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Oil price: the nature of the shocks and the impact on the French economy

Abstract

Since the late 70s and the first two oil shocks, many economic studies have explored the link between changes in oil prices and global economic growth. However, the causes of the variations in oil price have changed over this period. Thus the impact of these shocks on the economy may also differ. Developing a structural VAR model and the bootstrap-after-bootstrap methodology, this paper offers to identify three types of exogenous shocks to explain the dynamic of the real price of oil. This study then analyzes the impact on the French economy of these three shocks by identifying the channels through which these effects transit with a VARX model integrating data on exports and interest rates.

We find that the effects of an increase in the real price of oil, and the channels through which it affects the French economy, greatly differ depending on the nature of the shocks. The 80s were mostly dominated by oil supply shocks. Restricting oil production results in a significant decrease in the French Gross Domestic Product (GDP). The shock of the late 2000s can be explained by the development of global activity and the high demand for oil in emerging economies. A positive global activity shock causes a significant increase in French GDP, while the general price level is not impacted by the increase in oil prices.

Keywords : real price of oil, SVAR, historical decomposition, bootstrap-after-bootstrap, transmission channels

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Prix du pétrole : la nature des chocs et leur impact sur l'économie française

Résumé

Depuis la fin des années 70 et les deux premiers chocs pétroliers, de nombreuses études économiques ont exploré le lien entre les variations du prix du pétrole et la croissance économique mondiale. Cependant, les causes des variations du prix du pétrole ont évolué sur cette période. Ainsi les conséquences de ces chocs sur l'économie doivent également différer. En modélisant la dynamique du prix du pétrole à l'aide d'un modèle VAR structurel utilisant la méthode du bootstrap-after-bootstrap, ce document de travail propose d'isoler trois types de chocs exogènes affectant les équilibres du marché pétrolier. Cette étude propose d'analyser ensuite l'impact sur l'économie française de ces trois chocs en identifiant les canaux par lesquels ces effets transitent à l'aide d'un modèle de type VARX intégrant des données sur les exportations et le taux d'intérêt.

Nous constatons que les effets d'une augmentation du prix réel du pétrole, et les canaux par lesquels ils affectent l'économie française, varient considérablement en fonction de la nature du choc. Par exemple, les années 80 ont été dominées majoritairement par des chocs d'offre de pétrole. La restriction de la production de pétrole a pour conséquence une baisse significative du Produit Intérieur Brut (PIB) français. Par ailleurs, le choc de la fin des années 2000 s'explique plutôt par le développement de l'activité mondiale et la forte demande de pétrole des économies émergentes. Suite à un choc positif d'activité mondiale, le PIB français augmente significativement, le niveau général des prix étant cependant peu affecté par la hausse du prix du pétrole.

Mots-clés : prix réel du pétrole, modèle VAR structurel, décomposition historique, bootstrap-after-bootstrap, canaux de transmission

Classification JEL : E32, Q41, Q43

1 Introduction

The sharp increase in the real price of oil in the late 2000s and the following crisis have sparked off a renewal of interest for the empirical link between oil price fluctuations and macroeconomic performances. A large body of studies has attempted to clarify this economic link and provide theoretical analyses on the role played by the real price of oil in macroeconomic performances. The first issue on this topic occurred in the late 1970s and were justified by the specific economic situation of this period: the 1970s were characterized by a period of growing dependence on imported oil, exceptional disruptions in the global oil market due to geopolitical factors and relatively low overall global macroeconomic performances. During this period, the real price of energy had risen threefold and the annual world GDP growth declined.

Since the first oil price shock, there is a common belief about the role of the exogenous political events in the Middle East causing recessions in industrialized economies through the rise and instability of the real price of oil. Hamilton (2011) surveys the history of the oil industry with a particular focus on the events associated with significant changes in the price of oil.

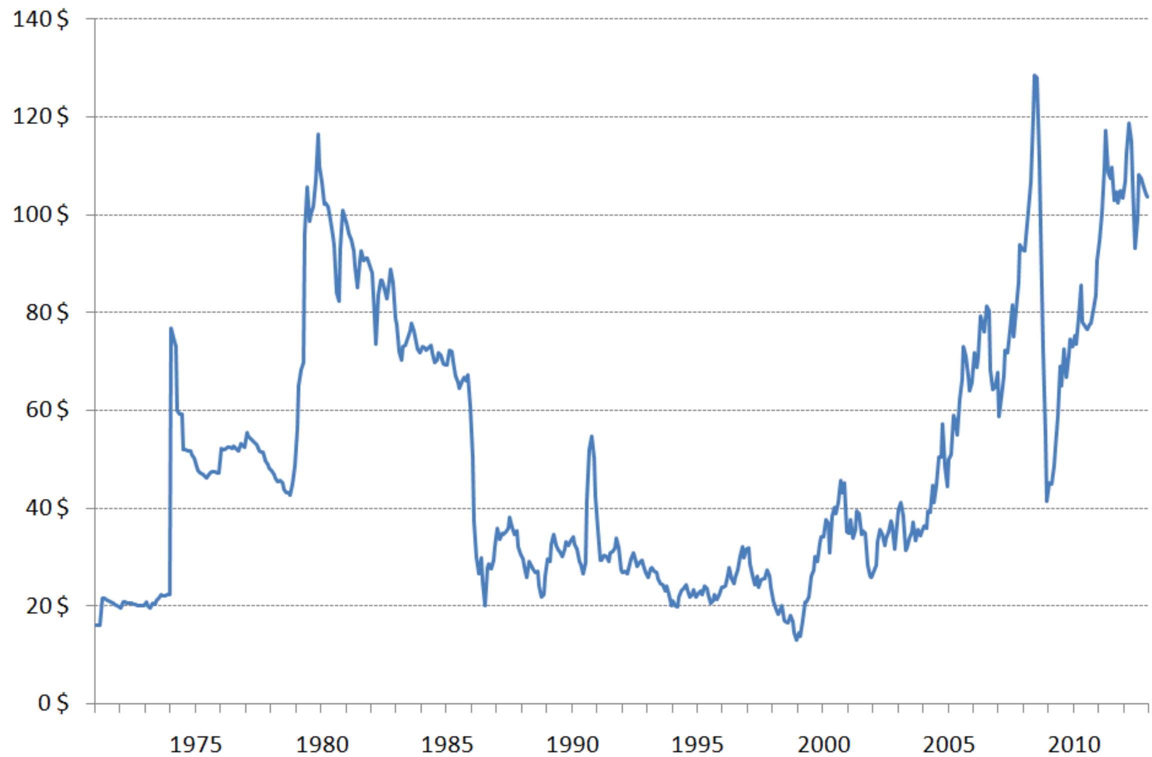

Figure 1: Real Price of Oil: composite Brent, in 2010 $

Figure (1) shows the real price of oil used throughout this paper. This composite price is constructed as a weighted geometric average of the nominal price of oil in four major currencies[1] deflated by the corresponding Consumer Price Index.

The periods of high oil price variations presented in figure (1) can be linked to some of the major economic events. Thus oil price fluctuations seem to have a strong impact on the global economy. The seminal paper on the link between Oil and the Macroeconomy is undoubtedly Hamilton (1983). This paper finds a statistically significant correlation between the price of crude petroleum and the real output in the United States over the period 1948-1973. Barsky and Kilian (2004) cast doubt however on the real nature of the links between the real price of oil and the global economy. They show that the effects of oil price shocks have differed a lot depending on the economic context. They also question the robustness of the regressions used by Hamilton, in that the real price of oil is an endogenous variable which reacts to the current state of the global economy.

While past oil price shocks seemed generally characterized by massive shortfalls in crude oil production, the recent increase in crude oil prices which began in 2005 seems to be driven by the demand side, mainly due to the emergence of new economies. The structural VAR (SVAR) methodology developed in this paper provides answers to these issues. If the nature of the shocks is different, the effects of these shocks on the economy may also differ. Thus, the aim of this paper is to disentangle the effects on the economy of different shocks affecting the real price of oil, depending on their nature.

Kilian (2009) addresses the issue of the endogeneity of the real price of oil by disentangling the nature of the exogenous shocks affecting the real price of oil through a SVAR decomposition. Three exogenous shocks are identified: an oil supply shock, a global activity shock, and an oil-specific demand shock. The oil price decomposition presented in this paper is largely inspired by Kilian's work. However, we put forth another index of global activity based on the global industrial production index instead of Kilian's one constructed from freight rates data. We also addressed the issue of the dependence of the exchange rate and the decline in oil intensity using a specific price index. Furthermore, following Kilian (1998) we develop a bootstrap-after-bootstrap methodology to correct from the bias created by the chosen specification.

[1] U.S. Dollar, Euro, Japanese Yen and Pound Sterling. The moving weights of each currency is defined as the total oil consumption of the corresponding economic area.

We then analyze the effects of these shocks on the French economy, depending on their nature. Moreover, it is also important to go one step further and to identify the different channels of transmission of these exogenous shocks. As discussed in Barlet and Crusson (2007), four effects are generally considered in the literature. First, the real price of oil can affect the French economy through an increase in the cost of inputs, leading to a slowdown in production and productivity. Second, an increase in the real price of oil causes higher inflation, possibly followed by second-round effects related to the adjustment of wages. Third, the uncertain economic environment linked to oil price volatility leads to a decrease in the consumption of durable goods and in investment. Finally, the rise in oil prices generates an important wealth transfer between oil importing and oil exporting countries.

These commonly accepted impacts of an oil price increase on the macroeconomy can be separated into direct and indirect effects. The direct effects correspond to the impact of the oil price increase on the French output which do not transit through links with economic partners. The indirect effects take into account the broader context of the global economy and especially the impact of the oil price increase on the other countries. The aim of this paper is to increase the knowledge on these indirect effects.

2 Identifying the nature of the shocks: a SVAR approach

The model we consider is a monthly SVAR with 3 variables and p lags. This model can be written as:

$$\begin{aligned} Y_t &= \mu + Y_{t-1}A_1 + ... + Y_{t-p}A_p + \eta_t R \\ &= [1 \quad Y_{t-1} \quad ... \quad Y_{t-p}]\, A + \eta_t R \\ &= Z_t A + \eta_t R \end{aligned}$$

where $\eta_t \sim \mathcal{N}(0, I_3)$ are independent structural innovations and the $(3p+1) \times 3$ matrix A contains coefficients of constants and lags.

The three endogenous variables in the SVAR are global oil production, a global industrial production index and the index of oil price, ordered in this way. Global oil production is narrowly defined as world crude oil production provided by the U.S. Energy Information Administration Monthly Energy Review, expressed in log-level. The construction of the industrial production index is presented in appendix A. It is also expressed in log-level. The index of oil price is the composite Brent displayed above, in level, multiplied by the global oil intensity so as to take into account the underlying decrease in oil dependence observed in most economies. The sample period is 1975m1-2012m12 and the number of lags p is set to 24, as in Kilian (2009). The number of lags is thus sufficiently large to warrant the asymptotic convergence of the SVAR parameters, whatever the order of integration of the three initial time series.

The impact of the exchange rate on the real price of oil is not straightforward. Since the price of oil is generally denominated in U.S. dollars, exchange rates should play a role in the demand for oil in economic areas using other currencies. On the other hand, the different reactions of central banks to changes in the nominal price of oil have an impact on the exchange rate. These intricate links between the nominal price of oil and exchange rates forbid a direct inclusion of exchange rates in the endogenous variables of the SVAR. We thus build a composite Brent price aggregating real price indices denominated in the four principal currencies weighted by their oil consumption. The corresponding economic areas are the United States, the euro area, Japan and the United Kingdom.

Furthermore, global oil intensity has followed a decreasing trend for 30 years. Both advanced countries and emerging economies are now able to produce a unit of GDP with a smaller quantity of crude oil. Reducing oil intensity in advanced economies resulted from an attempt to lessen oil dependence, especially after the two oil price shocks. In the 80s, oil intensity decreased by 3.5% a year in advanced economies. Since the 90s, oil intensity decreased by 2% every year in advanced economies and by 3% in emerging economies. Nowadays, oil intensity in emerging economies is almost similar to the oil intensity in advanced economies. In order to take into account this paradigm shift in the oil consumption, we constructed the series of global oil intensity as the ratio of the global oil consumption and the global industrial production index. This global oil intensity index is then filtered, using a one-sided HP-filter, so as to address endogeneity issues linked to the short term response of global oil intensity to oil price fluctuations. We then multiplied this filtered global oil intensity with the composite price of oil described above. Figure (2) displays the resulting real price of oil index. Finally, we rescale our composite price index so that its mean over 2010 is equal to the mean of the Brent price (in nominal dollars) over the same year.

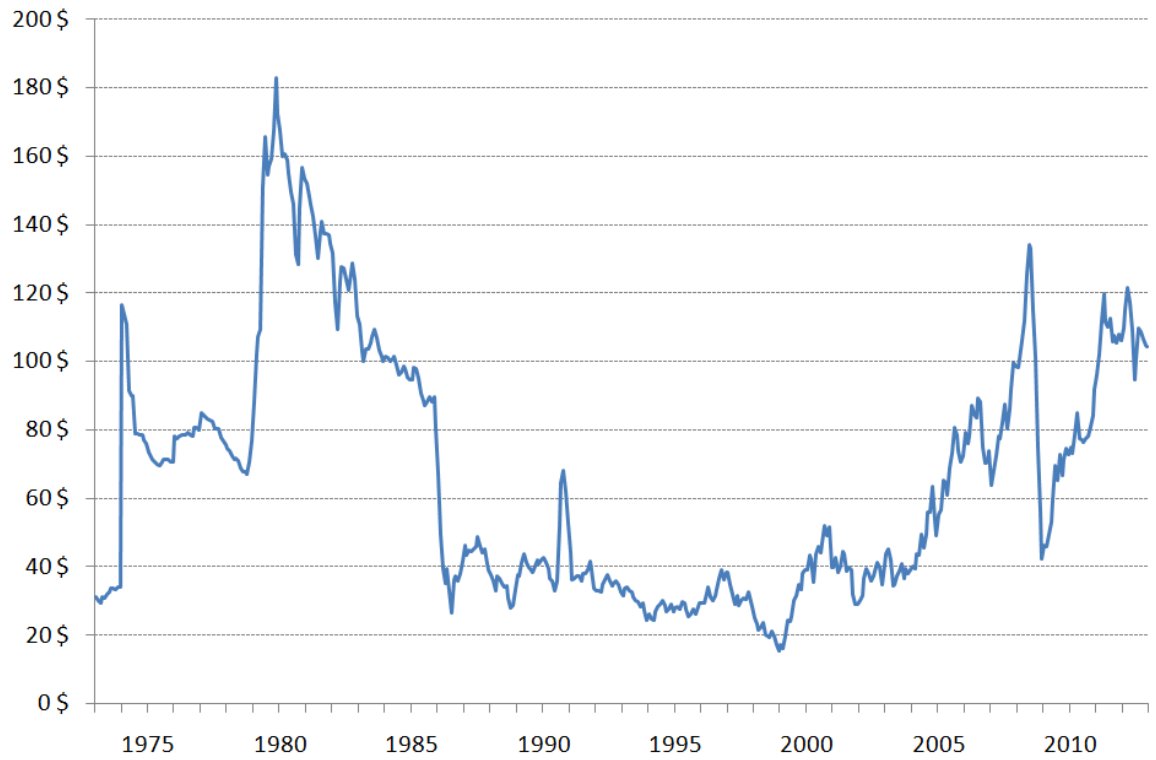

Figure 2: Real Price of Oil Index (multiplied by global oil intensity), in 2010 $

Finally, the upper triangular R matrix implements the Cholesky identification scheme of the three structural shocks: the oil supply shock, the global activity shock, and the oil-specific demand shock. We assume, as in Kilian (2009), that the global oil production cannot react within the same month to unexpected changes in oil demand, either driven by the global activity shock or by the oil-specific demand shock. The short-run supply curve of oil is thus vertical in the model. This assumption could be motivated by the presence of high adjustment costs in the oil production process, or incomplete information about the current state of the oil market. Furthermore, we also assume that oil-specific demand shocks have no instantaneous impact on global industrial production. Hence, increases in the real price of oil driven by the oil-specific demand shock will only affect economic activity with a delay of at least a month in the model. These restrictions only seem plausible at a monthly frequency. At last, we impose three additional sign constraints: the three structural shocks must have a positive initial impact on the real price of oil. Hence, the oil supply shock is a negative oil supply shock, while the demand shocks are positive demand shocks.

This identification strategy allows us to determine the three structural shocks: oil supply shocks, global activity shock and oil-specific demand shock. The interpretation of the third structural shock, the oil-specific demand shock is somewhat less straightforward than the two first shocks. This shock captures all variations in the real price of oil that cannot be explained by the standard effects of past and present values of global oil production and global industrial production. Hence, the oil-specific demand shock contains, among other sources of oil demand not captured by our activity index, all shocks related to precautionary demand linked to shifts in market anticipations about the future path of the real price of oil. Hence, we ought to remain cautious on the interpretation of the third structural shock.

2.1 Impulse Response Functions

The SVAR is estimated in levels rather than in first differences. Sims et al. (1990) show that the OLS estimator is consistent whether or not the SVAR contains integrated components, as long as the innovations in the SVAR have enough moments and a zero mean, conditional on past values on Y_t. The estimators of coefficients have a joint non-degenerate asymptotic normal distribution if the model can be rewritten so that these original coefficients correspond in the transformed model to coefficients on mean zero stationary canonical regressors.
However, the estimators of these coefficients are affected by finite sample bias. Kilian (1998) shows that in small sample, bias-corrected bootstrap tend to be more accurate than delta methods intervals, standard bootstrap intervals, and Monte Carlo integration intervals. In the following, we always adopt his bootstrap-after-bootstrap methodology for the computation of Impulse Response Functions (IRF) and of the corresponding confidence intervals.

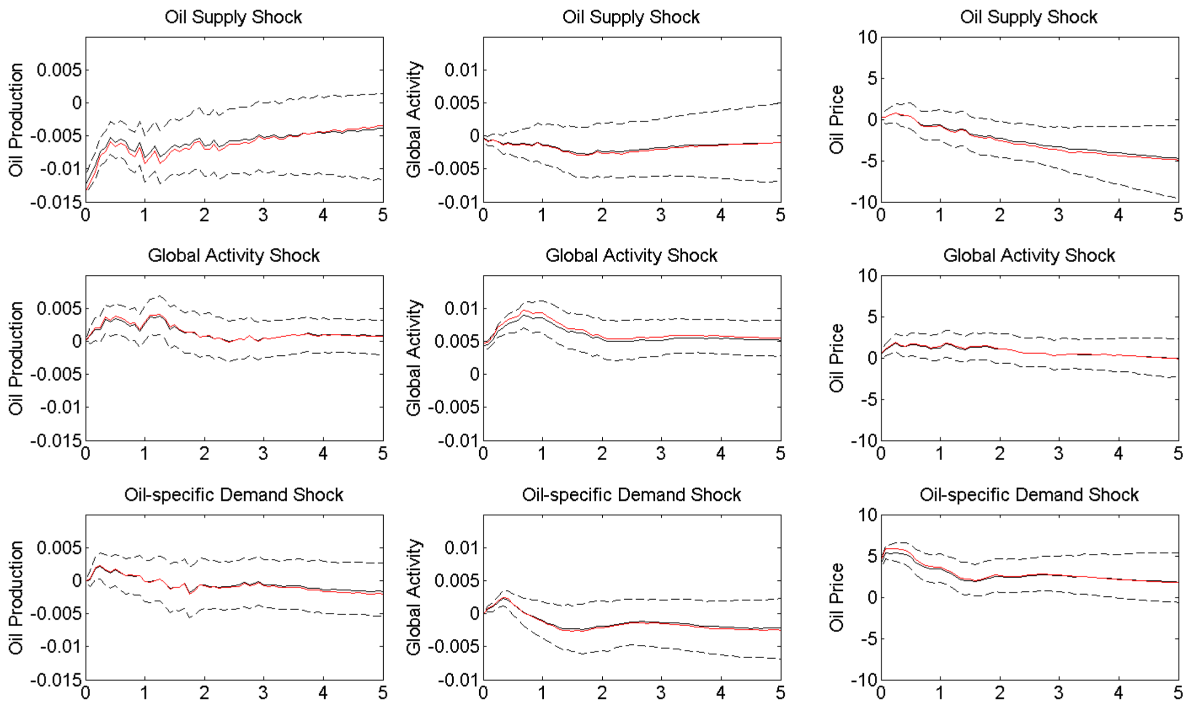

Figure 3: Impulse Response Functions of Oil Production, Global Activity and Oil Price to One-Standard-Deviation Structural Shocks. Point Estimates (red), Median and 95% Confidence Intervals (black) using Kilian's (1998) bootstrap-after-bootstrap

Figure (3) shows the responses of global oil production, global industrial production and the real price of oil to one-standard-deviation structural innovations.

Following an unexpected negative oil supply shock, oil production decreases by 1.3% and tends to return slowly back to its initial level afterwards. This pattern is consistent with the view that oil production disruptions in one region will tend to trigger oil supply increases elsewhere. Global industrial production decreases significantly a month after the negative oil supply shock, while the real price of oil increases only marginally during the first year after the shock and decreases afterwards, this decrease being marginally significant. Hence, oil production disruptions have almost no impact on the real price of oil. This result could ensue from the fact that these shocks might have been anticipated by oil markets, so that the real price of oil already contains a premium before the structural shock happens. This premium would then appear through the third structural shock in our structural decomposition.

The effect of an unanticipated positive global activity shock on global activity is very persistent and highly significant. Global industrial production increases by 0.5% on impact, the effect peaks at 1.0% after 8 months and remains above 0.5% thereafter. The real price of oil responds positively to this positive global activity shock, confirming its dependence to business conditions and justifying the structural decomposition. The real price of oil peaks at 1.9 $ above its initial level after 6 months and remains statistically significant 7 months after the shock. Responding to the increased demand for oil and to higher prices, the oil supply increases up to 0.4% and remains significantly positive 16 months after the shock.

Finally, unanticipated positive oil-specific demand shocks have an immediate large and persistent positive effect on the real price of oil. Following a one-standard-deviation shock, the real price of oil increases by 4.4 $ on impact, and up to 5.5 $ after a month. The real price of oil stabilizes around 2 $ above its initial level after a year and a half. Oil production increases significantly after an oil-specific demand shock, and the impact peaks at 0.2% after 3 months. Global activity increases slightly during the first 6 months after the oil-specific demand shock. This result might stem from an important fraction of oil-specific demand shocks being driven by (correct) anticipations of future global industrial activity increases in the oil market. As a matter of fact, the conditional correlation between commodity futures returns and U.S. stock index returns is positive and significant, as shown by Silvennoinen and Thorp (2010) for instance, which could suggest a positive link between news about the future state of the economy and current oil prices.

2.2 Historical decomposition of the real price of oil

The model also allows us to derive a historical decomposition of the real price of oil. However, the cumulative contribution of each structural shock involves the long-term effects of the historical shocks. These long-term effects rely on the estimated impulse response functions at long horizons, which are inconsistent in unrestricted VARs estimated on short samples with very persistent variables, as shown in Phillips (1998). Moreover, Kilian and Chang (2000) show that confidence bands may have poor coverage properties in small samples in the presence of very persistent variables, even if standard methods of inference are justified asymptotically.

In order to overcome this inconsistency, we apply an HP-filter to the real price of oil and to its historical decomposition. This linear filter cuts out the low-frequency movements of the impulse response functions at long horizons, while preserving the summability of the high-frequency contributions of the structural shocks. Results are shown in Figure (4).

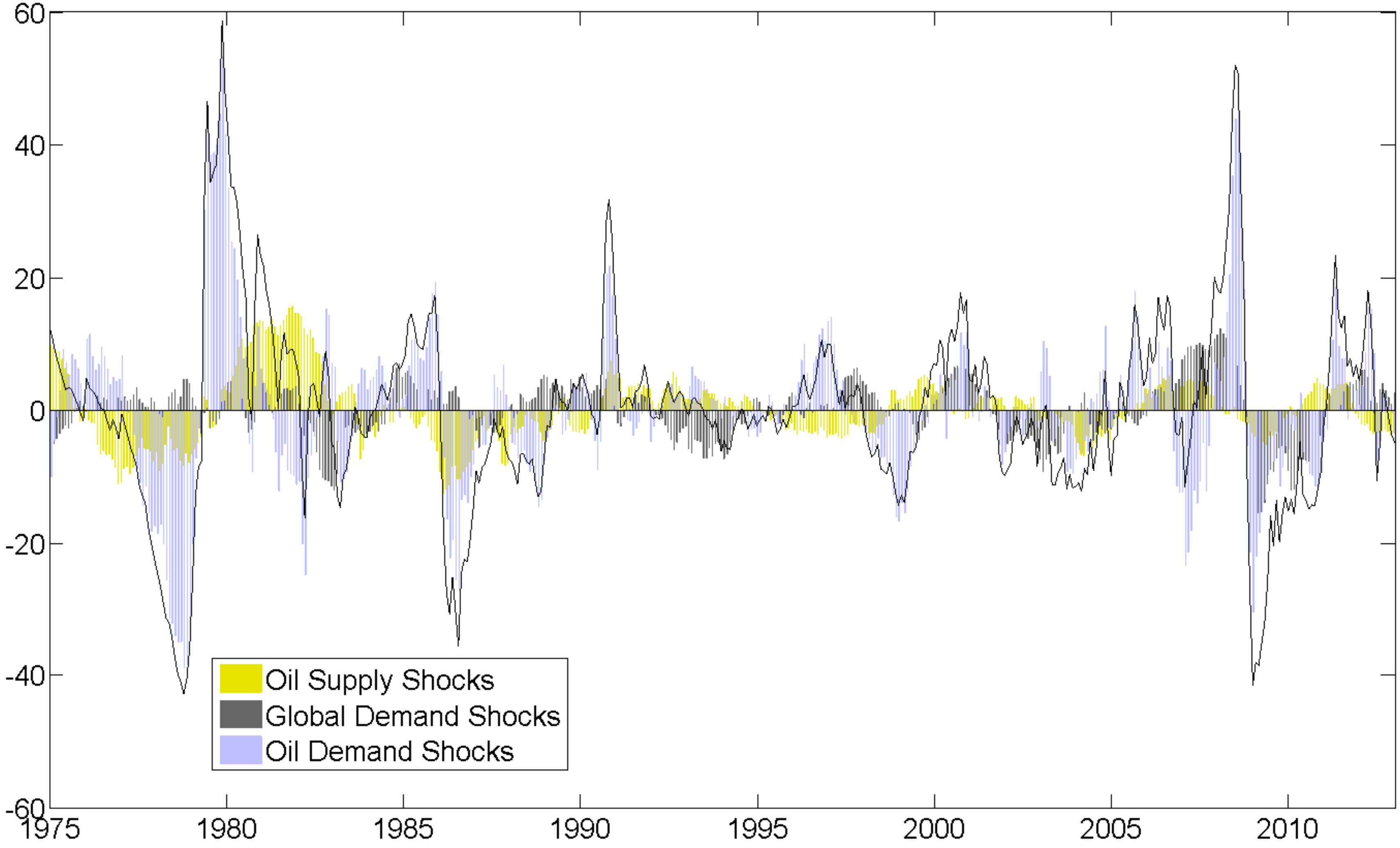

Figure 4: Historical Decomposition of the Real Price of Oil (HP-filtered)

The main driver of the HP-filtered real price of oil is the oil-specific demand shock. It is responsible for most of the short-term volatility. This fact is consistent with the view that precautionary demand shocks may reflect rapid shifts in the market's assessment of the future path for the price of oil. In particular, the second oil price shock in late 1978 and early 1979, during the Iranian revolution, appears to be driven almost exclusively by the third structural shock. As a matter of fact, the real price of oil rises from a trough of 42.7 $ in October 1978 to a first peak of 105.7 $ in June 1979, while global oil production declines by only 4.6% between November 1978 and January 1979, and exceeds its historical peak in July 1979 already. On the contrary, the Iran-Iraq war, starting in September 1980, leads to a 16.2% decline in global oil production between August 1980 and February 1983. According to our historical decomposition, this sharp decline in global oil production contributed positively to the high level of the real price of oil observed during this period.

The 1980s oil glut corresponds to a serious surplus of crude oil caused by falling demand following the two oil price shocks. By the end of 1985, global oil production has almost completely recovered from its drop in 1981-1982. Saudi Arabia abandons efforts to restrict its crude oil production. The real price of oil falls from a peak at 67.2 $ in November 1985 to a trough at 20.2 $ in July 1986. The contribution of the oil supply shock become negative in 1985 and remain firmly negative until 1989. Global activity shocks also contribute negatively to the real price of oil, starting in August 1986 until the end of 1987, though to a lesser extent. But even for this episode, the main driver of the severe decline in the real price of oil remains the oil-specific demand shock.

In 1990, Kuwait's invasion by Iraqi troops that begins the 2^{nd} of August is followed by a rapid surge in the real price of oil, from 28.9 $ in July 1990 to 54.7 $ in October 1990. By February 1991, the real price of oil is back down to 29.2 $. In our historical decomposition, this rapid increase is almost completely explained by the oil-specific demand shock, the positive contribution of the oil supply shock being quite negligible.

Finally, from the beginning of 2006 until September 2008, the global activity shock has contributed largely to the high level of the real price of oil of this period. The rapid economic transformation of new emerging countries during the last decade led to a sharp increase in oil demand, resulting in a strong and persistent rise in the real price of oil, overtaking the historical summits reached in the 1980s in real terms. Unlike many other historical oil price shocks, there was no dramatic geopolitical event associated with this. Though the peak at 128.4 $ in June 2008 seems largely explained by oil-specific demand shocks, the subsequent sharp fall in the real price of oil, reaching a trough at 41.3 $ in December 2008, is almost entirely due to the negative global activity shocks following the Great Recession.

Hence, the evidence in Figure (4) confirms that not all price shocks are alike. If the contributions of the oil supply shock have played some role during the Iran-Iraq war, it seems as though the global activity shocks play a more crucial role in explaining the recent variations in the real price of oil, starting in 2006.

2.3 Sensitivity Analysis

The assumptions underlying the identification scheme of the three structural shocks heavily rely on delay restrictions that are plausible only at monthly frequency. Measuring the current state of the global demand for commodities at a monthly frequency is a challenge. Technological changes over time may affect the link between rising global industrial production and the global demand for commodities. In his structural decomposition applied to the United States, Kilian (2009) constructs an index of single-voyage freight rates, based on various bulk dry cargoes consisting of grain, oilseeds, coal, iron ore, fertilizer, and scrap metal, collected by *Drewry Shipping Consultants Ltd*. Figure (5) shows the HP-filtered global industrial production index and the HP-filtered Kilian's index.

The two series depict a very similar picture of the global business cycles, and the associated global demand for commodities. The world economic activity seems to be the most important determinant of the global demand for transport services. Hence Kilian's index appears as a good measure of the component of global economic activity that drives global demand for industrial commodities. However, the real price of oil remains an important component of freight rates, since the provision of shipping services uses bunker fuel oil as an input. Thus, Kilian's restriction that innovations to the shipping rates do not respond to changes in the price of crude oil within the same month might not hold. Furthermore, Kilian's index does not take into account a situation in which a country is self-sufficient in commodities and thus does not use shipping for the development of its economic activity.

Results from the SVAR using Kilian's index are nonetheless very similar to our estimates using the global industrial production index. The responses of global oil production and of the real price of oil to the three structural shocks are essentially identical in the two cases.

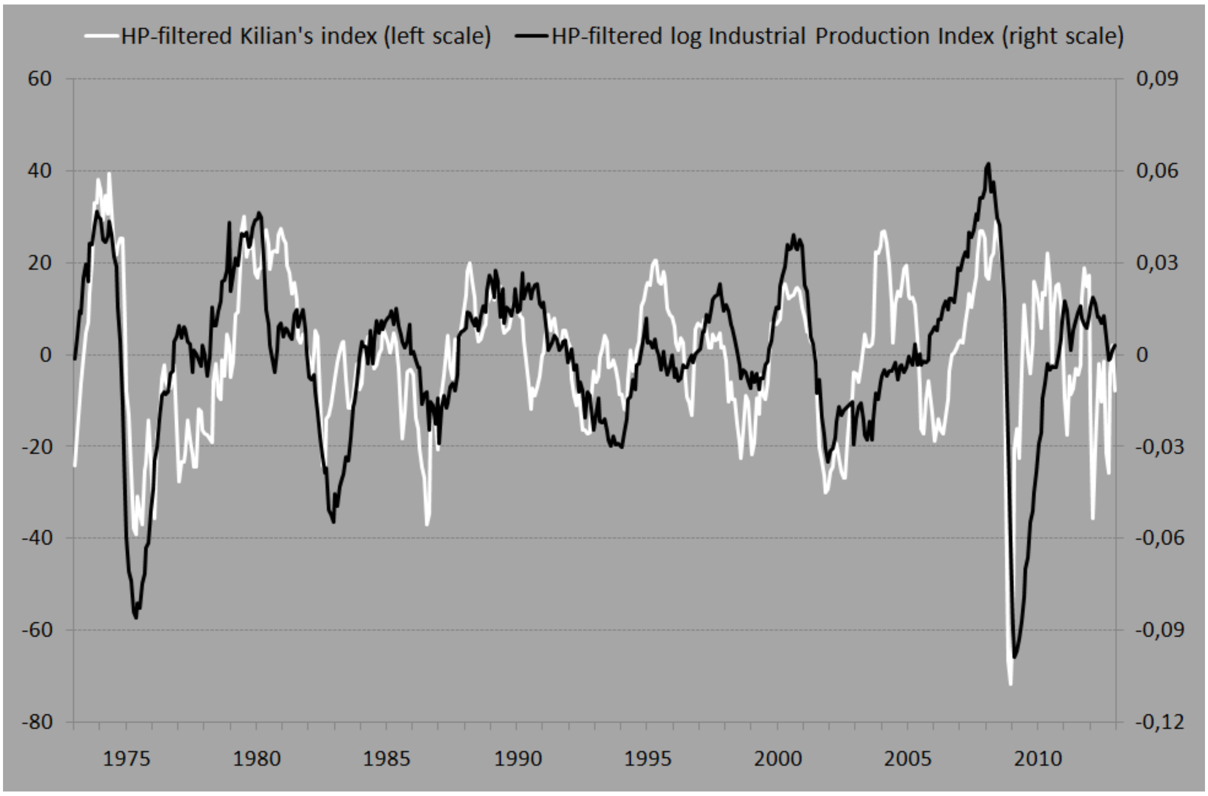

Figure 5: Comparison of the global industrial production index with Kilian's index

3 The effect of the structural shocks on French GDP: an ARX approach

Following Kilian (2009), this section offers a first simple model to study the impact of the structural shocks derived above on the French Gross Domestic Product (GDP). Since French GDP is only available at quarterly frequency, we have to compute quarterly series for the three structural shocks identified previously. It was not possible to keep the identifying assumptions of the monthly SVAR model to construct an analogous structural VAR model on data aggregated at quarterly frequency. Therefore, we consider the monthly series of the three structural shocks and take the sum of the shocks in three consecutive months.

We define ζ_t a 1×3 vector constructed as the sum of the monthly structural innovations for each quarter:

$$\zeta_t = \sum_{i=1}^{3} \eta_{t,i}$$

where $\eta_{t,i}$ refers to the vector of the three residual shocks in the i-th month of the t-th quarter of the sample. These quarterly series of structural shocks hold the same characteristics than the previous series constructed with the monthly SVAR: when summing the monthly series, we are sure to construct a white noise. Hence $\zeta_t \sim \mathcal{N}(0, 3I_3)$.

We then estimate the following quarterly ARX:

$$\begin{aligned} Y_t &= \mu + Y_{t-1}B_1 + ... + Y_{t-q}B_q + \zeta_t B_{q+1} + ... + \zeta_{t-q}B_{2q+1} + \varepsilon_t \\ &= [1 \quad Y_{t-1} \quad ... \quad Y_{t-q} \quad \zeta_t \quad ... \quad \zeta_{t-q}]\, B + \varepsilon_t \\ &= Z_t B + \varepsilon_t \end{aligned}$$

where $\varepsilon_t \sim \mathcal{N}(0, \sigma^2)$ are reduced form shocks and the $(4q + 4) \times 1$ matrix B contains coefficients of constant, lags of French GDP and present and past values of the exogenous variables. The endogenous variable Y_t is the quarterly French GDP, expressed in log-level. The three structural shocks ζ_t are exogenous in this ARX modelization. As French GDP only represents a small fraction of the global economy, it can be considered that internal developments in France, captured by the reduced form shocks ε_t have no effects on the real price of oil or on global activity.

We prefer to regress French GDP on the three structural shocks simultaneously while Kilian regresses on the three structural shocks separately. Our methodology leads mechanically to smaller confidence intervals. Since these shocks are orthogonal, there is no problem to regress on all three of them together. We consider this model over the period 1978Q1-2012Q4 and the number of lags q is set to 12, as in Kilian (2009).

3.1 Impulse Response Functions

The effects of the three structural shocks on French GDP are computed using the bootstrap-after-bootstrap methodology. It is important to note, however, that the confidence intervals computed here do not account for the uncertainty of the estimation of the monthly SVAR. Results in Figure (6) illustrate how different the response of French GDP is, depending on the nature of the shocks. An unanticipated oil supply disruption significantly lowers French GDP, although the effects are quite delayed. Following a one-standard-deviation negative oil supply shock, French GDP decreases by 0.6% after four years and continues to fall afterwards.

In contrast, an unanticiped shock on global activity raises French GDP. French GDP increases by 0.5% after one year, and then falls back somewhat but remains significant until two years after the shock. Thus, it seems as though the direct positive effects of a global activity shock on French GDP outweigh the indirect negative effects from the 2.7

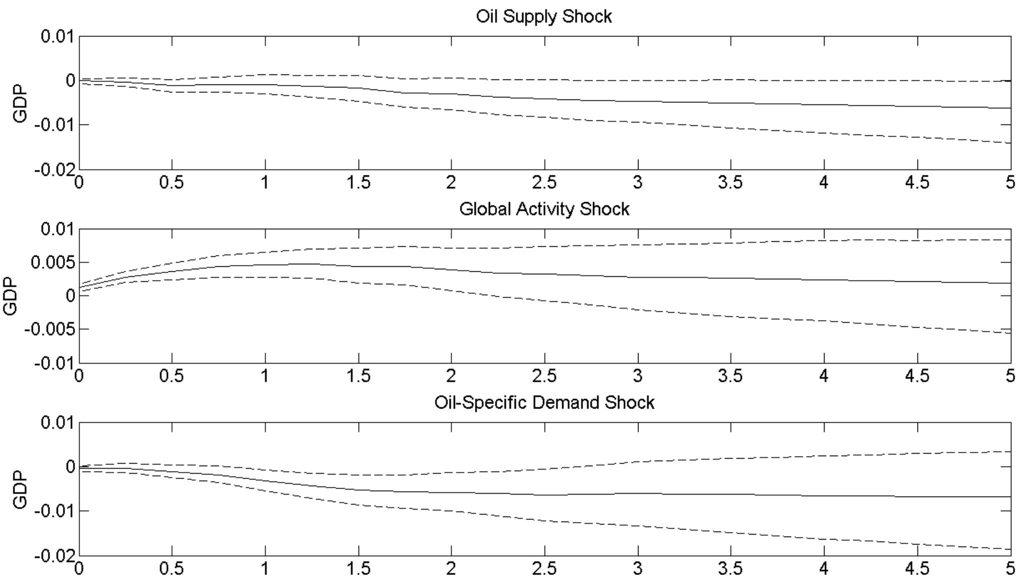

Figure 6: Impulse Response Functions of French GDP to One-Standard-Deviation Structural Shocks. Point Estimates (red), Median and 95% Confidence Intervals (black) using Kilian's (1998) bootstrap-after-bootstrap

$ increase in the real price of oil. Finally, the oil-specific demand shock has a negative effect on French GDP. A one-standard-deviation shock leads to an increase of 10.1 $ in the real price of oil. Two years after the shock, French GDP is 0.6% below the level that would prevail in the absence of the shock.

3.2 Historical contributions of the structural shocks to French GDP

The ARX model also allows us to derive the historical contributions of the three structural shocks to French GDP. Once again, in order to overcome the inconsistency of the estimated impulse response functions at long horizons, we apply an HP-filter to both the historical contributions of the three structural shocks and to French GDP. The filtered French GDP thus corresponds to the difference between the actual value of French GDP and its long term trend. Results are shown in Figure (7). It is important to note that the contributions of the three structural shocks do not sum up to the values of the filtered series for French GDP, since French GDP is also explained by internal factors captured by the reduced-form shock ε_t. However, in some historical episodes, an important fraction of the business cycle fluctuations in French GDP is explained by the effects of the three global shocks identified previously.

We observe a gradual change in the importance of the contributions of the three structural shocks to French GDP. Oil-specific demand shocks played an important role after the second oil price shock. From 1983 to 1987, following the Iran-Iraq war, oil supply shocks became the main driver in explaining the negative output gap prevailing at that time. Since then, the influence of those two shocks on French GDP somewhat faded, and global activity shocks have been the dominant factor to French business cycle fluctuations for the last 20 years. In particular, during the 2007-2011 period, French GDP is almost completely explained by the contributions of the global activity shocks.

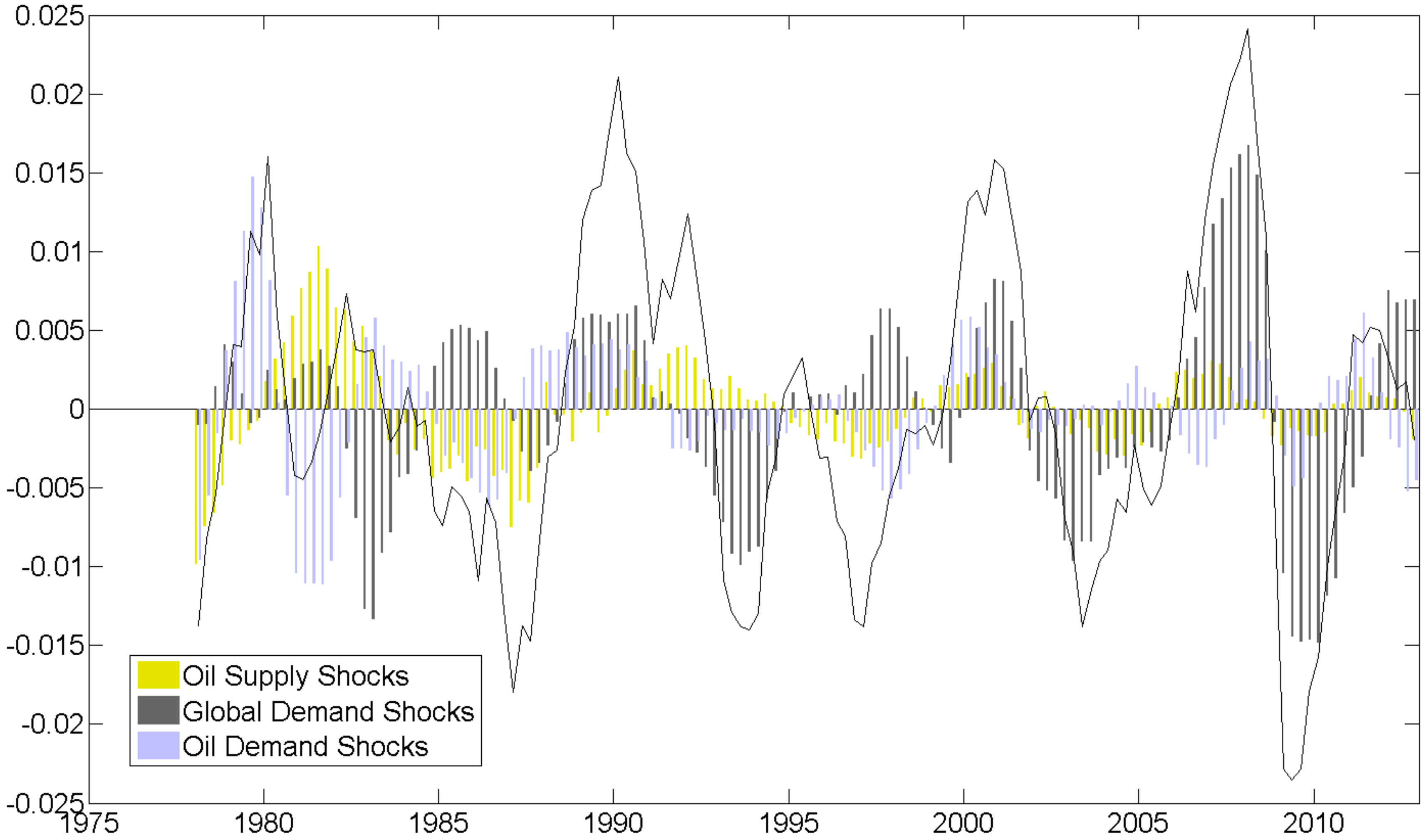

Figure 7: Historical Contributions of the structural shocks to French GDP (HP-filtered)

4 The effect of the structural shocks on the French economy: a VARX approach

We now study the channels through which these three identified structural shocks affect the French economy. We choose to highlight the direct effects on the French economy by including the French Consumer Price Index (CPI) as an endogenous variable. We also include a French short term interest rate to take into account the monetary policy reaction. The indirect effects, transiting through the effects of the shocks on the rest of the world, are modelized thanks to French exports. All in all, we estimate the following quarterly VARX:

$$
\begin{aligned}
Y_t &= \mu + Y_{t-1}C_1 + ... + Y_{t-r}C_r + \zeta_t C_{r+1} + ... + \zeta_{t-r}C_{2r+1} + \varepsilon_t \\
&= [1 \quad Y_{t-1} \quad ... \quad Y_{t-r} \quad \zeta_t \quad ... \quad \zeta_{t-r}]\, C + \varepsilon_t \\
&= Z_t C + \varepsilon_t
\end{aligned}
$$

where $\varepsilon_t \sim \mathcal{N}(0, \Sigma)$ are reduced form shocks and the $(7r+4) \times 4$ matrix C contains coefficients of constants, lags of the endogenous variables and present and past values of the exogenous variables. The four endogenous variables Y_t of the VARX are French GDP, French Exports, French CPI, and the three-month Euribor interest rate. All variables are expressed in log-levels. The three exogenous variables ζ_t are the three structural shocks. The sample period is 1978Q1-2012Q4 and the number of lags r is set to 12, as in the ARX approach.

4.1 Impulse Response Functions

The effects of the three structural shocks on the four endogenous variables are shown in Figure (8). Again, the bootstrap-after-bootstrap confidence intervals do not account for the uncertainty of the estimation of the monthly SVAR. Results illustrate the different channels through which the three structural shocks affect the French economy.

Following a negative oil supply shock, French GDP decreases by 0.4% after three years. The effects of the oil supply shock on French GDP transit almost exclusively through the direct effects on French CPI and interest rates. The CPI increases significantly by up to 0.5% after two years. Responding to the higher inflation induced by the first and second round effects of the oil supply shock, short term interest rates increase by 36 basis points after one year and remain significantly positive until two years after the shock. On the contrary, French Exports increase by up to 0.9% after a year and a half and become insignificant afterwards. This result could stem from increased demand

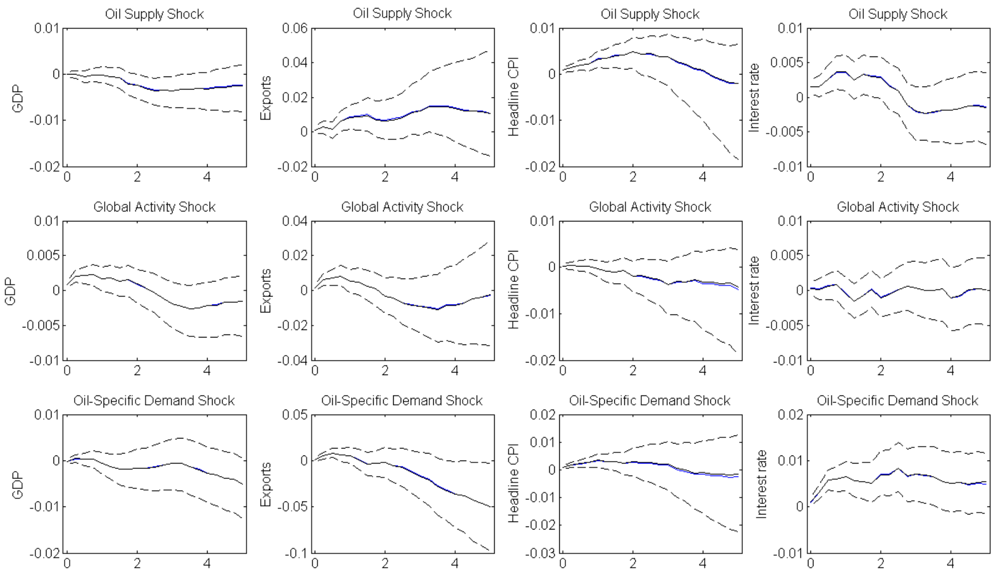

Figure 8: Impulse Response Functions of French GDP, Exports, CPI and Interest Rates to One-Standard-Deviation Structural Shocks. Point Estimates (red), Median and 95% Confidence Intervals (black) using Kilian's (1998) bootstrap-after-bootstrap

from oil exporting countries. All in all, the effects of a negative oil supply shock on the French economy transit through the direct effects of the shock on headline inflation and monetary policy.

On the other hand, a positive global activity shock causes a statistically significant increase of French GDP, reaching a peak at 0.2% after three quarters, driven by the increase of 0.8% of French Exports. The responses of French CPI and interest rates are insignificant. In the short run, the price level does not react to the increase in the real price of oil following the increase of the global activity. Thus the effects of a positive global activity shock on the French economy transit exclusively through the indirect effects of global demand addressed to France.

Finally, the oil-specific demand shock has no significant effect on French GDP in the VARX approach. French Exports increase by 0.8% after two quarters, in line with the significant increase in global industrial production following an oil-specific demand shock in the structural VAR. French CPI increases by 0.3% after one year and interest rates increase by up to 84 basis points after two years and a half. Hence, in the case of an oil-specific demand shock, the direct effects of the increase in the real price of oil, and the indirect effects from the puzzling increase in global activity cancel out.

4.2 Robustness Check

In order to check the robustness of our results, we compare the estimated impulse response functions of French GDP obtained through the VARX approach with those of the ARX. Results are presented in Figure (9).

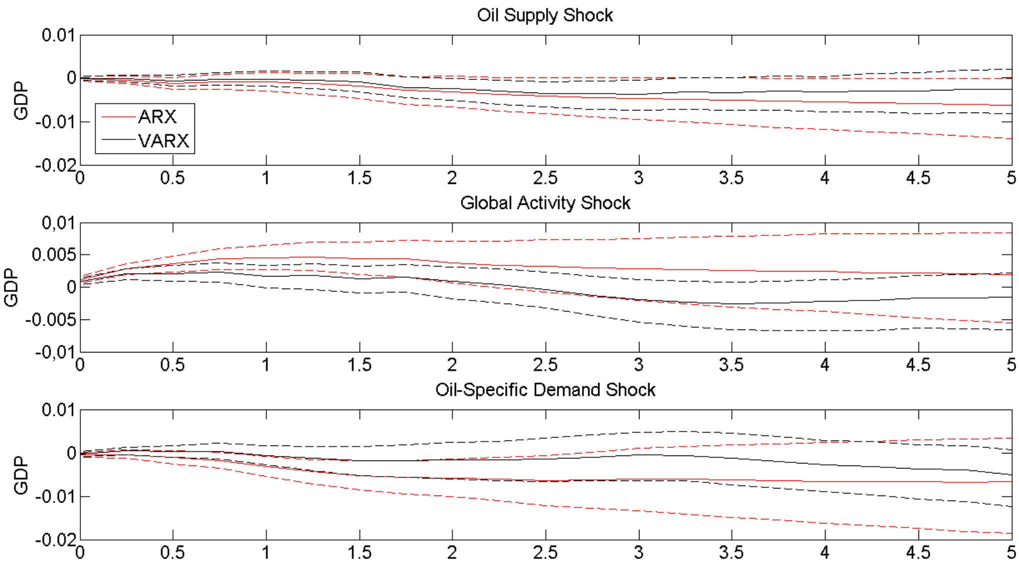

Figure 9: Impulse Response Functions to One-Standard-Deviation Structural Shocks. Comparison between our baseline methodology (black) and the Kilian ARX (red). Median and 95% Confidence Intervals (black) using Kilian's (1998) bootstrap-after-bootstrap

The impulse response functions of French GDP to the first structural shock are almost identical, irrespective of the estimation methodology. They depict a significatively negative but delayed response of French GDP to a negative oil supply shock. Concerning the global activity shock, the response of French GDP is somewhat stronger in the ARX methodology, although this difference is not significant. Results are also quite close concerning the responses to an oil-specific demand shock.

4.3 Comparison with standard results in France

In order to compare our estimated effects of an increase in the real price of oil on the French economy with existing results in the literature, we now normalize the size of the three structural shocks, so that the peak in the response of the real price of oil is at 10 \$. This corresponds to a 9.8-standard-deviation negative oil supply shock, a 3.7-standard-deviation positive global activity shock and a 1.0-standard-deviation positive oil-specific demand shock. Table (1) summarizes the results of our VARX, as well as that of the model MÉSANGE[2], presented in Klein and Simon (2010)[3] and of the model NIGEM[4], developed by the NIESR[5].

These comparisons are only illustrative on the range of the effects but the results should not be compared too precisely. The simulations with the models correspond to a permanent increase in the oil price. While the simulations with our VARX correspond to an increase with a peak at 10 $ and then the oil price evolves on the period following the dynamics given by the estimation. The first shock, the oil supply shock, is probably the closest one, in its nature, to a simulation with a macroeconomic model in which the economy respond to an exogenous oil supply shock. The second shock, the global activity shock, would be closer, in its nature, to simulations including an exogenous oil price shock and an exogenous global demand shock such as the simulations presented in Klein and Simon (2010). The third shock, the oil-specific demand shock, is the more difficult to interpret through macroeconomic simulations since it could hinder forecasts on future global demand.

The response of both French GDP and French Exports is much more negative in standard models than in our VARX specification after 1 year. After 5 years, results provided by macroeconomic models concerning the effects of oil price shocks on the French economy fall in between the estimated effects of the different structural shocks using our baseline methodology.

The VARX approach emphasizes that not all oil price shocks are alike. It shows that simulations with macroeconometric models may be too schematic since oil price shocks are rarely pure. Disentangling oil price shocks depending on their nature is thus key to understanding their effects on the French economy.

[2]Modèle Économétrique de Simulation et d'ANalyse Générale de l'Économie

[3]The version of NIGEM is not the one used in Klein and Simon (2010), but a more recent version. The effects of the oil price shock on the global demand addressed to France is much greater when using this more recent version than in the original version

[4]National Institute Global Economic Model

[5]National Institute of Economic and Social Research

VARX RESULTS	**after 1 year**	**after 5 years**
Oil Supply Shock		
GDP	-0.1	-2.3
Exports	8.4	10.3
CPI	3.2	-2.1
Interest Rates (pp)	3.5	-1.3
Global Activity Shock		
GDP	0.6	-0.6
Exports	1.9	-1.0
CPI	-0.1	-1.8
Interest Rates (pp)	-0.1	0.0
Oil-Specific Demand Shock		
GDP	-0.1	-0.5
Exports	0.5	-5.0
CPI	0.3	-0.2
Interest Rates (pp)	0.7	0.5
MÉSANGE + NIGEM	**after 1 year**	**after 5 years**
GDP	-0.4	-0.8
Exports	-1.3	-2.2
CPI	0.5	0.6
Interest Rates (pp)	0.4	-0.1
NIGEM	**after 1 year**	**after 5 years**
GDP	-0.5	-0.4
Exports	-2.0	-1.7
CPI	0.5	0.6
Interest Rates (pp)	0.2	0.0

Table 1: Comparison of the effects of the real price of oil on the French economy

5 Conclusion

Decomposing oil price shocks into three structural shocks *à la* Kilian (2009), we find that the effects of an increase in the real price of oil, and the channels through which it affects the French economy, differ greatly depending on the nature of the shock. Oil price shocks resulting from oil supply disruptions or oil-specific demand shocks have a negative effect on French GDP, transiting through the direct effects of the increase in the real price of oil on French CPI and interest rates. On the contrary, an unanticipated positive shock in the global economic activity tends to have a positive impact on French GDP, channeling through the global demand addressed to France, since the direct effects of the initial positive shock seem to dominate the negative effects stemming from the oil price surge.

While oil supply disruptions played an important role during the Iran-Iraq war in explaining the high levels of the real price of oil at that time, the recent increases in oil prices seem to be more driven by increased demand from new emerging economies. Our structural identification of the causes underlying the fluctuations in the real price of oil helps understand why higher oil prices seem to matter less today than in the 1970s and early 1980s. This methodology provides new explanations about the change that appears in the empirical relationship between oil price fluctuations and macroeconomic performance over the period. This paper also allows us to better understand the channels through which oil price shocks affect the French economy and to complete the view provided by the different models such as MÉSANGE.

Further investigation on the decomposition of this oil-specific demand shock between shifts in the oil-intensity of the world economy and speculation on the oil market is needed.

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A Construction of the monthly global Industrial Production Index

In order to disentangle the nature of the oil price shocks, it was necessary to build a monthly indicator able to capture global real activity, a proxy for the global demand for commodities. We decided to consider a global Industrial Production Index (IPI). Nevertheless, the data were only available from the World Bank for the global economy starting from 1991. So we had to construct a longer series using the pre-existent series from the International Monetary Fund (IMF) for available countries.

Prior to 1991, we collected the different data series available and we constructed an index able to represent global industrial production. The IMF provides data starting from January 1970 for Austria, Belgium, Canada, France, Germany, India, Italy, Japan, Korea, Luxembourg, Netherlands, Spain, Sweden, Switzerland, the United Kingdom and the United States. The index is set to 100 for the year 2005. These 16 countries represent a total share in global industrial production of 62.02% in 2005.

Our aim is to construct the best index in order to capture global real activity, thus we have to include countries even if the series do not begin in January 1970. When the data for a given country began between January 1970 and January 1991, we retropolated the series using our best available global IPI to take this country into account. For example, the IPI for Ireland begins in January 1975. Thus, we extend the series for this country following the methodology presented below:

- First, we add the data at the date they begin
- Second, we retropolate the series to January 1970 using the growth rate of the world IPI previously obtained
- Third, we compute a new world Index which contains the previous one and the index newly created.

We followed this methodology for three countries: Ireland, Mexico and Turkey. This pool of 19 countries represents 65.84% of global industrial production in 2005. Other countries like China or Brasil were not included in our pool because data were not available prior to 1991 but they did not account for a big share of the global industrial production at these dates.

Once we had computed an IPI for all these countries, we retropolated the World Bank Index from January 1991 to January 1970 using the growth rate of the world representative index previously built.

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