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Why the Nature of Oil Shocks Matters

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Abstract

This article studies the impact of oil shocks on the macroeconomy in two ways insofar unexploited in the literature. The analysis is conducted at the *global* level, and it explicitly accounts for the potentially changing *nature* of oil shocks. Based on an original world GDP series and a grouping of oil shocks according to their nature, we find that oil supply shocks negatively impact world growth, contrary to oil demand shocks, procyclical in their nature. This result is robust at the national level for the US. Furthermore, endogenous monetary policy is shown to have no countercyclical effects in the context of an oil demand shock.

Keywords: Oil shocks, Oil demand shocks, Oil supply shocks, Causality.

JEL classification: E32, Q43

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1. Introduction

Despite a surge in oil prices between 2001 and summer 2008, from 23 US $ per barrel up to 145 US $, the world economy has not undergone a recession caused by the price of oil, contrary to what happened during the early 1970s. A series of papers has argued that the impact of oil shocks on variables like GDP and unemployment has become more muted from the mid-1980s on. Three different explanations have been put forward: a non-linear reaction of macroeconomic variables to oil price shocks; structural changes in production and consumption patterns which have reduced the energy intensity of industrialized countries; and changes in macroeconomic policies which have reduced the pass-through from oil price shocks to inputs' and final goods' prices and better anchored inflation expectations.

Though abundant, this literature suffers from at least two pitfalls. First, most studies are circumscribed to the US economy; only a limited number extends the analysis to the G7 or the OECD group of countries, while none focuses explicitly on the patterns of *global* oil consumption, and on the impact of oil shocks on *world* economic performance[1]. Second, relatively little attention has been paid to the potentially changing nature of oil price shocks, and to whether correctly timing the change in their nature could help to explain the differential impact of shocks on world economy. Indeed, most studies mention that oil price shocks of the mid-1990s and 2000s have been demand shocks whereas oil price shocks of the 1970s and 1980s had been supply shocks. Several papers adopt a sample partitioning without explicitly testing for a break. Others test assumptions about the nature of oil shocks, but do not proceed to a sample partitioning needed to analyze their potentially different impact.

[1] For instance, the argument that a decrease in energy intensity in industrialized countries would explain the recent smoother world impact of oil shocks may not be fully consistent with the new geographical patterns of industrial activity (see e.g. Mucchielli and Mayer, 2004): relocations of energy-intense industries to emerging countries require a study at a *global* level.

Recently, Kilian (2006, 2008a,b) has aimed at disentangling the impact of supply and demand oil shocks on the economy. However, two drawbacks can be mentioned. First, Kilian's studies are mostly dedicated to the US or the G-7 economies. Second, Kilian is led to conclude that *all* oil price shocks since the beginning of the 1970s have been demand shocks. This finding is in contradiction with the author's motivation that demand shocks in the 1970s had quite a different impact on the US economy from demand shocks in the beginning of this century.

This paper's contribution to the literature will be twofold. First, it is necessary to focus on an adequate measure of the *world* demand for oil in order to clearly identify the nature of a given oil price shock. Second, a two-step procedure is implemented. After performing statistical tests that invalidate usual breaks in the literature, we introduce and justify a breakpoint in the series in the early 1990s. We study the relationship between the price of oil and our measure of *world* oil demand over the two subsamples in order to identify the different natures of oil shocks. We show why the nature of the oil shock matters: it is found to be an important determinant of the impact of a given oil price shock on the *global* economy. We test the robustness of this result on the US case and we also show that US monetary policy has not been countercyclical since 1992.

We construct an original series measuring the *world* GDP growth circumscribed to oil *consuming* countries, which constitutes the demand side of our study. As for the supply side, we adopt the methodology devised by Hamilton (1983). We argue that the oil price shocks of 1973/4, 1979/80, 1985/6, and 1990/1 were indeed *supply* shocks whereas those which have occurred during the most recent period can be correctly identified as *demand* shocks. A sample partitioning which regroups oil price shocks according to their nature gives interesting insights into the debate on causes of the muted impact of recent oil shocks. In the first subsample, which corresponds to the period characterized by supply shocks, oil price shocks are shown to have had a significant and countercyclical impact on real GDP growth whereas real GDP did not lead oil prices procyclically. This pattern is reversed in the second subsample which corresponds to a period of demand shocks: real GDP growth is shown to have had a procyclical and positive impact on the change in the real price of oil, while the increase in the real price of oil is shown to have had no countercyclical effects on real GDP growth.

The rest of this paper is organized as follows: section 2 presents a review of the literature; section 3 presents the data and the methodology, and justifies the sample partitioning; section 4 discusses the results; section 5 extends the analysis to the case of a specific country, namely the US, and section 6 sums up our main findings.

2. Literature review

In his seminal paper, Hamilton (1983) established that oil price shocks were a significant contributing factor of US recessions in the period 1949-1972, and he demonstrated that this relation still held in 1973-1980 even though the magnitude of the negative impact of the oil price shock on US real GNP growth had become smaller in the later subsample[2]. Hamilton (1983) also argued that oil price shocks prior to 1973 were pure *supply* shocks, i.e. unanticipated disruptions in the quantity of oil supplied to the market. Indeed, none of the macroeconomic variables tested by the author – output, unemployment, implicit price deflator for nonfarm business income, imported goods' prices, and money supply - allowed to predict the change in the price of oil in 1949-1972 whereas the change in the price of oil was shown to be a significant countercyclical determinant of real U.S GNP growth. Hamilton's (1983) findings were challenged by Hooker (1996), who reasserted the exogeneity of oil price shocks relatively to U.S. macroeconomic variables in both 1948-1973 and 1973-1994, but who found

[2] Hamilton (1983) used the nominal price of oil. The author argued that the lesser impact of the oil price changes in the second subsample was linked to the macroeconomic environment of higher inflation in 1973-1980 in which the same nominal oil price increase led to a smaller output effect than in a low inflation environment.

that oil price shocks ceased to be a significant determinant of either U.S. real GDP growth or U.S. unemployment rate in the second subsample. Moreover, Hooker (1996) found that for the whole sample (1948:1-1994:2) oil price changes did not Granger-cause either output or unemployment.

The historical decompositions of oil shocks' effects conducted by Hooker (1996) suggest however that the oil price shocks of 1973 and 1979 still had a significant impact on the US economy. Moreover, only the late 1980s testify for a change in the oil price – macroeconomy relationship which could not be adequately captured by either a linear or a non-linear specification of the relation. A series of recent papers have followed up on Hooker (1996) (e.g. Blanchard and Gali, 2007, Lescaroux and Mignon, 2008, and Kilian, 2008b) and they all admit a break in the sample in the 1980s. The sample partitioning is situated in 1983/4 by Blanchard and Gali (2007), and motivated by the beginning of the Great Moderation, or situated in 1986/7 in Lescaroux and Mignon (2008) who explicitly motivated this choice by Hooker's (1996) earlier findings of a break in the relation in the mid-1980s. Kilian (2008b) suggests a break in late 1985/7 linked to the disorganisation of the OPEC cartel. This finding is in turn consistent with the assumption of an asymmetric reaction of the G-7 economies to oil price increases and decreases evidenced by Mork et al. (1994), and later confirmed by Hamilton (2003, 2005).

All above-mentioned papers which opted for the change in the real price of oil as the appropriate proxy for the oil price shock concluded that oil price shocks have become either a non-significant or a weakly-significant determinant of real GDP growth in the U.S. and in other industrialized countries in the later subsample (mid-1980s-2005/7). However, if the net increase in the real price of oil above the peak reached in the three preceding years is chosen as the proxy for the oil price shock (see Hamilton, 2003), the oil price – macroeconomy relation is stable throughout 1949:2-1999:4, and the oil price shock remains a *significant* countercyclical determinant of real GDP growth.

It is therefore established that oil shocks were a significant determinant of the industrialized economies in 1949-1972, that they continued to exert, though to a lesser extent, a significant impact on these economies in 1973-1980 and that the evidence is mixed in the most recent period.

This observation has prompted a few authors to question the role of the *nature* of oil price shocks on the economy and to investigate whether the nature had changed overtime. Barsky and Kilian (2004) and Kilian (2008a) have pointed out the discrepancy between the oil shock measured in terms of the disruption of *quantities supplied* and the subsequent oil *price* shock, and suggested that oil price shocks had never been pure supply shocks, but rather wide swings in the price of oil resulting from a conjunction of capacity constraints on production, strong world demand for oil, and a shift in expectations as to future oil supplies. As further argued by Kilian (2006, 2008b), oil shocks would thus have been essentially demand shocks from the 1970s until today, and would have differed only in the nature of the demand shock itself: "precautionary demand shocks" in 1973-1987 which are shown to have had a significant and countercyclical impact on real GDP growth in the U.S., followed by "aggregate demand shocks" in 2002/3-2007 which are shown to have had an initially positive impact on real GDP growth in the U.S., but which eventually have led to a countercyclical reaction of U.S. output to increasing oil prices. The intermediate period, 1987-2001, is not precisely characterized by the author. Quite surprisingly, Kilian (2008a,b) argues that oil supply shocks[3] have roughly had nil effects on the price of oil over the whole sample while the same oil supply shocks are found to have had a negative and significant impact on real GDP growth.

[3] It is not absolutely clear whether the author defines an oil supply shock as the change in the quantity of oil produced worldwide, or as the disruption in supplies due to a particular political or military event.

Two critiques make the approach advocated by Barsky and Kilian (2004) and applied by Kilian (2006, 2008a,b) questionable. First, as shown by Hamilton (1983) and later confirmed by De Santis (2003), oil markets have been consistently characterized by a strongly regulated environment in which a dominant market player – the U.S. in the immediate after-war period, Saudi Arabia in the post-1973 period – maintained substantial leverage in changing the market equilibrium point by reducing or increasing the quantities of oil supplied. Moreover, both sub-periods have been characterized by a quota system[4] which was meant to absorb *anticipated* changes in supply and demand by allocating fixed production quotas, and which made the supply curve quasi-vertical in its short-term reply to unanticipated supply and demand shocks. De Santis (2003) shows how such a system produces a systematic price overshooting in response to oil supply quantity disruptions in the short term, and how the quota system brings about a progressive adjustment of the quantities supplied in the medium term, resulting in a much smoother trend in medium- and long-term real prices of oil.

In a similar manner, Hamilton (2008) argues that both the level of oil prices, and oil price changes have been highly unpredictable in 1970:1-2008:1[5]. The author shows that neither the lagged behaviour of real prices of oil, nor the growth rate of real U.S. GDP has had any predictive power of future oil price changes, and the null hypothesis of the necessity to estimate the forecasting regression in levels is rejected at the 1% level. The author further argues that given the low price elasticity of oil supply and demand, any unanticipated shock is translated into a short-term strong price overshooting. Both Hamilton (2008) and De Santis (2003) show that it is hazardous to infer anything about the *nature* of a given oil shock by simply analysing wide swings in the price of oil without acknowledging that the oil market is

[4] In the first sub-period, it is probably more justified to refer to a "regulated" environment rather than a quota system (see Hamilton, 1983, on this issue).

[5] Hamilton (2008) claims that the real price of oil "seems to follow a random walk without drift" over the entire period.

characterized by short term price overshooting. Indeed, such overshooting characterizes both unanticipated oil demand *and* supply shocks.

Second, as shown by Hamilton (1983) and Hooker (1996), there exists a well-suited methodology for assessing the link between macroeconomic variables and oil prices - the analysis of the direction of causality - which is not conducted by either Barsky and Kilian (2004), or Kilian (2006, 2008a,b). Applying Granger causality analysis, Hamilton (1983) and Hooker (1996) indeed showed that oil prices have been exogenous to U.S. macroeconomic variables in 1949-1972, as well as in 1973-1994 while Bénassy-Quéré et al. (2007) have shown that oil prices have been exogenous to the dollar exchange rate in 1974-2004. Lescaroux and Mignon (2008) have found that in 1960-2005, the causality runs from oil prices to macroeconomic variables, and not the other way around, for the group of oil-importing countries. Moreover, Lescaroux and Mignon (2008) find that splitting the sample for the U.S. results in the weakening of the link between oil prices and the economy, but not in a reversal of the direction of causality. However, Ewing and Thompson (2007), using monthly data for the U.S. economy in 1982:1-2005:11 and performing cyclical correlations (*cf*. infra), have found that the industrial production cycle leads procyclically the cycle of oil prices while oil prices lead procyclically the consumer price index (CPI).

To sum up, it appears that while oil prices have generally been found to be exogenous to the evolution of macroeconomic variables in any given industrialized country over the period 1949-2005, this finding is particularly robust for the 1949-1980 subsample, and less robust for the 1981-2005 sample. Furthermore, while oil prices are generally found to be a determinant of macroeconomic variables in any given industrialized country over the period 1949-2005, this finding is particularly robust for the 1949-1980/4 sample, and more fragile for the 1981/5-2000/5 sample. Moreover, we have highlighted that the sample partitioning in the mid-1980s suggested by the existing literature relies on the *assumption* of an asymmetry of reaction by macroeconomic variables to oil price increases relatively to decreases[6]. If this sample partitioning is mistaken, it could potentially contribute to the instability of the oil price – macroeconomy relationship which has been put forward in the most recent period. Finally, we have seen that none of the existing papers combine the following five-dimension focus: a focus on the *world* aggregate demand for oil, a focus on the impact of oil price shocks on *global* macroeconomic performance, a focus on identifying the *nature* of the oil price shock, a focus on grouping the oil price shocks by their nature in order to *ground* sample partitioning, and a focus on both the *historical* and the *causality* analysis for the whole OPEC period (1970-2007). This paper aims at filling this gap.

3. Data and sample partitioning

3.1 An original data series to account for the *world* demand for oil

In order to determine the nature of a given oil shock, it is necessary to construct an adequate measure of the *world* demand for oil. Indeed, one important contribution of this paper to the literature is the construction of an original measure of *world* real GDP growth, well-suited to the study of the oil price – aggregate growth relation.

It is noteworthy that Kilian (2006, 2008a,b) already pinpointed the necessity to base the identification of the nature of a given oil shock on an adequate measure of the *world* demand for oil. However, the data series suggested by the author is highly endogenous to the price of oil, as Hummels (2007) has shown recently. Therefore, the data series Kilian has been using cannot be relied on as an exogenous measure of "global real economic activity"[7]. More precisely, Kilian (2006) constructs a global index of dry cargo single voyage freight rates in

[6] Hamilton (2003) has indeed put this *ad hoc* sample partitioning into question, arguing that the correct measure of an oil price shock would then be the net percentage increase in the price of oil over the maximum price reached in the 1 or 3 previous years, rather than a break in the sample in the mid-1980s.

[7] Kilian (2006, p.6).

1970-2005 using monthly data from Drewry Shipping Consultants LTD, and he argues that this freight rates' series is a good proxy for global aggregate demand. Two pitfalls must be acknowledged. First, freight rates are a *price* indicator, not a quantity indicator: without checking further for oil markets' organisation[8], it is debatable to use a price as a pure indicator of quantity. Second, Hummels (2007) has shown that maritime transport freight rates are highly sensitive to oil price shocks: the elasticity of ocean shipments' costs with respect to fuel costs is estimated to be 0.327, and this coefficient is significant at the 1% confidence level. The endogenous character of the "global real economic activity" measure used by Kilian (2006, 2008a,b) might therefore explain why the author finds an initially positive response of this measure of economic activity to an adverse political oil supply shock: indeed, the freight rates increase in response to fuel costs' increase, whereas it might not be necessarily true for global economic activity *per se*[9]. The endogeneity of Kilian's measure makes the interpretation of his results as to the nature of oil shocks problematic.

We proceed in a different way. To identify a measure of *world* demand for oil, we construct a data series of *world* real GDP growth[10] restricted to major oil consuming countries, and weighted by their oil consumption share. When considering the oil price – macroeconomy relation, a focus on the macroeconomic performance of countries which do not consume oil – or which represent a marginal share of the world demand for oil – does not seem justified.

[8] Hamilton (2008) asserts that the Organization of Petroleum Exporting Countries (OPEC) does not behave like a traditional cartel, making the relationships between production, demand and prices all the more difficult to predict.

[9] Kilian (2006, p.14) assumes that this result is a coincidence, and imposes the restriction that political oil supply shocks can only affect real economic activity (which is proxied by the index of ocean freight rates) through their effect on the real price of oil.

[10] Real GDP series are taken from Datastream. For Taiwan and Singapore, initial series are nominal GDP deflated by the CPI index, both taken from Datastream.

Similarly, omitting a country which oil consumption is high would weaken the explanatory power of our measure. Therefore, the analysis of the oil price – macroeconomy relation focuses on the major oil consuming countries, which are both strongly impacted by oil price shocks, and best suited for identifying the possible demand nature of a given oil shock (i.e. if the shock is a demand shock, it will be predicted by the indicators of oil consumers' real GDP). Furthermore, in constructing our data series, we focus on *net* oil consumers since some countries simultaneously represent a significant share of world oil demand, and of world oil production.

The data series is constructed after computing oil consumption shares from the BP Statistical Review of World Energy 2007[11]. The review provides measures of annual oil production and oil consumption by countries over the sample 1965-2006. We select the countries which each represent more than 1% of total 2006 world oil consumption, are net oil consumers, and make available quarterly real GDP data on a long term basis. This leaves us with a group of 16 countries which on average represent 61% of world oil consumption in 1970-2006[12]. The aggregate GDP series is then built by weighing the seasonally adjusted measure of real GDP of each country by its share of oil consumption within the group. Five of the countries in the group, namely China, Brazil, India, Singapore, and Thailand, did not make real GDP data available on a quarterly basis in 1970. Each of these countries is integrated in our weighted world GDP series once it started publishing real GDP data on a quarterly basis. It is noteworthy that this does not create any significant breaks in the aggregate GDP measure as

[11] Available at www.bp.com/statisticalreview .

[12] USA, Brazil, France, Germany, Italy, Netherlands, Spain, United Kingdom, Australia, China, India, Japan, Singapore, South Korea, Taiwan, and Thailand.

each newly arriving country weighs between 0.25 and 3.3% of world oil consumption upon its entry in the aggregate data series[13].

Figure 1 shows that the first three oil shocks, from 1973 to 1988, coincided with periods of slowdown and even recession in the biggest net oil consuming countries. Over the remaining sample, the events highlighted do not correspond with particular evolutions in the data. The first Gulf War gave rise to a transitory fall in GDP, but its size was not similar to that of earlier oil shocks. The Asian crisis was not followed either by a strong slowdown and this is due to the fact that the magnitude of this shock was circumscribed in time and space. At the opposite, the slackening of world growth consecutive to the burst of the Internet bubble in 2000/2001 is a lot more visible owing to its broader dispersion. Finally, the trend of world growth is visible from 2003 on. We see that the series adequately capture the magnitude of global demand fluctuations.

It might be argued that we should have used *gross* GDP series to study whether oil consumption determines the price of oil, and *net* GDP series to study the effect of an oil price shock on macroeconomic performance. This is why we conducted robustness tests[14] using a second weighted real GDP measure constructed by including all major oil consuming countries which make available their quarterly real GDP data on a long term basis, and weighing each country's real GDP by its gross share of the group's oil consumption. This adds 4 net oil producer countries to the 16 net oil consumer countries, namely Canada, Mexico, Russia, and Indonesia. This second measure thus disregards whether the country is a net producer or consumer of oil and represents on average 67% of world oil consumption and 41% of world oil production in 1970-2006. The results presented in the following section are

[13] It should also be noted that in the final aggregate GDP series based on the economic performance of the most significant net oil consuming countries, oil producing countries represent 26% of world oil production in 1970, and only 19% of world oil production in 2006.

[14] See *infra*, section 4.

based on our net consumer weighted GDP series, but these results are robust if the gross consumer weighted GDP series are substituted for net figures.

3.2 The real price of oil

De Santis (2003) and Hamilton (2008) showed that the structure of the oil market leads to systematic price overshooting in response to unanticipated demand and supply shocks. This is the main reason why quantitative measures of oil shocks have been shown to inadequately capture both the actual magnitude and the duration of a given shock (Kilian, 2008a). Moreover, as the price of oil overshoots in reaction to all types of unanticipated shocks, it is indeed the adequate measure of the magnitude of a given oil shock. The question remains whether the nominal or real price of oil should be used.

It is commonly accepted in the literature that the change in the nominal price of oil is the best measure of an oil shock insofar as the statistical exogeneity of its determining variables is concerned[15]. However, according to economic theory, it is the real price of oil which should influence economic decisions. As the objective of this paper is to disentangle periods during which *world* demand has been endogenous to the price of oil and periods during which it has been exogenous, we use the real price of oil rather than its nominal value[16].

Finally, we have to address the choice of using a simple oil price measure or the net percentage increase above a previous peak oil price measure, as advocated by Mork et al. (1994) and Hamilton (1996, 2003). Indeed, as has been argued in section 2, an adequate measure of the magnitude of a given oil price shock would be the net percentage increase in the price of oil above the maximum price reached in the previous 4 (or 12) quarters.

[15] Hamilton (1983, 2005).

[16] Hamilton (2005, p.2) notes that nominal oil shocks are of magnitude greater than real shocks; hence, using the real price of oil measure does not change the substance of the results and incorporates less variance than nominal shocks.

Nevertheless, though the net increase in price variable may be best indicated for deriving the *magnitude* of a given oil price shock, it cannot capture the *duration* of the shock - by construction. We opt for the real price of oil as our preferred oil shocks' measure because it better captures both the magnitude and the duration of an oil shock.

3.3 The general framework

We use a bivariate model with a world aggregate demand indicator and a world aggregate supply indicator, in order to analyse the relationship between oil shocks and macroeconomic performance. The use of the real price of oil as a supply indicator is at odds with Kilian (2006)'s use of the same variable as an aggregate *demand* indicator[17]. The opposition stems from the fact that in Kilian (2006), the structural shock on the real price of oil is the 'residual' shock after the politically-driven supply shock, the shock on global crude oil production and the shock on real economic activity have been identified according to a Cholesky decomposition. We have already argued that the real economic activity indicator in Kilian (2006) was a price – freight rates – which is correlated with the price of oil. Therefore, his four-dimensional model appears to be a three-independent-dimension one. Moreover, these three dimensions are related to the supply side of the economy only.

Having a simple aggregate demand indicator like world GDP growth of net oil consuming countries, and confronting this indicator with the real price of oil seems a better approximation of an aggregate demand/aggregate supply model for studying oil shocks' effects. Nevertheless, we have lost one dimension as regards Kilian: shocks to the real price of

[17] In Kilian's (2006, pp.13-14) view, "innovations to the real price of oil that cannot be explained based on oil supply shocks or aggregate demand shocks will be viewed as shocks that reflect changes in the demand for oil as opposed to changes in the demand for all other commodities (…). The latter structural shock will reflect in particular fluctuations in precautionary demand for oil driven by fears about the availability of future oil supplies".

oil can be driven by political events and/or changes in global crude oil production[18]. This simplification is not decisive insofar as both types of supply shocks occurred during the same subsample, so that our sample partitioning can still be precisely interpreted as a supply-driven (whatever its type) / demand-driven shock partitioning. We have checked that this condition was met. In a series of estimations not shown here (but available upon request), we found that changes in the world production of oil are indeed a statistically significant determinant of oil prices in the 1973-1992 subsample while oil prices do not Granger cause oil production. This pattern is reversed in 1992-2006: oil prices are found to Granger cause oil production procyclically while oil production no longer Granger causes the real price of oil[19].

3.4 Sample partitioning

In order to determine the nature of oil shocks and their impact on the macroeconomy, we first proceed to Quandt-Andrews and Chow tests to check whether a precise breakpoint can be inferred from a statistical approach. Quandt-Andrews tests fail to identify a significant breakpoint in the data over the period 1970-2006 both in the oil price and in the *world* GDP equations. However, the most likely breakpoint for the oil equation is indicated to be in 1988:4, whereas the most likely breakpoint for the GDP equation is found to be in 1994:3. A first lesson thus arises: if a breakpoint occurred, it would have come rather late in comparison with assumptions made in the literature. Now, applying a Chow test for the oil equation, we reject at the 10 percent level the null hypothesis of no break in 1988:4. Furthermore, the

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[18] Although of interest, identifying different types of supply shocks and their macroeconomic impacts is beyond the scope of this paper.

[19] It must be acknowledged that we have not conducted the same analysis for world oil *consumption* and the real price of oil because quarterly data on aggregate oil consumption have become available only since 1982 for the OECD countries, and since 1994 for the entire world [this data series is made available by the U.S. Energy Information Administration].

Chow test rejects a breakpoint in the oil equation either in 1983, 1985, 1986, 1992, 1994, 1997 or 2001, whatever the quarter. A second lesson arises: these various years have long been assumed to testify for a break in the series, but a Chow test rejects the assumption. Applying a Chow test for the GDP equation, we reject at the 10 percent (resp. 5 percent) level the null hypothesis of no break in 1992 and 1997 (resp. 1994). A Chow test rejects a breakpoint either in 1983, 1985, 1986, 1988, or 2001 in the GDP equation. Finally, Quandt-Andrews and Chow tests suggest that if there were a structural change in the oil price – aggregate demand relation, the break would be situated in the mid-1990s. Moreover, they fail to indicate that a breakpoint in the mid-1980s is justified by the data.

We have seen that the previous approach fails to establish a statistical breakpoint. This is why we turn to the methodology devised by Hamilton (1983), in which institutional-historical analysis gives the indications necessary to formulate a hypothesis on the grouping of oil shocks according to their nature in 1970-2006.

In establishing the nature of oil shocks from 1970 until 1992, we turn to Hamilton (2003, 2005, 2008) who argues that the 1973/4, the 1978/9, the 1980/1, the 1985/6, and the 1990/1 oil shocks have been oil *supply* shocks. His finding is justified on the basis of the observation of the simultaneity of supply disruptions following political and military turmoil in oil-producing countries and major oil price increases, as well as his observation of a substantial price decrease in 1985/6 concomitant with the flooding of the market by major oil suppliers. None of these events coincided with a break in oil demand patterns. Moreover, Hamilton (2008) notes that even though investment cycles in the oil industry are lengthy, and the short-term price elasticity of supply is low, the scarcity rent was largely absent from the objective function of oil producing countries until the late 1990s.

Since the last major well-known supply shock dates back to 1990/91, we assume that 1992:3 can be an appropriate breakpoint.[20] At this quarter, the consequences of the supply shock are assumed to have vanished.

In establishing the nature of the oil shocks in 1992-2006, we have turned to Hamilton (2005, 2008), Nordhaus (2008), Bénassy-Quéré et al. (2007), Lescaroux and Mignon (2008), and Kilian (2006, 2008b). All of these authors agree that oil price shocks in the 2000s have been clear demand shocks linked to the strong growth of emerging economies. Hamilton (2008) shows that it is only in the very recent period that oil supply has not been able to follow oil demand: the author argues that it is indeed Saudi Arabia which, contrary to its dominant player stance of the 1973-2004 period, has been unable to sufficiently increase the quantities of oil supplied to the market since 2005. As to the nature of the oil shock in 1997/8, both De Santis (2003) and Hamilton (2003) argue that this shock was also a demand shock. These findings motivate this paper's decision not to break the sample in the mid-1980s but rather in the second half of 1992.

4. Characterization of the Oil-*world* GDP Relation

We proceed to the cyclical correlations', impulse response functions' and causality analysis to check the relevance of our oil shocks' grouping in supply shocks in 1970-1992, and demand shocks from 1992 on. It is noteworthy that the results presented in the next section are robust to a ± 4 quarters' change in the sample partitioning.

[20] We find that our partitioning is also robust to a separation at all quarters of 1994 for which structural break tests find some statistical evidence. Our results remain unchanged for a breakpoint of our samples comprised between 1991:4 and 1994:4. We choose the earliest possible bound to get the longest demand shocks' sample. It is noteworthy that Quandt-Andrews and Chow tests do not invalidate a sample partitioning in the 1990s; however, they do not provide strong evidence in favour of this choice.

4.1 Cyclical Correlations

We use cyclical correlations methodology to give a first assessment of the differential nature of oil shocks in the two subsamples. Serletis and Shahmoradi (2005) used this methodology to infer cyclical comovements between business cycles and natural gas prices. Ewing and Thompson (2007) applied this methodology to the relationships between oil prices and various macroeconomic variables, but they did not consider a possible break in the sample, nor did they interpret their results in terms of the nature of oil shocks.

First, we decompose the time series into long-run and cyclical components using the Hodrick-Prescott (1980) filter (HP); second, we compute the dynamic cross correlations of cyclical components of oil prices and real GDP and measure their degree of comovement. The cross correlation coefficient is noted $\rho(j)$, where $j = 0, \pm 1, \pm 2, \pm 3$, etc. This approach gives indications on the strength and synchronization of oil and *world* GDP's cyclical comovements.

We assert that the two cyclical components are strongly correlated, weakly correlated or uncorrelated according to the value of contemporaneous correlation, *i.e.* if $0.23 \le |\rho(0)| < 1$, $0.10 \le |\rho(0)| < 0.23$, $0 \le |\rho(0)| < 0.10$, respectively. The sign of $\rho(j)$ gives an indication on the direction of the relationship: if $\rho(j)$ is positive (negative), then oil prices are procyclical (countercyclical). Last, if $|\rho(j)|$ is maximum for a positive (negative) *j*, then the cycle of oil prices is leading (lagging) the GDP cycle.

Table 1 presents the results for the full sample and both subsamples. It is straightforward that on the full sample and the first subsample, the cycle of oil prices is leading countercyclically the GDP cycle: the maximum correlation is obtained for a positive *j*, and $|\rho(j)|$ for positive values of *j* are higher than negative values. For the second subsample, the relation between cycles of oil prices and GDP is procyclical. Concerning the leading or lagging forces, evidence is mixed: the maximum value of $|\rho(j)|$ is for a negative value of *j* and $|\rho(j)|$ for negative values are in general superior to $|\rho(j)|$ for positive values. This means that the cycle of oil is lagging the GDP cycle. However, according to Lescaroux and Mignon (2008)'s threshold[21], $|\rho(j)|$ for positive values are substantial (i.e. superior to 0.23) and they suggest that the cycle of oil is *also* leading (positively) the GDP cycle.

The relation between the cycles of oil prices and GDP on the first subsample can be interpreted in terms of supply shocks: large supply shocks, leading to large oil prices hikes, produce a subsequent lower *world* GDP growth rate. Over the second subsample, the procyclical relation between the cycles of oil prices and *world* GDP is consistent with an interpretation relying on demand shocks (see *supra*). As for the lagging/leading role of the oil prices on GDP, the ambiguity may stem from the nature of market expectations. If the price of oil were a forward-looking variable and if expectations were (almost) perfect or rational, it would lead GDP. On the contrary, backward-looking expectations would make the price of oil lag behind GDP (or demand). The case with gross (rather than net) oil consumers' weights for GDP figures gives more credence to the forward-looking expectations' hypothesis: although the highest value for $|\rho(j)|$ is still for a negative *j*, positive values for j from +1 to +3 are now all above Lescaroux and Mignon (2008)'s threshold.

To sum up, cyclical correlations analysis shows that there is a clear difference in the direction of the relation between the cyclical components of oil prices and *world* GDP. We interpret this difference as a robustness check of the appropriateness of our sample partitioning: exogenous supply shocks before 1992, and endogenous demand shocks since then.

[21] Lescaroux and Mignon (2008) adopt a very precise, though unexplained, threshold: if $|\rho(j)|$ is substantial (larger than 0.23) for a positive or negative value, then the cycle of oil prices is leading or lagging the GDP cycle.

4.2 Impulse Response Functions

We now proceed to a simple bivariate VAR[22] analysis in order to assess the direction and magnitude of the relationship between oil price and net oil consuming countries' real GDP. We then compute Impulse Response Functions (IRF) for both subsamples. Series are taken in first difference[23] and we set the number of lags to p=1 according to the four usual tests: the Final Prediction Error (FPE) test, the Akaike Information Criterion (AIC), the Schwarz information criterion (SC) and the Hannan-Quinn information criterion (HQ)[24].

Figure 2 displays results for the first subsample 1970:3 – 1992:3 and shows that world GDP growth rate reacts negatively to an oil inflation shock while world GDP growth rate has no significant impact on oil inflation though the sign of the relationship seems positive. This can be explained by the political nature of oil shocks during this period. Figure 3 presents the IRF of the second subsample 1992:4 – 2006:4. The relation has changed: world GDP growth rate has a stronger and significant impact on oil inflation, whereas it does not react significantly to oil inflation shocks. One interesting point is that world GDP growth rate rises after an oil inflation increase (although not significantly), contrary to the first subsample. Figure 4 shows the responses on the full sample. They are very close to Figure 2's.

The VAR specification has also been tested in levels as Sims, Stock and Watson (1990) advocated. The number of lags is 2 for the first subsample (1970-1992) and 3 for the second one (1992-2006) according to the same criteria as above. IRFs[25] are very similar to and similarly interpretable as those obtained with first-differenced data. We can thus conclude that the VAR analysis has pointed to the fact that the relationships between oil price and world

[22] We implemented Johansen cointegration tests and did not find evidence for the use of a VECM here.

[23] The real price of oil and *world* GDP are I(1) according to Augmented Dickey-Fuller, Phillips-Perron and Kwiatkowski-Phillips-Schmidt-Shin tests.

[24] Reported IRFs are robust to the introduction of 2 and 3 lags.

[25] They are available from the authors upon request.

GDP have been inverted over time and the partitioning between both subsamples, which has been characterized by the opposite nature of oil shocks, is illuminating in this respect: an oil shock slows down *world* GDP if it is correctly characterised as a supply shock, whereas it leads to a (non-significant) rise of *world* GDP if it is correctly characterised as an endogenous demand shock. Moreover, the first subsample being constituted of exogenous supply shocks, it is consistent that oil prices do not react to a GDP rise. In the second subsample, we also obtain the expected response: oil prices rise with a GDP increase.

The above-mentioned differences may explain why the effects of oil price rise on *world* real GDP have been rather low in 2003-2006: oil price rise has been due to an increase in world demand driven by stronger growth, and economic growth has kept on its endogenous dynamics without suffering further from the initial oil shock. In comparison with the pre-1992 period, it may be argued that the structures of the world economy between 1992 and 2006 have been more resilient to the oil shocks for they have been, at least in part, responsible for them.

4.3 Causality Tests

In order to investigate the direction of the relationship between oil prices and GDP, we have run Granger causality tests. Series are still in first difference. Results[26] are reported in Table 2. In the first subsample 1970:3 – 1992:3, neither null hypothesis is rejected: oil inflation and the world GDP growth rate do not cause each other. In the second subsample 1992:4 – 2006:4, the null hypothesis that world GDP growth does not Granger cause oil inflation is rejected at the 5% level, whereas the opposite hypothesis is still accepted. This result confirms the previous outcomes: to the extent that the sample is characterized by endogenous demand shocks, the recent oil shocks are shown to be driven by world economic growth. Surprisingly, one can wonder why in the first subsample, there is no link from oil prices to GDP, in

[26] Here again, results are robust to the inclusion of more lags.

opposition with the literature. Although one may be tempted to note that the probability associated with the test statistic concerning the null hypothesis that oil does not cause GDP is smaller in the first subsample than in the second, the puzzle remains.

The main significant result stemming from causality tests (the causality from GDP growth to oil inflation) is consistent with Barsky and Kilian (2004) and Ewing and Thompson (2007) who suggest a link from macroeconomic variables to oil prices. As reported in table 2, this causality runs over the full sample, though it is only significant at the 10% level. Moreover, unlike these authors, we have also checked that this causality was robust to a shortened sample and we have shown that the causality was not significant on the first subsample, therefore shedding critical light on the characterisation by Barsky and Kilian of oil shocks of the 1970s as demand shocks.

Since the variables have been transformed in first difference, the results of causality tests only provide information about their short-run relationships. Long-run dynamics can also be explored by performing causality tests in levels as proposed by Toda and Yamamoto (1995). They argued that in a VAR specification in level, it is possible to test causality with standard methods without concern about the possible presence of cointegration relations (in our case, we have none). They also advocated testing causality with usual methods under the condition that the estimation of the VAR process would be estimated with a specific number of lags. Indeed, we have to consider d_{max} as the maximum order of integration in the system (1, here); then a VAR($k + d_{max}$) has to be estimated to use the Wald test for linear restrictions on the k first parameters of the VAR, which follows an asymptotic χ_2 distribution. In this case, k is determined to be 2 by using the FPE, AIC, SC and HQ[27].

[27] In order to test for the robustness of this specification, we have also tested a VAR(4) whose results are qualitatively similar.

Results are reported in Table 3. In the first subsample of exogenous supply shocks, the null hypothesis of no causality from oil prices to GDP is rejected at the 1% level, while there is no significant link from oil to GDP. This point seems to resolve the preceding puzzle; thus, common wisdom for this period is confirmed. Over the more recent subsample of endogenous demand shocks, we reject both null hypotheses: at 1% for causality running from GDP to oil prices and at 5% for the opposite relationship. Interpretation for this result is that causality runs from GDP to oil prices while oil prices still impact GDP, but in a positive direction which is consistent with former cyclical correlations and IRFs.

The key point, then, is not that oil prices have had a lower impact (possibly thanks to a more credible monetary policy or more flexible wages, e.g. Blanchard and Gali, 2007), but that this impact has been different in nature from what it was before 1992. Our results suggest that the *nature* of shocks (which is completely different from one subsample to the other) is central in the *reversal* of impacts.

To conclude, a smoother endogenous demand shock as has occurred since 1992, has greater chances to be effortlessly incorporated in the economy structures than a sharp exogenous shock, like those that occurred before 1992. Because the assimilation of a shock is easier when it is gradual, oil shocks since the 1990s have not slackened the economy as toughly as before the 1990s.

5. The nature of oil shocks also matters at the national level: The US Case

In this section, we focus on the impact of oil shocks - a world driven phenomenon - on a specific country: the US, and we assess whether our assumption that oil shocks' impact on US macroeconomic performance differs according to their nature is robust. Conducting the analysis at this national level allows taking into account inflation and monetary policy variables in order to get a more complete picture of the mechanisms at work. In the VAR specification, we have added to US real GDP and the real price of oil, the US consumer price index and the federal funds rate. Series are stated in first difference (in percent), except the Fed's interest rate which remained in level. We set the number of lags at p=2 according to usual tests.

On figure 5[28], one can compare the impacts of oil shocks on US real GDP and GDP shocks on oil price increases in the 4-variable VAR with the same responses in the world bivariate VAR discussed in section 4. Oil price does not respond significantly to shocks on US growth in both periods, but it is noteworthy that oil price responses to both world and US growth shocks are higher in the demand shock sample than in the supply shock sample. The right hand side figure reports the response of world and US growth to an oil shock. Whatever the nature of the shock, an individual country like the US is more badly hit than the world economy. Moreover, the conclusion that growth is more badly hit during a period of supply shocks than during a period of demand shocks is confirmed in the case of a specific country. This result shows that the nature of shocks matters, not only for the world economy but also for an individual country like the US.

Moreover, figure 5 shows that the introduction of the central bank interest rate does neither remove the effect of oil price increases on GDP, nor the differences in these effects between the two subsamples. Thus, the 4-variable specification allows testing whether a recession following an oil shock is due to an endogenous monetary policy tightening and demonstrates this is not the case for the US.

Figure 6 reports that periods of demand and supply shocks have both created inflation in the US. However this is true to a lesser extent in the case of oil demand shocks. Moreover, we find that the response of the central bank has been broadly similar after these inflation increases in both subsamples.

[28] Confidence intervals on separate graphs are available from the authors upon request.

Finally, we have made use of the 4-variable VAR to gauge the impact of US monetary policy on both periods of oil shocks. Figure 7 shows that the response of GDP is significantly negative during the supply shocks' period, while it is quasi-null and not significant in the demand shocks' sample. While monetary policy reaction to oil shocks has not changed between both samples, we note that GDP is negatively affected by interest rate rises in the first sample and that demand shocks seem to lessen the negative effect of a tightening of monetary policy[29]. Two hypotheses emerge: either monetary policy has become ineffective since the beginning of the 1990s, in sharp contrast with conventional wisdom, or the nature of oil shocks modifies their impact. Indeed, a shock provoked by a persistent and world-driven growth has a lesser chance of engendering negative domestic effects than an oil supply shock. We may thus suppose that the absence of a negative GDP effect of domestic monetary policy can be due to the initial positive spiral of a growth period. The assumption that the impact of an oil shock differs according to its nature is also valid at a national level.

6. Conclusion

In this paper, we provide an empirical characterization of the link between oil price and real GDP at the world level, explicitly taking into account the nature of oil shocks. Most studies so far have been circumscribed to a limited number of developed countries, but none has focused explicitly on the patterns of *global* oil consumption, and on the impact of oil shocks on *world* economic performance. Moreover, little attention has been paid to the potentially changing nature of oil price shocks, and to whether correctly timing the change in their nature could help to explain the differential impact of shocks on the world economy. We use an original *world* GDP series based on countries' oil consumption. This allows us to conduct the analysis

[29] Bernanke, Gertler and Watson (1997) found that endogenous monetary policy magnified the real effects of oil shocks on the sample 1965-1995. Our results in the first subsample confirm this finding.

at a global level and to underline the importance of the nature of shocks in their impact on the world economy. We find that oil supply shocks have had a negative impact on GDP and have been independent from former GDP evolutions, while oil demand shocks are confirmed to be caused by GDP growth and to have a lesser or even no negative impact on macroeconomic performance.

Furthermore, we check the robustness of our assumption at the national level taking the US case. We confirm that the impact of an oil shock differs according to its nature and that a given country is more badly hit than the world economy. Taking into account the federal funds rate demonstrates that US monetary policy has not changed in the whole time span. Moreover, the monetary policy's impact has changed from one subsample to the other: in the case of an oil supply shock, monetary tightening has had a specific negative impact on GDP, whereas in the case of an oil demand shock, monetary tightening has been neutral. Mixed evidence in the literature on the relationship between monetary policy, oil shocks and macroeconomic performance may be due to the failure to account for the changing nature of oil shocks.

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8. Tables and figures

Table 1 : Cyclical correlations of crude oil prices with GDP

	j= -4	*j= -3*	*j= -2*	*j= -1*	*j= 0*	*j= 1*	*j= 2*	*j= 3*	*j= 4*
World GDP Measure 1: Net Oil Consumers									
Total Sample	0.2447	0.1763	0.1084	0.0421	-0.0865	-0.1898	-0.2526	-0.3131	-0.3444
1970Q3 - 1992Q3	0.3245	0.1679	-0.0012	-0.1337	-0.3117	-0.4357	-0.4801	-0.4936	-0.4737
1992Q4 - 2006Q4	0.0268	0.2199	0.4458	0.5713	0.5758	0.5285	0.4068	0.2009	0.024
World GDP Measure 2: Gross Oil Consumers									
Total Sample	0.2257	0.1731	0.123	0.0721	-0.0436	-0.1481	-0.2166	-0.2832	-0.3267
1970Q3-1992Q3	0.3242	0.1733	0.0132	-0.1121	-0.2832	-0.4081	-0.4532	-0.4704	-0.4576
1992Q4 2006Q4	-0.0417	0.1886	0.4479	0.6066	0.6384	0.5887	0.4504	0.2368	0.0379

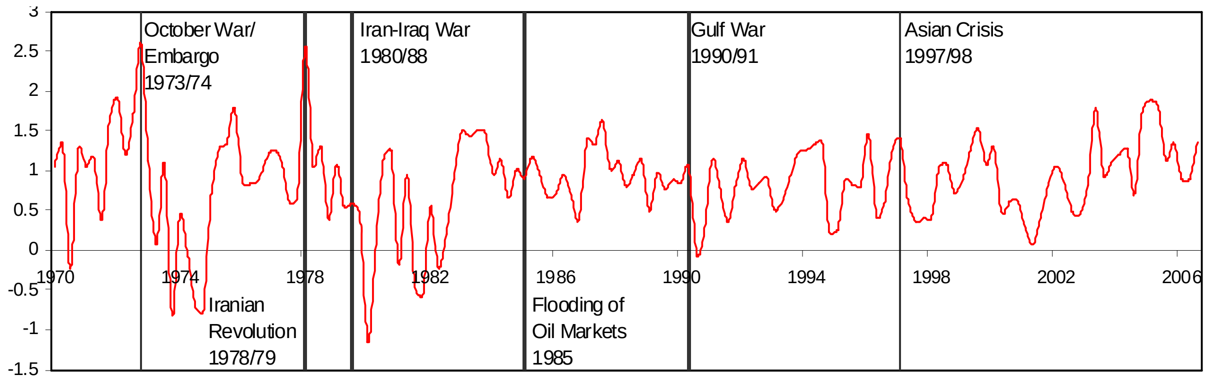
Table 2 : Granger Causality Tests

	1970Q3 - 1992Q3		**1992Q4 - 2006Q4**		**1970Q3 - 2006Q4**	
Null Hypothesis	F-Statistic	Prob.	F-Statistic	Prob.	F-Statistic	Prob.
OIL does not Granger Cause GDP	1.52199	0.2207	0.82875	0.3667	0.70304	0.4032
GDP does not Granger Cause OIL	0.85999	0.3564	4.83724	0.0322	3.36383	0.0687

Table 3 : Toda-Yamamoto Causality Tests

	1970Q3 - 1992Q3		**1992Q4 - 2006Q4**		**1970Q3 - 2006Q4**	
Null Hypothesis	χ^2-Statistic	Prob.	χ^2-Statistic	Prob.	χ^2-Statistic	Prob.
OIL does not Granger Cause GDP	9.506031	0.0086	7.278032	0.0263	6.876544	0.0321
GDP does not Granger Cause OIL	5.858726	0.0534	19.58162	0.0001	7.751485	0.0207

Figure 1 : Real GDP of net oil consumers
(Percentage change, quarter-over-quarter)



Sources: BP Statistical Review, Datastream, authors' calculations

Figure 2 : Impulse Response Functions to GDP and Oil Shocks 1970Q3 – 1992Q3

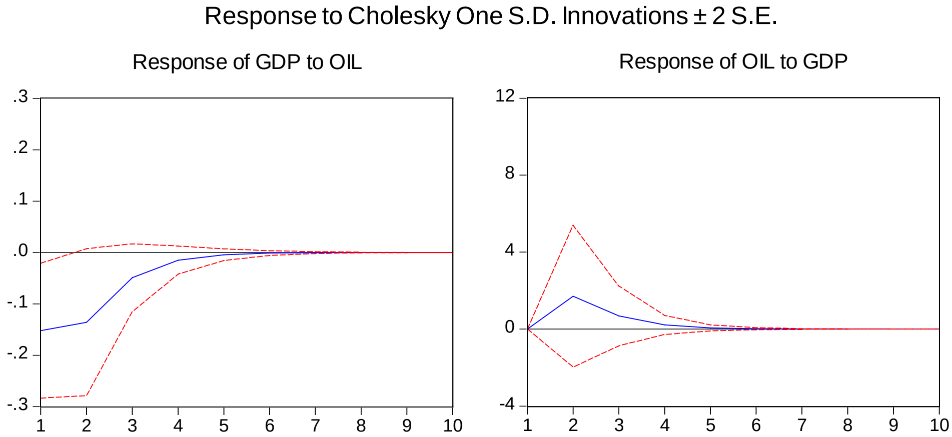


Figure 3 : Impulse Response Functions to GDP and Oil Shocks 1992Q4 – 2006Q4

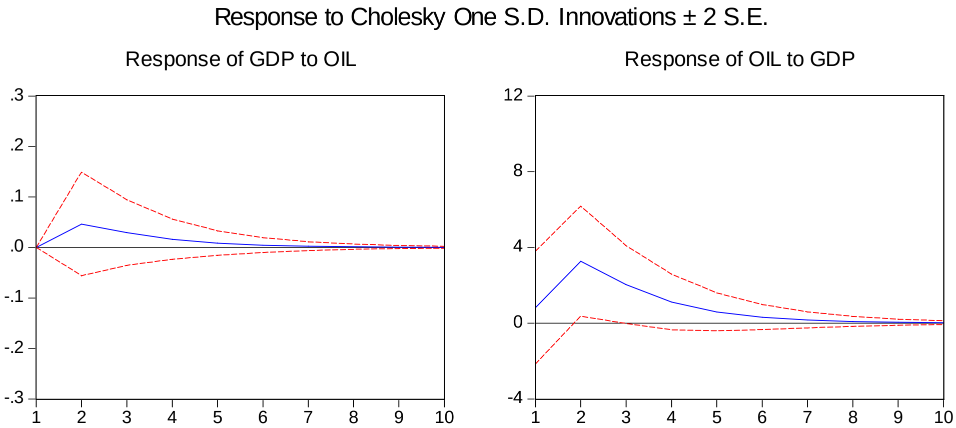


Figure 4 : Impulse Response Functions to GDP and Oil Shocks 1970Q3 – 2006Q4

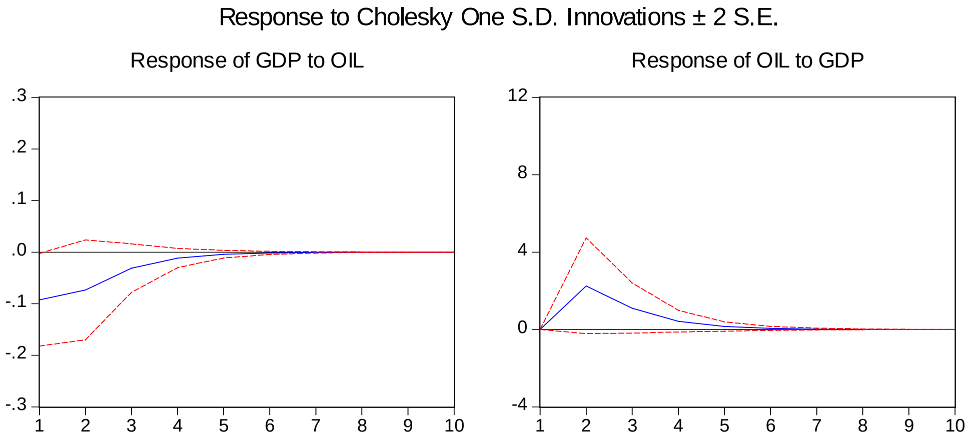


Figure 5 : Impulse Response Functions, US and the World Different samples

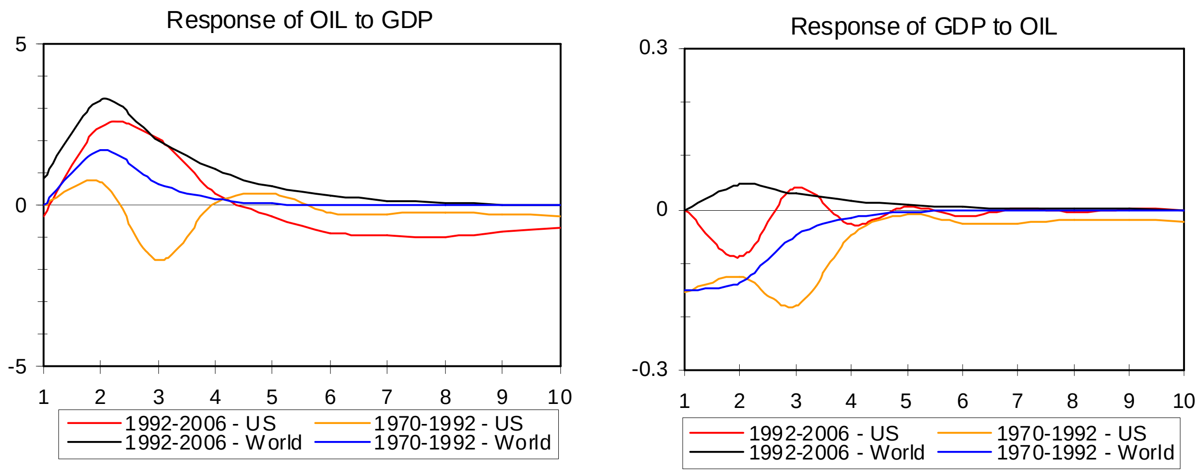


Figure 6 : Impulse Response Functions to oil shocks, US case

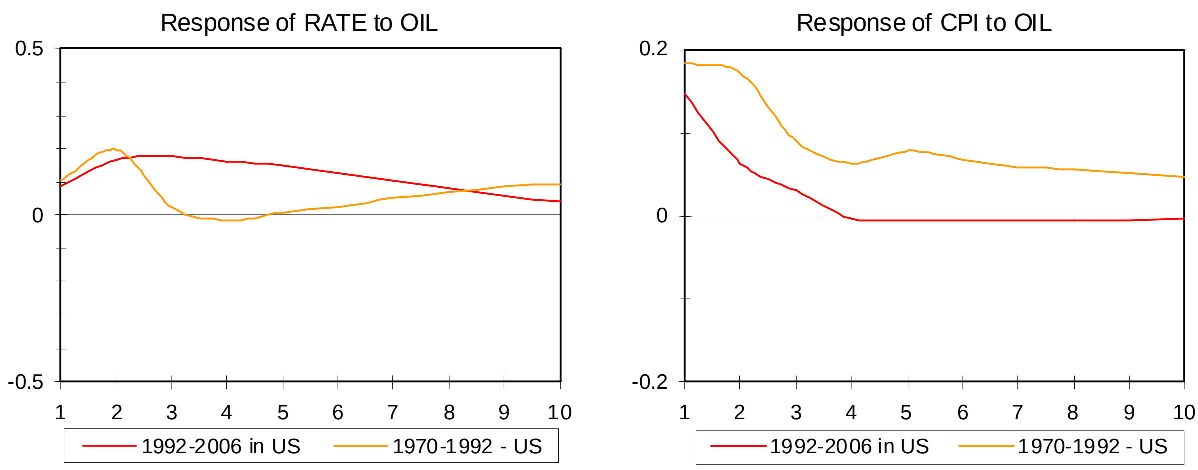


Figure 7 : US GDP's Response to monetary policy