Oil price shocks and the Portuguese economy since the 1970s

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Abstract:

This paper assesses empirically the effect of oil price shocks on Portuguese aggregate economic activity, industrial production and price level. We take the usual multivariate VAR methodology to investigate the magnitude and stability of this relationship. In doing so, we follow the approach presented in the recent literature and adopt different oil price specifications. We conclude that, as for most industrialized countries, the nature of this relationship changed in the mid-1980s. Furthermore, we show that the main Portuguese macroeconomic variables have become progressively less responsive to oil shocks and the adjustment towards equilibrium has become increasingly faster.

JEL Classification: E32, Q43

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1. Introduction

The relationship between oil prices and the main macroeconomic variables has been a recurrent research topic since the 1970s. Up to this decade oil prices exhibited a fairly stable and predictable behaviour. It was not until the oil shocks of 1973-74 and 1979-80 that this variable began to be regarded as a crucial determinant of macroeconomic stability.

The early studies documented and explained the inverse relationship between an increase in the oil price and aggregate economic activity. [1] [2] A major illustration of the extent and relevance of this relationship was put forward by Hamilton (1983), who showed in an influential paper that nine out of ten US recessions since World War II had been preceded by an oil price increase, i.e. he finds evidence in support of Granger causality between oil prices and real GNP.

Jones, Leiby and Paik (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 plethora of approaches is used when addressing this question: the use of disaggregated data at the firm level, theoretical models for different market set-ups, etc

A second sub-field addresses the problem of "attribution", which arose from the observation that oil shocks were often followed by monetary policy intervention. Some authors (for example, Hooker (2002)), believe it were not oil price shocks but monetary policy the main culprit for the stagflation episodes. In a very influential paper, Bernanke, Gentler and Watson (1997) showed that the Federal Reserve policy is largely endogenous due to the Fed's commitment to macroeconomic stabilization. They argue it is possible that, by reacting to oil price shocks, monetary policy has contributed to

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

[2] 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 in which rising oil prices are indicative of the reduced availability of a basic input to production. Other explanations include income transfers from the oil-importing nations to the oil-exporting nations, a real balance effect and monetary policy. Of these explanations, the classic supply-side effect best explains why rising oil prices slows GDP growth *and* stimulates inflation."

deepen stagflation episodes. Such statements lead to a series of replies and counterfactual studies, launching a debate which has not yet been settled.

A third perspective approaches the stability of the oil price-GDP relationship over time. Rotemberg and Woodford (1996), among other authors, 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. It is reasonable to assume that after this point variations in the demand for oil … began to be reflected in nominal oil prices immediately". 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. One fundamental question related to this discussion is the empirically observed degree of asymmetry exhibited by macroeconomic fundamentals in reaction to oil shocks. In other words, the effects of an increase in the oil price are substantially different from the effects of a fall in the oil price (see, for example, Mork (1989), who was the first author to suggest asymmetric specifications for oil price shocks).

The fourth branch is linked to the issue that probably ranks first among policymakers worries about oil prices: the so-called magnitude of the oil price-GDP relationship. For the US economy, the empirical tests have produced a negative relationship as expected.

The fifth and more recent area focuses on the links between oil prices and stock market performance.

Perhaps not surprisingly, the American economy has been the recipient of the bulk of empirical studies on the subject. [1] Some authors have extended the analysis to other industrialized countries (e.g., Cuñado and Pérez de Gracia (2003) for some European countries, or Jimenez-Rodriguez, and Sanchez (2005) for some OECD countries). Other authors have studied countries individually (e.g., de Miguel, Manzano, and Martín-Moreno's (2003) for Spain and Papapetrou (2001) for Greece). We know of no detailed or individual study for Portugal.

Our paper's ultimate purpose is then to investigate the impact of oil price shocks on the Portuguese 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

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

will restrict our work to the investigation of the magnitude, existence and stability of the oil price-Portuguese GDP relationship. The estimation of a multivariate VAR fits quite satisfactorily this goal.

The remainder of the paper is set out as follows. In the next section we present our methodology and discuss the choice of variables to include in the VAR. In section 3 we run a test on the stability of the oil price-GDP relationship. In section 4 we estimate the VARs and interpret the magnitude and assess the significance of the relationship between oil price shocks and our variables. In Section 5 we generate the impulse response functions and analyse the adjustment towards the equilibrium after an oil shock. In the last section we present our conclusions.

2. Methodology

We follow the usual vector autoregression (VAR) methodology (see, for example, Hamilton (1983) or Burbidge and Harrison (1984)) to study the magnitude effect and the response to impulse function of oil price across the main macroeconomic variables. [1]

The VAR methodology is very useful for this purpose and it is easy to use. 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.[2] These estimations will be both consistent and asymptotically efficient.

2.1 Choice of variables for the VAR

The variables considered for the 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).

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[1] **Vector autoregression (VAR)** is an econometric model used to capture the evolution and the interdependencies between multiple time series, generalizing the univariate AR models. All the variables in a VAR are treated symmetrically by including for each variable an equation explaining its evolution based on its own lags and the lags of all the other variables in the model. Based on this feature, 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”)

[2] Carlos Robalo Marques, 1998, “Modelos Dinâmicos, Raízes Unitárias e Cointegração”.

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. 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. The unemployment rate and total employment are included to clutch 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. The reason we leave out such variables is the fact that, throughout the period covered by this study, the instruments and the role of monetary policy in Portugal have been neither stable nor clear. 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.

2.2 Different specifications for oil price shocks

In part due to the volatile behaviour of oil prices, linear oil price specifications are no longer appropriate if we want to study the true effects of oil price shocks. Hooker (1996) 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 a paper by Hamilton (1996a), we will define three non-linear proxy variables for oil price shocks. The first is the evolution of the annual changes of world oil prices and is calculated as:

$$\Delta oil_t = \ln(oil_t) - \ln(oil_{t-1}),$$

where oil_t is the oil price in period *t*.

Then we specify a variable that considers only price increases. The rationale for this specification relies on the observed asymmetry in the way the main macroeconomic variables react to oil price changes:

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

Next 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 price increases that simply correct price volatility. This way it captures 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 defined as annual growth rates, we shall calculate:

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

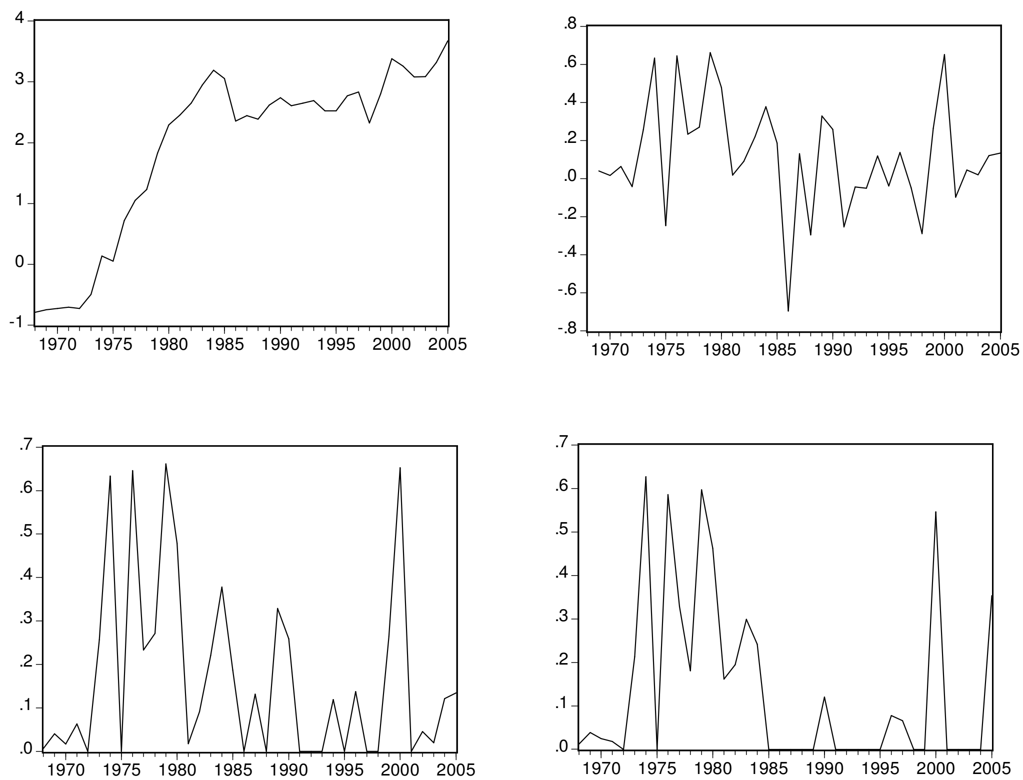

Fig. 1 – Alternative measures of oil price shocks. The first figure represents the logged oil price series in levels. The second one represents the oil price changes (first differences) (Δoil). The third figure represents the positive oil price changes (Δoil+). The last figure depicts the NOPI specification of oil prices.

3. Stability of the oil price-macroeconomy relationship

In this section we want to test whether the nature of the oil price-macroeconomy relationship changed for the Portuguese case when we assume a linear specification for oil prices. If this is 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.

We follow the methodology presented by Hamilton (1983) 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 (note that this is a linear specification). Any lag length choice can be subject to some kind of criticism. On a theoretical ground, our choice seems to be balanced.

Several possible breakpoints could be tested. As an illustration, let us mention that Hooker (1996a) supports the existence of a breakpoint in 1973 and Rotemberg and Woodford (1996) found a breakpoint in 1980, both for the American economy.

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 (Saudi Arabia drastically reduced oil prices around this period) and several authors point to the mid-1980s as the rupture point in the way economic agents react to oil prices. 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 5% significance level.[1]

This conclusion has two implications for the remainder of our work. First, we found more appropriate and insightful to estimate models for 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

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[1] In fact, this is also the point that maximizes the F-statistic for a break in regime for our sample. The test produced a value of 6,29, which for the F-distribution with 28 and 6 degrees of freedom corresponds to a p-value of 0,00.

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.

4. Magnitude and significance of oil price shocks effects

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. [1]

To analyze the effects of the different specifications of oil price changes, we first studied the coefficients obtained in the VAR estimation and then we performed the Granger Causality Tests. The VAR estimation produced the coefficients represented in *Table 1*.

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 of these effects increases as we pass from Δoil, to Δoil+ and from Δoil+ to *NOPI*. These variables act like a filter that transforms variations in the price of oil into shocks and, as a consequence, 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 two specifications of oil price variation in the first sub sample.

To analyse the statistical causality link between oil price shocks and the other variables, we will perform bivariate Granger Causality Tests. The Granger (1969) approach assesses whether past information on one variable helps in the prediction of the outcome of some other variable, given past information on the latter. It is important to note that the statement "x Granger causes y" does not imply that y is the effect or the result of x. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

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[1] Final Prediction Error , Schwarz information criterion and Hannan-Quinn information criterion

Table 1

	First Sub Sample (1968 - 1985)				
	INF	**GDP**	**UNR**	**Temp**	**IPI**
Δoil	**0,088***	-0,044	**0,009***	-0,012	-0,063
Δoil+	**0,077***	-0,026	0,007	-0,004	-0,026
NOPI	**0,101****	0,053	**0,008****	-0,013	-0,082

	Second Sub Sample (1986 - 2005)				
	INF	**GDP**	**UNR**	**Temp**	**IPI**
Δoil	**0,032****	-0,002	0,006	-0,009	-0,004
Δoil+	**0,050****	-0,004	0,007	-0,003	0,040
NOPI	0,035	-0,013	-0,007	0,018	**0,088****

	Entire Sample (1968 - 2005)				
	INF	**GDP**	**UNR**	**Temp**	**IPI**
Δoil	**0,055****	-0,026	0,006	-0,001	-0,017
Δoil+	**0,063****	-0,039	0,008	0,002	-0,019
NOPI	**0,076****	-0,061	0,007	0,006	-0,036

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 asterisks denote signifance at the 10%/5% level.

We present the *p-values* associated with this test in *Table 2*.[1]

Analysing the results for the whole sample we found Granger causality between two specifications of oil price and Total Employment, and between *NOPI* and the growth rate of GDP. It is important to refer that with this method we do not obtain significant causality over inflation.

Using only the first sub sample we found causality between all specifications of oil price and the rate of unemployment, which disappears in the second sub sample.
In the sub sample 1986-2005 we found Granger Causality only between Δoil and three variables: GDP growth rate, inflation and total employment growth rate.

[1] It is important to denote that larger *p-values* provide more support to reject the Granger Causality

Table 2

	First Sub Sample (1968 - 1985)				
	INF	**GDP**	**UNR**	**Temp**	**IPI**
Δoil	0,924	0,300	**0,096**	0,972	0,763
Δoil+	0,675	0,447	**0,035**	0,986	0,732
NOPI	0,613	0,504	**0,054**	0,966	0,836
	Second Sub Sample (1986 - 2005)				
	INF	**GDP**	**UNR**	**Temp**	**IPI**
Δoil	**0,060**	**0,067**	0,952	**0,010**	0,570
Δoil+	0,378	0,815	0,915	0,573	0,540
NOPI	0,662	0,501	0,874	0,538	0,572
	Entire Sample (1968 - 2005)				
	INF	**GDP**	**UNR**	**Temp**	**IPI**
Δoil	0,324	0,131	0,167	**0,025**	0,784
Δoil+	0,103	0,323	0,236	**0,035**	0,413
NOPI	0,155	**0,085**	0,263	0,109	0,326

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.

We do not observe strong evidence of causality neither for the two sub samples nor for the entire sample, with the exception of the effect over the unemployment rate in the first sub sample.

5. Impulse Responses analysis

In this section, we examine the response of each variable of the VAR equations to a shock in oil price proxy variables. The method that we use is the impulse response functions. 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. Therefore it is very useful for the analysis of the adjustment of each macroeconomic variable to the three different types of shocks in oil price.

In the Annex 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.

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 change significantly the results.

For Inflation, we obtain always the *desired* effect: 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+ 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 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 all oil price specifications. The adjustment is longer in the first sub sample. It is also visible that the 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 1986-2005.

6. Conclusions

In this paper we present a study on the effects of changes in oil price for the Portuguese economy. We use the VAR methodology, which is commonly employed for this purpose. We use different specifications for oil price variations and estimate the effects for different time intervals, namely before and after 1985.

With the VAR coefficient analysis we found a significant effect of variations on the price of oil over inflation and, only for the first time interval, over the unemployment rate. The magnitude of the coefficients becomes smaller in the second sub sample (1986-2005) if compared to the first sub sample (1968-1985).

The Granger Causality method allowed us to draw one significant conclusion: the existence of real causality between oil prices and the unemployment rate in the first sub 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 found that oil prices induce persistent effects on unemployment and inflation rates, and not so persistent effects on total employment and GDP. The response of industrial production is somehow ambiguous. This approach provided further support for an empirical fact referred in the literature: generally, after 1985 the effects of oil price shocks become more tenuous and the adjustment becomes faster.

We found some evidence for the change of the relationship between all economic variables for Portugal and oil price shocks from the 1980s on. The significance of the effects, the magnitudes and the velocity of the adjustments are smaller for the second time interval.

Appendix - Data Sources

In this appendix we present the data series we have used, together with the correspondent source. All series are annual and for Portugal:

GDP: Real GDP in chained 1995 euros; source: *Banco de Portugal*
INF: Inflation rate, annual Consumer Price Index variation; source: *Banco de Portugal*
UNR: Unemployment rate; source: *Banco de Portugal*
Temp: Total Employment; source: *Banco de Portugal*
IPI: Average of monthly Industrial Production Index; source: *Instituto Nacional de Estatística (Portuguese National Bureau of Statistics)*
OIL: Weighted average of crude oil prices; source: *Financial Trend Forecaster*
ER: Real Exchange Rate Index; source: *International Monetary Fund*

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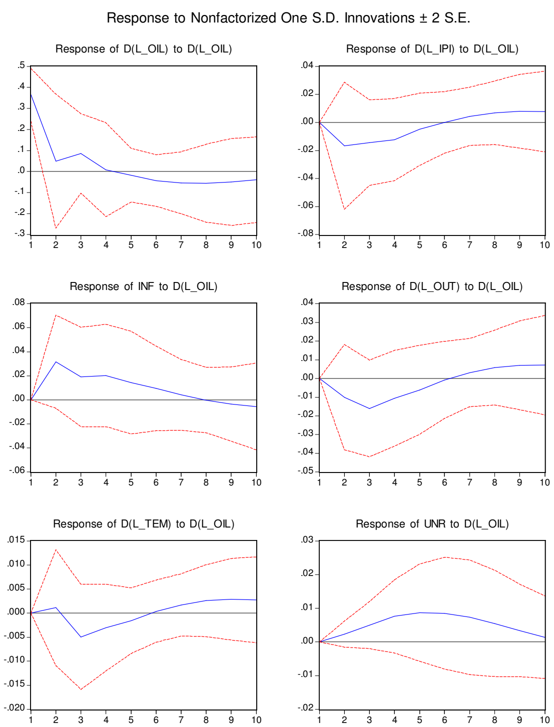
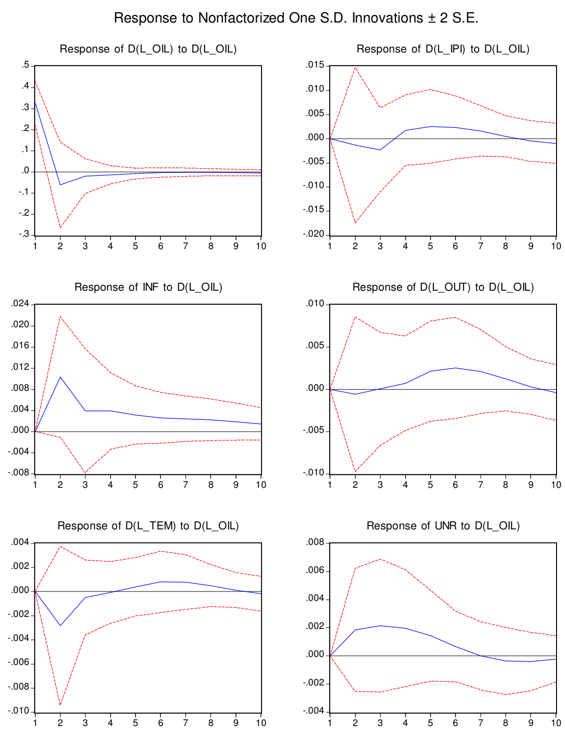
Fig. 2 – Impulse response functions for a one standard deviation innovation in Δoil

First Sub Sample (1968-1985)



Second Sub Sample (1986-2005)



Entire Sample (1968-2005)

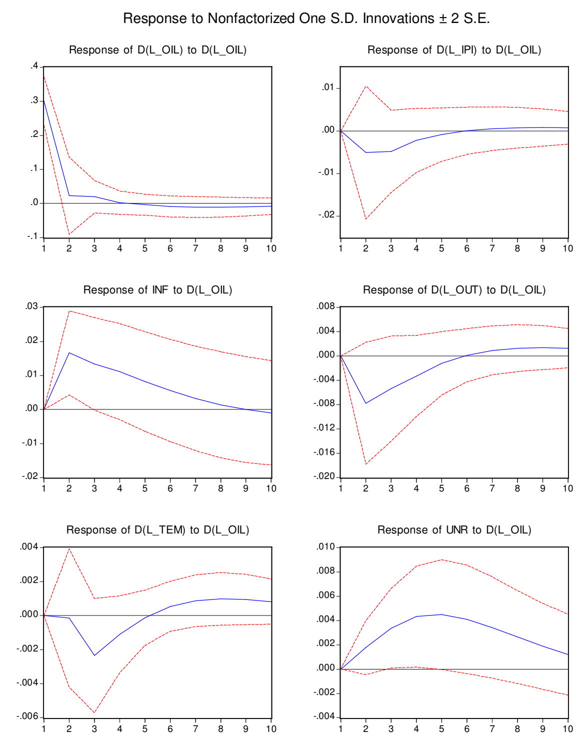
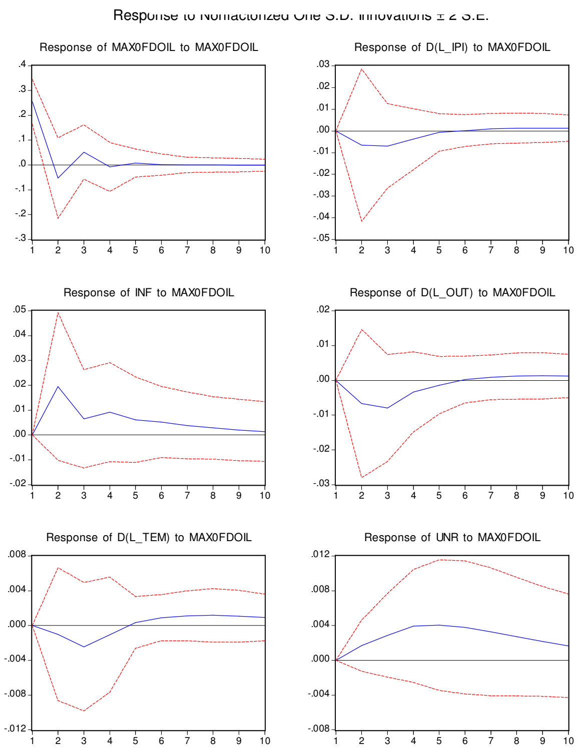
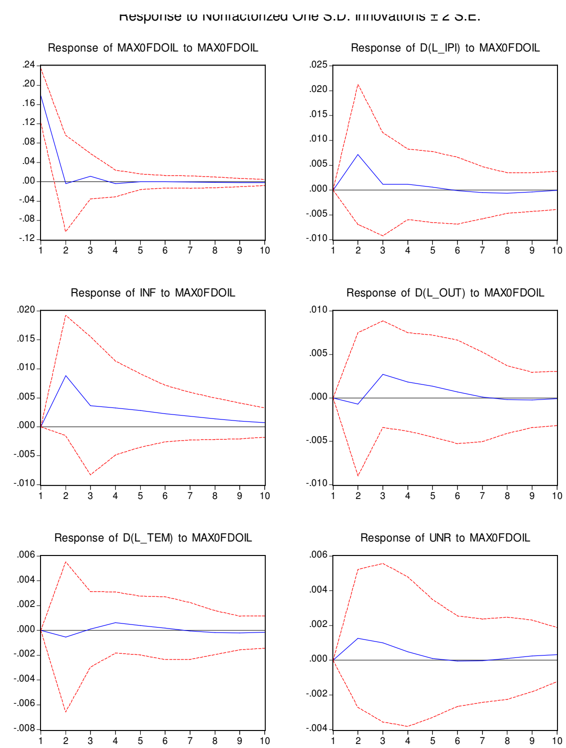


Fig. 3 – Impulse response functions for a one standard deviation innovation in Δoil+

First Sub Sample (1968-1985)



Second Sub Sample (1986-2005)



Entire Sample (1968-2005)

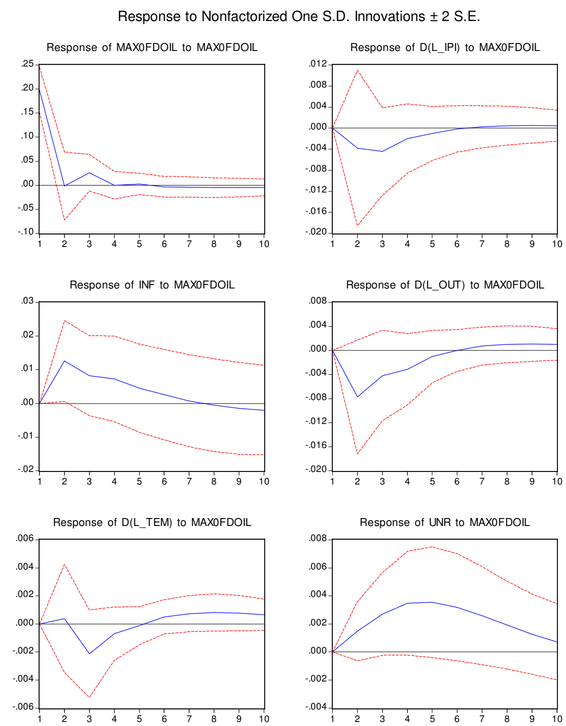
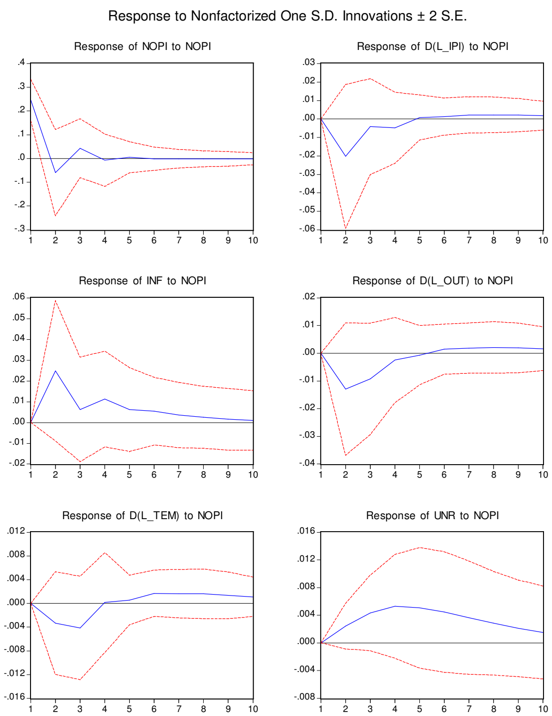
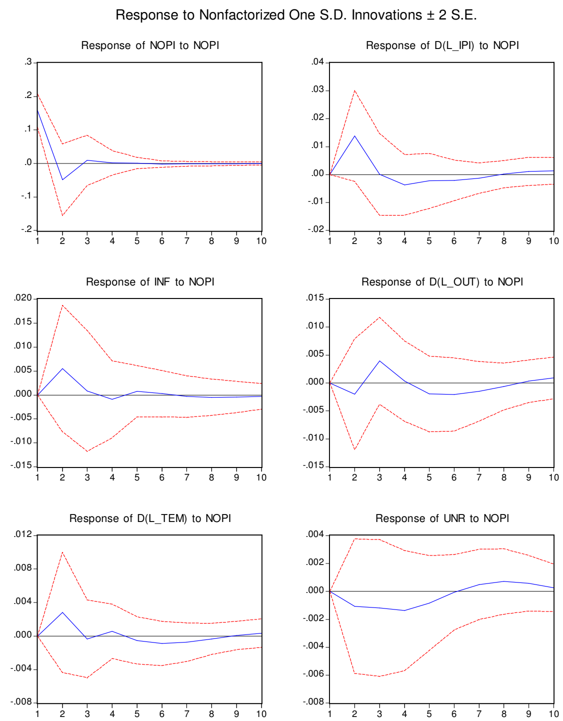


Fig. 4 – Impulse response functions for a one standard deviation innovation in *NOPI*

First Sub Sample (1968-1985)



Second Sub Sample (1986-2005)



Entire Sample (1968-2005)