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Do Oil Prices Matter? The Case of a Small Open Economy*

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This paper empirically evaluates the impact and effect of oil price fluctuations and shocks on French aggregate economic performance, industrial production index and inflation rate. Our methodology makes use of a multivariate VAR approach to analyse the stability and magnitude of this system by adopting different oil price specifications, together with a robustness check through the estimation of a St.Louis-type equation. We adopt several oil price specifications. Our results show that the main French macroeconomic aggregate variables have become progressively less reactive to oil price fluctuations and that the adjustment towards equilibrium levels have been done increasingly faster.

Key Words: Oil price fluctuations; Multivariate VAR; Causality; Impulse Response; St.Louis Equation.
JEL Classification Numbers: C32, E32, Q43.

1. INTRODUCTION

Since World War II severe supply shocks hit world economies by sharply increasing the price of oil and other energy products. All these episodes explain why oil price fluctuations have received so much attention for their presumed impact on macroeconomic performance. Theoretically several reasons can be referenced as why an ol shock should affect macro aggregates, some of them calling for a non-linear specification of this two-way relationship.In this context, the relation between oil prices and the macroeconomic variables has been a recurrent research topic since the 1970s. Up to this decade oil prices exhibited a fairly stable and predictable behaviour.

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After the oil shocks of 1973-74 and 1979-80, this variable began to be regarded as a crucial determinant of macroeconomic stability. [1]

Early studies documented and explained the inverse relationship between an increase in the oil price and aggregate economic activity. [2] [3] A major illustration of the extent and relevance of this relationship was put forward by Hamilton (1983), who argued in one important paper that nine out of ten North-American recessions since the Second World War had been preceded by increases in oil prices, i.e. he finds evidence of Granger causality between oil prices and real GNP.

Jones et al. (2003) identify five main branches of research when assessing the state of knowledge on the impact of oil prices in the economy.

The first is the "mechanisms of effect" topic, which deals primarily with the routes through which oil prices transmit their effects to the economy at the micro-level. A second sub-field addresses the problem of "attribution", which arose from the observation that oil shocks were often followed by monetary policy intervention (Hooker (2002), Bernanke et al. (1997)). A third perspective approaches the stability of the oil price-GDP relationship over time. Rotemberg and Woodford (1996), inter alia, argue that the nature of this relationship changed sometime in the 1980s. They justify this change with the fact that "sometime in the early 1980s, OPEC lost its ability to keep the nominal price of oil relatively stable". This claim poses the following dichotomy: either oil prices ceased to Granger-cause GDP or the previous linear relationship evolved into a somehow more complex one (Mork (1989). The fourth branch is the so-called magnitude of the oil price-GDP relationship. The fifth and more recent area focuses on the links between oil prices and stock market performance.

Several questions remain to be answers. First, more checking is needed to confirm the position of the oil price-macroeconomy relation broke down in mid 80s for other market economies bearing in mind whether such country is an oil importer or exporter. Furthermore, countries may react differently to oil price shocks due to heterogenous sectoral compositions of their main economic aggregates, such as the tax structure, role of monetary and fiscal policies. inter alia. Finally, it is worth noticing that oil price shocks trans-

[1] See Appendix - B.2 for a broader discussion of the most important causes of crude oil price increases between 1947-90.

[2] Among the early studies, a special mention is due to Pierce and Enzler (1974) and Darby (1982).

[3] Brown and Yucel (2002) account for the explanation of this inverse relationship in a clear way: "Several different channels have been proposed to account for the inverse relationship between oil price movements and aggregate U.S. economic activity. The most basic is the classic supply-side effect [...]. Other explanations include income transfers from the oil-importing nations to the oil-exporting nations, a real balance effect and monetary policy. [...] the classic supply-side effect best explains why rising oil prices slows GDP growth and stimulates inflation."

mission mechanisms have both a suppy as well as a demand side effect and channel.

Perhaps not surprisingly, the American economy has been the recipient of the bulk of empirical studies on the subject. [4] Some authors have extended the analysis to other industrialized countries (Cuñado and Gracia (2003) for some European countries, or Jimenez-Rodriguez, and Sanchez (2005) for some OECD countries). Other authors have studied countries individually (de Miguel et al. (2003) for Spain and Papapetrou (2001) for Greece). This paper extends the existing empirical literature in two main directions. First, unlike most of the literature on the subject, which focus on the oil producing US economy, we take a small industrialized open economy, France. Secondly, the relation between oil prices and real economic aggregates is assessed using linear and non-linear leading specifications.To the author's knowledge no detailed or individual study for France exists.

Our paper's ultimate purpose is then to analyse the impact of oil price shocks on the French economy - a small oil-importing open economy. An analysis encompassing the entire range of questions brought up so far would require us to employ multiple methodologies, therefore implying the risk of losing focus on the main results. Bearing this concern in mind, we will restrict our work to the investigation of the magnitude, existence and stability of the oil price-French GDP relationship. The estimation of a multivariate VAR fits quite satisfactorily this goal, together with a robustness check carried out by estimating a St. Louis-type equation.

The remainder of the paper is set out as follows. In the next section we present the economic context surrounding the relation between oil prices and economic activity. Then we describe our methodology and discuss the choice of variables to include in the VAR, as well as different oil specifications. In section 3 we conduct unit root tests to the economic series. In section 4 we run a test on the stability of the oil price-GDP relationship. In section 5 we estimate the multivariate VARs and interpret the magnitude as well as assess the significance of the relationship between oil price shocks and our variables. We also generate, in section 6, the impulse response functions and analyse the adjustment towards the equilibrium after an oil shock. In the last section we present our conclusions and the first appendix shows our digression into a St-Louis-type equation estimation. The latter uses monetary and fiscal policy measures to serve as a convenient backdrop against which the relative impact of oil prices can be brought out in sharp relief (also, policy represents a parsimonious control for the general state of the macroeconomy).

[4] We assume theoretical contributions are valid for any economy.

2. ECONOMIC CONTEXT

On the view of the third perspective discussed above empirical facts show that several recessions in many developed countries since the World War II were preceded by oil price increases. One way to see whether this might be just a coincidence is by performing a statistical regression of real GDP growth rates on lagged GDP growth rates differences and lagged logarithmic changes in nominal oil prices. The estimates from an OLS regression of such a relationship for the case of the French economy (using annual data) for t=1951-1980 are as follows[5] (standard errors in parentheses):

$$\underset{}{y_t} = \underset{(1.080)}{4.43} + \underset{(0.164)}{0.14} y_{t-1} + \underset{(0.164)}{0.05} y_{t-2} - \underset{(1.384)}{2.9} oil_{t-1} - \underset{(1.510)}{4.98} oil_{t-2}$$

The estimate on the second lagged oil price variable is negative and statistically significant at usual levels (p-value $= 0,0031$), and an F-test suggests a rejection of the null hypothesis of the joint estimates of lagged oil prices being all zero with a p-value of 0,0021. Some studies tested and rejected the hypothesis that the relation between oil prices and output just be a statistical coincidence, including Rotemberg and Woodford (1996) and Hamilton (2003), inter alia.

Additionally, one can see in Figure 1 for the French economy case, a clear negative relation between both the average annual crude oil prices (constant 2007 USD) and inflation rate with the real French GDP growth rate:

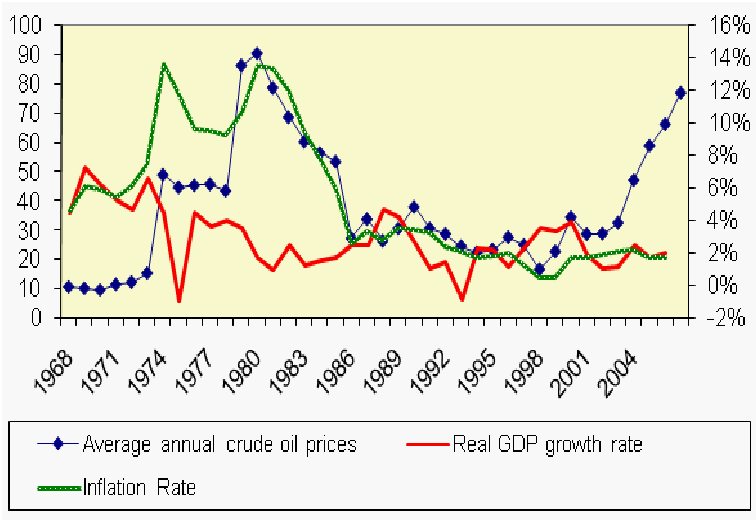
For our purposes it is interesting the fact that if one estimates a log linear relation between the growth rate of real GDP and lagged oil prices, the statistical significance of the relationship decreases as one adds more data (Hooker, 1996a), which might suggest that a linear relation is either unstable or misspecified. Take the relation described above but is re-estimated with data until 2006; then we get:

$$y_t = \underset{(0.468)}{1.05} + \underset{(0.130)}{0.46} y_{t-1} + \underset{(0.129)}{0.27} y_{t-2} - \underset{(0.963)}{0.25} oil_{t-1} - \underset{(0.962)}{2.19} oil_{t-2}$$

In spite of the fact that the t-statistic on oil_{t-2} remains significant with a p-value of 0,03, an F-test of the null hypothesis that the two coefficients on lagged oil prices are zero would not be rejected with a p-value of 0,077. The magnitude of the effect is largely smaller as well. This finding is corroborated by a number of economists who have argued that this instability is due to nonlinearity of the relationship, with a linear-relation collapsing

[5]Further discussion on data is presented on Section 3.1 "Variables Choice" and on Appendix B.1.

FIG. 1. Historical Evolution of Real French GDP growth, inflation rate and crude oil prices for the French Economy, 1968-2006.



Source: Real French GDP growth rate and Inflation Rate - IMF, International Financial Statistics (own calculations); The oil price index corresponds to the annual average crude oil prices inflation-adjusted (IMF, International Financial Statistics and Financial Trend Forecaster).
Note: Left Axis - Average annual crude oil prices; Right Axis - Real GDP growth rate and Inflation Rate.

empirically when the big oil price drops of 1985 failed to create an economic boom. This is an important point as it will define the rest of the paper as far as the discussion about different oil specifications is concerned.

In addition to the perceived relationship between big oil price increases and recessions, oil has been held responsible for the productivity slowdown in the 1970s. Table 1 relates the growth rates of total factor productivity (TFP) in France to the real price of oil for selected subperiods. The overall relation is significantly influenced by a period of unusually low growth in TFP in 1974-85 which coincides with an odd high real price of oil. This phenomenon has risen a theoretical interest that continues till now.

3. METHODOLOGY

Before analysing the impacts of oil shocks on economic activity, the paper starts by investigating the stochastic properties of the series used in the

TABLE 1.

Growth in Total Factor Productivity and the Real Price of Oil

FRANCE	1950-60	1961-73	1974-85	1986-95	1996-06
Real price of oil	22.55	19.80	60.45	28.47	36.34
TFP growth (percent)	2.9	1.7	0.4	0.5	0.4

Source: Groningen Growth and Development Centre, Industry growth accounting database, September 2006, http://www.ggdc.net/, updated from O'Mahony and van Ark (2003). The productivity series is annual multifactor productivity in the private manufacturing. The oil price index corresponds to the annual average crude oil prices inflation-adjusted (IMF, International Financial Statistics and Financial Trend Forecaster).

model by analysing their integration order. Specifically Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are performed.[6]

Secondly, we reach our main purpose and we follow the usual multivariate vector autoregression (VAR) methodology[7] (Hamilton (1983) and Burbidge and Harrison (1984)) to study the impact, magnitude and reaction to impulse oil price schocks across several macroeconomic variables[8].

3.1. Variables Choice

The variables considered for the multivariate VAR model are the following: average oil price (OIL), real Gross Domestic Product (GDP), Industrial Production Index (IPI), total employment (TEMP), unemployment rate (UNR) and the CPI-based inflation rate (INF).[9]

The average oil price is the annual average crude oil price converted to the domestic currency by using the appropriate exchange rate index. The GDP and INF are included in the VAR since our primary object of concern is the impact of oil prices on real output and the price level. We include IPI as a measure of industrial production because we are interested on capturing the effects of oil prices both on industrial production itself and on GDP through the production capacity usage channel (used to proxy

[6]Our analysis builds on Robalo and Salvado [2007] by taking a more complete and comprehensive look of the oil-price and macroeconomy relation and economic context. We also do a proper time series stochastic analysis and as a robustness check a St-Louis-type equation is estimated using quarterly data for the French economy.

[7]A VAR model can be seen as a reduced form of a simultaneous equations model and, thus, can be estimated by Ordinary Least Squares, equation to equation. These estimations will be both consistent and asymptotically efficient.

[8]Christopher Sims advocates the use of VAR models as a theory-free method to estimate economic relationships, thus being an alternative to the "incredible identification restrictions" in structural Vector models (Christopher A. Sims, 1980, "Macroeconomics and Reality").

[9]Summary Statistics and Correlation Coefficients between all variables are presented in Appendix A.4.

economic activity).[10] The unemployment rate and total employment are included to capture not only the direct effects of oil prices on the labour market but also the effects operating indirectly on output and inflation via labour market channels. Most studies include monetary policy variables. We leave out such variables because throughout the period covered by this study the instruments and the role of monetary policy in France have been neither stable nor clear. [11] We have taken the logarithm of the first four variables in order to obtain rates of growth with the first differences. We left the unemployment rate and the inflation rate in percentage terms.

3.2. Different specifications for oil price shocks

Due to the highly volatile behaviour of oil prices (particularly in recent times), linear oil price specifications are no longer appropriate if we want to study the true effects of oil price shocks. Hooker (1996a) showed that, for the American economy, (linear specifications of) oil prices ceased to Granger-cause most macroeconomic indicator variables, including the unemployment rate, real GDP, aggregate employment, and industrial production. Based on Hooker (1996a), we define three proxy variables for oil prices. The first is the evolution of the annual changes of world oil prices and is calculated as:

$$\Delta oil_t = \ln(oil_t) - \ln(oil_{t-a})$$

where, oil_t is the oil price in period t.

We then specify a variable that considers only price increases. The rationale behind this specification relies on the observed asymmetry in the behaviour of macroeconomic variables in reaction to oil price changes:

$$\Delta oil_t^+ = \max(0; \Delta oil_t)$$

Finally we define the Net Oil Price Increase ($NOPI$). This variable will take into account an oil price change only if the percentage increase in price is above the observed values for the previous four years. Otherwise it is zero. This specification eliminates any increases in prices that simply correct price volatility. Therefore one is able to capture more effectively the surprise element, which may be at the origin of a change in spending decisions by firms and households. In our case, since growth rates are

[10] It is important to stress that the industrial sector is much more responsive to a change in the price of oil than, for example, the services sector.

[11] France undertook several reforms of financial markets in the middle of the 80s, which have started in back in the 70s with the breakdown of the Bretton Woods in 1971. The two major changes with respect to monetary policy were the end of the "encadrement du crédit" and the move torward complete free circulation of capital, by announcing a program of financial deregulation. Mélitz (1986).

TABLE 2.

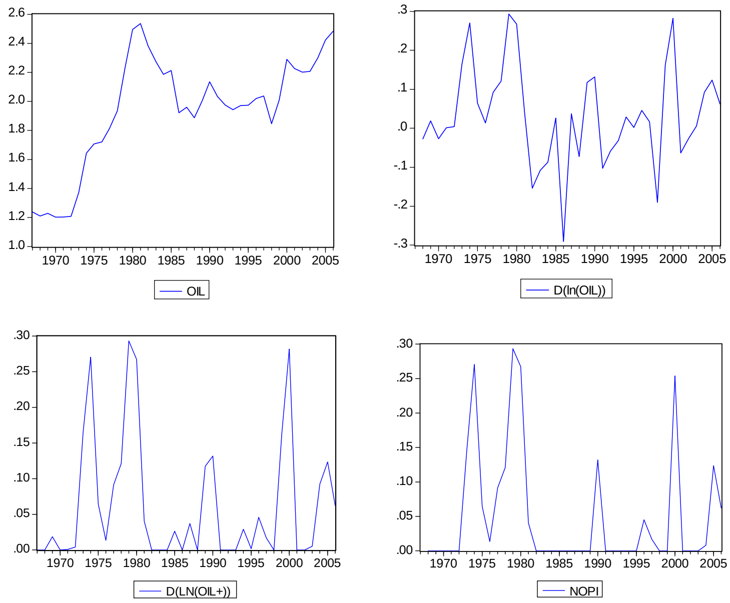
Correlation coefficients among oil price proxies

	Δoil	$\Delta oil+$	$NOPI$
Δoil	-	-	-
$\Delta oil+$	0.887	-	-
$NOPI$	0.796	0.925	-

defined as annual growth rates, we shall calculate:

$$NOPI_t = \max\left[0; \ln(oil_t) - \ln(\max(oil_{t-1}, oil_{t-2}, oil_{t-3}, oil_{t-4}))\right]$$

FIG. 2. Alternative measures of oil price shocks. The first figure represents the logged oil price series in levels. The second one represents the oil price changes (first differences) (Δoil). The third figure represents the positive oil price changes ($\Delta oil+$). The last figure depicts the $NOPI$ specification of oil prices.



Source: IMF and Financial Trend Forecaster. Note: author's calculations

4. EMPIRICAL RESULTS

4.1. Unit Roots and Stationarity

As a first step of the empirical analysis, unit root tests have been carried out for all of the variables for the time period 1968-2006. Table 3 A-B shows the results of the ADF and PP unit root tests.[12]

TABLE 3.

Results of unit root tests

A

	Model with constant & trend	
	ADF	PP
Real GDP in first-log differences	-4.422^{***}	-10.654^{***}
Inflation in first differences	-4.862^{***}	-4.759^{***}
Total Employment in first-log differences	-3.387^{*}	-3.450^{*}
Unemployment Rate in first differences	-3.801^{**}	-3.799^{**}
Industrial Production Index in first-log differences	-6.087^{***}	-6.089^{***}
Oil Price in first-log differences	-4.451^{***}	-4.339^{***}

B

	Model with constant	
	ADF	PP
Real GDP in first-log differences	-7.364^{***}	-8.448^{***}
Inflation in first differences	-4.889^{***}	-4.801^{***}
Total Employment in first-log differences	-7.223^{***}	-11.959^{***}
Unemployment Rate in first differences	-3.678^{***}	-3.745^{***}
Industrial Production Index in first-log differences	-10.914^{***}	-18.521^{***}
Oil Price in first-log differences	-4.488^{***}	-4.384^{***}

Note: Sample is 1968-2006 (annual) for all the variables. Data-driven lag selection procedures are used for the Augmented Dickey-Fuller tests, taking 9 as the maximum number of lags allowed in these procedures into account. One/two/three asterisks denotes the rejection of the null hypothesis at a 10%/5%/1% critical significance levels.

Results of these formal tests indicate that the first differences of all 6 variables are stationary at usual significance levels, and this fact is corroborated by testing for both the ADF and PP tests the cases with constant and with both constant and trend.[13]

[12]Results for unit root tests for the variables in levels did not give us stationarity, therefore the first log-differences were computed and then tested again for the order of integration.

[13]In case we had found I(1) series we would need to test for bivariate cointegration using one of the several common procedures, one of which a test based on the analysis of the stationarity of the residuals of the long-run relationship between the variables. If cointegration would be found to exist between two different variables, an error correction term would be required in testing Granger-causality (Cuñado and Gracia, 2003).

However, this test is suspect when the sample period includes some major events, as the four oil shocks we observe in oil price variables. Failure to consider it properly can lead to erroneous conclusions in the case when the null hypothesis is not rejected. [14] As an aside (but equally appealing and interesting) exercise, we have estimated a St. Louis-type equation in order to assess the significance of crude oil prices in the French Economy. Results obtained using this methodology only corroborate the conclusions we found using the VAR-approach. See further discussion of this St. Louis-type framework in Appendix A.

5. STABILITY AND BREAK-POINT TESTING FOR STRUCTURAL CHANGE

We aim to test whether the nature of the oil price-macroeconomy relationship changed for the French case when we a linear specification for oil prices is assumed as correct. If this is happens to be the case, we must resort to alternative specifications of oil prices. A good specification for oil prices is the one which successfully represents the oil price-macroeconomy relationship.

Following Hamilton's (1983) methodology (in which he tests a brak due to the OPEC embargo) and perform the Chow Breakpoint Test on the following equation:

$$y_t = \alpha + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 oil_t + \beta_4 oil_{t-1} + \beta_5 oil_{t-2} + u_t$$

where y is the log of real GDP and oil is the log of average oil prices. Any lag length choice can be subject to some kind of criticism. On a theoretical ground, our choice seems to be balanced.

We have chosen not to test for breakpoints in the 1970s due to the risk of obtaining results with little robustness, given that the first observation in our sample is 1968. We have tested for a breakpoint on 1985 for two main reasons: there was a clear collapse of oil prices in 1985-1986 (due to Saudi Arabia) and several authors point to the mid-1980s as the rupture point in the way economic agents react to oil prices.[15] Both facts can be corroborated by a simple observation of the series graph. The Chow breakpoint test provides evidence for the existence of a structural break in this point at the 1% significance level. [16]

This fact has two main implications for the remainder of this paper. First, we found more appropriate and insightful to estimate models for

[14] To circumvent this problem, Zivot and Andrews (1992) introduced an alternative formulation to overcome pre-testing problems.

[15] Other possible breakpoints could be tested instead (see Hooker (1996a) and Rotemberg and Woodford (1996)).

[16] Corresponding to an F-statistic of 3,37 and associated to a p-value of 0,0136.

different time periods: for the entire sample, for a first sub-sample (1968-1985) and for a second sub-sample (1986-2005). Second, we chose to carry out the estimation with the alternative specifications of oil price shocks presented above. This will allow us to perform a comparative analysis and conclude if the nature of the relationship has indeed changed.

6. MULTIVARIATE VECTOR AUTOREGRESSION: THE OIL PRICE-MACROECONOMY RELATIONSHIP

The following vector autoregression model of order p is considered:

$$y_t = c + \sum_{i=1}^{p} \Phi_i y_{t-i} + \varepsilon_t$$

where y_t is a $(n \times 1)$ vector of endogenous variables, $c = (c_1, \ldots, c_n)'$ is the $(n \times 1)$ intercept vector of the VAR, Φ_i is the ith $(n \times n)$ matrix of autoregressive coefficients for $i = 1, 2, \ldots, p$, and $\varepsilon_t = (\varepsilon_{1t}, \ldots, \varepsilon_{nt})'$ is the $(n \times 1)$ generalization of a white noise process.

As we are working with annual data we should expect that one lag of the endogenous variables should be enough to conduct the VAR estimation without problems. The usual lag length criteria provided support for this choice, so we estimated VAR Models of order 1. [17]

In this context the relation between oil prices and the other variables of the model are investigated, with a focus on the significance of the impact of oil prices on real economic activity. Several tests are carried out, the first being the Wald test statistic, which tests the null hypothesis that all of the oil price coefficients are jointly zero in the equation for GDP in the VAR model. For each coefficient of the oil price specification we obtain p-values equal to 0,48, 0,25 and 0,24 respectively for Δoil, $\Delta oil+$ and $NOPI$. As for the joint null hypothesis of zero coefficients we get a p-value of 0,64, suggesting that we don't reject the hypothesis that the different oil price variables are not statistically significant at usual levels. This means that oil prices do not appear to have a significant direct impact on real activity. Secondly, in order to analyze the effects of the different specifications of oil price changes, we first studied the coefficients obtained in the VAR estimation (see Table 4) and then we performed the Granger Causality Tests.

For the whole sample only the effect to inflation seems to be significant, and this is verified across all specifications of oil prices. The magnitude

[17] To find the suitable lag lenth, different tests are considered, namely, the modified Likelihood Ratio test, as well as the Final Prediction Error, Akaike, Schwarz and Hannan-Quinn Information Criteria. All tests suported the use of 1 as the proper lag length at a 5% level. See Appendix B. 3.

TABLE 4.

Estimated Coefficient of the VAR equation

	INF	GDP	UNR	Temp	IPI
A - First Subsample 1968-1985					
Δoil	10.596^{***}	-0.006	-0.295	-0.004	0.001
$\Delta oil+$	14.257^{***}	-0.007	-0.563	-0.004	0.002
$NOPI$	14.387^{***}	-0.009	-0.474	-0.004	-0.002
B - Second Subsample 1985-2006					
	INF	GDP	UNR	Temp	IPI
Δoil	2.997^{**}	0.003	-0.681	-0.001	-0.002
$\Delta oil+$	1.675	0.015	-2.558	0.008	0.045
$NOPI$	0.803	0.008	-3.029^{*}	0.006	0.027
C - Entire Sample 1968-2006					
	INF	GDP	UNR	Temp	IPI
Δoil	7.354^{***}	-0.004	-0.457	0.001	-0.010
$\Delta oil+$	10.412^{***}	-0.005	-1.315	0.004	0.002
$NOPI$	10.803^{***}	-0.008	-1.003	0.001	-0.007

Note: INF is the Inflation rate, GDP is the growth rate of Real GDP, UNR is the unemployment rate, Temp is the growth rate of Total Employment and IPI is the growth rate of industrial production index. One/Two/Three asterisks denote signifance at the 10%/5%/1% level for the null hypothesis that the coefficient is zero.

of these effects increases as we pass from Δoil, to $\Delta oil+$ and from $\Delta oil+$ to $NOPI$. These variables act like a filter that transforms variations in the price of oil into shocks and therefore it is expectable to obtain greater effects.

Analysing each of the two sub samples separately, we observe that the coefficients are more significant and that the magnitudes are higher for the first sub sample.

For inflation we obtain exactly what we made reference to: a higher and more significant effect for the first sub sample than for the second. The effect on the unemployment rate, despite not being significant for the whole sample, it becomes significant for the $NOPI$ specifications of oil price variation in the second sub sample.

To analyse the statistical causality link between oil price shocks and the other variables, we will perform bivariate Granger Causality Tests (see p-values associated with this test in Table 5).[18]

[18]It is important to note that larger p-values provide more support to reject the Granger Causality.

TABLE 5.

P-values associated with the bivariate Granger Causality Test (from oil specs to variables)

A - First Subsample 1968-1985

	INF	GDP	UNR	Temp	IPI
Δoil	**0.00198**	0.11618	**0.07159**	0.80669	**0.08186**
$\Delta oil+$	**0.00153**	**0.01518**	**0.09198**	0.34123	**0.01317**
$NOPI$	**0.00308**	0.01625	**0.05515**	0.30036	**0.01151**

B - Second Subsample 1985-2006

	INF	GDP	UNR	Temp	IPI
Δoil	0.62838	0.58800	**0.03977**	0.96891	0.83901
$\Delta oil+$	0.76381	0.21707	**0.00284**	0.85231	0.59721
$NOPI$	0.87644	**0.08228**	0.24556	0.53381	0.85212

C - Entire Sample 1968-2006

	INF	GDP	UNR	Temp	IPI
Δoil	**0.06131**	0.11138	0.44111	0.79651	0.30423
$\Delta oil+$	**0.04878**	**0.00466**	0.65875	0.54475	**0.09136**
$NOPI$	**0.03602**	**0.00367**	0.38244	0.21530	**0.08040**

Note: The bivariate regressions take the form

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots + \alpha_l y_{t-l} + \beta_0 x_{t-1} + \cdots + \beta_l x_{t-l} + \epsilon_t$$
$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \cdots + \alpha_l x_{t-l} + \beta_0 y_{t-1} + \cdots + \beta_l y_{t-l} + u_t$$

for all pairs (x, y) series in the group.

INF is the Inflation rate, GDP is the growth rate of Real GDP, UNR is the unemployment rate, Temp is the growth rate of Total Employment and IPI is the growth rate of industrial production index.

Analysing the results for the whole sample we found indication of Granger causality between two specifications of oil price ($\Delta oil+$ and $NOPI$) with both GDP and IPI and between the three oil specifications and the inflation.

Using only the first sub sample we found causality between all specifications of oil price and the rate of unemployment as well as again with the inflation rate, which disappears in the second sub sample. We continue to find Granger-causality between the three oil price specifications and IPI. Finally there is also evidence of causality between $\Delta oil+$ and GDP.

In the sub sample 1986-2006 we found Granger Causality only between Δoil and $\Delta oil+$ with the unemployment rate and between $NOPI$ and GDP. In this subsample, no causality was found as far as the inflation rate is concerned.

In sum, we do observe some evidence of causality especially in the first sub-sample and in the entire sample for the variables inflation rate and industrial production index, and in the first sub-sample for the unemployment rate as well. Evidence is not strong as far as GDP is concerned across different specifications and samples.

7. IMPULSE RESPONSE ANALYSIS

In this section, we examine the response of each variable of the VAR equations to a shock in oil price proxy variables. To facilitate the description of the results, the relative performance of the different specifications is evaluated. This can be done in two different ways. First, the precision of the estimation of the impulse responses can be gauged by looking at the confidence bands. Secondly, the goodness of fit of the different specifications is assessed. Given that these models are non-nested, selection criteria such as the Akaike Information Criteria (AIC) and the Schwarz Bayesian Information Criteria (BIC) are looked at.

An impulse response function traces the effect of a one-time residual shock to one of the innovations on current and future values of the endogenous variables.[19] [20]

In the Appendix B.5 we present all graphical representations of the impulse response functions that we have generated. By observing them we can conclude some interesting features; we will organize our findings variable by variable.[21]

The GDP growth rate responds negatively to all oil price shocks specifications for every sub sample. The initial response is always larger and lasts longer in the first sub sample for the different specifications of oil price, and changing these specifications does not alter significantly the results.

For Inflation, we obtain the desired effect in the first sub-sample and entire sample: positive responses to positive shocks. The structure of adjustment after the shocks is very similar across the sub samples, but the magnitude of the initial impact is bigger for the period 1968-1985.

For the Industrial Production Index, even if it is not very large, the initial response is always negative for the first sub sample and for the whole sample. If we observe the responses to Δoil, $\Delta oil+$ and $NOPI$ in the second sub sample, the conclusions are different: the responses are positive. This may seem a bit confusing; however, it might simply be related to a

[19]Given that the chosen lag-length was 1, one cannot use the Choleski decomposition when representing the impulse response functions (see Lütkepohl 1991, pp. 155-158).

[20]Given that one cannot obtain impulse responses by Choleski decomposition, one is unable to do variance decompositons of the variables in the VAR. Note that since non-orthogonal factorization will yield decompositions that do not satisfy an adding up property, the choice of factorization should be limited to orthogonal factorizations, which is not the case.

[21]The two standard error bands around the impulse responses are based in Lütkepohl (1990).

weakened relationship between oil prices and industrial production due to a change in the oil price behaviour.

In what concerns the Unemployment Rate, we obtain the same structure of adjustment and the expected positive effects for the $NOPI$ specification and first subsample for both Δoil and $\Delta oil+$. The adjustment is longer in the first sub sample. Additionally, Unemployment Rate is the variable that takes more time do adjust completely.

The effects on the growth rate of Total Employment are similar to the one that we have observed for the growth rate of GDP. The response is initially negative and the adjustment occurs faster in the sub sample 1986-2006.

As far as the second point is concerned one can evaluate the overall goodness of fit of each different oil price specification using the AIC and BIC. Table 6 reports these results and on the basis of the two criteria, it is concluded that the $NOPI$ specification performs somewhat better than the other approaches used in the present study.

TABLE 6.

Relative Performance of the different specifications (entire sample)

France		Δoil	$\Delta oil+$	$NOPI$
	AIC	-18.24775	-18.36027	-18.37654^*
	BIC	-16.95491	-17.06744	-17.08371^*

Note: * indicates the chosen specification.

8. DISCUSSION AND CONCLUDING REMARKS

In this paper we present a study on the effects of changes in oil price for the French economy. We used the multivariate VAR methodology, which is commonly employed for this purpose, together with different specifications for oil price variations and estimated the effects for different time intervals, namely before and after 1985. A St.Louis-type equation was estimated to provided robust support to previous findings.

With the multivariate VAR coefficient analysis we found a significant effect of variations on the price of oil over inflation and, only for the second time interval, over the unemployment rate. The magnitude of the coefficients becomes smaller in the second sub sample if compared to the first sub sample. In this sense the main macroeconomic aggregates became progressively less reactive to oil price fluctuations and shocks.

The Granger Causality method supported the existence of real causality between oil prices with the inflation rate, unemployment rate and the industrial production index in the first sub sample; and between oil prices and the inflation rate in the entire sample.

The impulse response functions were extremely useful in analysing the adjustment and the initial impact of the variations in the price of oil. We also found the NOPI is the oil price specification that better performs in our study compared with the other approaches. Furthermore, we were able to show that the adjustment towards equilibrium levels have been done increasingly faster in recent years.

A possibility for further research in this area might be to try and find a constant-parameter model that does not undergo a structural break - this might be possible by somehow weighting the variables to reflect the declining importance of oil in the economy in the later period, for instance.

APPENDIX A

A.1. ST. LOUIS-TYPE EQUATIONS

In order to assess the significance of crude oil prices in the French economy, monetary and fiscal policy measures are used to serve as a convenient backdrop against which the relative impact of crude oil prices can be brought out in sharp relief. Also, policy represents a parsimonious control for the general state of the macroeconomy.

Our approach is to estimate a St. Louis-type equations of five indicators of macroeconomic performance. The indicators are real GDP (GDP), the CPI based inflation rate (INF), the rate of unemployment (UNR) and the Gross Fixed Capital Formation (INV). Additionally we introduce a forth indicator not previously used in the literature, namely Imports (IMP) in order to see whether there is evidence of a relation between oil prices and volume of imports by France. Each equation takes the form:

$$X_t = \alpha_0 + \sum_{i=0}^{2} m1_i M1_{t-i} + \sum_{i=0}^{2} g_i GOV_{t-i} + \sum_{i=0}^{2} oil_i OIL_{t-i} + \varepsilon_t$$

where X_t is an indicator of macroeconomic performance, $M1_{t-i}$ is the money supply (M1B), GOV_{t-i} is the government expenditure measure of fiscal policy and OIL_{t-i} is the nominal price of crude oil.[22]

In the line of more recent work on these equations (Batten and Thornton, 1983) we work with the data in growth rate, instead of levels or first differences. Therefore, all variables are changed into compound annual growth rate form using the filter

$$100\left\{[1+\ln(X_t/X_{t-1})]^4 - 1\right\}$$

[22]See data descriptions in Appendix B.1.

Table 7 below contains the results of the five St. Louis-type equations. The sample is quarterly data for the period 1970:II to 2006:I, exclusive of lags.[23]

The first column of Table 7 contains the results for the annual percentage rate of change of real GDP, GDP. The main impact of monetary policy appears to be contemporaneous, with a 1 percent increase in M1 resulting in a 0,23 percent increase in real GDP. The impact of monetary policy drops off sharply after that. The pattern of monetary policy coefficients confirms the literature suggesting that monetary shocks have profound short-run impacts and long-run neutrality. The sum of the three coefficients is not small and statistically significant at 1%. Fiscal Policy is not significant in the short term but significant a year out (as well as the three-lag sum). Crude oil prices show a pattern that steadily increases with lag length, reaching a maximum at 2 years. However, the three-lag sum, despite having the expected sign, is not statistically significant.

The results for the GDP deflactor INF are somehow different. Monetary policy continues to be significant both in the short-term and lagged periods, however one cannot reject the hypothesis that the sum of coefficients is zero. As for fiscal policy all the individual coefficients are their sum are statistically significant but very small in size. The three-lag sum of crude oil prices has a small and significant positive impact on the general price level, as one could expect.

For changes in the rate of unemployment, the three-lag sum of coefficients in money and fiscal policy are not statistically significant. As in the case of the price level, again we see the pattern of an oil price impact skewed toward the last lag.

While the choice of GDP, INF and UNR as indicators of macroeconomic performance is obvious, real investment INV may be less so. The choice arises from accumulating evidence on links in the causal chain between oil prices and the macroeconomy. James Wilcox (1983) has convincingly argued the net complementarity between capital and oil is the main reason behind so low real interest rates in the 1970s. A St. Louis-type equation on investment is an experiment to examine that relation, even if indirectly. The results suggest that the three-lag sum impact of oil prices is small but statistically significant (as well as the sum in the fiscal policy coefficients).

Finally, we thought economically intuitive to relate general import volume with crude oil prices and we found a statistically and positive, although with small maginitude, relationship in the three-lag sum at a 10% level.

Further evidence is obtained through bivariate Granger-causality tests, which are described in Section 6.

[23] An examination of the transformed series reveals that the data are stationary, with all series rejecting the null hypothesis of unit root at 1% significance (the exception in the general price leve which is significant at 5%).

TABLE 7.

St. Louis-type Equations

	Dependent Variables				
Independent Variables	GDP	INF	UNR	INV	IMP
Constant	2.23^{***}	0.29	-9.13	1.23	3.92^{*}
$M1$	0.23^{***}	0.16^{***}	3.30^{***}	0.29^{*}	0.21
$M1_{-1}$	0.19^{**}	0.19^{***}	-0.49	0.21	0.12
$M1_{-2}$	0.17^{**}	0.22^{***}	-0.77	0.33^{**}	0.17
$\sum M_t$	0.59^{***}	0.58	2.04	0.84	0.49^{**}
GOV	0.027	0.02^{*}	-0.19	-0.04	-0.02
GOV_{-1}	0.036^{**}	0.05^{***}	-0.22	0.03	0.002
GOV_{-2}	0.029	0.03^{**}	0.62^{***}	0.05	0.07
$\sum GOV_t$	0.09^{***}	0.09^{***}	0.2	-0.35^{**}	0.06
OIL	-0.01	0.003	0.015	0.01^{**}	0.045^{***}
OIL_{-1}	-0.01	0.005^{*}	-0.009	-0.004	0.01
OIL_{-2}	0.003	0.003	-0.017	0.01^{*}	0.01
$\sum OIL_t$	-0.01	0.01^{**}	-0.02^{**}	0.02^{*}	0.07^{***}
$adjR^2$	0.48	0.51	0.14	0.28	0.22
Durbin-Watson	1.01	0.54	1.92	2.01	1.66

Note: One/Two/Three asterisks denote signifance at the 10%/5%/1% level for the null hypothesis that the coefficient or sum of coefficients is zero. The sample period is 1970:II - 2006:I.

APPENDIX B

B.1. DATA SOURCES

The data used in this study are mainly obained from International Monetary Fund (IMF) - International Financial Statistics. Data are quarterly from 1970.II to 2006.I. for St. Louis-type Equations section and annual from 1968 to 2006 (series were extended back to 1951 for GDP and oil prices for use in Section 2 - "Economic Context"). See below description of variables and additional data sources whenever relevant for the purposes of this paper:

• GDP: Real GDP in chained 2000 euros; source: IMF

• INF: Inflation rate, annual Consumer Price Index variation; source: IMF

• UNR: Unemployment rate; source: IMF and French National Bureau of Statistics

• Temp: Total Employment; source: IMF and French National Bureau of Statistics

• IPI: Average of monthly Industrial Production Index which acts as a proxy of economic activity; source: IMF and French National Bureau of Statistics

• OIL: Weighted average of crude oil prices; source: IMF and Financial Trend Forecaster

• M1: Monetary Aggregate M1-type; source: IMF and Banque de France

• INV: Gross Fixed Capital Formation volume; source: IMF

• IMP: Total Imports volume index; source: IMF

• ER: Real Exchange Rate Index; source: IMF

B.2. PRINCIPAL CAUSES OF CRUDE OIL PRICE INCREASES, 1947-1990

Oil Price Episode	Principal Factors
1947-48	Previous investment in production and transportation capacity inadequate to meet postwar needs; decreased coal production resulting from shorter workers; European recons truction
1952-53	Iranian nationalization; strikes by oil, coal and steel workers; import posture of Texas Railroad Commission
1956-57	Suez Crisis
1969	Secular decline in US reserves; strikes by oil workers
1970	Rupture of trans-Atlantic pipeline; Libyan production cutbacks; coal price increases
1973-74	Stagnating US production; OPEP embargo
1978-79	Iranian Revolution
1980-81	Iran-Iraq war; removal of US price controls
1990	Persian Gulf war

Sources: Hamilton (1983), until the “Oil Price Episode 1980-81”

B.3. VAR LAG-LENGTH SELECTION CRITERIA

VAR Lag Order Selection Criteria						
Endogenous variables: INF GDP UNR TEMP IPI						
Exogenous variables: OIL						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	161.6928	NA	1.14e-10	−8.705154	−8.485220	−8.628391
1	359.0568	328.9401*	8.04e-15*	−18.28093	−16.96133*	−17.82036*
2	383.4414	33.86750	9.06e-15	−18.24674	−15.82748	−17.40236
3	411.6365	31.32786	9.57e-15	−18.42425*	14.90532	−17.19605
Exogenous variables: OIL+						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	170.5579	NA	6.97e-11	−9.197661	−8.977728	−9.120899
1	360.8728	317.1916*	7.27e-15*	−18.38182*	−17.06223*	−17.92125*
2	384.1986	32.39693	8.68e-15	−18.28881	−15.86955	−17.44442
3	409.4207	28.02451	1.08e-14	−18.30115	−14.78222	−17.07295
Exogenous variables: NOPI						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	168.4425	NA	7.84e-11	−9.080141	−8.860207	−9.003378
1	361.3497	321.5120*	7.08e-15*	−18.40832*	−17.08872*	−17.94774*
2	384.4307	32.05690	8.57e-15	−18.30171	−15.88244	−17.45732
3	406.9400	25.01034	1.24e-14	−18.16333	−14.64440	−16.93513

Note: * indicates lag order selected by the criterion; LR: sequential modified Likelihood Ratio test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion

B.4. SUMMARY STATISTICS AND CORRELATION COEFFICIENTS BETWEEN VARIABLES

Summary Statistics for the VAR analysis data

	INF	GDP	UNR	Temp	IPI
Mean	5.262654	0.011439	7.946154	0.002423	0.007304
Median	3.380112	0.010520	9.100000	0.001943	0.007808
Maximum	13.64927	0.029345	11.90000	0.011484	0.048156
Minimum	0.550052	0.001211	2.300000	−0.005628	−0.050375
Std. Dev.	4.064517	0.006650	3.154266	0.003632	0.017834
Skewness	0.765438	0.639532	−0.621799	0.110247	−0.834343
Kurtosis	2.248087	2.832207	1.948465	3.172695	5.537623
Jarque-Bera	4.727055	2.704261	4.309925	0.127467	14.98907
Probability	0.094088	0.258688	0.115908	0.938255	0.000556
Sum	205.2435	0.446115	309.9000	0.094493	0.284846
Sum Sq. Dev.	627.7713	0.001680	378.0769	0.000501	0.012086
Observations	39	39	39	39	39

Correlation Coefficient between variables

	Oil	GDP	UNR	Temp	IPI
Oil					
GDP	−0.671				
UNR	0.674	−0.588			
TEMP	−0.166	0.571	−0.133		
IPI	−0.439	0.735	−0.399	0.419	

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