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"Oil Shocks and Monetary Policy: An Empirical Investigation with US Data"

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Abstract

Sin dalla fine degli anni ’70, gli economisti si sono interrogati sul ruolo degli shock ai prezzi del petrolio nell’influenzare la performance macroeconomica statunitense. In questo periodo, la credenza comune era che ci fosse un collegamento diretto tra shock ai prezzi del petrolio, recessioni, e aumento dell’inflazione, generando così la situazione comunemente denominata “Stagflazione”. Questi modelli di trasmissione diretta, tuttavia, iniziarono ad essere inconsistenti con l’evidenza empirica, sollevando domande sulla veridicità di tali modelli. Fu soltanto dal lavoro di Bernanke, Gertler, and Watson (1997) che un filone di letteratura iniziò a ipotizzare che gli effetti macroeconomici degli shock ai prezzi del petrolio non furono causati direttamente da essi, ma piuttosto furono amplificati dalla politica monetaria della Federal Reserve. Questa ipotesi riuscirebbe a spiegare perché gli shock petroliferi hanno avuto un impatto così forte durante gli anni ’70, mentre pressoché nullo dal 1984 in poi, l’anno in cui iniziò la “Great Moderation”. Lo scopo di questa tesi è dunque quello di investigare come e in quale misura la Federal Reserve ha risposto agli shock ai prezzi del petrolio nel tempo. Per fare ciò, viene svolta una sintesi, che non vuole essere esaustiva, della letteratura esistente per poter al meglio presentare questa ipotesi. Successivamente, viene costruito un semplice modello econometrico per poter testarla empiricamente con dati statunitensi. I risultati ottenuti attraverso la stima di questo modello sono consistenti con la teoria economica presentata, concludendo che la risposta da parte della Federal Reserve agli shocks petroliferi è stata forte fino ai primi anni ’80, per poi svanire completamente dal 1984 in poi.

NOTA: lunghezza elaborato (bibliografia esclusa) = 8122 parole.

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Introduction

It has been a long time since scholars began to be puzzled by empirical evidence suggesting a causal link between oil price shocks and macroeconomic performance. This interest sparked from the U.S. experience of the 1970s. Until the early 1970s, the price of oil in the U.S. was regulated to a large extent by government agencies, leading to prolonged periods in which the price of oil remained constant. In those years, however, the country's production capacity was no longer able to cope with growing domestic demand, leading the U.S. to depend strongly on imports of oil from the major producing countries in the Middle East. With the 1974-75 oil crisis, the world's balance was upset, bringing oil prices to unexpected peaks over a single quarter. Since then, economists have debated intensely about which causal relation links oil price shocks, macroeconomic changes, and political factors. The common wisdom was that increases in the price of oil were direct culprits of recessions, excessive inflation, and reduction of economic growth and productivity in the U.S..

But what if the impact of oil price shocks in the U.S. economy was indirectly amplified by the monetary policy of the Federal Reserve, rather than a direct cause of oil price shocks themselves? Since the work of Bernanke, Gertler, and Watson (1997), the literature has focused on this indirect link to explain why the effect of oil price shocks was so strong during the 1970s, while practically non-existing since 1984. The aim of this thesis, therefore, is to investigate how and to what extent oil shocks have affected the monetary policy of the Federal Reserve from the early 1970s until recent years.

This thesis is organized as follows: Chapter 1 provides a synthesis, by no means exhaustive, of the existing literature accumulated during the last 50 years. In Chapter 2, the role of oil shocks in influencing the monetary policy of the Federal Reserve is tested empirically with the help of a simple econometric model.

Chapter 1

Oil Shocks and Monetary Policy

1.1 Oil Shocks Transmission Channels in U.S. Macroeconomic Variables

It is widely believed that abrupt changes in the price of oil are caused by unexpected exogenous political events in the Middle East, such as the outbreak of wars, embargoes, and pricing policies put into place by OPEC members, representing shifts in the supply curve for oil.

Such shocks are often known to be responsible for significant fluctuations in a specific set of macroeconomic variables: output and inflation. However, to the extent that disruptions in the oil market have a causal effect on these variables, through what channels do they operate?

Many attempts have been made to understand the transmission mechanisms of such shocks. Barsky and Kilian (2004) show that a certain correlation between oil shocks and these macroeconomic variables exists, but also how this is not as strong as claimed by other economists such as Bernanke (1983), Hamilton (1988), and Rotemberg and Woodford (1996).

Each relationship between oil price shocks and the main economic variables will be analyzed individually in the following paragraphs.

1.1.1 Oil Shocks and Recessions

As mentioned before, conventional wisdom suggests that exogenous political events in the Middle East cause recessions in the U.S. through their effect on the price of oil.

Table 1 provides a list of the coincidence of oil dates and recessions in the United States since 1972, as dated by the National Bureau of Economic Research. As one can see, most of the recessions started just after some exogenous political events in the Middle East, nourishing the common belief that these events were responsible for a consequent rise in oil prices, causing a recession.

At first sight, the evidence for such a connection is tainted by the long and floating lags between oil events and recessions in some instances. For example, there is a considerable lag between the Iranian revolution and the recession of January 1980 and between the outbreak of the Iran-Iraq war and the recession of July 1981. Even if we refute the hypothesis that exogenous political events in the Middle East are the source of U.S. recessions, there is no doubt that many recessions since 1972 have been related to the major oil price increases, even though the relationship is not perfect.

Table 1
The Coincidence of Oil Dates and Recessions after 1972

Business cycle peak	*Events associated with subsequent major oil price increase*
November 1973	October War and Oil Embargo October 1973–early 1974
January 1980	Iranian Revolution October 1978–February 1979
July 1981	Outbreak of Iran-Iraq War September 1980
July 1990	Invasion of Kuwait August 1990
March 2001	OPEC Meeting March 1999

Source: The business cycle dates are from the National Bureau of Economic Research at ⟨http://www.nber.org/cycles⟩.

Scholars who have tried to explain a direct relationship between oil price shocks and recessions have developed their theories along three lines of thought: a) the direct effect of a mark-up pricing; b) the presence of capital-energy complementarities in production; c) the transfer of wealth due to higher oil import bills. Each of these possibilities, however, turns out to be weak.

a) The direct effect of mark-up pricing is analyzed by Rotemberg and Woodford (1996). They suppose that gross output Y is given by the production function $Y = Q[V(K, L), O]$ where K, L, O are the quantities of capital, labor and imported oil, respectively, and $V(K, L)$ is the domestic value-added, which might be thought of as real GDP. As a result, under perfect competition the direct effect of an oil price shock on value-added is non-existent because the demand curve for capital and labor, as a function of rental rates and the wage measured in terms of value-added, is invariant with respect to changes in the price of oil. If we drop the assumption that firms produce for a perfectly competitive market this result is weakened. In fact, under mark-up pricing, an oil price shock does diminish not only the demand for labor and capital, but also the demand for imported oil, as firms apply the mark-up to all cost components. However, its impact on value-added is likely to be limited for realistic mark-up ratios (Rotemberg and Woodford, 1996).

b) The presence of capital-energy complementarities in production implies that a rise in the price of oil will lower real GDP by decreasing the demand for capital. Consequently, part of the energy-intensive capital stock will be made obsolete, leading to a reduction in output and a depreciation of capital that should be mirrored by cheaper used equipment. This hypothesis, however, is disproved by Hulten, Robertson and Wykoff (1989). They provide empirical evidence that the price of used equipment not only did not suffer much, particularly from the oil price shock of 1973, but in some cases it even increased. Moreover, it is also natural to think that with the depreciation of energy-inefficient capital, the most appropriate thing to do is to increase investment in new energy-saving equipment to compensate for the possible recessionary effect of the oil price shock (Barsky and Kilian 2004).

c) Finally, another potential transmission channel is the transfer of wealth due to higher oil import bills from the industrialized countries to oil-producing countries. However, the transfer of wealth is likely to be small since the expenditure on foreign oil in relation to GDP is low. As shown by Olson (1988), the estimates of the extra import in the U.S. were only 1 percent of GDP for the period 1974:1978 and about 2-3 percent for 1979:1981.

Given the weakness of the preceding theoretical assertions, some economists attempted to explain the recessions in the U.S. by analyzing the indirect effects of oil price shocks triggered by the response of economic agents. Let us consider a) the sectoral shifts model of Hamilton (1988) and b) the uncertainty effect of Bernanke (1983).

a) The sectoral shifts model of Hamilton (1988) predicts that an increase in the price of oil will lead to a reduction in the demand, and hence a decrease in purchases, of energy-using goods. This change in demand will cause, in turn, a redistribution of labor across sectors, and since the mobility of labor generates a cost, it will result in a reduction in value-added, and since the response is assumed to be symmetric these effects on output are expected for both positive and negative shocks. However, while the 1980 oil price increase was followed by an increase in unemployment, it did not happen with the 1986 shock, thus demonstrating the inconsistency of this theory (Barsky and Kilian, 2004).

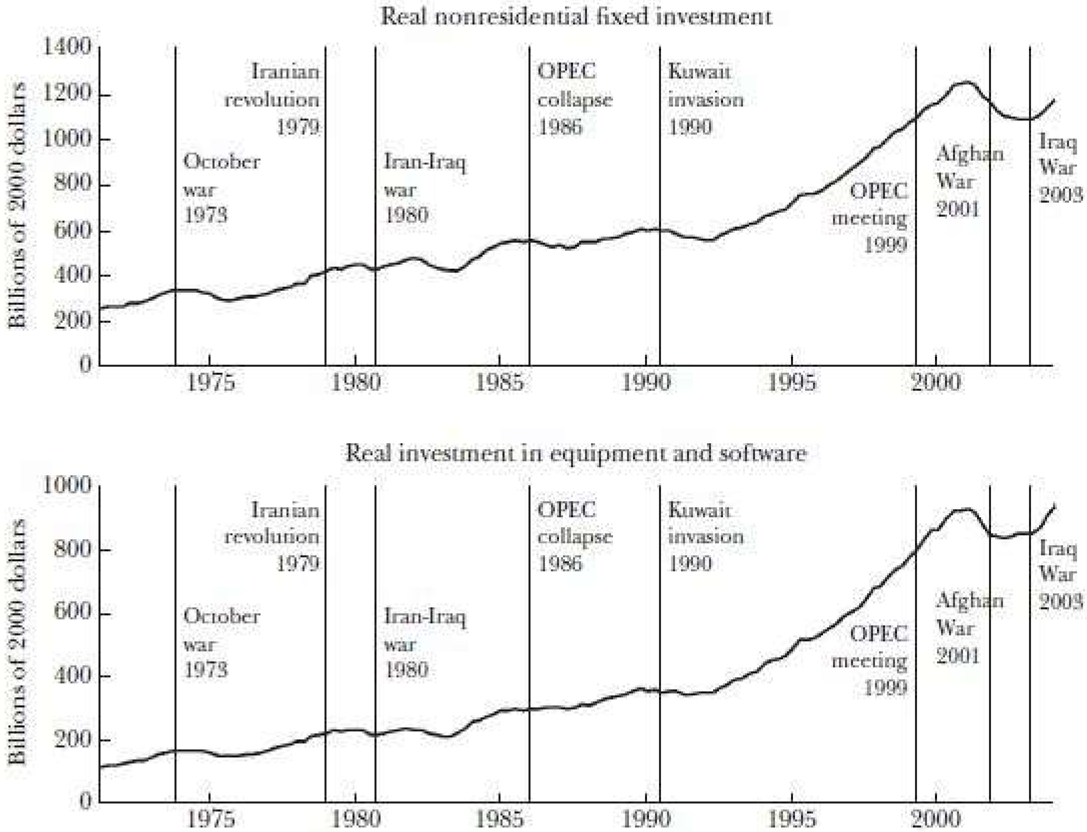
b) Bernanke (1983) focuses instead on the uncertainty of economic agents in response to oil price shocks. He shows in a partial equilibrium model that oil price shocks will make firms postpone investments while waiting to see if oil price increases are transitory or permanent, thus lowering real GDP. However, as shown by Barsky and Kilian (2004), the "waiting" effect hypothesis discussed by Bernanke (1983) is not sufficiently solid.

Figure 1

Oil Price Uncertainty and Real Investment, Quarterly 1971.I–2003.IV

a)

b)



Source: Federal Reserve Economic Database (FRED).
Notes: Oil dates have been imposed as vertical lines.

Figure 1a and Figure 1b show series for real non-residential fixed investment and real investment in equipment and software, respectively. As one can see, by focusing on firms' investment decisions, there is no significant decrease in investment in response to a rise in uncertainty after oil dates.

1.1.2 Oil Shocks and Inflation

The second effect of oil price shocks is to be found on inflation, which deserves to be explored. The studies carried out over the years established the broadly accepted theory that oil price shocks are necessarily inflationary.

Barsky and Kilian (2002), following the example of Rotemberg and Woodford (1996), show that this theory is only partially true. Their paper demonstrates that oil price shocks, although being

unambiguously inflationary for the price of gross output (such as the CPI), can have a deflationary effect on the price of value-added (such as the GDP deflator). As a result, one would expect oil price shocks to increase inflation in the CPI, but the same model cannot give any theoretical presumption that the GDP deflator would increase. The only empirical evidence provided is that oil price shocks have an impact on the CPI inflation rate (Barsky and Kilian, 2002).
Such conclusions led many scholars to question the common belief centered on the causal relation of oil price shocks on recessions and inflation and consider a radical change of approach.

1.2 Oil Shocks, Monetary Policy, and Stagflation

The oil shock picture has proved resistant because of the appearance of a controversial phenomenon in the U.S.: the Great Stagflation that occurred in the 1970s and early 1980s. Stagflation is defined as a period of unemployment above its natural rate (NAIRU) combined with increasing inflation. Until the 1970s the widespread belief was that inflation was caused by an excess of demand. This view was supported by the accelerationist Phillips curve, which implies a negative correlation between unemployment and inflation. However, in the 1970s the accelerationist model could no longer explain this underlying statistical relationship, since in that period there was a combination of *rising* inflation and a level of unemployment *above* the NAIRU. To explain this controversial situation, some economists hypothesized whether a supply shock can shift the Phillips curve, and this fact helps explain the growing focus on oil price shocks as supply shifters in the early 1970s (see, e.g., Gordon, 2008).
Even though the recessions of the 1970s and early 1980s are commonly attributed to oil price shocks, it has proven difficult to justify such disproportionate real effects based solely on standard macroeconomic models of the transmission channels of oil price shocks (see section 1.1.1). In the attempt to provide a consistent explanation to this phenomenon, some scholars, such as Bernanke, Gertler and Watson (1997) and Barsky and Kilian (2002), have directed their attention to

the behavior of the Federal Reserve as a potential channel that may have amplified the effects of oil price shocks on unemployment and inflation during that period.

1.2.1 Systematic Monetary Policy Hypothesis

The pioneering work of Milton Friedman opened the road to the concept that monetary policy could be a significant cause of real fluctuations in the economy. By considering this aspect, Bohi (1989) argued that the recessions that happened just after the major oil shocks were not caused by oil shocks themselves, but rather by the contractionary response of the Federal Reserve to inflationary concerns attributable in part to oil shocks. Since then, there has been an increasing interest in the extent to which the response of the U.S. economy to oil price shocks is driven by the endogenous response of monetary policy. This line of thought was motivated by the perception that oil price shocks alone could not account for the large recessions that happened in the U.S. during the 1970s and 1980s.

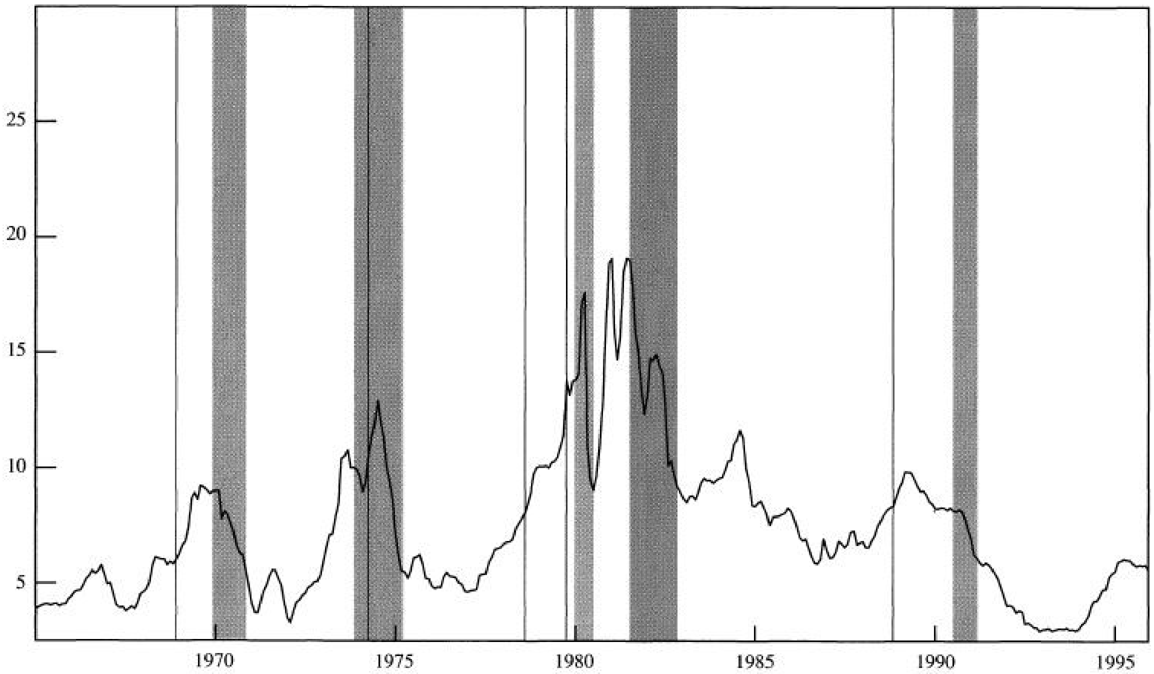
Bernanke, Gertler and Watson (1997) provide key evidence in support of this hypothesis, commonly referred to as *systematic monetary policy hypothesis*. As was first pointed out by Hamilton (1983), they notice that all the U.S. recessions in the period 1970:1995 were preceded by both oil price shocks and a tightening of monetary policy, as seen in Figure 2a and Figure 2b (recessions indicated by grey areas), raising the question to what degree the resulting economic downturn can be attributed to each factor.

Figure 2

Federal Funds Rate, Oil Prices, and NBER Recessions, 1965–95[a]

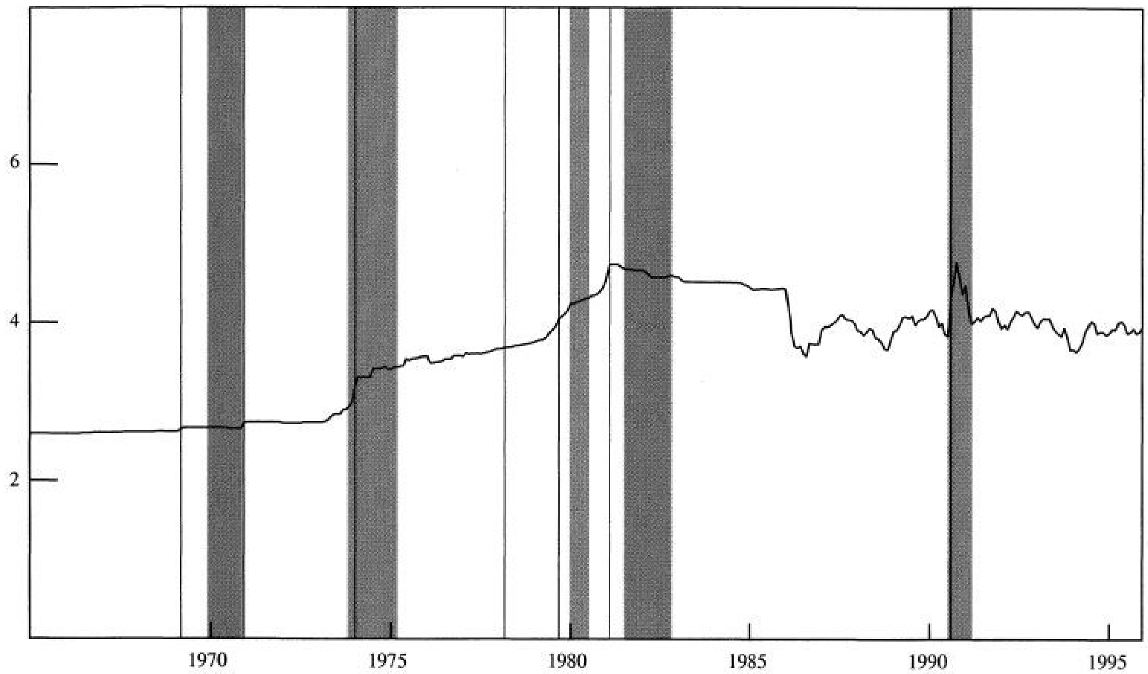
Federal funds rate (percent)

a)



Log crude oil price index[b]

b)



Source: CITIBASE, series FYFF (federal funds rate) and PW561 (crude oil prices); see appendix B for details of all variables. Also (see note a) Romer and Romer (1989) and Hoover and Perez (1994).

a. Data are monthly; tic marks correspond to January. Shaded bands correspond to recessions as dated by the National Bureau of Economic Research. In the upper panel, vertical lines mark contractionary policy changes by the Federal Reserve, as dated by Romer and Romer. In the lower panel, vertical lines mark oil market disruptions, as dated by Hoover and Perez, plus the month of August 1990, when Iraq invaded Kuwait.

b. Log of index that is constructed so that 1982 = 100.

Based on their VAR model estimates, Bernanke, Gertler and Watson (1997) illustrate the aggregate effect of exogenous oil price increases on real output relative to its natural level, including both the effect associated with the monetary policy response to higher oil prices and the direct effect of oil price shocks. They conclude that endogenous monetary policy response can account for a quite significant fraction of the recessionary effects of oil price shocks, whereas the response of the economy to oil price shocks alone was not significant. To further demonstrate their hypothesis, Bernanke, Gertler and Watson (1997) postulate a counterfactual in their VAR model in which the Federal Reserve keeps the federal funds rate constant, that is, the Federal Reserve is not responding to any oil price shock at all. They show that without a systematic and anticipated response of the Federal Reserve, the resulting direction of real output would have been substantially less recessionary. Hence, the recessionary consequences of an oil price shock could have been avoided at the cost of higher inflation by simply holding constant the federal funds rate. This result can explain the controversial combination of a high level of inflation generated by the oil price shock alone, and high unemployment generated by the monetary policy reaction, which characterizes the stagflation of the 1970s. Moreover, they show that the "systematic" response of monetary policy to oil price shocks was strongest during the Volcker period, when the concern of the Federal Reserve to inflationary pressures was also the greatest (Bernanke, Gertler and Watson, 1997).

Despite the fact that many scholars explored the endogenous monetary policy response to oil price shocks suggested by Bernanke, Gertler and Watson (1997) (see, e.g., Leduc and Sill, 2004; Carlstrom and Fuerst, 2006), Kilian and Lewis (2009) show that there are three problems with the consistency of their model: a) the incomprehensible low response of monetary policy to the direct recessionary effects of oil price shocks, b) the assumption that oil price shocks are necessarily inflationary, and c) the assumption that oil price shocks are exogenous.

a) It is broadly accepted that the Federal Reserve during 1970s was more interested in preserving output and containing unemployment than containing inflation (Barsky and Kilian, 2002). Therefore, as far as oil price shocks have a recessionary effect, one would have expected the Federal Reserve to carry out an accommodative monetary policy rather than a monetary tightening. In addition, even if one assumes that oil price shocks are also inflationary, there is no guarantee that the monetary policy on the balance of the two effects would have been a monetary tightening, since the weight put on the stabilization of the output level was higher than the one put on inflation. In fact, the result obtained by Bernanke, Gertler and Watson (1997) is more consistent with the period when Paul Volcker was appointed chairman of the Federal Reserve, since the weight assigned to inflation was higher.

b) As we saw in section 1.1.2, there is no clear evidence that oil price shocks are necessarily inflationary. Oil price shocks generally have two effects on inflation: the first one is that the cost of producing domestic output increases, which translates into an adverse supply shock; the second one is the reduction in real wages of domestic households, which translates into an adverse demand shock. As shown by Kilian (2008), there is empirical evidence that the latter effect dominates the former. Therefore, when an exogenous oil supply shock occurs, one would expect it to be deflationary and recessionary, debunking the view that the Federal Reserve should respond to an oil price shock with a tight monetary policy.

c) As we will see in section 1.2.2, the assumption in Bernanke, Gertler and Watson (1997) that oil price shocks are exogenous in relation to the U.S. economy is only partially correct. Barsky and Kilian (2002) show that the price of oil is endogenous with respect to other macroeconomic variables, such as the federal funds rate. Therefore, as suggested by Kilian (2008), the Federal Reserve should respond directly to the causes that drive the price of oil, rather than the price of oil itself.

The inconsistencies mentioned above of the model of Bernanke, Gertler and Watson (1997) in explaining the Great Stagflation led some scholars to reject the hypothesis that oil price shocks had an essential role in that story and to explore an alternative view, which will be discussed in the next section.

1.2.2 An Alternative Explanation

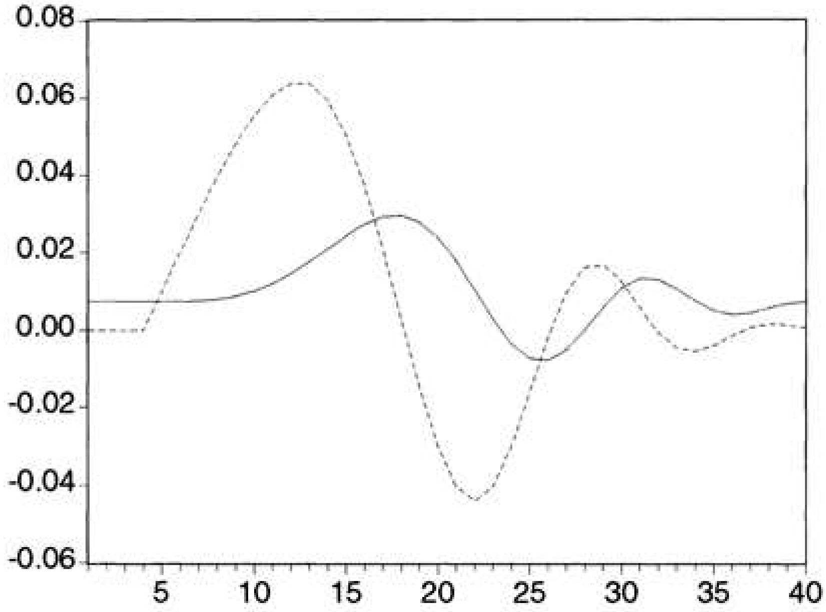
As we saw in the last section, economists such as Bohi (1989), and Bernanke, Gertler, and Watson (1997) show that possible indirect effects were not stemming from oil price shocks themselves, but from the monetary policy response of the Federal Reserve to the inflation caused by oil price shocks.

Barsky and Kilian (2002), however, provide an alternative model to give a monetary explanation of both the Great Stagflation and the price of oil during that phase of the economic cycle. Their paper shows how stagflation may occur even without any supply shock when there is "sluggish inflation", as defined by Nelson (1998). They show that after a monetary expansion (as the one that occurred in the early 1970s) the increase in inflation and output is not simultaneous, as inflation peaks with a moderate delay (about four quarters) compared to the moment when output reaches its highest level. A reasonable explanation of this phenomenon is that economic agents adapt gradually to shifts in monetary policy. For example, agents were used to the low inflation rate of the 1960s, and when they faced the unusual monetary expansion acted upon by Arthur Burns in 1970 they did not reconsider their expectations on inflation immediately, thus causing the "sluggish inflation" circumstance (Barsky and Kilian, 2002).

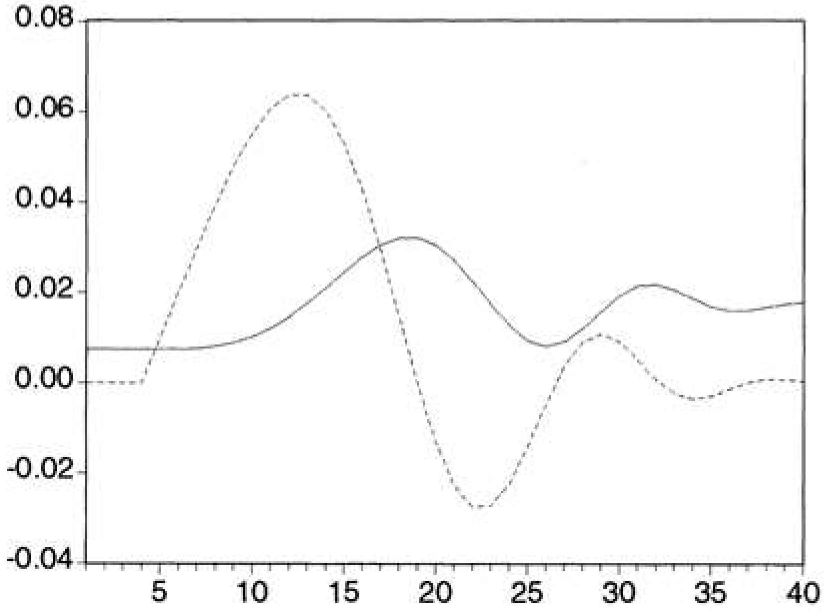
Figure 3 shows the Federal Reserve's response to a shock of 100 basis-points rise in the money growth in period 5, as postulated in their model with (Figure 3a) and without (Figure 3b) policy feedback. Figure 3a shows exactly the pattern described above after a monetary expansion: sluggish inflation and the hump-shaped reaction of output, thus generating stagflation. Moreover, Figure 3b illustrates that even without policy feedback, i.e., only in the presence of exogenous monetary policy shocks, the economy reacts similarly, showing that the endogenous monetary policy response to oil price shocks of the Federal

Reserve postulated by Bernanke, Gertler and Watson (1997) although important, is by no means the cause of the Great Stagflation.

Figure 3 IMPLICATIONS OF A PURELY MONETARY MODEL OF STAGFLATION: (a) WITH POLICY FEEDBACK; (b) WITHOUT POLICY FEEDBACK



(a)



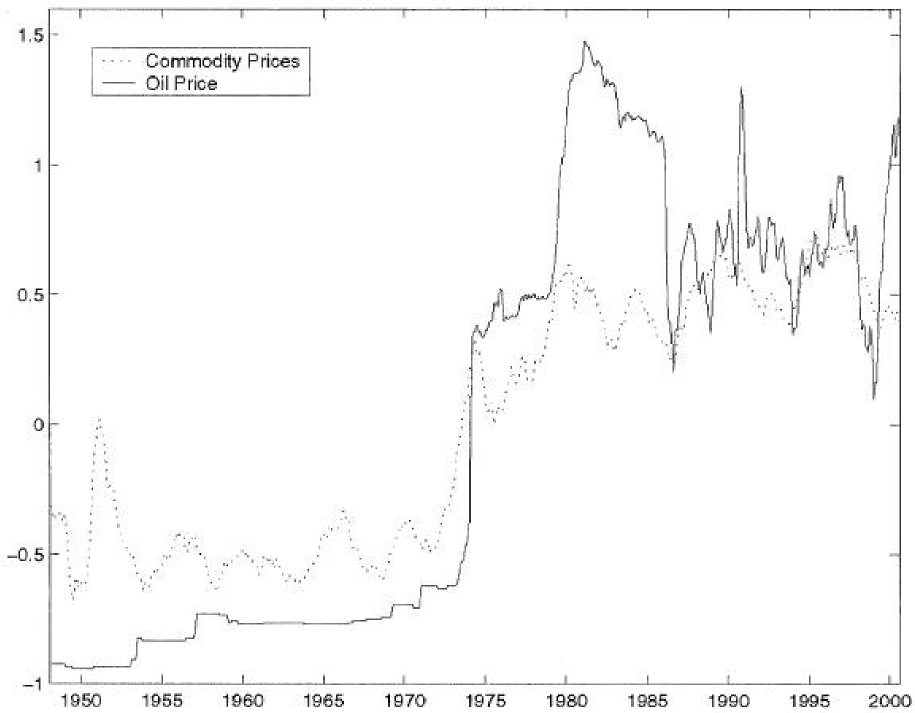
(b)

Notes: Solid curves: quarterly inflation rate. Dashed curves: output gap. Models described in text. Responses to a permanent 1-percentage-point increase in money growth in period 5.

Source: Barsky and Kilian, 2002

A further element supporting a monetary explanation of the Great Stagflation is provided by observing the evolution of non-oil and oil prices. Barsky and Kilian (2002) stress the point of the steep and overall rise in industrial commodity prices anticipating the increase in the price of oil in the period 1973:1974, which occurred much earlier than the October War of 1973, and too general to be explained by a supply shock. This view is consistent with the increase in liquidity generated by an expansionary monetary policy resulting in a general increase in demand, which led to an increase in the prices of industrial commodities (Figure 4). To provide some examples: the price of scrap metal almost

Figure 4 NOMINAL PRICE INDEXES FOR CRUDE OIL AND FOR INDUSTRIAL COMMODITIES, JANUARY 1948 TO JULY 2000



Source: All data are logged and de-meaned. The commodity price index excludes oil and food. The index shown is an index for industrial commodity prices (DRI code: PSCMAT). Virtually identical plots are obtained using an index for sensitive materials (DRI code: PSM99Q). The oil price series is defined as in Figure 1.

quadrupled between 1972 and the following year; similarly, the price of timber and pulp doubled between 1971 and 1974. An analogous situation happened in 1979 when the rise in the price of oil was, once again, preceded by an increase in the price of other non-oil commodities.

However, how the lagged response of oil price shocks can be explained by a strictly monetary explanation of the Great Stagflation? A possible explanation of this phenomenon is that, unlike the more openly traded commodities, crude-oil procurements took place in the context of long-term contractual prices until the early 1980s. Therefore, with the appearance of different demand conditions, the adjustment of crude-oil contractual prices tended to be slower compared to other industrial commodity prices (Barsky and Kilian, 2002).

Even though they have shown that oil prices are not a crucial part of the story, Barsky and Kilian (2002) provide a justification for the almost simultaneous appearance of rises in the price of oil and the aggravation of the stagflation of the 1970s. They show that the common wisdom based on the exogeneity of oil supply shocks is surely important, but it is not fundamental to explain the substantial changes in the price of oil in that period. They provide evidence that oil prices were responding endogenously to circumstances happening in the oil market, which in turn were responding to change in macroeconomic conditions, such as the monetary stance. They observe that oil and other industrial commodities prices behave accordingly to economic theory: they rise because of high output and low real interest rate. Their analysis starts with the classic resource extraction model provided by Hotelling (1931), which suggests that monetary policy influences oil prices through multiple channels. To begin with, a permanent decline in real interest rates increases the initial price and suggests slower price growth in the future. Second, as real income rises, the demand for oil moves outward, and since oil is being consumed at a faster rate, oil prices must increase to clear the market. Therefore, oil prices rather than influencing the Federal Reserve's monetary policy, are responding endogenously to it.

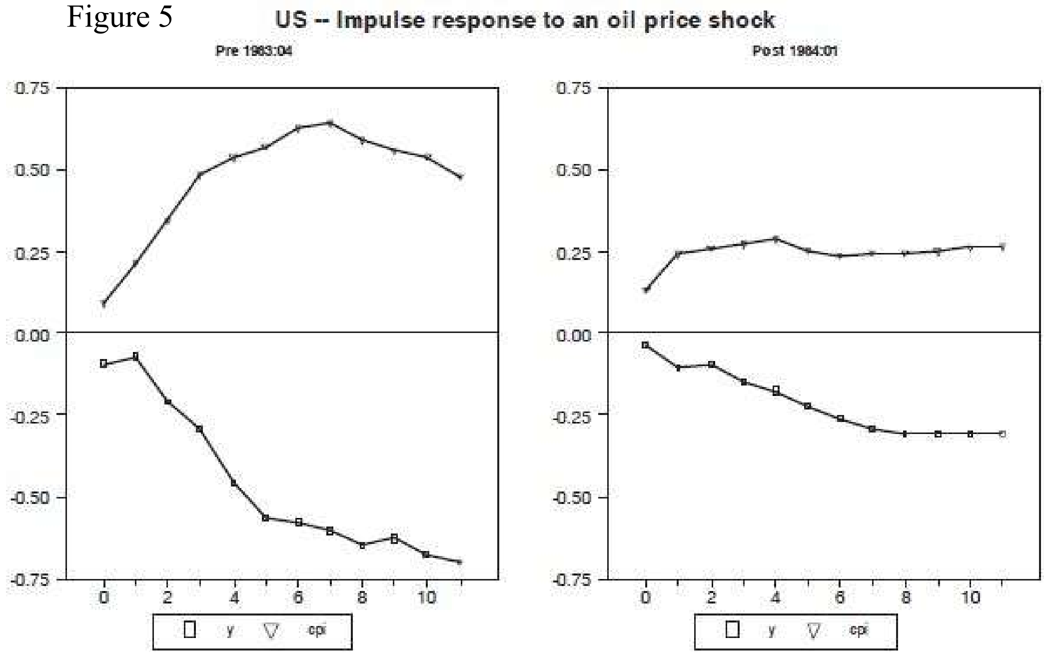
In conclusion, Barsky and Kilian (2002) provide a more valid explanation of the Great Stagflation by showing that the primary cause is the excess in demand caused by a monetary expansion. In contrast, disturbances in the oil market appear to be less decisive than anticipated to explain the controversial economic situation in the 1970s in the U.S..

1.3 Oil Shocks, Monetary Policy, and the Great Moderation

As we saw in section 1.1.1, some macroeconomists viewed increases in the price of oil as the primary source of significant economic fluctuations that happened in the 1970s. However, some authors (Bernanke, Gertler and Watson, 1997; Barsky and Kilian, 2002) argued that the Great Stagflation was caused either indirectly by oil or directly by other non-oil factors, such as the monetary policy of the Federal Reserve. Therefore, oil price shocks explained only part of the stagflation episodes of the 1970s.

Moreover, since 1984 the U.S. economy has experienced a considerable reduction in inflation and output volatility, a phenomenon commonly referred to as the "Great Moderation". In this context the impact of changes in the price of oil on macroeconomic performance has diminished considerably, casting even more doubts on the relevance of oil price shocks as a source of economic fluctuations (Figure 5).

Figure 5



Source: Blanchard and Galì, 2007

In fact, since the late 1990s there have been two other major oil price shocks of similar size to those in the 1970s, and after those shocks the changes in the level of output and inflation were relatively small. Some scholars, such as Clarida, Galì and Gertler (2000) and Blanchard and

Galì (2007) study some possible causes which may have helped muting the impact of oil price shocks after the 1970s, suggesting that the U.S. economy has improved the trade-off between stabilizing inflation and stabilizing the output gap.
Each of these hypotheses will be discussed individually in the following paragraphs.

1.3.1 Real Wage Rigidities

Blanchard and Galì (2007) show that real wage rigidities could have declined over time, diminishing the impact of oil price shocks in the U.S. economy. Their analysis starts from the observation that the 1970s were characterized by strong labor unions and a relevant wage indexation, whereas in the 2000s these characteristics almost disappeared. They illustrate that the presence of real wage rigidities, which retard the adjustment of real wages to changes in economic conditions, can generate substantial fluctuations in inflation and economic activity.
However, to what extent a decrease in the degree of real wage rigidities may have silenced the effects of oil price shocks in recent years? To answer this question, Blanchard and Galì (2007) set up a VAR model to provide evidence of an increase in the rate of adjustment of real wages in the recent period by studying the response to a 10 percent rise in the price of oil. According to their model, consumption wage tends to decrease in response to an oil price shock, whereas unemployment tends to rise. Nevertheless, the response to oil price shock for the former is constant over time, whereas for the latter has plunged dramatically, suggesting that a decrease in real wages is now achieved with only a slight increase in unemployment, compared to the large increase in unemployment required in the 1970s. This observation, in turn, suggests that real wages adjust at a faster rate.
A similar conclusion can be achieved by looking at the evolution of the wage mark-up. Blanchard and Galì (2007) show that since a rise in the price of oil leads to a rise in the wage mark-up, it means that the consumption wage declines less rapidly than the marginal rate of

substitution. However, this effect has become weaker over time, suggesting that the consumption wage and the marginal rate of substitution move more similarly now compared to what they did in the 1970s, thanks to a more flexible labor market.

1.3.2 Monetary Policy Innovations

Another plausible reason which may help explain the weaker impact of oil price shocks on macroeconomic performance since the early 1980s are the innovation of the monetary policy rule followed by the Federal Reserve and its improved credibility.

As Clarida, Galì and Gertler (2000) pointed out, there was a significant difference in the way monetary policy was conducted before and after 1979, i.e., the year Paul Volcker was put in charge of the Federal Reserve. Before 1979 the Federal Reserve reacted to an increase in expected inflation with only a slight increase in the nominal interest rate, thus allowing the real interest rate to decrease as anticipated inflation soared. On the contrary, after 1979 the Federal Reserve responded by raising the nominal interest rate more than the increase in expected inflation, thus increasing the real interest rate. This result leads Clarida, Galì and Gertler (2000) to conclude that after 1979 the Federal Reserve has had a stronger commitment to combating inflation, and therefore the inflationary effect of oil price shocks has been less persistent over time.

Blanchard and Galì (2007) show that although this commitment in combating inflation has lowered fluctuations in inflation, it should have increased the volatility of the output gap, rather than diminishing it. To solve this empirical puzzle, they suggest that this has not happened since the credibility of the Federal Reserve has improved, thanks to better communication, higher transparency and the adoption of an explicit inflation target. With the help of their model, Blanchard and Galì (2007) show that these gains in credibility have helped to improve consistently the trade-off faced by the Federal Reserve, suggesting that this may have helped to decrease fluctuations in inflation and in unemployment after an oil price shock simultaneously. They show that

after a 10 percent rise in the price of oil, the response of expected inflation has plunged substantially over time. Moreover, the response of the nominal interest rate has been relatively stable across sample periods, suggesting that the response of the real interest rate has been stronger due to the diminishing reaction of expected inflation to oil price shocks. Therefore, while the lower response of expected inflation to oil price shocks is seen as a consequence of the higher weight put on stabilizing inflation, the evidence of a smaller increase in unemployment suggests that the Federal Reserve's improved credibility may also have had a fundamental role. This view is consistent with the fact that the reaction of inflation expectations to oil price shocks plunged substantially since the 1970s (Blanchard and Galì, 2007).
The natural question arising from this analysis is: why the Federal Reserve followed such a harmful monetary policy rule before 1979? As Clarida, Galì and Gertler (2000) suggest, policymakers in that period did not know the fundamental role of expectations in generating inflation and the importance of credibility.

1.3.3 Share of Oil in the Economy

Another hypothesis that may help to explain the improved trade-off is the possible decline in the share of oil in production and consumption since the 1970s. Blanchard and Galì (2007) provide evidence of such changes by estimating two versions of their model, using data on the share of oil in production and consumption in years 1973 and 1997, respectively. They conclude that the reduction in the share of oil in the economy since the 1970s, once again, cannot explain the total reduction in the volatility of unemployment and inflation experienced during the Great Moderation, but it clearly has had a role.

The three hypotheses presented above, however, taken individually can explain only partially the tremendous reduction in volatility that happened since 1984. Blanchard and Galì (2007) show that their effect can more than explain the improvement in the trade-off observed in the actual data when they are combined.

Chapter 2

Oil Shocks and Monetary Policy: The Evidence

In Chapter 1 we saw different channels of transmission through which oil price shocks may have affected the U.S. economy. The occurrence of the Great Stagflation, however, provided new pieces of information which made the prevailing theories of that time inconsistent with the empirical evidence, suggesting the indirect effect of oil price shocks in the economy through the monetary policy response of the Federal Reserve. In this chapter is shown how the Federal Reserve sets its monetary policy reaction function and we derive a simple monetary policy rule which assumes a systematic response of the Federal Reserve to oil price shocks. Subsequently, we test this model empirically for the period [1975Q2:2020Q2].

2.1 A Simple Monetary Policy Reaction Function for the U.S.

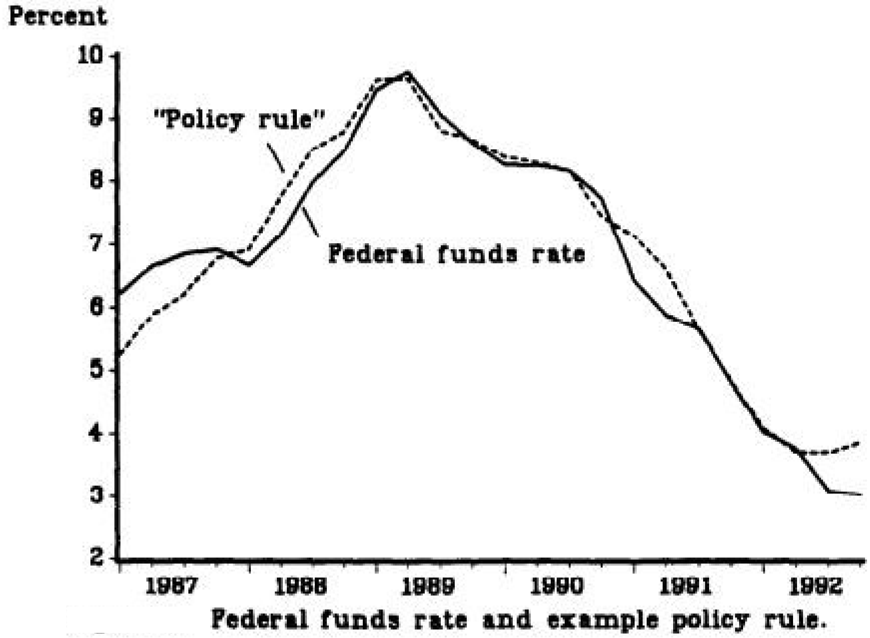
It is widely known that fluctuations in output and inflation cause a net loss in economic welfare: social welfare will increase if policymakers diminish the volatility of output and inflation in the economy through monetary policy (see Clarida, Galì, and Gertler, 1999). However, what rule should the Federal Reserve follow to minimize the social loss? In his famous paper, Taylor (1993) argues that the Federal Reserve should adjust the interest rate in response to the ascertained deviations of output and inflation from their target and potential levels. The rule proposed is the following:

$$i_t = i^* + \beta(\pi_t - \pi^*) + \gamma(y_t - \bar{y}) \qquad (1)$$

where i_t is the nominal interest rate at time t, i^* is the natural nominal interest rate when inflation and output are both at their target levels, π_t and π^* are the inflation rate at time t and the inflation target rate respectively, and $(y_t - \bar{y})$ is the output gap at time t (the log-deviation of real output from its potential level at time t). Equation (1) is the famous *Taylor Rule.* In the view of John Taylor, the parameters γ and

β should reflect the Federal Reserve's aversion to output and inflation instability and are chosen arbitrarily by policymakers. Moreover, to be optimal the rule should follow the so-called *Taylor Principle:* the value of β should be greater than 0 to increase the real interest rate when inflation goes up. If such a condition is not met, an increase in inflation will bring down the real interest rate, further alimenting inflation by boosting the aggregate demand for goods. Even though the Taylor Rule was proposed only in 1993, it has proved to be a good empirical description of the actual monetary policy reaction function followed by the Federal Reserve in the period [1987:1992] (see Figure 6 below: "Policy rule" refers to equation (1)).

Figure 6



Source: Taylor, 1993

Since we are interested in studying the effect (if there is one) of oil price shocks in the behavior of the Federal Reserve, we expand equation (1) by including a component o_t^p which represents a shock in the price of oil at time t. Thus, equation (1) becomes:

$$i_t = i^* + \beta(\pi_t - \pi^*) + \gamma(y_t - \bar{y}) + \delta o_t^p \qquad (2)$$

The assumption that the Federal Reserve responds directly to oil price shocks is justified by the results obtained by Kilian and Lewis (2011).

According to their analysis of the VAR model in Bernanke, Gertler, and Watson (1997) (see section 1.2.1), the Federal Reserve did not respond to the higher inflation stemming from exogenous shocks in the price of oil during the Great Stagflation, but rather it responded directly to them to anticipate their potential inflationary pressures. However, there could be a reverse causality problem since oil price shocks might be affected by the monetary stance of the Federal Reserve, as suggested by Barsky and Kilian (2002) (see section 1.2.2). For that reason, we assume that the Federal Reserve reacts directly to exogenous oil *supply* shocks, which is consistent with the results obtained by Baumeister and Hamilton (2019) that a shock in the supply of oil is one of the most important factors in historical oil price movements, and it is not endogenously determined by the monetary stance of the Federal Reserve. Thus, the component o_t^p is substituted by s_t^{oil} in equation (2), representing an exogenous shock in the supply of oil at time t.

Another factor to consider is the tendency of the Federal Reserve to adjust the nominal interest rate cautiously, a practice commonly referred to as *interest rate smoothing.* Empirical evidence of this practice is provided by Rudebusch (1995), who shows the presence of serial correlation of interest rate changes. Possible explanations of this phenomenon, as pointed out by Clarida, Galì, and Gertler (2000), are the fear of disruption of financial markets (Goodfriend, 1991), and the uncertainty about the effect of changes in the interest rate (Sack, 1997). The partial adjustment of the nominal interest rate implied by interest rate smoothing is best described by the following equation (Clarida, Galì and Gertler, 1999):

$$i_t^p = (1-\rho)i_t + \rho i_{t-1} \tag{3}$$

where i_t^p is the *actual* policy interest rate, i_{t-1} is the nominal interest rate at time $t-1$, and ρ represents the degree of interest rate smoothing. Equation (3) assumes that there is only a partial adjustment to deviations of inflation and output from their target levels since the

actual policy interest rate is a weighted average of the desired nominal interest rate and its lagged value.
By combining equations (2) and (3), we get:

$$i_t^p = (1-\rho)\left(i^* + \beta(\pi_t - \pi^*) + \gamma(y_t - \bar{y}) + \delta s_t^{oil}\right) + \rho i_{t-1} \quad (4)$$

For the sake of simplicity, we assume that there is a one-to-one relationship between an increase in output and a decline in unemployment (note that γ will have the opposite sign), thus equation (4) becomes:

$$i_t^p = (1-\rho)\left(i^* + \beta(\pi_t - \pi^*) + \gamma(u_t - u_N) + \delta s_t^{oil}\right) + \rho i_{t-1} \quad (5)$$

where u_t is the unemployment rate at time t, and u_N is the natural rate of unemployment (NAIRU). Equation (5) is the equation that will be estimated in section 2.3.

2.2 Data

The data used to estimate the model above are quarterly time series spanning the period [1975Q2:2020Q2]. The choice to use quarterly data stems from the fact that they are typically used to study the U.S. economic cycle. With some exceptions, the data are seasonally adjusted and are acquired from the FRED online database. As an indicator of the policy interest rate, we use the average federal funds rate in the first month of each quarter (FEDFUNDS), expressed in percentage, combined with a series for the shadow rate from 2008Q4 onwards, since from that date the federal funds rate hit the 0% value and the monetary policy entered the zone called "zero lower bound". The "output gap", is measured by the deviation of the unemployment rate from its natural level. As an indicator of the unemployment rate, we use the average unemployment rate in the first month of each quarter (UNRATE), whereas for the natural rate of unemployment we use the long-term NAIRU rate estimated by the U.S. Congressional Budget Office (NROU). The inflation rate is measured as the annualized percentage rate of change of the GDP deflator (USAGDPDEFQISMEI). We measure the "inflation gap" as the deviation of inflation at time t from its average value computed in the period [1959Q1:2020Q4]. The data representing oil supply shocks is the series created by Baumeister and Hamilton (2019).

2.3 Estimates and Results Interpretation

Column (1) of Table 2 provides the OLS estimates of equation (5) with usual standard errors. Column (2) shows the regression of the squared residuals $\hat{u}^2$ on the independent variables, which is the basis of the Breusch-Pagan Test to check the presence of heteroskedasticity in the data. By looking at the p-value (0.000) of the F-statistic in Column (2), we reject the null-hypothesis of homoskedasticity, therefore statistical inference that rests on usual standard errors can be strongly misleading (Breusch and Pagan, 1979). For that reason, to avoid heteroskedasticity we use the HAC estimator of the covariance matrix (Newey and West, 1987). Column (3) shows estimates of equation (5) with HAC standard errors.

Table 2 OLS Parameters Estimation

Regressor	FEDFUNDS (1)	$\hat{u}^2$ (2)	FEDFUNDS (3)
i^*	6.174***	0.121	6.174***
	(0.839)	(0.330)	(0.801)
$(\pi_t - \pi^*)$	2.013***	0.382***	2.013***
	(0.366)	(0.010)	(0.239)
$(u_t - u_N)$	−1.523***	0.215**	−1.523***
	(0.512)	(0.101)	(0.420)
s_t^{oil}	−0.052	−0.285	−0.052
	(0.780)	(0.179)	(0.824)
ρ	0.915***	0.082	0.915***
	(0.019)	(0.052)	(0.025)
N	181	181	181
R^2	0.965	0.218	0.965
F-statistic		12.270	
p-value		0.000	

(Standard errors in parentheses)
Column (1): usual standard errors;
Column (3): HAC standard errors.
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

By observing the parameters estimated in Column (3), we can see that they are all highly statistically significant, except for the one related to oil supply shocks. As a result, in the period [1975Q2 :2020Q2] the Federal Reserve's monetary policy is consistent with what was discussed in section 2.1: the Taylor Principle is respected ($\beta > 1$), the weight put to deviations of unemployment from its natural rate is negative, and the degree of interest rate smoothing is consistent with the results obtained by Clarida, Galì, and Gertler (1999), indicating that there was only a partial adjustment of the interest rate over time. The parameter δ related to oil supply shocks, however, is not statistically significant, meaning that the monetary policy of the Federal Reserve did not react to oil supply shocks during that span of time. A possible explanation of this apparent non-reaction to oil supply shocks is to be found in the presence of structural breaks in the data, which means that the independent variables could have different impacts on different subsamples of our dataset. For example, Clarida, Galì, and Gertler (2000) show that there is a consistent difference in how monetary policy was conducted before and after 1979, the year in which Paul Volcker was appointed chairman of the Federal Reserve. This fact could explain why the estimated response of the Federal Reserve to oil supply shocks was not statistically significant, even though oil supply shocks could have had a substantial impact during the Great Stagflation. For that reason, we present in Table 3 the result of the Chow Test in two *a priori* determined dates to illustrate the presence of structural breaks in our dataset, showing that estimates presented in Table 2 explain the behavior of the Federal Reserve only on average (Chow, 1960).

Table 3

Chow Test

Breakpoint	F-statistic	p-value
1983Q2	2.947	0.014
2007Q3	2.297	0.047

Table 3 shows that there are two different structural breaks in our dataset, 1983Q2 and 2007Q3, which are consistent with two major historical events that occurred in the U.S.: the beginning of the period called the "Great Moderation", and the "Great Recession". Therefore, it seems necessary to estimate equation (5) in three different subsamples: [1975Q2:1983Q1], [1983Q2:2007Q2], and [2007Q3:2019Q4]. The reason we use 2019Q4 as the end date of the last subsample is that, starting from 2020Q1, the economy experienced the COVID-19 shock, therefore it seems reasonable to study the Federal Reserve behavior until 2019Q4.

Table 4 Subsamples Parameters Estimation (OLS)

	i^*	β	γ	δ	ρ
1975Q2:1983Q1					
	7.126	1.534	-1.450	-2.137**	0.853***
	(5.823)	(1.069)	(2.303)	(0.924)	(0.077)
1983Q2:2007Q2					
	7.809***	3.356**	-1.771*	0.405	0.932***
	(1.536)	(1.403)	(0.904)	(0.930)	(0.019)
2007Q3:2019Q4					
	0.239	-0.361	-0.731**	0.201	0.855***
	(1.169)	(0.336)	(0.327)	(0.383)	(0.076)

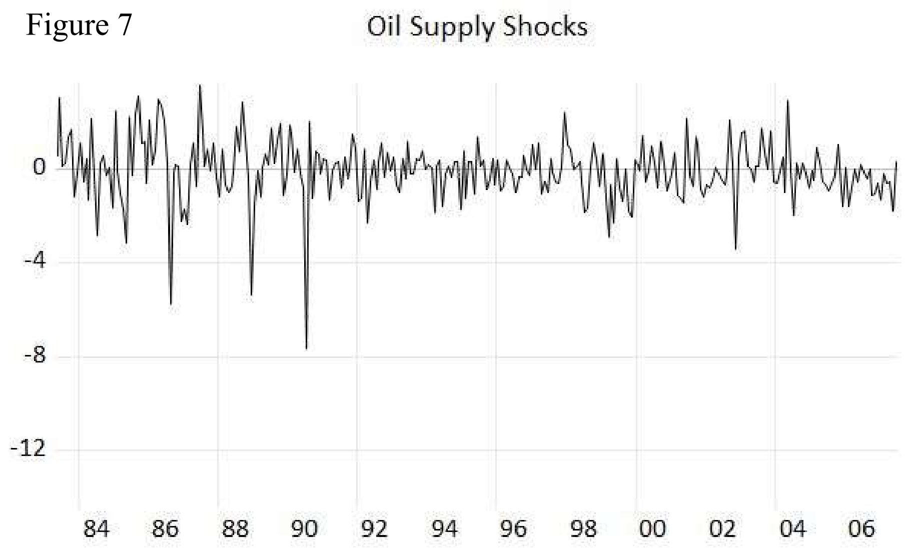
(HAC standard errors in parentheses)
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 4 shows the estimation of equation (5) in the subsamples mentioned above.

a) In the subsample [1975Q2:1983Q1], the only statistically significant parameters are the ones related to the response of the Federal Reserve to exogenous oil supply shocks (δ) and the degree of interest rate smoothing (ρ). The high and negative value of δ shows that the Federal Reserve reacted heavily to exogenous shocks in the supply of oil, which is consistent with the result obtained by Kilian and Lewis (2011). As assumed by Bernanke, Gertler, and Watson (1997), the Federal Reserve amplified the recessionary effects of oil price shocks through its monetary policy (see section 1.1.1), and it did it by simply reacting directly to the assumed underlying cause of these shocks: shocks in its supply. A possible explanation of this phenomenon is that policymakers assumed that oil shocks were necessarily inflationary, therefore raising the federal funds rate when a negative shock in the supply of oil occurred. This direct response to oil supply shocks had the result that the almost mild recessionary effects linked to oil price shocks were amplified in magnitude by the presence of higher interest rates. However, as we saw in section 1.2, it is unlikely that the effect of oil shocks alone explains the Great Stagflation. The result obtained cannot explain the presence of increasing inflation accompanied by higher unemployment, since oil price shocks are not necessarily inflationary (see section 1.1.2). As stated also by Bernanke, Gertler, and Watson (1997), it was possible that several price shocks in commodities other than oil could have had an inflationary effect during that period.

b) The value of the parameters in the subsample [1983Q2:2007Q2] (see Table 4) is consistent with the monetary policy shift that occurred with the non-explicit inflation targeting strategy adopted firstly by Paul Volcker. As we can see, the Federal Reserve's monetary policy was highly responsive to deviations of inflation more than it was in the previous period, consistently with the results obtained by Clarida, Galì, and Gertler (2000). Note that our subsample differs from the one in Clarida, Galì, and Gertler (2000) since the monetary policy shift that occurred during the Paul Volcker administration became effective only in the first quarter of 1983 (see Table 3) and not immediately in 1979. Only in the early 1980s, in fact, the main economic variables became less volatile, beginning the period called the "Great Moderation". Moreover, the Federal Reserve response to deviations of unemployment from its natural rate is only slightly significantly different from zero, further alimenting the hypothesis that the Federal Reserve was concerned only with controlling inflation in that period. Furthermore, it can be noticed that the response of the Federal Reserve to oil supply shocks is not statistically significant, which can explain why the impact of oil shocks in the U.S. economy was not as high as it was in the 1970s, even though there were consistent negative exogenous oil supply shocks in 1986, 1988 and 1990 (see Figure 7).

Figure 7



Source: Baumeister and Hamilton, 2019

This result is consistent with the view that there was an innovation in how monetary policy was conducted in that period. It was possible that the Federal Reserve understood that an oil supply shock was not a good predictor of future inflation, whereas gains in credibility stemming from a strong commitment to curb inflation could improve substantially the trade-off faced by the Federal Reserve, as hypothesized by Blanchard and Galì (2007) (see section 1.3.2).

c) The estimates for the subsample [2007Q4:2019Q4] show explicitly the reaction of the Federal Reserve to the severe financial crisis commonly referred to as the Great Recession. The years that followed the financial crisis were characterized by a deep recession, low levels of inflation, and by a "disappointing recovery" as stated by Taylor (2014). These facts could explain why the only statistically significant parameter in our analysis is the negative value of γ, showing that the Federal Reserve was concerned only with stabilizing the very low unemployment level caused by the financial crisis, rather than stabilizing the inflation rate, as was done from Paul Volcker onwards. This view is consistent with the shift in monetary policy, from a more predictable and conservative rule to a more discretionary and interventionist rule, observed by Taylor (2014), contradicting the macroeconomic theory underlining the importance of time consistency and the predictability of policy, thus resulting in poorer performance

(Taylor, 2014). However, it can be noticed that the Federal Reserve, once again, did not respond directly to oil supply shocks, consistently with the very low impact of oil shocks in the U.S. economy during this period.

In conclusion, the model estimated above shows that the Federal Reserve responded substantially to shocks in the supply of oil only during the Great Stagflation of the 1970s, thus deepening its recessive effects. On the other hand, from 1983Q2 onwards oil supply shocks have not had any role in the monetary policy response, even though there were major shocks in this period, thus reinforcing the hypothesis that the impact of oil shocks in the U.S. economy was not direct as believed, but rather it was amplified by the direct response of the Federal Reserve to those shocks.

Conclusion

The common belief in literature was that there is a direct link between oil price shocks and the behavior of the main economic variables: output and inflation. Since the work of Bernanke, Gertler, and Watson (1997), however, this view turned out to be anything but correct. In this thesis is shown how the relevant literature has gone toward the idea that direct traditional transmission mechanisms of oil price shocks in the U.S. economy fail to explain such a link, while the indirect link that passes through the monetary reaction to such shocks of the Federal Reserve can explain both the controversial situation that occurred during the Great Stagflation, and the almost irrelevant role of oil price shocks from 1984 onwards. Subsequently, the direct response of the Federal Reserve to oil shocks was tested empirically with the help of a simple econometric model. The results obtained showed that the response of the Federal Reserve to oil supply shocks, here used as a proxy of oil price shocks, was strong and statistically relevant only during the 1970s, thus suggesting that the substantial impact that oil shocks had during that period resulted from a tightening of monetary policy, rather than from oil shocks themselves. There are certainly some gaps in the model presented above which would benefit from further research, including the usage of more realistic proxies for oil price shocks, and the incorporation of outside lags in the monetary response of the Federal Reserve.

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