rise in the federal funds rate. From the estimate reported in column (IV), if oil prices rose 10%, this would lead to an associated 25 basis point rise in the federal funds rate. Indeed, the effect of oil prices on the Fed's behavior is consistent with Hooker's (1999) finding that oil prices contain information about future inflation that may not be contained in a backward looking Taylor rule which only uses lagged inflation as a measure of future inflation. Also, under the pre-Volcker 1970's the estimate coefficient on inflation falls below 1.0, which is likely related to the fact that lagged inflation may have been a worse proxy for future inflation than oil prices, and further suggests the lack of aggressiveness against inflation during this time period.

However, the effect of oil prices on a backward looking Taylor rule has changed during the tenures of Volcker and Greenspan. For Volcker (column (V)), oil prices do not seem to predict federal funds rate changes. They do, however, for Greenspan (column (VI)). In direct contrast to the findings for the pre-Volcker time period, oil price rises (decreases) are met with interest rate decreases (rises), everything else equal. The interpretation would have to be that the Fed feels that oil price rises do not bring about worries of future inflation so much as they bring worries of future output losses which need to be offset. Based on the estimate coefficient on OIL in the backward looking Taylor rule, the recent 50% rise in oil prices has shaved 50 basis points off the funds rate.

A shortcoming of the results from backward looking Taylor rules is that the Fed does not target past inflation and output gaps in its interest rate setting, but rather it is concerned about future inflation and the current output gap. Hence the presence of oil prices in backward looking

Taylor rules may simply be pick up these future effects rather than being an independent measure which affects monetary policy deliberations. To overcome these worries, Table 2 presents results for forward-looking Taylor rules. The key statistical issue is that I estimate the coefficients in the forward looking rule taking into account that while I do not know the exact values of these future variables I know that they are correlated to information that I (and the Fed had) at time t. This information includes things like lagged values of inflation, the output gap, oil prices, and interest rates. This statistical approach is referred to as `Instrumental Variables".

The estimates of the forward looking rule, equation (1), where the Fed rule includes next periods inflation (k=1) and the current output gap, are presented in columns (I)-(VI) of Table 2. The Table is organized as in Table 1. There are two key findings. First, the response of the funds rate to lagged oil prices during the Pre-Volcker period of the 1970's is no longer statistically significant (column (IV) of Table 2) as it was in the backward looking rule (column (IV) of Table 1). This suggests that for this time period, the fact that oil prices were significant in the backward looking rule but not in the forward looking rule means that oil prices during this time period were helpful at forecasting future inflation and did not have an independent impact on policy. Furthermore, during the pre-Volcker 1970's the responsiveness of the nominal federal funds rate to changes in inflation expectations, while slightly greater than one, is not likely to have been large enough to keep inflation from accelerating.[6]

The second key finding is that oil prices remain statistically significant and negative in a forward looking Taylor rule during the Greenspan era. For example, as reported in column (VI), the responsiveness of the funds rate to future inflation remains more than one-for-one, but changes in oil prices still suggest that the Fed keeps monetary policy looser (tighter) than it would be otherwise in response to an oil price rise (decline). Just to check to make sure that this finding does not change if I were to slightly alter the nature of the Taylor rule, in column (VII) I re-estimate the Taylor rule but allow the Fed's rule during Greenspan's chairmanship to include inflation four quarters ahead (k=4). The findings are similar in that the coefficient on future inflation is still above one (it actually rises to 1.8 as compared to 1.3 when the Fed targeted inflation 1 quarter ahead), while the coefficient on oil remains negative. Namely, rises in oil prices puts downward pressure on the funds rate. In column (VIII), I allowed the Fed to include the output gap four quarters ahead in its policy rule rather than just the current quarter. Indeed, the Fed's anti-inflation response continues to grow (the coefficient on future inflation is over 2.1), the coefficient on the future output gap is not statistically significant, while the coefficient on the oil price variable remains negative and statistically significant. Across all thee specifications for the forward looking rule under Greenspan (columns (VI)-(VIII)), suggests that a 50% increase in oil prices lowers the federal funds rate by between about 70 and 100 basis points.

Policy Conclusions

So what has this analysis taught us about the effect of oil prices on Federal Reserve behavior? First, that during most of the 1970's, oil price changes did affect the Fed's behavior because they contained essential information about expected future inflation. The Fed raised rates in response to oil price rises in order to help contain future inflation. After controlling for this effect of oil prices on future inflation, however, oil prices did not independently affect the path of the federal funds rate during this time period. However, the Fed's response against inflation is likely to have been insufficiently aggressive to stop inflation from accelerating.

Second, the Fed's response to oil prices has changed under Greenspan. Rather than treating oil prices as harbinger's of future inflation, he has treated them as harbinger's of weakness in real side activity that need to accommodated with easier monetary policy. For example, I calculate that the recent 50 percent rise in oil prices may account for the federal funds rate being 50 to 100 basis points below where it would be otherwise.

This is not to say that Greenspan has taken his eye off inflation. He has managed to keep inflation low, and he has responded to increases in future inflation aggressively which has stopped inflation from ever accelerating. Nevertheless, the wisdom of this new accommodative response to oil price changes is unclear. Since oil price spikes (both up and down) are largely temporary, and their effect on real output since 1980 is deemed to be quite small and statistically insignificant, such a policy may foster a environment of unnecessary monetary "fine tuning". Rather, the Fed's objectives are likely to be better served by concentrating on maintaining an environment of low inflation than by accommodating temporary, relative price shocks whose impact and exact timing on the economy are likely to be small and unknown.

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[6] A further issue is that the Fed's long run inflation target may have differed across these two time periods, which is buried in the estimate of the coefficient "a" (not reported). Differences in inflation targets would be a further reason why inflation was substantially higher in the pre-Volcker 1970's.

Table 1: Estimates of a Backward Looking Taylor Rule using Quarterly Data

Variable	Without OIL Pre-Volcker (I)	Without OIL Volcker (II)	Without OIL Greenspan (III)	With OIL Pre-Volcker (IV)	With OIL Volcker (V)	With OIL Greenspan (VI)
$(Y - \bar{Y})_{t-1}$	.952***	−.013	.779***	.853***	−.012	.825***
	(.142)	(.110)	(.127)	(.104)	(.111)	(.132)
$(\Sigma^4_{j=1}\ \pi_{t-j}/4)$	1.020***	1.232***	1.093***	0.899***	1.202***	1.124***
	(.154)	(.136)	(.348)	(.120)	(.147)	(.325)
OIL_{t-1}				.025***	.004	−.010**
				(.007)	(.005)	(.005)
R^2	.903	.879	.971	.924	.881	.974
NOBS	38	32	52	38	32	52

Standard errors are reported in parentheses. ***, **, and * refer to statistical significance at or below the .01, .05 and .10 level of statistical significance, respectively. R^2 is the R-squared or correlation between the actual value of the dependent variable and the predicted one. NOBS is the number of quarterly observations. The pre-Volcker time period is 1970:Q1-1979:Q2, the Volcker time period is 1979:Q3-1987:Q2 and the Greenspan period is 1987:Q3 – 2000:Q2. A dummy variable for the credit control period of 1980:Q3 is included in the Volcker time period.

Table 2: Estimates of a Forward Looking Taylor Rule (Using Instrumental Variables) Using Quarterly Data

	Without OIL			With OIL				
Variable	Pre-Volcker	Volcker	Greenspan	Pre-Volcker	Volcker	Greenspan		
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
$(Y_t - \overline{Y}_t)_t$	$.506^{**}$	$-.177$	$.625^{***}$	$.486^{**}$	$-.171$	$.631^{***}$	$.435^{*}$	
	(.209)	(.202)	(.217)	(.225)	(.206)	(.213)	(.247)	
$(Y_{t+4} - \overline{Y}_{t+4})$								.421
								(.292)
π_{t+1}	1.180^{***}	1.629^{***}	1.142^{**}	1.296^{***}	1.566^{***}	1.310^{***}		
	(.154)	(.338)	(.542)	(.196)	(.316)	(.462)		
π_{t+4}							1.804^{***}	2.158^{***}
							(.532)	(.532)
OIL_{t-1}				$-.012$	.008	$-.014^{*}$	$-.018^{*}$	$-.021^{**}$
				(.007)	(.008)	(.005)	(.008)	(.009)
R^2	.875	.864	.970	.851	.869	.972	.966	.962
NOBS	38	32	51	38	32	51	48	48

The estimates were obtained using instrumental variables that are know as of time t, i.e. lagged inflation rates, oil prices, federal funds rates and output gaps. Standard errors are reported in parentheses. ***, **, and * refer to statistical significance at or below the .01, .05 and .10 level of statistical significance, respectively. R^2 is the R-squared or correlation between the actual value of the dependent variable and the predicted one. NOBS is the number of quarterly observations. The pre-Volcker time period is 1970:Q1-1979:Q2, the Volcker time period is 1979:Q3-1987:Q2 and the Greenspan period is 1987:Q3 – 2000:Q2. A dummy variable for the credit control period of 1980:Q3 is included in the Volcker time period. The number of observations declines for the Greenspan period as one loses values of future inflation that go beyond 2000:Q2.

Figure 1: Real GDP Growth and Oil Prices

Oil prices measured as PPI for crude and oil inflation relative to overall inflation. Data are quarterly and expressed as annualized growth rates.