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ABSTRACT

Many papers have been documenting and analysing the asymmetry and the weakening of the oil price – macroeconomy relationship as off the early eighties. While there seems to be a consensus about the factors causing the asymmetry, namely adjustment costs which offset the benefits of low energy prices, the debate about the weakening of the relationship is not over yet. Moreover, the alternative oil price specifications which have been proposed by Mork (1989), Lee et al. (1995), and Hamilton (1996) to restore the stability of the relationship fail to Granger cause output or unemployment in post-1980 data. By using the concept of accelerations of the oil price, we show that the weakening of this relationship corresponds to the appearance of slow oil price increases, which have less impact on the economy. When filtering out these slow oil price variations from the sample, we manage to rehabilitate the causality running from the oil price to the macroeconomy and show that far from weakening, the oil price accelerations – GDP relationship has even been growing stronger since the early eighties.

JEL Classification: Q43, C22

Keywords: Oil prices, Gross Domestic Product, recursive causality tests.

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1. Introduction

Ever since Hamilton (1983) reported the existence of a statistical relationship between oil price variations and GDP, many were the authors (Mork (1989), Lee et al. (1995), Hooker (1996), Hamilton (1996), Hooker (2000)) who showed that this relationship was suffering from breakpoints, and worse, that it was globally weakening after 1980. Efforts were therefore devoted to restore a stable relationship between the oil price and the economic activity. The most notable attempts were aimed at transforming the oil price variable, by ways of filters and other non linear transformations, so that the alternative models would be able to restore causality running from the oil price to GDP. Mork (1989), Lee, Ni and Ratti (1995) and Hamilton (1996), offered alternative oil price specifications, which are able to restore a globally stable relationship between their variables and GDP. However, Hooker (2000) showed that none of these asymmetric and nonlinear transformations of the oil price were satisfying as they were not able to Granger cause output or unemployment in post-1980 data.

In this paper, we offer a simple and intuitive alternative to these specifications, by separating oil price increases into two components, simple increases and accelerating increases. While the simple increase corresponds to Mork (1989)'s oil price increase, the accelerating increase is an original specification, easily interpretable, and with excellent fitting properties. Without having to switch from quarterly to annual data as Hooker (2000) did to regain significance, this new specification enables us to show that while other oil price specifications do not Granger cause US GDP after 1980, oil price accelerations do. Our findings lead to the conclusion that the non accelerating oil price variations (the slow oil shocks probably caused by demand shocks rather than by oil production disruptions), that appeared after the early eighties are causing the weakening of the oil price – macroeconomy relationship.

The paper is organized as follows. Section 2 is reviewing the arguments explaining the asymmetry and weakening of this relationship. Section 3 presents and compares the perfomances of some of the oil price specifications aiming at restoring the stability of the relationship, by carrying out recursive causality tests in a VAR model inspired by Hamilton (1983) and Mork (1989). Section 4 presents our proposed specification, based on the concept of oil price accelerations, and shows how it out-performs the other specifications in Granger causing US GDP. Section 5 concludes.

2. An asymmetric and weakening oil price – GDP relationship

Ever since the first oil shocks in the seventies, the oil price – macroeconomy relationship has become a major center of interest for economists. Many transmission routes have been identified to explain how oil price increases work their way up to affect economic activity, and may be found in the exhaustive reviews of the large literature on the subject made by Jones and Leiby (1996), Jones et al. (2001) and Brown and Yücel (2002).

Yet, no sooner had Hamilton (1983) established that oil price variations Granger caused US GDP variations, that Mork (1989) showed that this did not hold after the 1986 collapse of the oil price. Indeed, it became obvious that while oil price increases induced recessions, oil price decreases did not stimulate economic activity in a symmetric manner. To account for this asymmetry, Hamilton (1988) suggested that some attention be given to adjustment costs. Indeed, these costs appear whether the oil price goes up or goes down. When the oil price goes up, the adjustment costs merely represent additional costs to the direct oil shock impact, but when it goes down, they may offset the benefits of low energy prices. A review of these adjustment costs can be found in Jones et al. (2002) and Brown and Yücel (2002). They include costs related to sectoral shifts, changes in the capital stock, coordination problems between firms and finally costs related to the uncertainty of future oil prices.

The sectoral shifts costs were initially identified by Lilien (1982), who established that inter-sectoral reallocations of labour following exogenous shocks were a major cause of increases of the unemployment rate. Oil price increases or decreases cause labor reallocations between energy intensive sectors and energy efficient ones, which in the short term lead to unemployment and underutilisation of resources. Using Lilien's findings in an empirical study, Davis and Haltiwanger (1999) identified two transmission mechanisms through which oil price variations affect economic activity and which provide an explanation for the asymmetry. The first one is the aggregate channel, which works through potential output, income transfer and sticky wages effects, as well as imperfect competition effects (evidenced by Rotemberg & Woodford (1996)). The second one is the allocative channel, which reflects the mismatch between a firm's desired and actual levels of labor and capital. The authors observe that oil price increases have a negative impact on unemployment through both channels, while oil price decreases have a negative impact on the allocative channel, which cancels out the positive impact on unemployment obtained through the aggregate one.

To explain the costs induced by changes in the capital stock following energy price variations, Atkeson and Kehoe (1999) use KLEM production functions (relating output to capital, labor, energy and non energy material). The authors assume that technology is following a putty-clay model, which allows for ex-ante substitutions of factors but not ex-post ones, which means that industries can take into account the trends of energy and of other factors to make their investment, but once the technology is adopted, there is no turning back. In the short term, a variation of energy which necessitates a change in the capital stock therefore induces a costly reorganisation.

Due to their experience of prior oil price shocks, it is also safe to assume that firms know what their reaction will be to oil price variations. However, they do not know how other firms, especially in different sectors, will react to these shocks, which may induce economic disruptions due to wrong expectations and inadequate coordination, as explained in Huntington (2000).

Finally, Federer (1996) and Lee et al. (1995) have showed that both oil price variations and oil price volatility have a negative impact on output growth, through the postponing of irreversible investment.

In addition to the asymmetry induced by the above mentioned adjustment costs, it was also noticed by some authors (Hooker (2000), Loungany and Yücel (2000)) that the oil price – economic activity relationship was weakening. Main factors to explain this weakening are the changes that have transformed the US monetary policy and its response to oil price shocks in the early eighties, the decline of the energy consumption to GDP ratio, the growing endogeneity of energy prices with regards to the economic activity which makes oil price increases less disruptive, the gains in productivity which may enable firms to suffer less from high energy prices and finally, the so-called "experience effect" which leads to better policy responses, better coverage against high energy prices and lower adjustment costs, based on prior experience of oil price shocks. Blanchard and Gali (2007) have also identified the decrease in real wage rigidities to account for the weakening of the oil price –

GDP relationship. In a rigid labour market in which real wages adjust slowly, an adverse supply shock will induce an increase of inflation and a decrease of output. The increased flexibility that has characterized the US labour market ever since the early eighties may therefore account for the mild influence of oil price variations on GDP.

Given the asymmetry and the weakening of the oil price – macroeconomy relationship, many efforts were then devoted to restore its stability. Below are presented some of these attempts, followed by our own proposition.

3. Attempts to restore a stable GDP – macroeconomy relationship

3.1 Data and Methodology

In his 1983 article, Hamilton used a multivariate reduced-form VAR approximation to macroeconomic reality inspired by Sims (1980). To represent the oil price variable, Hamilton used the log change of the Producer Price Index for crude oil. Since this index does not take into account international movements of the oil price prior to 1974 (due to oil price controls in the US in the 1970s), we decided to follow Mork (1989) by using the composite refiner acquisition cost (RAC), a weighted average of domestic and imported crude oil costs, including transportation and other fees paid by the refiners in the US. This index is available from the US Energy Information Agency at a quarterly rate from 1974Q2 until today, and at an annual rate from 1968 until today. It is therefore necessary to extend it so that our sample spans the whole 1948-2009 period at a quarterly rate. To do so, we constructed the following oil price variable:

- For 1974Q2 until today, we use the log change of the refiner acquisition cost for crude oil (source: US Energy Information Agency).
- For 1971Q3 to 1974Q1, we use the log change of the PPI for crude oil (source: US Bureau of Labour Statistics), which annual variations are corrected to correspond to the RAC's annual variations (source: US Energy Information Agency).

- For 1948Q1 to 1971Q2, we use the log change of the PPI for crude oil (source: US Bureau of Labour Statistics).

The sample Hamilton (1983) used to estimate his model, 1949Q2-1972Q4, did not include major oil price decreases, as Mork (1989) noted, and thus was not likely to hold after the large drop of the oil price in 1986. To investigate the validity of this assumption, we estimate Hamilton's VAR model and apply recursive exclusion tests, which are explained below, for all oil price coefficients in the GDP equation. This model includes four lags and the following variables: the log change in the real GDP, the log change of the GDP implicit price deflator, the log change of the average hourly earnings in the manufacturing sector, the log change of the oil price specification, the level of the US civilian unemployment rate and the level of the three months Treasury bill rate (the secondary market one). The data is provided by the Federal reserve Bank of St Louis, taken at a quarterly rate (a simple average is performed for the monthly data), and spans the period starting in the 1st quarter of 1948 and ending in the 2nd quarter of 2009, which offers 246 observations.

To determine the order of integration of these variables, augmented Dickey Fuller tests were carried out. GDP, the oil price and the treasury bill rate were found to be integrated of the 1st order. The unemployment rate was found to be stationary. However, earnings and inflation were found to be integrated of the 2nd order. The first difference of these two variables were used nevertheless, in order to be able to compare the results with Mork's and Hamilton's who had used the first difference as well[1]. The recursive exclusion test consists in estimating the Fisher statistics for the joint significance of oil price coefficients in the GDP equation, in sub-samples in which we add one observation at each iteration. The first sample's size must be strictly superior to the number of parameters (25 including the constant), and the last sample's size corresponds to the whole sample. As in Andrews (1993), it is likely that the Fisher statistics at the beginning of the sample is degenerate. A trimming of 13% of the observations was therefore carried out at the beginning of the sample. These recursive exclusion tests

[1] The same regressions with the second differences of earnings and inflation do not produce significantly different results. All results are available upon request to the author.

help us understand how the oil price – GDP relationship has been evolving along time, and at which dates breakpoints may have occurred.

3.2 Recursive causality tests

Figure 1 reports the value of the F statistics for recursive exclusion tests for all oil price coefficients in the GDP equation of the 4 lags VAR model used by Hamilton. Apart from a short episode in 1975-1976 during which the 4 oil price lags were only significant at the 5% statistical level (and not at 1%), we observe that the relationship is mostly significant on the first part of the sample, between the early 1950s until the early 1980s. It then starts to weaken around 1982Q2 when a first breakpoint occurs, and sees the oil price variable's significance fall below the 1% curve. This breakpoint is then followed by a second sharp breakpoint in 1986Q2 when the curve drops below the 5% significance level. Ever since this period, we note that the simple oil price variations never became significant again in the model. A reason which might explain this breakpoint has been put forward by Hooker (2000) who suggested that it may be caused by systematic changes in the US monetary policy from the end of the 1970s on. With regards to the second breakpoint, it simply coincides with the 1986 negative oil shock, and had been evidenced by Mork (1989).

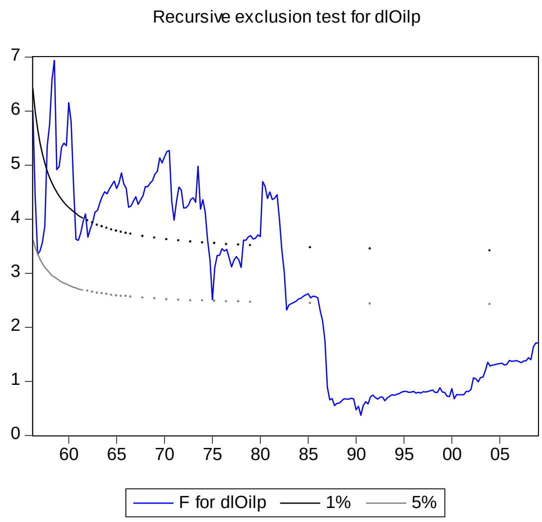

FIGURE 1 Recursive exclusion tests for dlOilp coefficients in the dlGDP equation of the VAR, where $dlOilp_t = \log(Oilp_t / Oilp_{t-1})$ and $dlGDP_t = \log(GDP_t / GDP_{t-1})$. Sample beginning in 1956Q2 and ending in 2009Q2.

In order to restore a significant relationship, Mork (1989) offered to separate the oil price variable into two components, oil price increases and oil price decreases. His positive specification was defined as follows: $dlOilp1_t^+ = dlOilp_t$ if $dlOilp_t > 0$, else 0. In the rest of the paper, we will refer to this specification as dlOilp1, as the negative counterpart of Mork's specification is not significant in any of our estimations. As can be seen on Figure 2, the use of dlOilp1 somehow enables to rehabilitate the oil price – GDP relationship.

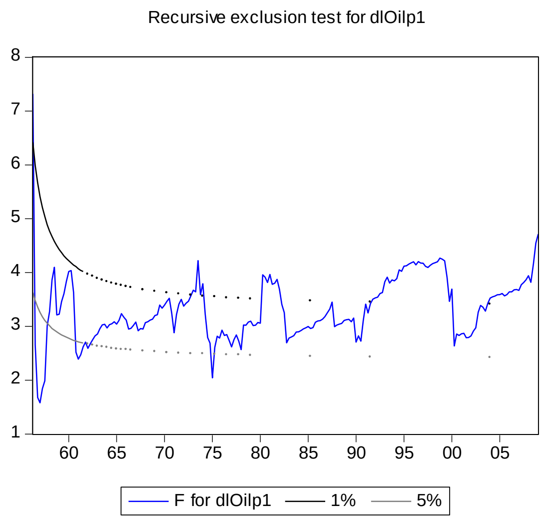

FIGURE 2 Recursive exclusion tests for dlOilp1 coefficients in the dlGDP equation of the VAR. Sample beginning in 1956Q2.

While Mork's specification loses in significance in the first half of the sample compared with dlOilp, we note that it clearly gains in significance in the second half. It does not provide a very significant relationship with the real GDP as the curve rarely reaches above the 1% confidence curve, but it does provide a more stable one as the F curve is above the 5% confidence curve on most of the sample.

Following Mork, Hamilton (1996) offered a new specification, the Net Oil Price Increase (NOPI), defined as the percentage of increase of the oil price compared with its values at the 4 previous quarters (resp. 36 quarters for another version), and zero if there is no increase. We will refer to this measure as NOPI 12 when the number of quarters used for the comparison is 12, and as NOPI 36 when this number is 36 . The idea behind such measures is to filter out oil price increases that merely correspond to corrections of former oil price decreases, and hence to capture a “surprise effect”. Figure 3 represents the recursive exclusion tests for NOPI 12 and NOPI 36.

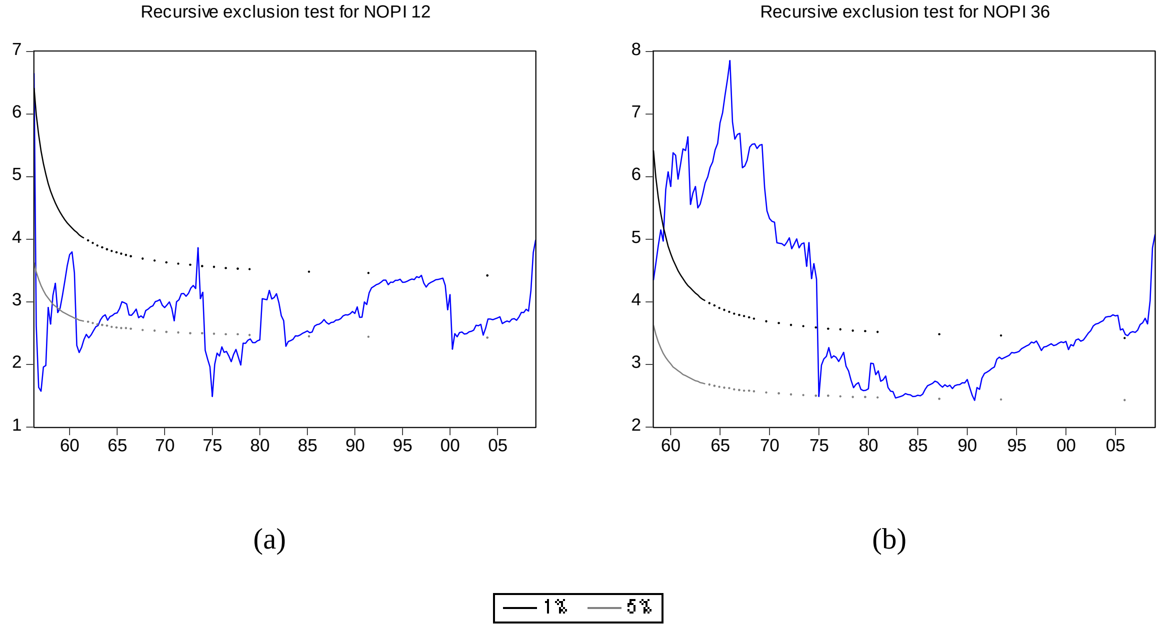

FIGURE 3 (a) Recursive exclusion tests for NOPI12 coefficients in the dlGDP equation of the VAR. (b) Recursive exclusion tests for NOPI36 coefficients in the dlGDP equation of the VAR. Sample beginning in 1956Q2 for (a) and in 1958Q2 for (b).

While the NOPI 12 does not seem to improve significantly the performance of dlOilp1 as can be seen on figure 3 (a), their F curves being almost identical, we note on figure 3 (b) that the NOPI 36 does provide an excellent fit for the first half of the sample, with values well above the 1% confidence curve. However, after 1975, the curve drops abruptly and stays below the 1% confidence curve until 2002. As was already noted by Hooker (2000), Hamilton’s specification seems to derive much of its apparent success to an improved fit in the pre-1970s data.

Overall, these specifications offer a more stable relationship between the oil price and GDP, as they all manage to regain some significance in the second half of the sample. But they do not manage to reach often above the 1% confidence curve, and mostly hover between the 5% and 1% lines. This means that they probably do not properly reflect what has been happening to this relationship ever since the early 1980s.

4. Slow and accelerating oil price increases

4.1 Methodology

Following Huntington (2005, 2007) who stresses the distinction between sudden and gradual oil price increments, we offer a simple and intuitive alternative to the above mentioned specifications, by separating oil price increases into two components, simple increases and accelerating increases. The classical way in economics to deal with a non stationary variable is to take its first difference (or its log first difference) in order to eliminate the secular time trend. Which is why in most papers dedicated to the oil price – macroeconomy relationship, the common approach is to consider the first difference of the oil price. This basically means that these studies choose to focus on the speed of the oil price (the ratio of the first difference of a variable on a time unit). However, in many other academic disciplines, physics and mechanics for instance, the sole speed does not suffice to explain all, and higher differencing is often needed. The second derivative, i.e. the acceleration, is a fundamental variable in mechanics. The third derivative, called "jerk"[2], which corresponds to a variation of the acceleration, can also be used in many applications (to measure a train's comfort for example). Based on these concepts, we decide to consider a new specification, which we call an accelerating increase. It should be noted that our variable is not an acceleration per se, since we do not want to over-differentiate the series. We keep the first difference of the oil price, but we filter out oil price variations whose accelerations are not positive:

$$dlOilp2_t = dlOilp_t \text{ if } dlOilp_t > 0 \text{ and if } dlOilp_t - dlOilp_{t-1} > 0 \text{ else } 0.$$

[2] The tests performed with oil price accelerations were also performed with oil price jerks, and did not come up with significantly different results regarding the impact on GDP. However, at the sectoral level, when considering the impact on sectoral output, we did find that some sectors were much more responsive to oil price jerks than to oil price accelerations. This observation is to be further developed in a coming paper.

Carrying out the same recursive exclusion tests as above on this new specification provides the graph represented in figure 4.

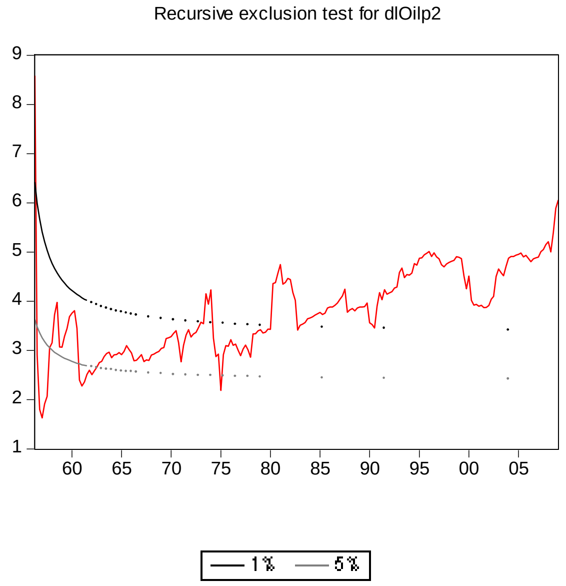

FIGURE 4 (a) Recursive exclusion tests for dlOilp2 coefficients in the dlGDP equation of the VAR. Sample beginning in 1956Q2.

While dlOilp2 offers a poor fit for the first half of the sample, it exhibits excellent F statistics for the second half of the sample. After 1980, its F value is always above the 1% confidence curve, and clearly outperforms the previously shown specifications. Far from weakening, the oil price acceleration – macroeconomy relationship seems to grow even stronger after 1980.

4.2 Interpretation

There is a very simple explanation to this phenomenon, which can be found on figure 5, representing the difference between dlOilp1 and dlOilp2. On the figure are represented all the oil price variations which are not accelerating ones.

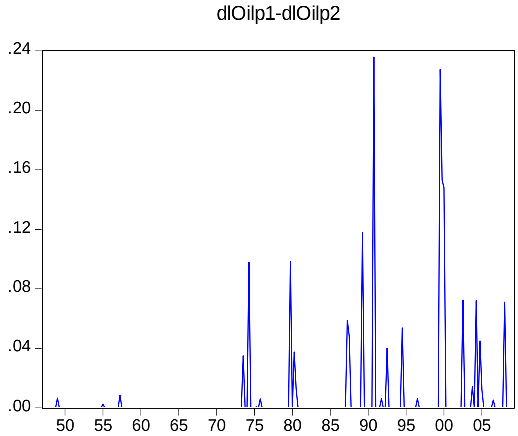

FIGURE 5 Representation of dlOilp1-dlOilp2.

Prior to 1975, we note that all oil price variations were also accelerating ones, since the difference is almost always null. Then during the first and the second oil shocks, slow oil price variations events started to appear, represented by the two remaining peaks around 1974 and 1980. After the second half of the eighties, slow oil price variations become much more common, including the periods around the first Gulf war and the 2000's oil price increases. These slow oil price increases, which can be more easily anticipated by economic actors, are likely to have less impact on the economy than accelerating oil price variations, which carry a much larger surprise effect. When using other oil price specifications, which do not separate slow and accelerating oil price variations, previous papers were carrying their econometric estimations with both kinds of shocks combined, therefore averaging the impact on the economy and concluding with a weakening of the oil price – macroeconomy relationship. But it is the apparition of slow oil price variations, which do less harm to the economy, that seems to be the cause of this weakening.

Two questions therefore arise: why did these slow oil shocks start to appear as off the early eighties? And why would they cause less harm to the economy?

An answer to the first question may be found in Kilian (2006), which is addressing the nature of oil price shocks. Using an SVAR, the author decomposes the real oil price into four components: oil supply shocks driven by political events in OPEC countries, other oil supply shocks, aggregate shocks to the demand for industrial commodities, and demand shocks that are specific to the crude oil market.

Thanks to this orthogonal decomposition of shocks affecting the oil market, Kilian manages to show that shocks to the world aggregate demand and fears about future supplies of oil have much more influence on oil price variations than shocks to the crude oil production do. Do the slow oil price shocks identified in figure 5 correspond to Kilian's aggregate demand and oil market specific demand shocks? It seems at least consistent with the intuitive idea that oil price variations should be driven more slowly by progressive demand shocks than by brutal oil production disruptions, and makes it plausible to conclude that the appearance of the slow oil price shocks may have been caused by the growing importance of oil consuming emerging countries like China and India ever since the early eighties. However, it would require another study to prove this theory, along with another methodology that would enable to separate exogenous and endogenous components of oil price variations, as was suggested in Barsky and Kilian (2002) and implemented in Kilian (2005, 2006).

As to why these non accelerating oil price increases do less harm to the economy than oil price accelerations, Huntington (2005) showed how sudden oil price increases scare households and firms, and induce brutal adjustments with regards to investment, production, consumption and to the negotiations of wages and prices. These brutal adjustments can temporarily leave plants and equipments idle, and hence workers unemployed. While non accelerating oil price increases, by allowing more progressive adjustments, enable firms and households to adopt more efficient strategies. This issue of adjustment was also addressed by Blanchard and Gali (2007), who showed how the increased flexibility of the labour market may have also played a crucial role in explaining the milder impact of oil price shocks on inflation and output. Combined together, these two arguments support the theory according to which slow oil price shocks may have favoured progressive and harmless adjustments for firms and households, helped in that by the increased flexibility of the labour market.

6. Conclusion

The aim of this paper is to investigate the oil price – macroeconomy relationship using a new specification for the oil price variable, based on the concept of acceleration. Using a VAR model inspired by Hamilton (1983) and Mork (1989) and carrying out recursive exclusion tests, we are able to show that the so-called "weakening of the oil price – macroeconomy relationship" observed by many authors seems to be due to the appearance of slow oil price shocks as off the seventies and eighties. These slow oil price shocks, by allowing firms and households to adjust more progressively, have less impact on the economy. Factors causing the appearance of these slow oil price shocks remain to be identified, but are more likely to be found in the increasing importance played by demand shocks rather than oil supply disruptions. By filtering out these slow oil price increases from the sample, and by focusing only on accelerating oil price increases, we show that far from weakening, the oil price accelerations – GDP relationship has been steadily growing stronger ever since the early eighties.

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