AN ABSTRACT OF THE THESIS OF

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During the 1970's the United States experienced several periods of high inflation that have been at least partially attributed to positive oil price shocks. The effectiveness of the Organization of Petroleum Exporting Countries at controlling the price of oil has varied over time, as well as the responsiveness of U.S. inflation to an oil price shock. Current economic theory, supported by empirical data, suggest that oil price shocks can lead to short run changes in inflation. Since the GDP deflator can be considered the average price of final goods produced in an economy, the effects from an input price change can be quite different on the GDP deflator from the Consumers Price Index which measures the average price of consumption. As the price of oil rises, nominal value added falls while domestic real value added remains constant, creating a short run deflation in value added measures such as the GDP deflator. The CPI experiences rising inflation because the consumer's goods basket has now become more expensive from the rising price of oil. In the long run, inflation is not affected by an oil price shock because it is controlled by monetary policy.

Key Words: oil price shock, inflation, OPEC, monetary policy

Corresponding e-mail address: whitaken@onid.orst.edu

The Effects of Oil Price Shocks

on U.S. Inflation

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Natasha M. Kilfoil

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APPROVED:

Mentor, representing Economics

Committee Member, representing Economics

Committee Member, representing Economics

Chair, Department of Economics

Dean, University Honors College

I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

Natasha M. Kilfoil, Author

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The Effects of an Oil Price Shock on U.S. Inflation

INTRODUCTION

Positive oil price shocks lead to consumer concerns and negative effects on output. Hamilton (2006) found that nine out of the ten recessions since World War II were preceded by an oil price shock. This leads to the generalized conclusion, and statistically supported conclusion, that oil price shocks are correlated with negative GDP growth. While much of the research focuses on how oil price shocks affect GDP, we will explore how oil price shocks affect inflation. Carlstrom and Fuerst (2005) found that both an oil price shock and a rise in the federal funds rate preceded every recession since 1971. While both variables theoretically can affect inflation, determining the amount that each does affect inflation is important in evaluating the role of the Federal Reserve Board. Using current economic theory, supported by empirical data, we will demonstrate that an oil price shock will lead to short run inflation changes in the United States, but that it has no sustained impact on inflation measures.

The research suggests that short run inflation measures peak about a year after the initial oil price shock and subsequent change in monetary policy. Barsky and Kilian (2001) find that this delay is due to sluggish firms taking time to realize that there was a change in monetary policy. The firm’s slow response leads to CPI inflation peaking three to four quarters after an oil price shock and the GDP deflator experiencing a sharp drop during the fifth quarter. Neither inflation measure experiences a long run impact from an oil price shock. Economic theory suggests that any long run increase in inflation has stemmed from the Federal Reserve Board's monetary policies.

In order to understand the theory and empirical evidence behind an oil price shock, it is important to define what an oil price shock is and what its causes are. According to the Department of Energy (2006), the United States imported 66% of its crude oil supply in 2005. While the countries that we import the most oil from are Canada and Mexico, 47% of imported oil comes from members of the Organization of Petroleum Exporting Countries. Hamilton (2002) and Kilian (2005) examined several historical events to determine what periods of time may have experienced an oil price shock. They also normalized oil production levels over time to statistically find what periods experienced an oil price shock.

To analyze what happens to inflation in the short run and long run we use models developed by Barsky and Kilian (2001). The long run model utilizes the slow response of sluggish firms to explain why it takes three to four quarters to experience an inflationary response. This model was also desirable because it has the Federal Reserve Board establishing an adjusted inflationary target and using a mechanical adjustment to move inflation. This model clearly shows that it is only through a change in monetary policy that the United States will experience a long run increase in inflation.

Barsky and Kilian's (2001) short run model derives the deflator for value added. The value added deflator comes from nominal value added divided by domestic real value added. Nominal value added is defined by nominal gross output less nominal oil imports. As the price share of oil rises, nominal value added falls while domestic real value added remains constant. Nominal value added falling as real value added remains constant creates a short run deflation in value added measures such as the GDP deflator. This model suggests that an oil price shock can lower the price of value added while raising the price of gross output in the short run.

Hamilton (2005) found that the period under analysis mattered greatly in analyzing the size of the GDP growth response to an oil price shock. The same regression analysis showed an average 2.9% slow down in GDP growth caused by an oil price shock from 1949 to 1980. The slow down in GDP growth from an oil price shock fell to only a 0.7% decline over the period of 1949 to 2005. Based on the changes in the strength of OPEC, along with U.S. changes in monetary policy and increased dependence on foreign oil, I chose to consider the current era of how oil price shocks affect inflation beginning in 1973. Hamilton (1996) and Hooker (1996) found that from 1973 until the mid-1990's oil price shocks did not have a statistically significant impact on GDP growth. Kilian (2006) found that since 1973 the GDP deflator dropped sharply during the fifth quarter after an oil price shock supported at the 95% confidence interval. A slight decline in the GDP deflator is supported at the 68% confidence interval until the seventh quarter. Using a similar approach, Kilian (2006) found that the only time that a positive CPI inflation spike is supported by at least the 68% confidence interval is three to four quarters after an oil price shock.

The paper is organized as follows: Section II looks at the long run theory on inflation responses from an oil price shock; Section III looks at the theory analyzing short run inflation impacts from an oil price shock; Section IV defines an oil price shock; Section V looks at how oil price shocks have varied over time; Section VI looks at the empirical inflation results from an oil price shock; and Section VII concludes.

LONG RUN INFLATION THEORY

Bernanke, Gertler, and Watson (1997) and Barsky and Kilian (2001), propose that it was the Federal Reserve Board's monetary policy changes, rather than increases in the price of oil, that have lead to long run increases in inflation. This varies from an early theory, argued by Hamilton (1983), that political unrest in OPEC countries led to higher oil prices and then subsequently to higher levels of U.S. inflation. While monetary policies may be influenced by a rising oil price, it is argued that it is expressly the Federal Reserve Board's changes in monetary policy that lead to changes in long run inflation. The positive or negative inflation changes associated with the rising price of oil and change in monetary policy will be discussed later in this paper. It has been generally accepted that monetary policy changes can lead to a sustained inflationary response, and I will utilize Barsky and Kilian's (2001) model to investigate if oil price shocks can lead to a sustained inflationary response.

Barsky and Kilian's (2001) model suggests that inflation rates return to the steady state in the long run. They propose a market composed of firms that are "sleepy" and firms that are "awake." The sleepy firms, w_t, are sluggish and only learn slowly about the monetary policy shift. They continue to set their output price, p_t^s, based on the previous period's price and inflation rate. The firms that are awake, $(1-w_t)$, realize that monetary policy has changed, and adjust their output prices to $p_t^w = p_t + \beta(y_t - y_t^f)$. In this formula, β is a constant, y_t is the log of real GDP, and y_t^f is the log of potential real GDP. The percent of agents that remain unaware of the regime change evolves over time according to $w_t=e^{-\lambda t}$. Combining these pieces establishes the aggregate price-setting equation

(A) $p_t=w_t\, p_t^s + (1-w_t)\, p_t^w = e^{-\lambda t}\,(2p_{t-1}-p_{t-2})+(1- e^{-\lambda t})(\, p_t+ \beta(y_t-y_t^f))$.

The next piece added to this model is a simple money demand equation, where

(B) $\Delta y_t = \Delta m_t - \Delta p_t$.

In this equation, the Δp_t is the inflation rate --defined in this model as the GDP deflator-- and Δm_t is the rate of monetary growth. The money demand equation tells us that if there is no change in output, then the growth in the money supply determines the rate of inflation.

The last piece of this model is a policy reaction function. Let π be defined as the level of inflation prior to and as it responds to an oil price shock. Following the oil price shock, the Federal Reserve Board establishes π^{new} as the new inflationary level that they deem acceptable. When $\pi > \pi^{new}$ the Federal Reserve Board decelerates monetary growth by some small fraction γ until $\pi = \pi^{new}$. This becomes part of the formula

(C) $\Delta^2 m_t = -\,\gamma\,\Delta\, p_{t-1} I(\Delta\, p_{t-1} > \pi^{new}) + \Delta\varepsilon_t$.

In this equation $I(\cdot)$ is an indicator function, ε_t represents the increase in the money growth rate associated with the Federal Reserve Board's expansionary policy, and γ represents the deceleration rate of monetary growth when considering last periods excess inflation rate.

With the model established, I will analyze what real values of the parameters will imply in terms of long run inflation. In Barsky and Kilian's analysis they set $\pi = 3\%$ annually, $\beta = 0.06$, $\lambda = 0.08$, and $\gamma = 0.05$. I will specifically look at Barsky and Kilian's values for π, λ, γ, and examine the implications and accuracy of the values they chose.[1]

The value of λ is important because it establishes the rate at which agents become aware of the monetary change, determining when sluggish inflation hits the market. Barsky and Kilian's value of $\lambda = 0.08$ means that they believe that it takes two years for only about half of the economic agents to realize that there has been a change in monetary policy. This value may be true for some markets, such as their pharmaceutical example. Since Kilian (2006) found that the median CPI inflation responds to an oil price shock by a short run increase peaking in the third to fourth quarter, followed by a declining impact, this assumption does not seem to hold for our market. Even the change in the GDP deflator due to an oil price shock is only supported in Kilian's (2006) model at the 68% confidence interval only until the seventh quarter after the initial shock. If it took two years for only half of the economic agents to discover that a monetary change occurred, the longest inflationary response would not be dissipated by the seventh quarter following the initial change in monetary policy.

While I believe that they underestimated the speed at which sluggish inflation would hit the market by nearly half, this model does help to counter Hamilton and Herrera's (2004) argument against Bernanke, Gertler, and Watson's findings. Bernanke, Gertler, and Watson (1997) found that the change in long run inflation results not from the oil price shock, but rather from the initial

[1] The value of β, the slope of supply, seems reasonable since it is a positive constant.

monetary tightening from the Federal Reserve Board. They suggest that the change in monetary policy could explain Hamilton's results of a rather large short run inflationary response from an oil price shock. In response to this, Hamilton and Herrera argue that if Bernanke, Gertler, and Watson were correct, then why did the inflationary response not surface for three to four quarters following the shock? In Barsky and Kilian's model, sluggish inflation occurs when agents are slow to adjust their prices based on being unaware of or not believing that a change in monetary policy has occurred. This varies from explaining the slow inflationary response by the expenses associated with changing menu costs, or Herrera's (2000) argument of excess inventories, following an oil price shock.

Setting $\gamma = 0.05$ implies that in the long run, the inflation rate returns to the steady state, as would any other positive value of γ. Should $\gamma = 0.05$, then that means that the Federal Reserve Board will decelerate monetary growth by 1/20th of the initial monetary expansion. The 0.05 value does not necessarily reflect the absolute value of γ, but rather illustrates the point that the Federal Reserve Board may use a mechanical adjustment to reach their inflation target. Returning to the inflation target implies that the initial change in monetary policy will not result in sustained inflationary pressure because they will slow down their initial monetary expansion.

If the Federal Reserve Board set $\gamma = 0.00$, then the initial monetary expansion would lead to a sustained level of higher inflation. Since ε_t represents an increase in the money growth rate associated with the Federal Reserve Board's expansionary policy, combined with zero deceleration in the monetary growth rate, the Federal Reserve Board will have a sustained increased rate of growth for the money supply. Recalling the money demand equation, it becomes clear that without a change in output, inflation must increase by a proportional amount to the increase in money supply growth. This intuition helps explain that an oil price shock which causes CPI inflation to rise will require the Federal Reserve Board to increase the money supply growth rate to accommodate a steady level of output. The policy reaction function illustrates that as long as the inflation rate is above their inflation target that the Federal Reserve Board will gradually decelerate the monetary growth rate, following the initial expansion, until the inflation target is reached.

The values of π and γ also depend on inflation expectations. The level of π^{new} is established based on what level of inflation is now deemed acceptable by the Federal Reserve Board. Sommer (2002) compared the period before and after Volcker's disinflation that occurred in the early 1980's. He found that prior to Volcker, oil price shocks had a long-run affect on inflation of approximately half the size of the initial impact. From 1983 to 2000, Sommer found that the effect of inflation shocks dissipated within half a year, and had a negligible effect on long run inflation levels. He argues that this is because the public expects the Federal Reserve Board to act, resulting in oil price shocks no longer affecting long run inflation. The public now expects that the Federal Reserve Board will lower inflation to an acceptable rate, π^{new}, following a monetary expansion.

De Long (1995) found that during the 1970's the professional forecasters consistently underestimated inflation for the following year's GDP deflator. Based on their previous experiences during the 1950's and 1960's, the forecasters expected inflation to fall the following year. Since they expected inflation to fall, in Kilian and Barsky's model the value of γ would be very small or perhaps even negative. The Federal Reserve Board also expected a fall in inflation and so were not concerned with their expansionary monetary policy.

De Long (1995) believes that part of the monetary policy choices were also made with the intent of keeping high levels of employment. He called this the "shadow of the Great Depression" because policymakers believed that expansionary policy was necessary to maintain high employment levels and keep the economy running strong. During the 1960's President John F. Kennedy believed that we could not "afford to settle for any prescribed level of unemployment;" Samuelson and Solow (1960) believed that a 4-5% inflation rate would keep unemployment below 3%; and Arthur Okun, the former Council of Economic Advisors Chair, thought that the U.S. should set a target of 4% unemployment and a 2% inflation level. (De Long 1995) With this background it is easier to understand how the professional forecasters consistently underestimated the following year's inflation.

The relationship between the Federal Reserve Board and inflation is certainly not static. When an oil price shock causes short run inflation the Federal Reserve Board uses a reactionary monetary policy to adjust the inflation rate back to what they deem acceptable. As long as the current inflation rate is higher than the Federal Reserve Board's inflation target, they will adjust the money supply to diminish any potential long run inflationary effects from an oil price shock.

SHORT RUN INFLATION THEORY

While oil price shocks may not cause sustained higher levels of inflation, it is important to understand what is occurring in the short-run. I will utilize a model proposed by Barsky and Kilian (2001) to analyze what is happening to short run inflation in response to an oil price shock. I will use this model to carefully assess if there is a short run inflationary response to an oil price shock, as well as to determine the sign of the inflationary shock. While CPI inflation will certainly rise with an oil price shock, we will analyze the more ambiguous effects that an oil price shock has on the GDP deflator.

A typical production function looks like Y=F(K,L), where output is a function of capital and labor. Blanchard (2006) helps to develop this basic model by expanding it to capture a change in technology. As an independent variable, the state of technology, x, informs us of how much output can be produced from a given amount of capital and labor. Output can be defined as Y=F(K,L,x), where output is a function of capital, labor, and technology change.

Barsky and Kilian (2001) assume that gross output depends on domestic production, adjusted for value added, as well as the quantity of oil imports. Their model begins with the gross output quantity being given by the production function

(1) $$Y = Q[V(K,L,x),O],$$

where O is the quantity of oil imports and V(K,L,x) represents the domestic value added. The sum of value added in domestic production, V(K,L,x), is an interpretation of real GDP. Blanchard (2006) describes value added as the sum of the value of produced goods less the value of intermediate goods used in production.

Finn (2000) compared oil price shocks to a negative technology shock, but our model has separated these two market factors. Blanchard (2006) describes technological progress as the increases in output that can be produced from a given number of workers. A negative technology shock would imply declining output from a given number of workers. Jones, Leiby, and Paik (2002) examine this relationship and find that an oil price shock reduces potential output because it is similar to a reduction in resources available. They also argue that an oil price shock can affect the economy through sticky wages and income transfers to oil exporting countries. An oil price shock changes the amount of resources available for purchase, but does not change the rate of domestic value added. Even though separating oil from the production function is a debatable decision, I find that oil price shocks should be separated from a technological change because the effects on the economy are beyond the scope of being fully captured by treating them as a change in technology.

By considering symmetric firms that produce a similar good, Barsky and Kilian derive the gross output production function

(2) $$Y_t = Q(V_t(L_t), O_t).$$

In this model O_t is the quantity of foreign oil used in production, Q is homogenous of degree one in its arguments, and V_t represents function of labor hours and capital, and is equivalent to real GDP. Capital stock is assumed to be fixed in the short run, ensuring the concavity of V_t.

By assuming that demand for money balances is proportional to nominal gross output, Barsky and Kilian (2001) find that

(3) $M_t = kP_tY_t$.

In this model P_t is the price of gross output. Nominal gross output, P_tY_t, is determined solely by the money stock.

Barsky and Kilian logarithmically differentiate (2) and (3) with respect to P_t^o. Assuming perfect competition and an inelastic labor supply, they find that the change in gross output production is

(4) $\Delta Y_t = -(s_o/(1-s_o))\ \varepsilon_{o,v}\ \Delta P_t^o$;

and the change in the price of gross output is:

(5) $\Delta P_t = (s_o/(1-s_o))\ \varepsilon_{o,v}\ \Delta P_t^o$.

where s_o is the cost share of oil in gross output, $\varepsilon_{o,v}$ is the elasticity of substitution between value added and oil, and Δ expresses percent change. An increase in the import price of oil leads to a decrease in the quantity of gross output and an increase in the price of gross output.

Nominal GDP can be represented by $P_tY_t-P_t^oO_t$, where P_t^o is the price of imported oil, and P_t is the price of gross output. The deflator for value added can be defined as the ratio of nominal price increases over the real value added:

(5) $P_t^v= (P_tY_t-P_t^oO_t)/(V_t(L_t)) = (P_tY_t(1-s_o))/(V_t(L_t))$

For this model, $V_t(L_t)$ is assumed to be the domestic value added associated with capital and labor. Domestic value added can be thought of as real GDP, and an increase in the price of foreign oil imports will not produce any short run change in the denominator. Since nominal gross output is determined solely by the money stock, as the cost share of oil, $P_t^o O_t$, rises, the numerator will fall if the money supply is held constant.

Since nominal GDP falls as real GDP remains constant, this model suggests that the GDP deflator may decline. In order for the GDP deflator to be inflationary from a positive oil price shock would require a decline in real value added or a proportional increase in nominal gross output. This model held real GDP constant because an oil price shock does not change the domestic value added in the short run.

The negative percent change in the price of value added is equivalent to the positive percent change in the price of gross output. A positive oil price shock can lower the price of value added as it raises the price of gross output. This implies that an oil price shock may be deflationary for value added measures even as it is inflationary on measures of gross output.

The GDP deflator is a measure of inflation that relates the growth of nominal GDP to the growth of real GDP. The Consumer Price Index, or CPI measures the average price of consumption. Blanchard (2006) helps to separate these two measures by considering the GDP deflator as the average price of outputs, or the final goods produced in an economy.

The Department of Energy (2006) found that 66% of the U.S. crude oil consumed in 2005 was imported from abroad. Since most of the oil is not produced domestically, an oil price shock can have different effects on the CPI than on the GDP deflator. The consumer price index is inflationary in the short run because the consumer's goods basket has become more expensive associated with rising oil prices. Even though the CPI may be a better measure of what the consumers are experiencing, as well as a more important index for political re-election, the short run results of an oil price shock on the CPI are less ambiguous.

This model has demonstrated that an oil price shock will lead to deflationary pressure on the GDP deflator while simultaneously putting inflationary pressure on the CPI. While these results may seem counterintuitive, we will find that the empirical evidence supports the findings from this model.

DEFINING AN OIL PRICE SHOCK

The way that oil price shocks affect the U.S. economy has varied over time, and our definition of an oil price shock begins by identifying the time period under consideration. We will identify two methods of defining an oil price shock. The first method examines exogenous political events and the effects that they have had on oil prices. The second method identifies the periods of time in which there was a real net oil price increase that was statistically significant for that particular period under consideration. We will then examine the relationship between real net oil price increases and exogenous political events.

While it may be important to focus on the Federal Reserve Board’s monetary policy changes that have occurred since Volker’s disinflation, I will consider the modern OPEC period beginning in January 1973. During this era the Organization of Petroleum Exporting Countries strengthened significantly. Before this time period the Texas Railroad Commission had held a large enough share of the market to offset the consequences of an oil supply disruption from exogenous political events.

Since there is a statistically strong relationship between an exogenous event in an OPEC country and a recession in the United States, it is important to examine what impact specific events may have had on the U.S. economy. Hamilton (2005) found that nine out of ten U.S. recessions since World War II have been preceded by a spike in oil prices, and it is important to investigate the cause of these oil price shocks.

Kilian (2005) and Hamilton (2003) identified several oil price shocks that have occurred exogenous with respect to the U.S. economy since 1973. Exogenous oil price shocks are those that are based on political events instead of those affected by changes in demand of oil. Kilian's selection of what exogenous events cause an oil price shock generally agrees with Hamilton, while differing on whether the Arab and Israeli War of 1973 was an oil supply shock.

While Hamilton includes the Arab and Israeli War of 1973 and the subsequent oil embargo of 1973 to 1974, Kilian questions the validity of including this as an exogenous event. During this War there was no destruction of OPEC facilities and no unplanned production shortfalls. By 1973, global productivity increases had caused a shift in aggregate oil demand, and demand of industrial inputs, such as steel and lumber, had already risen substantially in the early 1970's. Because of the long-term contracts setting oil prices, the price of oil had not risen even as oil producing countries produced more oil. During the Arab/Israeli War the countries in OPEC reneged on their agreements with the oil production companies, and the rising price and declining quantity could be seen as the oil price and quantity levels reaching the new equilibrium due to the previous aggregate demand shift.

The other conflicts that Kilian (2005) and Hamilton (2003) mention as exogenous with respect to U.S. macroeconomic aggregates are: the Iranian Revolution of 1978-1979; the Iran/Iraq War of 1980-1988; the Gulf War of 1990; the Civil unrest in Venezuela in 2002-2003, and the Iraq war of 2003. While these events are exogenous to the U.S. economy, this does not necessarily imply that the choices on oil supply production were made exogenous to the global economy. The most impartial way to analyzing the data is to statistically define an oil price shock, and then utilize those findings instead of relying on established dates of exogenous political events.

Hamilton (2003) defined of an oil price shock to be a nominal net oil price increase that is statistically higher than the highest oil price during the previous three years. If a positive oil price shock follows a greater decline in oil prices, then it will have little effect on the economy. Using this definition, Kilian (2006) finds that there are major nominal oil price shocks in 1973/74, 1979/80, 1981, 1990/91, 2000/01, 2002/03, and 2004. Additionally, he found that there were minor nominal oil price shocks in 1975/76, 1989/90, and 1996/97. While many of these events can be associated with exogenous political events, not all of them are. This is not only true for the minor nominal oil price shocks, but also for the oil price shock in 2000/01 and in 2004. While political events in OPEC countries may be a good indicator of a forthcoming oil price shock, it does not hold true for every case.

Hamilton (2003) chose to utilize nominal oil prices, while using the real price of oil will better define the relative importance of different oil price shocks. Kilian (2006) found that by utilizing real oil prices that there was not an oil price shock associated with the 2002 Venezuelan crisis or with the 2003 War in Iraq. Using real oil prices he also found that there was an increase in inflation in 1996/97, 1999/2000, and 2004 that were not preceded by an oil price shock.

Kilian (2006) proposes normalizing the production shortfall over time to determine whether or not there statistically was an oil supply shock. He found that oil supply shocks from exogenous political events range from +4% to -7% of world crude oil production at quarterly frequency. This accounts for only 6% of the variability in world crude oil supply changes, and he finds that only the 1980/81 exogenous political event led to a subsequent oil price shock. Kilian provides interesting counterfactual arguments as to why the other political events did not lead to a supply disruption.

Comparing time periods experiencing an exogenous political event and a statistical analysis illustrates the close relationship between exogenous political events and oil price shocks. We find that an oil price shock is certainly correlated with exogenous political events. As oil supply volatility increases, the prices around the world increase to account for the additional risk factor. However, not all exogenous political events lead to a significant oil price shock, and further research into analyzing the amount of impact from varying exogenous political events should be conducted.

OIL PRICE SHOCK EFFECTS VARIED OVER TIME

The effects of oil prices shocks on the U.S. economy have certainly varied over time, and I will investigate the literature to find how the effects have changed over time. Lutz Kilian (2005) and Mark Hooker (1996) argue the strengthening of the Organization of Petroleum Exporting Countries (OPEC) in 1973 marks the current era in how the U.S. economy responds to changes in foreign oil prices. Prior to 1973 the Texas Railroad Commission had held a large enough share of the market that they had been able to absorb OPEC's negative supply shocks to the United States and abroad. In 1956 and 1967 they were able to increase their supply and lessen the impact of OPEC's oil embargoes.

Around 1980 another significant change in how an oil price shock could affect U.S. inflation occurred. During the early 1980's, OPEC seemingly lost their ability to keep nominal oil prices stable. The United States' inflation response to oil price shocks also changed during this time period. Hooker (2002) found that oil price shocks had a strong effect on inflation prior to 1981, and that they have had very little effect on inflation since then.

Humpage and Pelz (2002) explored what led to the necessity of a monetary change in 1980. During the 1970's the United States was experiencing a period of high inflation. Prior to the 1972-73 oil price shock the Federal Reserve Board had already tightened monetary policy, and when there was a subsequent oil price shock, the Federal Reserve Board had to loosen monetary policy by an even more substantial amount. Following 1973 the Federal Reserve Board continuously cut the federal funds rate to accommodate output levels faced with higher oil prices, and inflationary growth remained at a high level. In 1979 the Federal Reserve Board again tightened monetary policy before the oil price shock, which again magnified the effects of the subsequent oil price shock. Combining an oil price shock with an already tightened money supply can compel the Federal Reserve Board to increase the money supply by even more to accommodate a continuous output level.

When Volker became the Chairman of the Federal Reserve Board in 1979 the Federal Reserve Board changed their policy to focus on reducing inflation. Under Volker and Greenspan, the Federal Reserve Board has had the ability to commit to long-term price stability in a believable and credible manner. During this time period they have responded less to oil price shocks, and as a result inflation expectations have not closely tracked oil price changes. According to Humpage and Pelz (2002), in the absence of a monetary policy response, oil price shocks have little effect on the business cycle.

Based on current economic research, it becomes apparent that while oil price shocks may have once impacted even long run inflation, their effects on U.S. inflation have been minimal during the last few decades.

EMPIRICAL EVIDENCE

While we have established theoretical models to analyze how oil price shocks can affect short run and long run inflation, we will now examine the empirical evidence to determine if it supports our theory. It is important to look at older research, especially focusing on the oil price volatility of the 1970's. However, it is the current relationship between oil price shocks and inflation that we are analyzing.

From 1948 until 1980 Hamilton (1983) found that there was a statistically significant relationship between oil price changes and GNP growth. During this time period there were two different periods of both oil price volatility and volatility in inflation. Prior to 1970, the United States experienced low to moderate inflation and oil prices varied little. Oil prices increased substantially and we experienced high levels of inflation during the 1970's. As was discussed in analyzing how oil price shock effects have varied over time, it would be inappropriate to look at this early range of data and extrapolate the results forward.

Hamilton (1996) found that from 1973 to 1994 net oil price increases did not have a statistically significant effect on GDP growth, but from 1948 to 1994 that this relationship was statistically significant. Data during World War II and the Great Depression is accepted by the literature to be outside the current range. Looking at a larger range of data statistically should strengthen the results, but as mentioned before, there was a change in the effectiveness of the power of the Organization of Petroleum Exporting Countries in 1973, and a change in monetary regime in 1980. Hamilton (1983) recognized that there was a change in 1973, and so it would seem more appropriate to investigate the modern OPEC period since 1973 rather than spanning both periods. As oil price volatility continues over time we will be able to establish a longer range of data samples in the current period to improve our understanding of the effects of oil price shocks on U.S. inflation.

Hooker (1996) looked at the data set from 1973 to the mid-1990's and found that oil prices did not significantly affect macroeconomic variables. He found that adjusting for improper measurements or accounting for an asymmetric effect from an oil price shock failed to explain the declining impact of oil price shocks on the economy. He found that oil prices do not seem to be any more endogenous to the U.S. economy since 1973 than it was before, varying from Kilian's claim that since 1973 oil prices have been fully endogenous to the U.S. economy.

Kilian (2006) regresses oil prices using OLS with constant, eight lagged values of exogenous oil supply disruptions, and constant four lagged values of GDP. His use of these lagged variables builds on Hamilton's (2003) proposal to use lags to capture the relationship of real GDP growth to past oil price changes and past real GDP growth. His regression finds that the nominal GDP growth rate is sharply negative during the fifth quarter, then the inflationary response returns to zero. The negative GDP growth rate is supported at the 68% confidence level for seven periods and at the 95% confidence level for one period. The real GDP growth rate has a decline in the fifth quarter, but this is not supported at the 68% confidence interval.

Kilian used a similar OLS regression for the consumer price index and found that CPI inflation experiences a sharp spike three to four quarters after the oil price shock, and otherwise the shock has very little effect on the CPI. This spike is the only time that the change is supported by at least the 68% confidence level. At every other point the change is insignificant at the 68% level, supporting the theory that oil price shocks do not have a significant effect on long run inflation.

While the negative GDP response to an oil price shock may be similar across the G7 countries, Kilian (2005) found that the inflationary responses varied across the G7 countries. This variation supports the theory that it is the monetary response to an oil price shock that causes U.S. inflationary pressure. Kilian found that since the 1970’s CPI inflation in the G7 countries would have evolved similarly even in the absence of oil price shocks. Three years after the oil price shock the inflationary impact was insignificantly negative for the United States and Great Britain while it was slightly positive for Japan, Italy, Canada, and France. Out of the G7 countries, Germany was the only one that endured positive, long run inflation from an oil price shock. The variability of the inflationary response to an oil price shock across the G7 countries supports the monetary policy explanation of why there could be sustained inflation stemming from an initial oil price shock.

In 1986 the price of oil experienced a negative oil price shock, and some of the literature has examined the asymmetrical relationship between oil price shocks and core inflation. While a positive oil price shock affects short run inflation, the 1986 negative oil price shock had no statistical impact on inflation. Hooker (1999) argues that a change in monetary reactions provide a better explanation than an asymmetrical analysis. He finds that specifying the data based on a structural break around 1980 creates a better data set than several asymmetric alternatives. While Hooker may find that the Volker-Greenspan era of less accommodation for oil price shocks as a better explanation for this change, the asymmetric relationship that oil prices have on the economy is generally accepted in the literature. The amount, longevity, and even the sign of inflation following a positive oil price shock may be debated in the literature, but a negative oil price shock is generally thought to have very little, if not any affect the economy. While the models have not captured the asymmetry of this relationship, the few periods of a negative oil price shock, such as 1986, suggest this asymmetric relationship.

Hamilton (2005) found that from 1949 to 1980 his regression would predict a 2.9% slow down in GDP growth following an oil price shock. Using the same regression he found that if you extended the data to include everything from 1948 to 2005 that you would only experience a decline in GDP growth of 0.7%.

Another potential explanation for the declining impact of oil prices on inflation could be the increasing energy efficiency and decreasing intensity of energy use in the U.S. economy. Fieleke (1990) found that in the United States, Japan, and West Germany that the Oil-to-GDP relationship declined over the period of 1973 to 1988. He also found that during this period the role of crude oil as an energy component declined from 47.9% to 37% as other energy sources, such as hydroelectric and natural gas, increased.

The empirical evidence supports the theoretical models of Barsky and Kilian (2001). Oil price shocks have a positive effect on short run CPI inflation, a negative effect on the GDP deflator in the short run, and no long run effect on either measure. The relationship between oil price shocks and inflation may have declined because of the change in the Federal Reserve Board’s responses or because of our increasing energy efficiency.

CONCLUSION

Since an oil price shock and a tightening in monetary policy have preceded every recession after 1971 it becomes difficult to separate the effects of one from the other. While one variable may be more significant than the other, it becomes clear that at least for the short run an oil price shock is inflationary as measured by the CPI. While the effects on GDP deflator are more ambiguous, the model and the results indicate that for the short run an oil price shock has a deflationary impact on the GDP deflator. The actions of the Federal Reserve Board in expanding or contracting the money supply are the only means of impacting long run inflation.

The current era of oil's relationship with macroeconomic variables began in 1973 with the strengthening of OPEC and our increased dependence on foreign oil. Hamilton (1983) found that prior to 1973 oil price shocks did have an effect on GDP growth. Hooker (1996) and Hamilton (1996) found that from 1973 to the mid-1990's oil price shocks had an insignificant effect on the United States macroeconomic variables. Barsky and Kilian's (2001) models suggest that oil price shocks have a short run inflationary impact on the CPI, have a less clear deflationary impact on GDP growth, and have no long run impact. Kilian (2006) found that the CPI spikes after three to four quarters following an oil price shock, and then has no other significant effects. He also found that the GDP deflator is sharply negative the fifth quarter after an oil price shock, and then the oil price shock has no other significant impact on the GDP deflator. Kilian (2005) found that while the GDP responses were similar across countries in the G7, the inflationary responses varied greatly. This variance across countries supports the theory that it is the monetary policies that ultimately determine long run inflation.

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