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THE ECONOMIC EFFECTS OF OIL PRICES SHOCKS ON THE UK MANUFACTURING AND SERVICES SECTOR*

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Abstract

This paper investigates the relationship between changes in oil prices and the UK's manufacturing and services sector performances. Only a few studies have been conducted at the sector level: the goal of this paper is to contribute in that direction. After presenting review of existing literature about oil effects on the UK's sectors of manufacturing and services, an econometric analysis is carried out. In a more detailed analysis, three sets of vector autoregressive (VAR) models are employed using linear and non-linear oil price specifications among several key macroeconomic variables. From the linear oil price specification VAR model, the impulse response function reveals that oil price movement causes positive effects in both the output of manufacturing and services sectors. The variance decomposition shows that oil prices are quite important as a cause of the variance of the UK services sector output, while they do not have such a large role in the variance of the UK's manufacturing output. From the asymmetric specification, it has been found that positive oil price changes determine a consistent contraction in manufacturing output, while the services sector does not seem to be affected by increases. Alternatively, negative oil price changes, show that manufacturing output does not increase so much despite a decrease in oil prices. The services sector is much more affected by oil prices decreases than increases. Finally considering the net oil price increase (NOPI) specification, it has been found that the manufacturing sector is much more affected by oil price changes than the services sector.

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Keywords: Oil shock, VAR, impulse response function, variance decomposition.

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Introduction

Oil prices have increased sharply over the past few years. Being prone to sharp fluctuations, oil prices have repeatedly been blamed for causing undesirable macroeconomic impacts. The UK economy is a distinct case not only because it was a net oil exporter (until the end of 2005) but oil price changes are crucial in explaining economic performances of that economy as a whole.

The growth of both UK manufacturing and services sectors is regarded as a crucial element in the future of the UK not only because of the sectors' contribution to external financing but also because of their importance as sources of both employment and wealth.

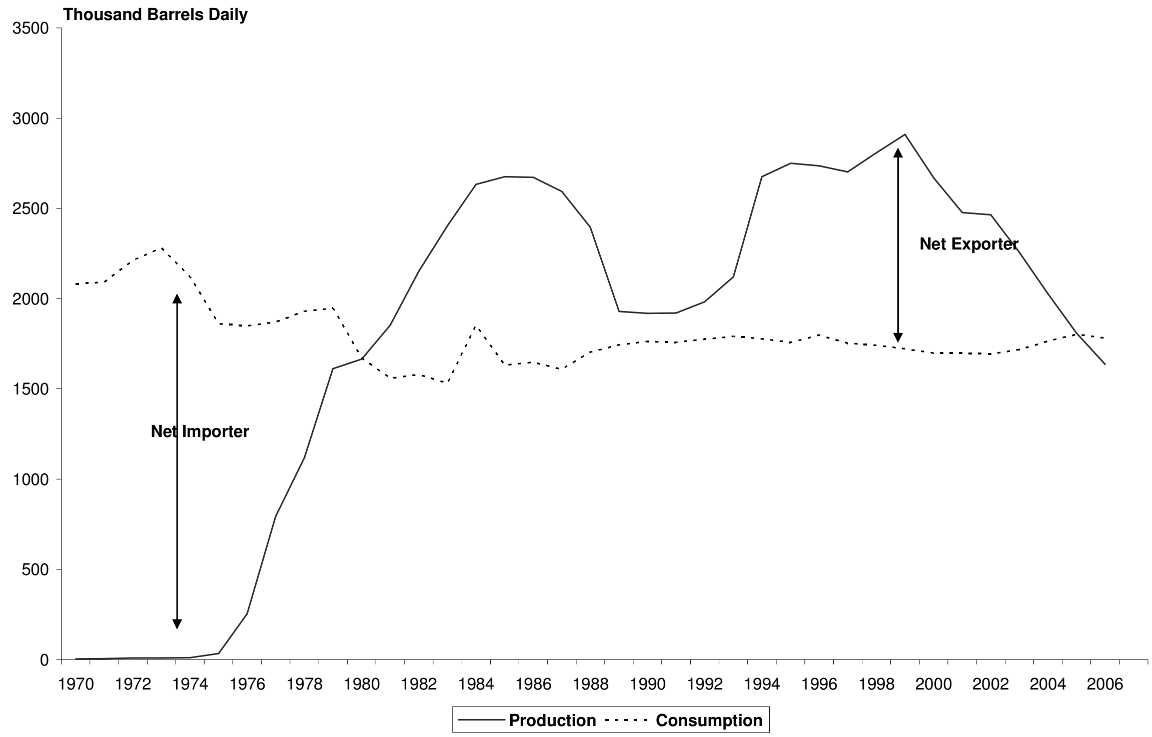
Relative to the importance of these sectors in the UK economy, this paper aims to discover if the volatility of the UK manufacturing and services output is due to fluctuations in oil prices. It also employs the VAR analysis in order to forecast the effects of an oil price shock on the variables used in this analysis, how long such effects last, and when maximum repercussions can be expected. The results of this study can add something new to the dearth of existing economic literature about effects of oil prices on different economic sectors.

This study is organised as follows. In paragraph 1, the relationship between UK manufacturing and services sectors on one hand and oil price shocks is given. In paragraph 2, the theoretical framework used in this study is discussed to assess the relationship above mentioned. Paragraph 3 contains the econometric analysis' results. A concluding paragraph summarizes the major findings of the present work.

1. The relationship between Oil Prices and UK manufacturing and services sectors: a review of literature

The discovery of oil in the North Sea represented large increases in the national wealth of the UK, at the same time this discovery contributed to the rapid growth of the UK energy sector. Together with the great increase in energy prices during the 70's, the development of oil resources allowed this country to move from the position of being a net importer to being a net exporter of oil (see Figure 1).

Figure 1 - UK Oil Production and Consumption, 1970-2006



Source: British Petroleum (2007).

As we can see, at the end of 2005, total UK oil production was 1.81 million barrels per day, although from 1999 there was a decline in production due to several reasons mainly the maturity of the UK's oil fields and the growth of costs due to the shifting of production to remote areas in the North Sea.

During the first half of the 70's the UK economy was mainly based on the manufacturing sector, much of the discussion following the energy boom in the UK did not focus on these new-found riches, but on the probable adverse effects of the booming energy sector on that sector. Although the boom increased national wealth and improved the balance of payments, there was a fear that the manufacturing sector would decline in a prolonged and costly adjustment process (Hutchison, 1994): as a result it was predicted that manufacturing would contract, and adversely affect whole regions and major segments of the work force. A natural resource based export boom with these adverse effects has been named the *Dutch Disease*[1]. Several studies have been realised in order to explain the *Dutch Disease* phenomenon. For example Corden and Neary (1982), consider a model characterised by three sectors, where there are two tradable goods sectors – a primary commodity (the "booming" energy sector) and manufacturing – and a third sector producing non-traded goods. Corden and Neary (1982) argued that in a full employment context a boom in the natural resource sector would draw resources out of manufacturing and contract traditional industry through both a resource movement effect[2] and a spending effect[3]. The natural resource boom transmits its effect to the manufacturing sector through higher real wages by appreciating the real exchange rate, making production in traditional industry less competitive. Assuming normal growth in the economy's productive capacity, the general prediction is that an energy boom will lead to a smaller manufacturing sector than would otherwise be the case.

Can the *Dutch Disease* be considered negatively if it reduces the manufacturing output? In order to answer this question Forsyth and Kay (1980) argued that the reduction of the manufacturing output in the UK, as a consequence of Oil Revenues from the North Sea, and the consequent growth of imported manufactured goods could not be considered an undesirable effect of North Sea Oil rather "*…the only means by which the British economy can benefit from North Sea Oil*": in other words the *Dutch Disease* that affected the UK economy after discovering oil and making the UK self sufficient did not have negative effects on the economy as a whole. In order to have an immediate understanding of that change we can have a look at the following tables. The first one shows the

[1] The term *Dutch Disease* was originally used to point out the adverse effects on Dutch manufacturing of the natural gas discoveries of the 60's, which led to the appreciation of the Dutch real exchange rate and the following high prices for Dutch manufactured products which became less competitive with respect to other similar products manufactured abroad. On the other hand, it might be said that the *Dutch Disease* in the Netherlands was not the adverse effects on manufacturing of real appreciation but rather the use of Booming Sector revenues for social service levels which were not sustainable, but which were difficult to reduce (Ellman, 1981; Corden, 1984).

[2] The resource movement effect comes from the fact that the boom in the energy sector determines a growth in the marginal products of the factors employed in that sector, by so doing it draws resources out of other sectors; at the same time it determines various adjustments in the economy as a whole, among these adjustments one of the most important is that relative to the real exchange rate.

[3] The spending effect is related to the kind of resources the energy sector uses: in other words if the energy sector uses resources that cannot be drawn from other sectors of the domestic economy, then the resource movement effect is small and the impact of the boom will come through the spending effect (Corden and Neary, 1982). In fact the boom will lead to higher real income which leads to extra spending on services, the strong demand of services will lead to raising their prices and further adjustments for other economic variables.

structure of the UK economy before the discovery of oil in Britain in 1976: as we can see from the table 1, Britain used its surplus obtained from selling both manufactures and services to buy primary products, fundamentally it exported manufactures and services to buy primary products.

Table 1 - The structure of the UK Economy, 1976 (UK £ bn, 1980 prices)

	Production	Exports	Imports	Consumption
		(by value added)		
Primary Production	9.0	-1.2	+8.0	15.8
Manufacturing	48.9	-24.9	+22	46.0
Construction and Housing	22.5	-0.2	+0.3	22.6
Distribution and Services	88.1	-18.8	+16.9	86.2
Public Administration	13.5	-	-	13.5
Total	181.9	-45.1	+47.3	184.1

Source: Forsyth and Kay (1981).

The post-oil economy (table 2) reveals a fall in the manufacturing production as well as a growth in the consumption of manufactured products compared to the figures in table 1. On the other hand both the production of services and primary goods have increased with respect to the 1976 figures.

Table 2 - The UK Post-oil Economy, 1980 (UK £ bn, 1980 prices)

	Production	Exports	Imports	Consumption
Primary Production	19.0	(-2.3)		16.7
Manufacturing	46.1	-22.2	+24.6	48.5
Construction and Housing	23.7	-0.2	+0.3	23.8
Distribution and Services	88.9	-16.9	+18.9	90.9
Public Administration	14.2	-	-	14.2
Total	191.9	(+2.2)		194.1

Source: Forsyth and Kay (1981).

Table 3 compares the pre-oil economy with the post-oil economy in percentage terms. As we can see the output grows much faster in the primary sector and less in either construction and public administration. The distribution and services sector grows less quickly: on the other hand the manufacturing sector declines both in absolute and relative terms.

Table 3 - Production Changes by Sector (UK £ bn, 1980 prices)

	Pre-oil	Post-oil	Variation Rate (%)
Primary Production	9.0	19.0	+111.1
Manufacturing	48.9	46.1	-5.7
Construction and Housing	22.5	23.7	+5.5
Distribution and Services	88.1	88.9	+0.9
Public Administration	13.5	14.2	+5.5
Total	181.9	191.9	+5.5

Source: Forsyth and Kay (1981).

In order to explain the trend in manufacturing from 1976 to 1980, Forsyth and Kay (1981) argued that North Sea Oil certainly contributed to the growth of the UK economy during that period, but this growth was concentrated in a single sector, that is the primary sector. More significantly Forsyth and Kay (1981) argued that oil revenues could not be converted directly into the housing and distribution services. All that happened during that period was an exchange between oil and trade goods – fundamentally manufactures – and the use of revenue achieved by these sectors in other non-tradable sectors of the economy.

Recognising that a strong squeeze on the UK tradable goods (that is manufacturing goods) during the 70's was due not only to a monetary contraction (which had as a main consequence the appreciation of the sterling) carried out by the Bank of England in order to reduce inflation, Corden (1981) also pointed out that North Sea Oil revenues played a strong role on the poor performance of the UK manufacturing sector. In particular he tried to highlight both the short-run and the medium-run effects of North Sea Oil. The short-run effects were negative on tradable because Oil revenues contributed to an appreciation of the UK Sterling, on the other hand this appreciation determined a growth in household consumption: the main consequence was an increasing demand for importing manufactured goods whose prices were more competitive with respect to the domestic manufacturing production. Considering the medium-run, Corden (1981) argued that North Sea Oil revenues had a structural effect on the economy: that is, resources and investment were moved from the tradable to the non-tradable sector. In other words in the middle period there was a decline of the manufacturing sector.

As we have seen previously, the UK manufacturing sector seemed to be negatively hit by the *Dutch Disease*[4]. An interesting question about this result was raised by Corden (1984): who investigated whether policies should be implemented to reduce the adverse impact on the *Lagging Sector* (as he called the UK manufacturing sector). Pointing out that it was necessary to protect the *Lagging Sector*, the best method would have been a policy aimed at subsidizing output of that sector:

[4] Also Eastwood and Venables (1982) argued that North Sea oil significantly contributed to the decline in the UK manufacturing output.

financial resources could have been found by increasing taxes on the *Booming sector* (that is the Energy sector)[5].

One further question was raised by Bean (1988) about the relation between real wages and the discovery of oil in the UK. He began from the consideration that in the UK, wages were characterised by a high level of real inertia: in other words the quantity of goods which could be bought by these wages did not change over time. Starting from this consideration, he found that it was more probable to have a recession in an economy where the share of tradable goods employment was high because of the effects of the discovery of oil on the real exchange rate, on the other hand a rigid-wage structure was another element which contributed negatively to the economy. Because this was the situation of the UK in 1970s, the adverse effect of oil on the UK economy was explained. By using several models, Bean (1988) found that the probability of avoiding a prolonged recession and unemployment due to oil discovery in the UK was based on the way of employing revenues from oil: that is, he suggested using those revenues by cutting labour taxes. So fewer taxes on labour costs should have been offset by increasing taxes on oil revenues. By so doing it would have been possible to cut labour costs and avoid a growth in the rate of unemployment.

Bjørnland (1998) tried to analyse the economic effects of North Sea oil both in the UK and Norway on the manufacturing sectors in both countries[6]. Considering only the UK result, the author found that in the long term, the *Dutch Disease* affected the UK manufacturing sector: but this effect was not so great and the fall of the manufacturing output could have been also due to factors apart from North Sea Oil.

[5] By so doing, Corden (1984) argued that these kinds of policies would have sterilised the impact of the Booming sector on the manufacturing sector rather than using two classical protectionist approaches to protect manufacturing. That is the Exchange Rate Protection (defined as a " *…policy of avoiding real appreciation and hence protecting tradeables at the expense of non-tradeables*") and the ordinary protection Policy (defined as a policy conducted "*…by raising tariffs or tightening import quotas*"). Avoiding conducting these two policies is a way of eliminating the possibility that the *Lagging* sector would be hit by real appreciation of the national currency.

[6] Bjørnland (1998) used an econometric model based on a structural VAR, where four variables were considered; that is manufacturing production, oil and gas extractions, real oil prices and the inflation rate. Estimation of this VAR model was sufficient to identify several structural shocks (that is energy booms, real oil price shocks, aggregate demand shocks and aggregate supply shocks). Using these shocks, it was possible to evaluate effects of each of them on the manufacturing sector in both the UK and Norway.

It is worth pointing out that although in Norway the manufacturing output did not fall as a consequence of *Dutch Disease*, in the UK this happened because the government did not give subsidies to the manufacturing sector as the government did in Norway. As an increasing number of UK manufacturing firms were in trouble, the UK government preferred to use revenues from North Sea Oil both in social security and to reduce external debts.

Until now the discovery of North Sea oil discovery has been responsible for the manufacturing decline in the UK. It is worth pointing out that several authors have tried to explain this decline using two main reasons. The first one argues that the decline is related to the monetary aspect, the second one can be attributed to the fall of the share of the manufacturing sector in the economy to energy price hikes.

In the case of the UK, for example, Buiter and Miller (1981) as well as Hutchison (1994) argued that the decline in UK manufactures and the appreciation of sterling was mainly due to a monetary tightening which characterized the Thatcher government during the ‘70s. Buiter et al. (1983) argued further that the adoption in the UK of targets for the public sector borrowing requirement starting with the 1980 budget produced a extremely restrictive fiscal policy, which also reduced the aggregate demand for manufactures. Bean (1987) also found that oil price shocks could have had an unclear effect on the UK manufacturing sector. Also Corden and Neary (1982) argued that, in the long run, when all domestic factors are in principle, mobile, the effect of an energy boom on the manufacturing sector is not completely clear.

On the other hand, Rose et al. (1984) argued that North Sea Oil contributed strongly to the decline of the UK manufacturing industry. They argued that the main reason was found in the exchange rate between the US dollar and UK sterling. In fact between 1979 and 1981 there was a strong appreciation of British sterling against the US dollar: this appreciation affected the competitiveness of manufactured products in the UK and by so doing it hit negatively the manufacturing industry. On the other hand the increased size of the service sector during that time was due only to the reduction of the work force inside manufacturing. In real terms, within the service sector, only banking and finance recorded a weak growth in the labour force. Despite this, the manufacturing industry was rarely in surplus in order to give a positive contribution to the UK's international trading position.. After that period, invisible earnings of the UK service sector was the only way to pay for the food and raw materials bill for goods bought abroad. From the second half of the 70's there was a considerable deterioration in Britain's trade performance, culminating in the large account deficits of the late 1980s. Muellbauer et al. (1990) argued that the deterioration of the non-oil trade account in the UK balance of payments during the second half of the 80's was simply the counterpart of discovering oil and gas, that is the conventional *Dutch Disease* explanation in which a real exchange rate appreciation crowded out non-oil tradables to keep the overall current account roughly in balance. Since manufacturing was the non-oil component most sensitive to relative price movements, it was in this sector that the effects were most striking.

Another question relative to oil prices shocks was based on the intensity ratio of using energy inside a sector. Industries that were less subject to competitive pressures, or where demand conditions were cyclically strong at the time of the energy price shocks, were more likely to be able to pass on higher input costs in the form of higher charges. For instance, UK utilities – by far the most energy intensive sector according table 4 – were characterized by a number of high profile price increases in the past, while the manufacturing sector, being more exposed to global competition, was largely hit by such pricing power. All sectors were exposed to these price increases, but the size of the impact depended on a number of diverse factors such as their energy intensity ratio and dependence upon discretionary consumer expenditure. The impact of high oil prices upon the various sectors could therefore have been difficult to predict, and it does not necessarily follow that those industries with the highest energy intensity ratios- outlined for the various UK sectors in the following table – would have been the most adversely affected.

Table 4 - UK sector energy intensity ratios, 2002

Sector	% Value
Agriculture	5.7
Manufacturing excluding refining	2.0
Chemicals	3.4
Non-metallic minerals	4.5

Basic metals	5.4
Machinery and equipment	1.6
Transport equipment	1.1
Utilities	22.9
Construction	0.8
Services	1.7
Distribution	2.5
Transport	7.0
Communication	1.4
Other	0.8
Total	2.3

Notes. Values indicate the ratio of spending on crude oil, gas and on refined petroleum as a % of total output.
Source: Oxford Economic Forecasting (2007), using 2003 Blue Book Supply/Use tables.

2. Theoretical framework

This paragraph has two main objectives. Firstly, a short overview of VAR analysis is given in order to describe the tools used to assess empirically the effects of oil prices shocks on the UK manufacturing and services sectors. Secondly, the estimation methods and the data are described to evaluate economic effects of oil price shocks.

2.1 The VAR methodology

When we have several time series, we need to take into account the interdependence between them. One way of doing this is to estimate a simultaneous equations model with lags on all the variables: such a model is usually called a dynamic simultaneous equations model. However, this formulation involves two steps: first, we have to classify the variables into two categories, endogenous and exogenous, and second, we have to impose some constraints on the parameters to achieve identification (Maddala, 2001). Both these steps involve many arbitrary decisions, Sims (1980) suggests as an alternative, the vector autoregression (VAR) approach. The VAR model is easy to estimate because we can use the Ordinary Least Squares (OLS) method.

Informally, a VAR consists of regressing each variable from a set of variables (e.g. $[x_1, x_2, x_3]'$) on its own lagged values together with the lagged values of the other variables. Basically, the VAR approach is designed to avoid endogeneity problems. At the same time in this study, impulse response function and variance decomposition were utilized to asses the relationship between oil price shocks and the UK manufacturing and services activity. Impulse response functions allows us to examine the dynamic effects of oil price shocks on economic activity. It traces, over time, the expected responses of current and future values of each of the variables to a shock in one of the VAR equations. Through matrix manipulation it is possible to analyse the effect of a shock on all the variables of the system, thereby generating the impulse response function. However, in order to isolate the effect of a "pure" shock to a given variable it is necessary to orthogonalize the error terms[7]. On the other hand, a variance decomposition provides the variance of forecast errors in a given variable to its own shocks and those of the other variables in the VAR. It allows us to assess the relative importance of oil price shocks on the volatility of the other variables[8].

There are, however, two aspects of formulating VAR models which are not solved quite as easily. These issues concern the choice of variables to be included into the VAR system and the choice of the lag length p: both questions can be answered empirically. These choices are made keeping in mind that the model should be as parsimonious as possible (Enders, 2004).

Most commonly one bases the lag length decision on one or more so-called information criteria. It is well known from standard regression theory, that every additional variable increases the fit of any regression. Hence it is not surprising, that a VAR(p+1) will fit the data better than a VAR(p). However, one should be aware that this improved fit comes at the cost of $p \times k$ additional parameters (where p is the number of lags and k is the number of regressors): information criteria are measures which formalise this trade-off. As information criteria provide a trade-off between the "goodness of fit" and the number of parameters estimated, we need a measure of the "goodness of fit". The two most common information criteria are the Schwarz Bayesian Criterion (SBC) and the Akaike Information Criterion (AIC):

$$\text{AIC} = \ln|\Sigma| + \frac{2pk^2}{T-p}$$

[7] It needs to be emphasised that the ordering of the variables in the VAR can have a substantial impact on the orthogonalised impulse response functions: in other words one would obtain different impulse response functions (Becker and Osborne, 2005).

[8] For a full technical account of VAR methods see for example Enders (2004), Hamilton (1994), and Greene (2003).

$$\mathrm{SC} = \ln\left|\Sigma\right| + \frac{pk^2 \ln(T-p)}{T-p}$$

Where p is the number of lag, k is the number of regressors and T is the sample size. In practice Σ is unknown and will be replaced by the variance covariance matrix of the estimated residuals $\hat{\Sigma}$. Different text books will have slightly different versions of these criteria but they all have in common the fact that smaller values of the measure indicated improved models. In practice these measures are calculated for a range of different lag lengths p and calculate the associated AIC and SBC. As pointed out by Enders (2004), these values can be negative. The lag length which results in the smallest SBC or AIC is then seen as the optimal lag length. These criteria may not always agree on the optimal lag length to be chosen and the SBC tends to select a more parsimonious model as compared to AIC (Enders, 2004)[9].

The individual coefficients of a VAR(p) are very difficult to interpret. One problem is that there are many coefficients involved. For example, for a relatively simple system for quarterly data, if we consider the order $p = 3$, and say $k = 3$ variables to be included, in this case each of the VAR equations involves 11 coefficients plus an intercept, making $12 \times 3 = 36$ coefficients in the total system of 3 equations. These difficulties in interpretation of the VAR often mean that little or no attempt is made to interpret the coefficients themselves. Rather, economists often use so-called impulse response functions to aid interpretation and to consider the economic implication of a particular VAR.

2.2 Application of the VAR methodology to the UK's sectors of manufacturing and services

To address the question of the impact of the price of oil on economic variables, a complete model is probably the most appropriate. Such a model can be extremely tightly structured, and simulation models are typically of this type. Alternatively, much less can be incorporated into the maintained hypothesis, particularly when, as Sims (1980) notes, specifying a model often involves

[9] Also Greene (2003) points out that the SBC will lean toward a simpler model in terms of optimal lag.

imposing many quite arbitrary restrictions. Such a warning seems especially indicative in the present context, when the channels of influence of the price of oil may be many and varied. The innovation-accounting techniques pioneered by Sims (1980), can therefore be said to be potentially more informative than standard macroeconomic modelling might be.

Following the above considerations, a *pth-order* vector autoregression, denoted VAR(p) is considered:

$$y_t = c + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + ... + \Phi_p y_{t-p} + \varepsilon_t \qquad (1)$$

with ε_t ~$\mathrm{N}(0,\Omega)$.

The equation (1) can be re-written in more compacted form as:

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

where c denotes a $(n \times 1)$ vector of constants and Φ_i a $(n \times n)$ matrix of autoregressive coefficients for j=1, 2,…,p. On the other hand, the $(n \times 1)$ vector ε_t is a vector generalization of a white noise process.

For estimation purposes about the UK manufacturing sector, the following set of quarterly variables are used[10]: Index Manufacturing Production (IMP), Real Effective Exchange Rate (REER), Real Oil Price (ROP), Real Manufacturing Wage Sector (RWM), Rate of Inflation (INF), Short-term Interest Rate (SR), and Long-term Interest Rates (LR).

For the UK service sector, the following variables are used: Index Services Production (ISP), Real Effective Exchange Rate (REER), Real Oil Price (ROP), Real Services Sector Wage (RWS), Rate of Inflation (INF), Short-term Interest Rate (SR), and Long-term Interest Rates (LR).

The sample used in the present analysis runs from 1970:1 to 2005:4 for a total of T = 140 available observations. By so doing we use a quarterly seven-variable VAR for each sector considered[11].

[10] It was decided to use these variables, quite similar to those used in Jimenez and Rodriguez (2004) as it can be considered quite descriptive of the economic environment where manufacturing and services sectors operate.
[11] More details about variables used in that sample can be found in the Appendix.

More in depth, oil prices are defined in real terms by dividing the price of an internationally traded variety of crude (UK Brent) in US dollars by the UK Producer Price Index. The remaining variables are included to capture some of the most important transmission channels through which oil prices may affect economic activity indirectly. Those channels include effects of oil prices on inflation and exchange rates, which then induce change in real economic activity. The VAR model also incorporates a monetary sector (by means of short-and long-term interest rates rather than money supply indicators which can react to inflationary pressures). A labour market channel (by using a real wages index) is allowed for, in light of the role it may play with regard to aggregate demand or supply.

The decision to include the above variables have been based on several macroeconomic considerations. First of all, IMP have been enclosed because the main target of this work is to analyse how the manufacturing sector behaves towards oil price shocks. Usually, this variable gives an immediate overview of the production level. At the same time, because this sector is usually energy intensive[12], its performances could be affected by fluctuations in oil prices.

ISP have been enclosed for the same reasons above[13]. We need to point out that some sub-sectors of this sector were not energy intensive so they could have been hit by fluctuations in oil prices less than in the manufacturing sector. However, the importance of this sector on the UK economy is so great that we cannot avoid projecting some effects of oil prices over that sector.

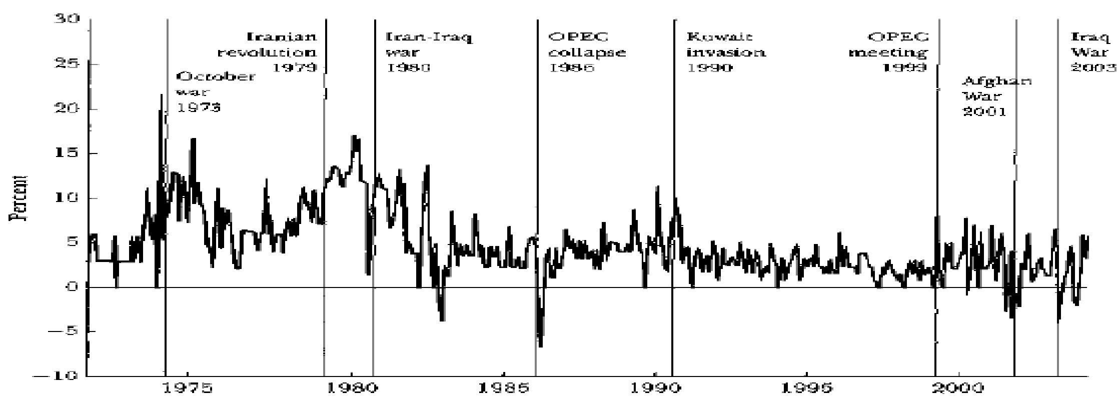
REER has been included because, as we have seen in the first paragraph, fluctuations of oil prices have often led to an appreciation of the UK Sterling: in that perspective, appreciation of the national currency may reduce the competitiveness of both UK manufactured goods and services on the international markets: so it was decided to enclose the REER in the VAR models given the high level of openness of the UK economy.

[12] See for example table 4 in the paragraph 1 of this work: that table shows that several sub-sectors of the UK manufacturing sector are more energy-intensive than others.

[13] Also inside the UK services some sub-sectors are energy-intensive: for example transport is the most energy-intensive (see table 4).

RWM has been included because it is affected by fluctuations of the oil prices in terms of real consumption power, with workers asking for a salary increase as a consequence of an oil price shock as pointed out, among others, by Hunt et al. (2002) "*…workers respond asymmetrically to oil-price increases and oil-price declines, pushing for higher wages to resist the declines in their real consumption power that result from positive oil price shocks, but not resisting the increases in real consumption power that result from oil price declines*". On the other hand, a further reason to use RWM is that probably manufacturing output increases or reduces as a consequence of a change in oil prices, manufacturing wages may change as a consequence of a higher or lower demand for labour from firms. Finally It was decided to use the rate of inflation (INF) because an increase in the real oil prices *"…is a major cause of inflation … both in the United States and abroad*" (Darby, 1982), as we can see from the following figure.

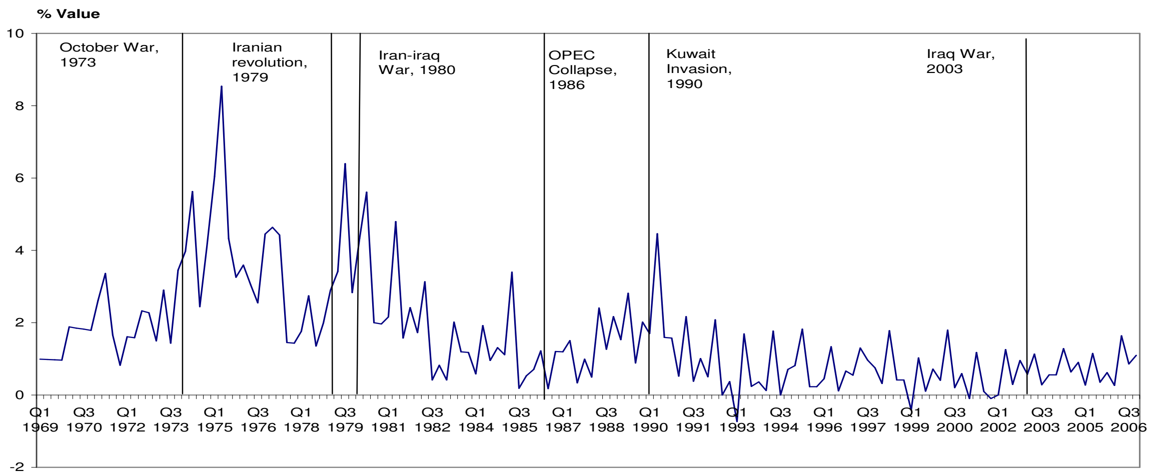
Figure 2 - Inflation rate and oil price shocks in the USA, 1971-2004



Source: Barsky and Kilian (2004).

On the other hand, a similar relationship between inflation and oil price shocks can be found in the case of the UK (Figure 3).

Figure 3 - Inflation rate and oil price shocks in the UK, 1970:1 – 2006:4



Source: Elaboration using OECD main data indicators (see Appendix).

Let us consider the data set used for this work. First of all, it is necessary to point out that many economic processes exhibit some form of seasonality. In fact, the seasonal variation of a series may account for the preponderance of its total variance. So forecasts that ignore important seasonal patterns will have a high variance. The data used in this work comes from the OECD website and they have already been seasonally adjusted[14].

Before studying the effects of oil shocks on the UK manufacturing and service sectors, the study investigates the stochastic properties of the series considered in the model by analysing their order of integration on the basis of a unit root test: specifically the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979, 1981) and the Phillip-Perron test (Phillips and Perron, 1988) have been used. The ADF Unit Root test is based on the following three regression forms:

a) Without constant and terms: $\Delta_t = \delta Y_{t-1} + u_t$

b) With constant: $\Delta Y_t = \alpha + \delta Y_{t-1} + u_t$

c) With constant and trend: $AY_t = \alpha + \beta T + \delta Y_{t-1} + u_t$

So we go to test the following hypothesis:

[14] It is possible to find this information on the following website address www.oecd.org/dataoecd/48/0/2073999.pdf

$$H_0 : \delta = 0 \text{ (Unit Root)}$$

$$H_1 : \delta \neq 0$$

The hypotheses is evaluated using the conventional t-ratio for δ :

$$t_\delta = \frac{\hat{\delta}}{se(\hat{\delta})}$$

where $\hat{\delta}$ is the estimate of δ, and $se(\hat{\delta})$ is the coefficient standard error. Dickey and Fuller (1979) show that under the null hypothesis of a unit root, the statistic does not follow the conventional Student's t-distribution.Then the decision rule is the following:

If t_δ > *ADF critical value*, ==> not reject null hypothesis (i.e. unit root exists).

If t_δ < *ADF critical value*, ==> reject null hypothesis (i.e. unit root does not exist).

At the same time, it was decided to perform a Phillip-Perron (PP) Test to supplement the ADF test. The PP test is similar to the ADF test but Phillips and Perron (1988) incorporate an automatic correction to the DF procedure to allow for an autocorrelated residual.

The VAR model in equation (1) is estimated for both a linear specification and the two leading non-linear approaches in the literature. The latter are the following: (i) asymmetric specification (Mork, 1989), in which increases and decreases in the oil prices are considered as separate variables; (ii) Net Oil Prices Specification (Hamilton, 1996) , where the relevant oil price variables is defined to be the net amount by which these prices in quarter t exceed the maximum value reached in the previous four quarters.

The asymmetric specification (Mork, 1989) distinguishes between the positive variation in oil prices, o_t^+, and its negative rate of change, o_t^-, which are defined as follows

$$a_t^+ = o_t \text{ if } o_t > 0 \text{ or } 0 \text{ otherwise}$$

$$a_t^- = o_t \text{ if } o_t < 0 \text{ or } 0 \text{ otherwise}$$

where o_t is the rate of change in the real oil price.

Hamilton (1996) proposed a different non-linear transformation, by using as an explanatory variable what he calls the Net Oil Price Increase (NOPI). This variable is defined as the amount by which oil prices in quarter t, exceed the maximum value over the previous four quarters, and 0 otherwise: that is:

$$NOPI_t = \max\{0, p_t - \max[p_{t-1}, p_{t-2}, p_{t-3,} p_{t-4}]\}$$

As pointed out by Hamilton (1994), the VAR system can be transformed into its vector MA(∞) representation in order to analyse the system's response to a real oil price shock, that is:

$$y_t = \mu + \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \ldots \quad (2)$$

Where the above equation can be re-written as:

$$y_t = \mu + \sum_{i=0}^{\infty} \psi_i \varepsilon_{t-i}$$

In order to assess the impact of shocks on endogenous variables, orthogonalised impulse response functions are examined. This requires choosing an ordering for the variables in the system, which is assumed to be the following for the baseline model: IPM (IPS)[15], ROP, INF, SR, LR, RWM (RWS)[16], and REER[17]. This ordering assumes that the first variables, have an immediate impact on the following variables. In other words, we know from the economic theory that an expansion (contraction) of the industrial production can increase (reduce) the demand of oil which can influence the rate of inflation and so on the remaining economic variables.

3. Empirical results

In this paragraph, the preliminary tests and data transformations are presented. Moreover, the empirical results obtained from the estimated VAR models using linear and non-linear oil price specifications are discussed. The impulse response functions and variance decompositions obtained from the estimated VAR models are also expounded.

[15] That is, IPS instead of IPM is used when considering the UK Services Sector.
[16] That is, RWS instead of RWM is used when considering UK Services Sector.
[17] The two standard error bands around the impulse responses are based on Lutkepohl (1990).

3.1 Presentation of results

Econometric analysis using time-series data requires it to be stationary. To have stationary representations of the VAR models, each variable was tested for unit root specification using both the augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. The following table 5 provides the unit root regression results in levels and first differences of the variables entered in the models and the corresponding critical value to reject the null hypothesis of the presence of a unit root. For example, if we consider the model with constant, all the variables in levels are observed to be nonstationary at the 5% level. These non-stationary variables were transformed by taking their first differences in order to exhibit stationarity, indicating that the mean, variance and covariance of the time series are independent of time.

Table 5 - Results of Unit-Root tests

		Model with constant		
Variables	ADF Statistic (in levels)	ADF Statistic (in first difference form)	PP Statistic (in levels)	PP statistic(in first difference form)
IPM	-1.54	-3.56**	-1.99	-20.9***
IPS	6.31	-3.44**	4.36	-9.77***
REER	-2.17	-9.82***	-1.97	-9.84***
INF	-2.37	-7.03***	-7.04***	-26.67***
ROP	-3.03**	-11.86***	-2.99*	-11.85***
RWM	-0.04	-13.47***	0.128	-13.62***
RWS	0.19	-6.17***	-0.40	-19.63***
SR	-2.31	-9.17***	-1.91	-9.10***
LR	-0.59	-9.94***	-0.73	-9.95***
		Model with constant and trend		
Variables	ADF Statistic (in levels)	ADF Statistic (in first difference form)	PP Statistic (in levels)	PP statistic (in first difference form)
IPM	-2.40	-3.54**	-4.25***	-20.84***
IPS	0.87	-6.38***	0.24	-11.01***
REER	-2.92	-9.78***	-2.66	-9.80***
INF	-3.81**	-7.01***	-8.82***	-26.57***
ROP	-3.03	-11.81***	-2.98	-11.80***
RWM	-2.61	-9.64***	-2.29	-13.58***
RWS	-2.64	-6.17***	-5.11***	-19.56***
SR	-3.06	-9.17***	-2.55	-9.10***
LR	-2.76	-9.99***	-2.76	-9.95***
		Model without constant		
Variables	ADF Statistic (in levels)	ADF Statistic (in first difference form)	PP Statistic (in levels)	PP statistic(in first difference form)
IPM	0.67	-3.47***	0.69	-20.53***
IPS	15.91	-1.78*	10.69	-5.06***
REER	0.27	-9.83***	0.36	-9.83***
INF	-1.65*	-7.05***	-3.93***	-26.75***
ROP	-0.84	-11.9***	-0.84	-11.89***
RWM	4.34	-11.78***	5.01	-11.96***
RWS	4.09	-2.03**	4.25	-14.59***
SR	-0.95	-9.20***	-0.84	-9.13***

LR	-0.77	-9.94***	-0.77	-9.96***

Notes. The rejection of the null hypothesis at 10%,5%, and 1% critical levels are denoted with */**/***.
Critical levels used for both the ADF and PP tests are the following:

- in the model with constant and trend: -4.05 (1%), -3.45 (5%) and -3.15 (10%).
- in the model with constant: -3.50 (1%), -2.89 (5%) and –2.58 (10%).
- in the model without constant: -2.59 (1%), -1.94 (5%) and –1.62 (10%).

After the above tests, I used both the Akaike Information Criterion (AIC) and the Schwarz Bayesian Information Criterion (SBC) to assess the performance of the VAR model with varying lag length specifications. The optimal lag length is the one that minimizes either the AIC and SBC.

In the manufacturing sector case (see the following table) the tests above-mentioned gave very different suggestions: here I have chosen to adopt the parsimonious model with lag length 1 as suggested by the SBC.

Table 6 - Identifying the Optimal Lag Length – Manufacturing sector VAR

	Manufacturing Sector					
	Linear Oil price Specification		Asymmetric Specification		NOPI	
Var order	AIC	SBC	AIC	SBC	AIC	SBC
1	6.70	7.93*	22.64	24.75*	6.42	7.65*
2	6.09	8.39	22.42	26.41	5.85	8.15
3	5.74	9.12	22.24	28.11	5.39	8.77
4	5.41	9.87	21.84	29.59	4.91	9.37
5	5.42	10.95	21.64	31.26	4.87	10.40
6	5.15	11.76	19.9	31.41	4.34	10.95
7	4.77	12.46	17.8	31.25	3.98	11.67
8	4.57	13.32	14.95*	30.22	3.85	12.61
9	4.20	14.03	-	-	3.41	13.24
10	3.94	14.84	-	-	3.15	14.05
11	3.73	15.71	-	-	2.69	14.67
12	2.81*	15.87	-	-	2.33*	15.38

Notes. *Optimal lag length.

Also in the case of the service sector (see the following table) I decided to adopt the parsimonious model (lag length 1).

Table 7 - Identifying the Optimal lag Length – Services sector VAR

	Services Sector					
	Linear Oil price Specification		Asymmetric Specification		NOPI	
Var order	AIC	SBC	AIC	SBC	AIC	SBC
1	4.82	5.98*	18.91	20.55*	4.69	5.86*
2	4.79	6.94	18.5	21.69	4.58	6.77
3	4.23	7.46	18.3	23.16	3.94	7.18
4	3.44	7.73	17.9	24.53	3.28	7.57
5	3.39	8.74	18.01	26.55	3.01	8.36
6	3.27	9.69	17.32	27.92	2.66	9.08
7	2.94	10.44	15.9	28.7	2.62	10.11
8	2.76	11.34	10.88*	26.14	2.4	10.99
9	2.61	12.30	-	-	2.11	11.79
10	2.73	13.53	-	-	2.17	12.97
11	2.66	14.58	-	-	2.14	14.07

12	1.97*	15.03	-	-	1.85*	14.91

Notes.*Optimal lag length.

In conclusion, the tests above indicate that for all specifications and both manufacturing and services sector VAR models with a lag length equal to one, are used.

3.2 Impulse response function

An impulse response function (IRF) was computed from the coefficients of vector regression using an orthogonalized set of residuals. IRF traces the effect of one standard deviation shock to one of the innovations on current and future values of each of the endogenous variables in the system. The particular effects of oil price increases and decreases were also given importance in connection to other variables.

As we can see from the following Figure 4 (panel a), the IRF generated from the VAR model using linear specification of oil price shocks to the manufacturing sector , during the first period, leads to an increase of the IPM[18], after the second period the effect is negative before recovering between the third and the fourth period. At the end of the fifth period the fluctuations tend to die out.

In contrast, pressures of the oil shock on real wages in manufacturing[19] tend to have an initial negative effect until the end of the second period and the magnitude is quite severe in the first period. After the third period the effects tend to die out.

Shifting to the Services sector, Figure 4 (panel b) shows a positive effect of real oil price shocks on the Services output[20] until the fourth quarter: in other words oil price shocks have a stimulative effect on the Services sector. On the other hand the effect of an oil price shock on the real wages in services[21] is negative until the end of the second period. From the third to the fourth period the effect is positive before disappearing in the long-term.

[18] See “Response of DIPM to DROP” in the cited panel (a), where the letter D stands for First Difference of the variable considered in log form.
[19] See “Response of DRWM to DROP” in the panel (a).
[20] See “Response of DIPS to DROP” in the panel (b).
[21] See “Response of DRWS to DROP” in the panel (b).

Figure 4 - Multiple graphs of IRF's using Linear Oil Price Specification

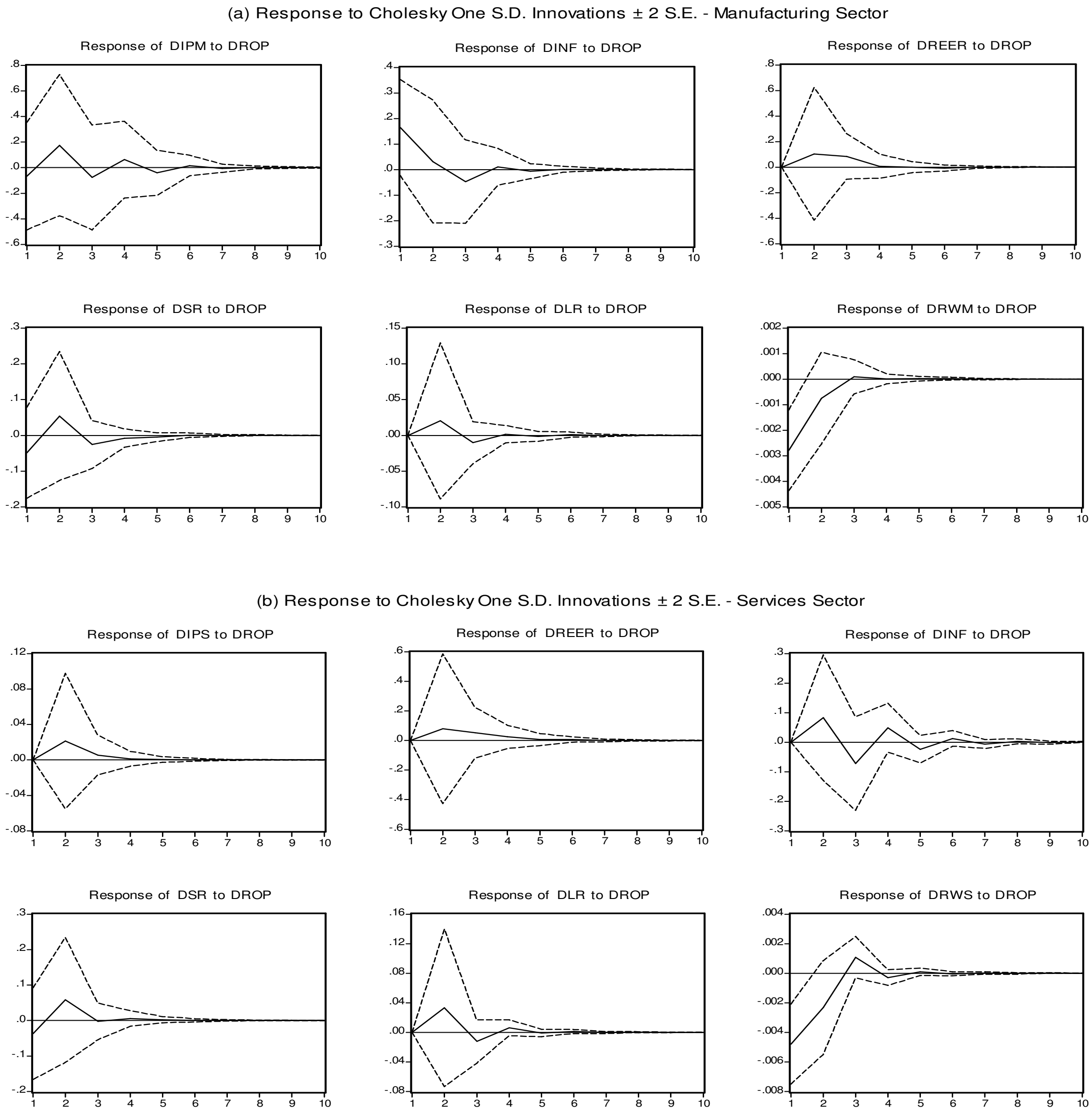


Figure 5 show the IRF's obtained from the VAR model applying the first of the two non-linear oil price specifications defined in the previous paragraph 2, that is the positive oil price increases. As we can see from Figure 5 (panel a), increases in oil prices have a negative effect on the manufacturing sector until the first half of the third period, after that the effect is positive for just one period, before being newly negative until about the end of the fifth period[22]. After that the effect of increases tends to disappear gradually. It must be noted that increases have an immediate

[22] See "Response to DIPM to increases" in the panel (a).

negative effect on the real manufacturing wage variable[23]. In fact the effect is negative until the first half of the second period. After that the effect is positive until the end of the third period before being newly negative and then it dies out. Keane and Prasad (1996) studying the effects of oil prices on wages for the USA economy, found that "*…oil price increases cause real wages to decline…in virtually all sectors*". Given that the UK and the USA are both advanced economies, although with their differences, we can presume that what Keane and Prasad (1996) found for the USA case, is also valid also for the UK economy: in other words we can suppose the same trend for the wages of the UK manufacturing sector as the empirical results in the following figure show relatively to the relation between Increases and RWS.

Moving to services (Figure 5 panel b), increases in oil prices do not seem to affect the services sector greatly. Until the first half of the third period, the effect on the Services output is wholly positive, after that period we have either negative and positive effects but the magnitude of the fluctuations is very low and disappear gradually[24].

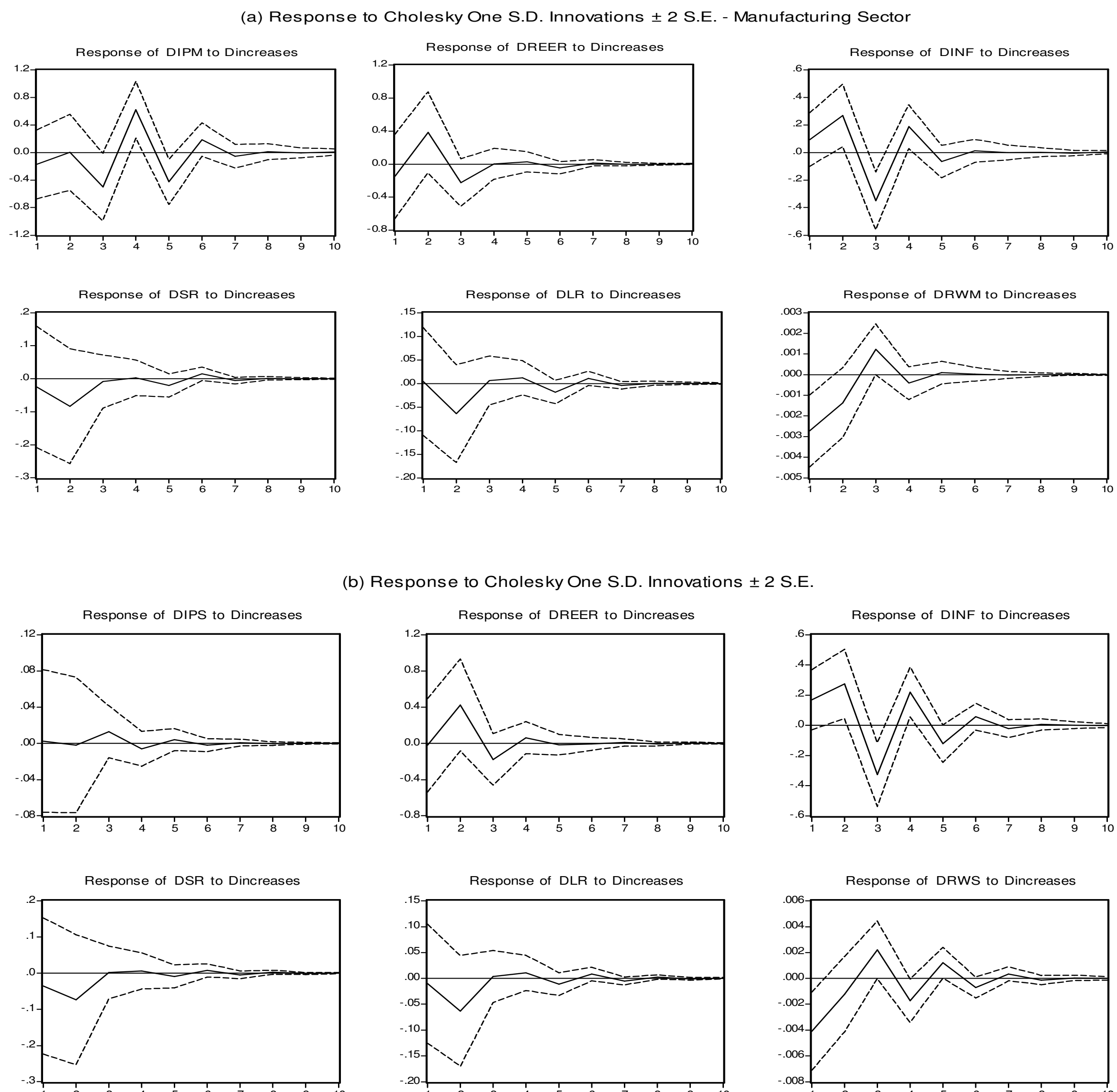
On the other hand the effect of Increases on RWS is negative until the second half of the second period, after that it is positive until the first half of the third period. After that period the effect on RWS is either negative and positive before dying out in seventh period[25].

Until now, we have seen that the effects of increases in oil prices do not have such an important effect on both manufacturing and services output, so can we compare these results with other similar studies? If we consider Bjørnland (2000), we note she argues that "*An oil price increase will typically lead to a transfer of income from the oil importing countries to the oil exporting countries…the increase in income in the oil exporting countries will increase demand from the oil importing countries*": because the UK is an exporting country, as we have seen in the first paragraph, we can suppose that the UK manufacturing and services output do not rise so much as a consequence of oil price increases because households and firms will buy both goods and services

[23] See "Response of DRWM to decreases" in the panel (a).
[24] See "Response of DIPS to Increases" in the panel (b).
[25] See "Response of DRWS to Increases" in the panel (b).

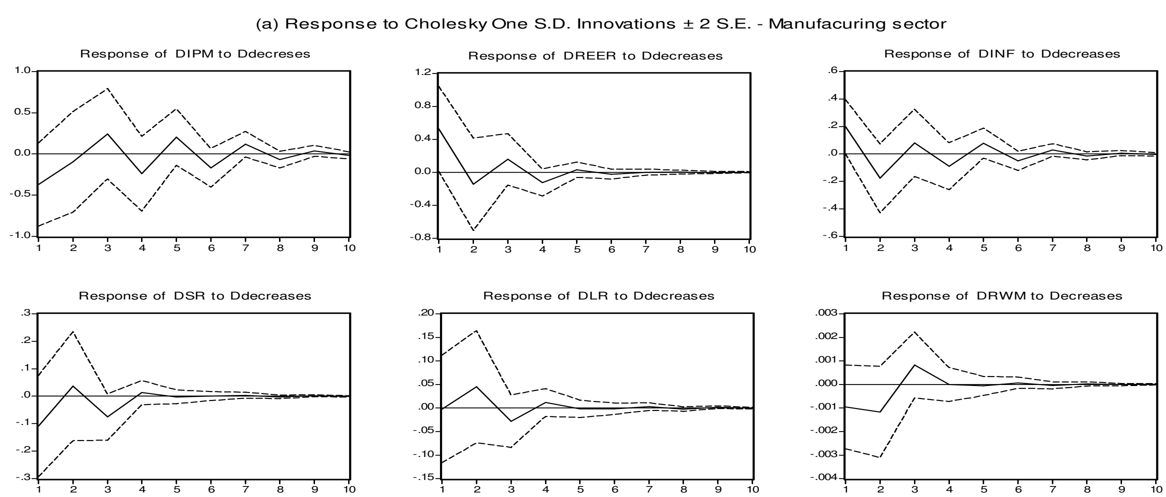
produced domestically and abroad. In other words, we can suppose that the UK domestic demand of goods and services fuelled by oil prices revenue, is partly satisfied by the domestic production, it will be the foreign production to cover the remaining part of the UK's domestic demand. This explanation seems to be consistent with Bjørnland (2000) noted above and what has been found empirically.

Figure 5 - Multiple graphs of IRF's using Non Linear Oil Price Specification Increases (Asymmetric Specification)

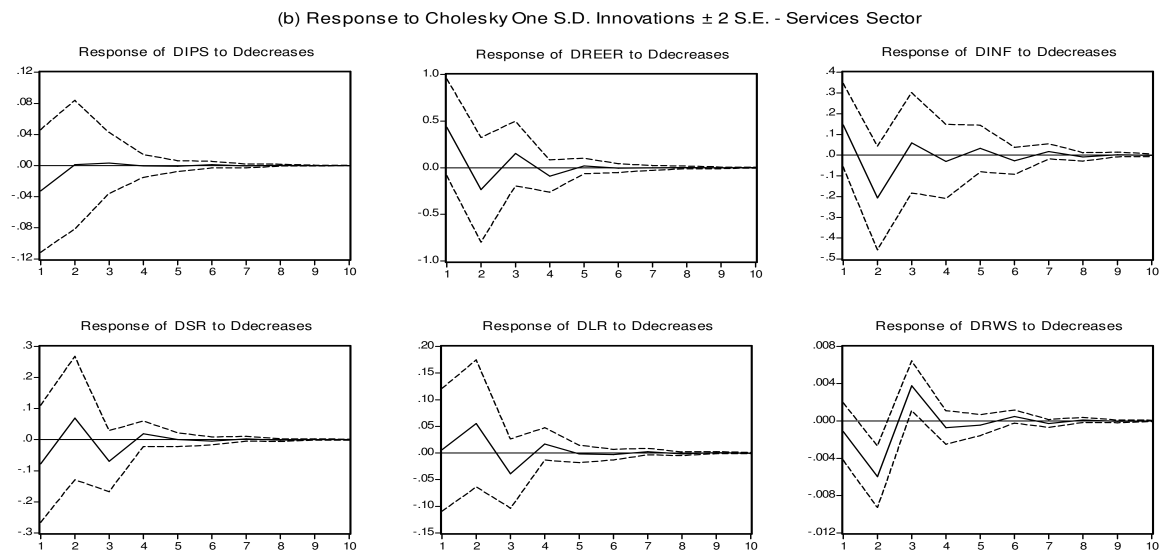


Considering negative oil price changes (decreases), we can see from the Figure 6 (panel a) that decreases have a negative effect on the manufacturing output[26], until the first half of the second period. After that we can see both positive and negative effects with a decreasing magnitude: these fluctuations tend to disappear from the ninth period. It is worth pointing that decreases tend to shock the manufacturing output for many more periods than oil price shocks and increases in the previous graphs. If we consider the effects of decreases on RWM (Figure 6 panel b), we can see a negative effect until the end of the second period, until the effect is positive until the end of the third period before dying out in the long term. Moving to the services sector, decreases have a negative effect on the services output only until the end of the first period: after that, decreases seem to have no effect on the IPS[27]. On the other hand, wages of the services are affected negatively by decreases[28] until almost the end of the second period. From the end of the second period until the end of the third period, decreases have a positive effect on the wages of the services. After that, the effect is negative until the end of the fifth period before starting to gradually die out in the long term.

Figure 6 - Multiple graphs of IRF's using Non Linear Oil Price Specification Decreases (Asymmetric Specification)



[26] See "Response of DIPM to Decreases".
[27] See "Response of DIPS to Decreases".
[28] See "Response of DRWS to Decreases".



If we consider the NOPI specification (the amount by which oil prices in quarter t exceed the maximum value over the previous quarters; and 0 otherwise) applied to the UK manufacturing sector (panel a of the Figure 7), we can see that manufacturing output increases immediately after an oil price shock but the magnitude is quite small. However, such an increase does not last long: it becomes negative from the second period until the third period. After that there is a positive effect which reaches a peak in the fourth period before starting to assume a negative trend in the second half of the fourth period. After that there are positive and negative effects with quite an important magnitude; between the seventh and eighth period the effects start to gradually die out. From that trend, we can say that the NOPI specification does well have has a not well defined effect on IMP: in other words a clear response does not emerge to the IMP during the period considered,

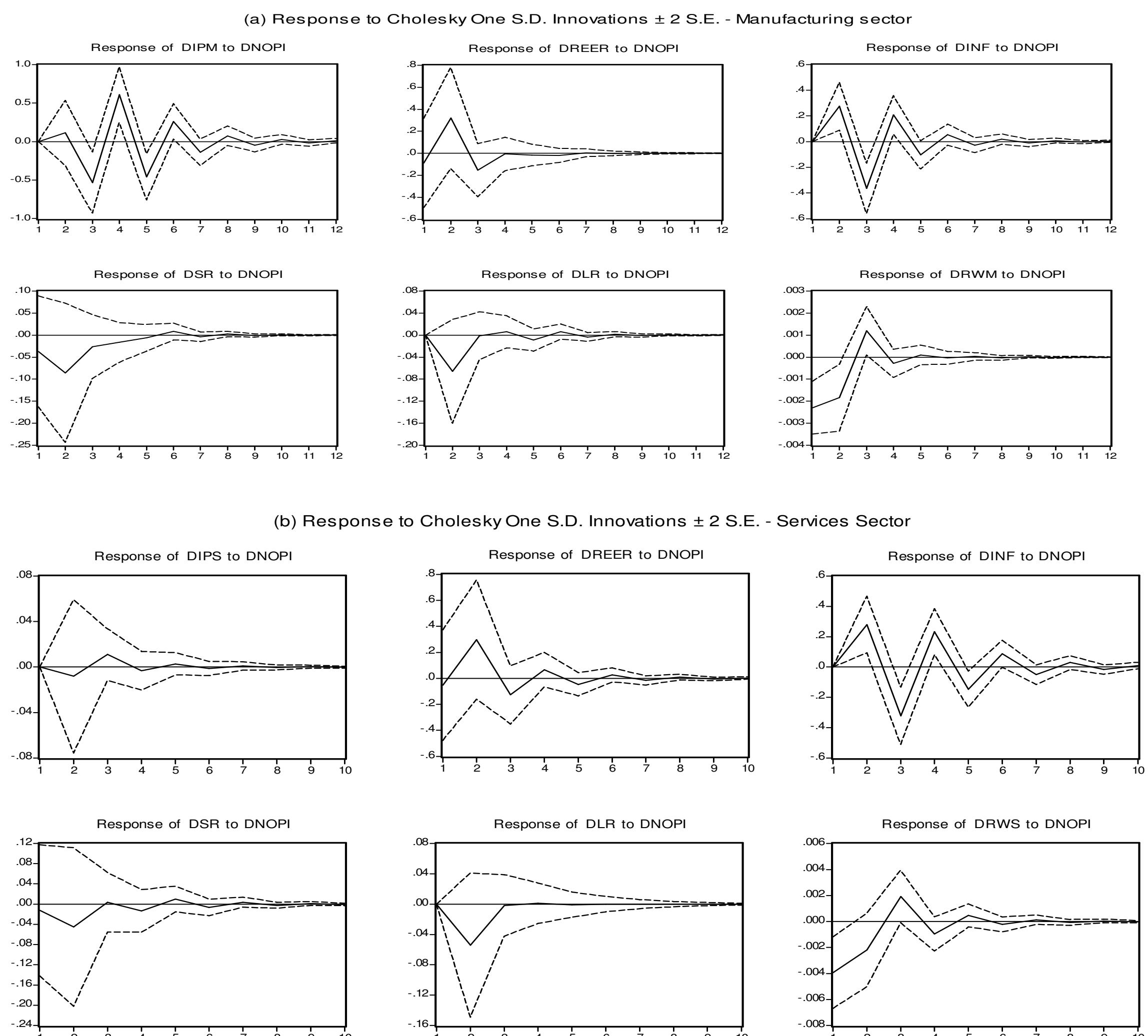
The effects of NOPI on the real wages manufacturing[29] is quite severe initially: in fact we can see a steady negative effect on wages until the first half of the second period. From the end of the second period to the end of the third period the effect is positive; after that real wages return gradually to their pre-shock level.

[29] See “Response of DRWM to NOPI” in the panel (a).

Considering the services sector output[30] , it does not seem to be affected by NOPI. The effect is negative with a small magnitude until the first half of the second period, after that it is positive (with a significant magnitude at the beginning of the third period) until the end of the third period: from the fourth period the effects of NOPI start to disappear quite quickly.

Effects of NOPI on services wages[31] seem to be more consistent: as we can see from the following panel b, in the first few periods there is a negative effect in which magnitude is quite pronounced. After that the fall of the service wages is off-set by a short positive growth which is followed by a fall of service wages which ends as we continue with the periods considered.

Figure 7 - Multiple graphs of IRF's using Non Linear Oil Prices Specification (NOPI)



[30] See "Response to DIPS to NOPI" in the panel (b).
[31] See "Response to DRWS to NOPI" in the panel (b).

3.3 Variance decomposition analysis

Variance decomposition represents the VAR system dynamics by giving information about the relative importance of each random to the variable in the model. It shows how much unanticipated change or variation of the variables in the model are explained by different shocks. The following table shows the variance decomposition of the VAR model for the manufacturing sector using different oil price specifications.

As we can see in the following table 8, considering the linear oil price specification, the largest source of variation of the IPM is the variable itself, which accounts for 61.42% of the variation. After that, IPM variation is mainly due to LR (8.12%) and REER (6.96%). ROP accounts for IPM's variation by 5.92%. Is this result consistent with other studies? Among the few studies about the relationship between oil prices and manufacturing output in the UK, Bjørnland (1998) could be considered. In his work it is argued that oil price shocks explain *"…less than 5% of the variance in manufacturing in the UK"*. Therefore it can be said that these present results are consistent to what Bjørnland found. On the other hand in the study of Herrera and Pesavento (2007), the contribution of an oil price shock to the variance of the USA manufacturing is on average 7.11%[32]. Of course there are differences between the USA and the UK manufacturing sectors, but they are both industrialized economies so we can say that present results on the effect of an oil price shock on the UK manufacturing output are quite similar to what Herrera and Pesavento (2007) discovered.

Moving to the asymmetric case, both oil price increases and decreases influence the volatility of the manufacturing output in varying degrees. The contribution of oil price increases on manufacturing output variation is greater than oil price decreases. For manufacturing output, oil price increases account for 11.2% of its variation while decreases in oil price changes contribute to around 1.96%. So in the Asymmetric case, increases are the largest source of IPM variation (other than the variable itself). Barrel and Pommerantz (2004) studying the effects of oil prices on the industrialized

[32] Herrera and Pesavento (2007) consider the USA total manufacturing output during the period 1959-2006 and disaggregate it in several sub-sector voices, that is *Sales* (where 9.15% is the variation due to an oil price shock), *Finished Goods* (6.33%), *Work-in-Process* (5.75%), *Materials and Supply* (7.22%). So an average value of those values for the USA total manufacturing is 7.11% which is the variance of the USA manufacturing due to an oil price shock.

economies, argue that the size of output effect those economies (without distinguishing between sectors) "*… from an increase in oil prices depends on the intensity of oil use in production*". If we go back to the end of the chapter 1 of this work, we can see in table 3 that the average value of energy intensity ratio for the manufacturing sector in the UK is about 2 (with a minimum of 1.1 for transport equipment and a maximum of 4.5 for basic-metals). Then considering the above affirmation of Barrel and Pommerantz and the UK energy ratio for the manufacturing sector we can presume that the variation of output in UK manufacturing due to increases is quite high because the weight of high-ratio energy intensity sub-sectors of the manufacturing sector could be higher with respect to the weight of low-ratio energy intensity sub-sectors of the manufacturing sector. If we consider the NOPI specification, this is not a relevant source of variation for IPM: in fact the volatility of IPM due to oil price fluctuations accounts for 6.06%, ranking as the fifth source of its variation: the main sources of IPM's variation are RWM (7.6%) and SR (7.01%).

Table 8 - Estimated Variance Decomposition on a 10-period horizon: Manufacturing sector

Linear oil price specification							
	IPM	REER	ROP	RWM	INF	SR	LR
IPM	**61.42**	**6.96**	5.92	4.12	5.67	6.19	**8.12**
REER	**8.12**	**59.07**	4.12	7.19	3.19	6.19	**12.12**
ROP	4.12	**6.86**	**78.2**	1.18	4.02	**4.42**	1.2
RWM	**13.11**	5.03	8.4	**34.65**	**21.32**	8.02	7.02
INF	**17.25**	4.20	7.20	**10.23**	**51.02**	6.44	3.66
SR	**8.25**	4.25	6.32	**7.79**	6.69	**62.2**	4.5
LRM	2.01	3.45	**14.25**	9.75	5.20	**23.14**	**42.2**

Non-Linear oil price specification (asymmetric case)								
	IPM	REER	Increases	Decreases	RWM	INF	SR	LR
IPM	**60.12**	5.65	**11.2**	1.96	2.81	5.12	**9.56**	5.96
REER	**11.65**	**32.56**	**21.63**	8.96	5.21	4.23	7.89	11.25
RWM	9.12	5.12	11.36	6.23	**26.23**	**24.5**	**13.12**	4.32
INF	**16.23**	5.12	**14.25**	3.12	6.58	**42.23**	9.76	2.71
SR	5.12	**14.25**	6.36	**7.23**	5.23	6.60	**51.23**	3.96
LR	6.21	8.26	**13.23**	9.23	6.23	6.25	**18.36**	**32.23**

Non-Linear oil price specification (NOPI)							
	IPM	REER	NOPI	RWM	INF	SR	LR
IPM	**62.25**	4.11	6.06	7.6	5.99	**7.01**	**6.98**
REER	7.12	**55.63**	6.25	6.54	5.21	**8.02**	**11.23**
NOPI	2.03	3.02	**77.65**	**3.77**	3.12	**8.60**	1.81
RWM	**16.23**	4.39	5.12	**35.65**	**29.12**	5.23	4.26
INF	**18.23**	3.25	4.80	**12.35**	**51.23**	6.12	4.02
SR	5.23	6.36	4.98	**11.23**	**6.61**	**65.23**	2.98
LR	2.02	4.90	**17.69**	9.71	1.02	**25.65**	**39.01**

Notes. The variables in the first column are being decomposed by the right-hand side variables shown from the top of columns 2 to 7. Values in bold are the three largest sources of variation of each of the left-hand side variables.

Moving to the Services sector (see table 9), linear oil price specification shows that an oil price shock is the third largest source of variation of Services output, contributing to 6.12% of the variation of IPS. The main source of IPS variation, after the variable itself, is SR which accounts for 17.14%. So considering the linear oil price specification, we can say that in the UK services sector, oil price shocks contribute more to the variation in services output than in the manufacturing sector (as we have seen in the previous table). At the same time monetary shocks (defined by the SR and LR) contribute respectively to 17.14% and 4.05% to the variance of the UK services sector output against 6.19% and 8.12% in the manufacturing sector. In other words we can say that monetary shocks contribute sharply to the variation of the Services output, while in the manufacturing sector their contribution is lower.

Considering the asymmetric specification, we can say that increases is the first largest source of variance of the IPS (after the variable itself), on the other hand, decreases do not significantly affect the IPS variation. We can therefore say that increases of oil prices affect the UK services sector variation much more than decreases. We can also see that RWS is one of the most important sources of IPS variation: it accounts for about 9.13%.

Considering the NOPI specification, variation in IPS is influenced by the variable itself (57.03%) together with SR (13.23) and NOPI (7.85). In this case NOPI contributes more than in the linear specification to the variation of the IPS (in fact in this last case, ROP accounts for 6.12 of the total variation of IPS) but less if we consider the contribution to Increases in the IPS variation. At the same time SR and LR have a large impact on the IPS variation (they contribute respectively by about 13.23 and 6.42 to the variation of IPS).

Table 9 - Estimated Variance Decomposition on a 10-period horizon: Services sector

	Linear oil price specification						
	IPS	REER	ROP	RWS	INF	SR	LR
IPS	**61.23**	3.65	**6.12**	3.12	4.69	**17.14**	4.05
REER	11.12	**43.12**	9.65	3.98	7.38	**13.52**	**11.23**
ROP	**11.50**	9.31	**48.23**	7.12	6.65	**11.01**	6.23
RWS	8.12	5.85	**28.32**	**45.35**	**15.36**	4.81	2.20
INF	12.25	4.21	**16.25**	8.78	**39.02**	**15.26**	4.65
SR	7.85	6.26	**11.02**	4.85	**8.14**	**57.32**	4.56
LR	8.06	6.32	**13.22**	8.56	7.23	**26.3**	**30.31**
	Non-Linear oil price specification (asymmetric case)						

	IPS	REER	Increases	Decreases	RWS	INF	SR	LR
IPS	**57.5**	4.30	**11.72**	2.32	**9.13**	6.45	4.71	3.87
REER	8.33	**45.12**	7.82	2.07	4.32	**11.72**	**12.26**	8.36
RWS	11.32	4.22	**13.65**	6.65	**33.67**	12.32	**13.96**	4.21
INF	**7.65**	3.03	2.08	12.2	7.23	**56.36**	**8.55**	2.35
SR	8.23	4.98	5.06	**8.53**	**9.56**	4.98	**54.43**	4.23
LR	6.66	5.63	**16.49**	4.46	**32.32**	**18.79**	11.32	4.33

Non-Linear oil price specification (NOPI)

	IPS	REER	NOPI	RWS	INF	SR	LR
IPS	**57.03**	5.89	**7.85**	4.26	5.32	**13.23**	6.42
REER	10.21	**42.12**	11.23	4.69	7.23	**11.23**	**13.29**
NOPI	4.53	**5.65**	**66.08**	5.23	5.02	**9.23**	4.26
RWS	7.23	8.56	**11.21**	**46.18**	**20.36**	4.23	2.23
INF	**12.23**	4.65	11.23	10.23	**41.23**	**16.23**	4.20
SR	5.56	**9.56**	**15.23**	2.65	5.65	**58.32**	3.03
LR	4.23	5.69	**16.19**	9.32	9.02	**25.23**	**30.32**

Notes. The variables in the first column are being decomposed by the right-hand side variables shown from the top of columns 2 to 7. Values in bold are the three largest sources of variation of each of the left-hand side variables.

Concluding remarks

This work analysed the relationship between oil prices and economic variables referring to the UK manufacturing and services sector. Three sets of VAR models have been used: (1) linear oil prices specifications; (2) asymmetric specification as defined by Mork (1989), and (3) Net specification as defined by Hamilton (1996). Impulse response function and variance decomposition have been obtained from each set of model specifications in order to understand how oil price shocks influence the economic activity of each sector that have been considered and how much such shocks contribute to the variability of the variables in the system.

Several economic variables have been considered: Index Production Manufacturing (IPM), Index Production Services (IPS), Real Wages Manufacturing (RWM), Real Wages Services (RWS), Real Effective Exchange Rate (REER), Short Term Interest Rate (SR), Long term Interest Rate (LR), and Real Oil Prices (ROP).

The results from the linear oil price specification indicates that oil price shocks affect the UK manufacturing sector output much more positively than negatively. Manufacturing wages are affected negatively for a shorter period. Services output is affected positively although wages in services are affected mainly negatively.

Moving to the first of the Non-linear specifications, that is, increases, it was found that manufacturing output is affected much more if we consider increases rather than the simple linear oil price specification. On the other hand, increases affect manufacturing wages negatively for a short period, after that the effect tends to die out. Increases do not seem to have a sharp effect on Services output, on the other hand, increases have a much sharper effect on wages in Services.

Regarding decreases, we can see that manufacturing output is affected both negatively and positively with quite an equivalent magnitude for all periods considered. Manufacturing wages are hit quite negatively in the first few periods after the shocks.

On the other hand, output in services seems to be quite indifferent to decreases, although the same thing does not occur at least initially for wages in services.

The last non linear specification, that is the Net Oil Prices Increase, highlights more consistent effects of oil shocks on the manufacturing rather than on the Services Sector, although the effects on the wages of both sectors are quite similar.

The variance Decomposition estimated from the linear model shows that the oil prices are not the main source of variance of manufacturing output, and this is consistent with other studies (Bjornland 1998).

Moving to the asymmetric specification, it was found that the contribution of oil prices increases on manufacturing variation is greater than oil prices decreases Regarding the services sector, It was found that oil price shocks contribute more to the variance of the UK's services output rather than the in the case of the UK's manufacturing output.

Considering the asymmetric specification, it was found that increases are the first largest source of variance of the UK's services output (after the variable itself).

Finally, Net Oil Prices Increase contribute more than in the linear specification to the variation of the IPS but less if we consider the contribution of the Increases (that is one of the non linear specifications) to the UK's services output variation.

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Appendix

Data sources

The data used in this work came from the OECD Main Economic Indicators database. This database can be easily found by using the ESDS international website (http://www.esds.ac.uk/international/). Data used in this work are from 1970:1 to 2005:4. The corresponding sources are as follows:

Nominal Oil Price: IFS, UK brent price, line 11276AAZZF

Real Oil Price: Nominal Oil Price deflated by the UK Producer Price Index

Consumer Price Index: OECD data from Main Economic Indicators, line GBR.CPALTT01.IXOB

Real Wage: Nominal Wage deflated by the corresponding CPI

Nominal Wage UK Manufacturing Sector: IFS, GBR earnings, line GBR.LCEAMN02.IXOBSA

Nominal Wage UK Services sector: OECD data from Main Economic Indicators line GBR.LCEATT02.IXOB

UK Producer Price Index: OECD data from Main Economic Indicators, GBR PPI, line GBR.PPIPFU01.IXOB

UK Index Production Manufacturing Sector: OECD data from Main Economic Indicators, line GBR.PRMNTO01.IXOB

UK Index Production Services Sector: OECD data from Main Economic Indicators, line GBR.PRSOTO01.IXOBSA

Long-Term Interest Rate: IFS, line 61ZF (Government Bond Yield)

Short-Term Interest Rate: IFS, line 60CZF (Treasury Bill Rate)

Real Effective Exchange Rate: IFS, line GBR.CCRETT01.IXOB

UK Producer Price Index: OECD data from Main Economic Indicators, line GBR.PPIPFU01.IXOB

Real Effective Exchange Rate: OECD data from Main Economic Indicators line GBR.CCRETT01.IXOB