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DO OIL PRICE SHOCKS MATTER? EVIDENCE FOR SOME EUROPEAN COUNTRIES

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Do oil price shocks matter? Evidence for some European countries*

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Abstract
This paper analyzes the oil price-macroeconomy relationship by means of analyzing the impact of oil prices on inflation and industrial production indexes for many European countries using quarterly data for the period 1960-1999. First, we test for cointegration allowing for structural breaks among the variables. Second, and in order to account for the possible non-linear relationships, we use different transformation of oil price data. The main results suggest that oil prices have permanent effects on inflation and short run but asymmetric effects on production growth rates. Furthermore, significant differences are found among the responses of the countries to these shocks.

JEL Classification: E32

Key words: oil price shocks, inflation, economic activity

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1. Introduction

Among the most severe supply shocks hitting the world economies since World War II were sharp increases in the price of oil and other energy products. During the period 1960 to 1999, we have witnessed four important oil shocks: in 1973-1974, when the Organization of Petroleum Exporting Countries (OPEC) first imposed an oil embargo and then greatly increased crude oil prices, the price of the barrel increased from \$3.4 to \$13.4; in 1978-1979, after the Iranian revolution disrupted oil supplies, the price rose from \$20 to \$30; a third one followed Iraq´s invation of Kuwait in 1990, when prices went from \$16 to \$26; finally, and due to the most recent oil shock, prices have grown up from \$12 to \$24 in 1999.

The negative impact of these oil price changes was evident in most cases, as the magnitude of growth rates of industrial production indexes and inflation rates of some countries the immediate periods after these shocks suggest. Table 1 shows the lowest growth rate of the industrial production index of each of the countries within the first periods after each of the first three shocks already mentioned, and the greatest increase in the inflation rate within the same period. For example, we could mention the great decrease in the Industrial Production Index in Luxembourg after the shocks in 1974 and 1979 or the negative impact on the Greek inflation rates. As far as the most recent shock is concerned, the European Central Bank states that the recent increase in the euro area inflation rates was almost entirely caused by developments in energy prices.[1]

[Insert Table 1]

These four episodes may explain why oil price shocks receive important consideration for their presumed role on macroeconomic variables. They are included in several models such as those of Rasche and Tatom (1981), Bruno and Sachs (1982) and Hamilton (1988). Furthermore, they have been credited with affecting the natural rate of unemployment (Phelps, 1994; Caruth, Hooker and Oswald, 1998), reducing the role of technology shocks in real business cycle models (Davis, 1986) and depressing irreversible investment through their effects on uncertainty (Ferdered, 1996). Thus, from a theoretical point of view, there are different reasons why an oil shock should affect macroeconomic variables, some of them calling for a non-linear specification of the oil price-macroeconomy relationship. For example, the oil shock can lead to lower aggregate demand since the price rise redistributes income between the net oil countries which are net oil importers and exporters. Second, the oil price increase reduces aggregate supply since higher energy prices mean that firms purchase less energy; consequently, the productivity of any given amount of capital and labor declines and potential output falls. The decline in factor productivity implies

[1] See Annual Report 1999 from the European Central Bank.

that real wages will be lower. If some labor supply is withdrawn voluntarily as a result, potential output will be lower than it would otherwise be, thus compounding the direct impact of lower productivity. Furthermore, it may have a non-linear effect on economic activity if it affects through sectoral reallocations of resources or depressing irreversible investment through their effects on uncertainty (Ferdered, 1996).[2]

From an empirical point of view, considerable research finds that oil price shocks have affected output and inflation (Hamilton, 1983, 1988, 1996, 2000; Tatom, 1988; Mork, 1989, 1994; Kahn and Hamptom, 1990;Hooker, 1996, 1999a, 1999b; Huntington, 1998). Research also supports the view that these shocks have been an important source of economic fluctuation over the past three decades (Kim and Loungani, 1992).

However, there are various questions, which are still far from a consensus. First, there are several papers that support the position that the oil price-macroeconomy relationship for the US case broke down amidst the falling oil prices and market collapsed occurred in 1985, suggesting misspecification of the oil price rather than a weakened relationship. Based on this empirical evidence, different asymmetric and non-linear transformations of oil prices have been proposed in order to evaluate the possible non-linearities of the oil price-macroeconomy relationship (Lee et al. 1995; Hamilton, 1996).

Second, and in an international context, an oil shock may have a differential impact on each of the countries due to some variables such as their sectoral composition, their relative position as oil importer or exporter or their differential tax structure.[3] As far as the countries belonging to the European Union is concerned, great differences in the impact of oil price shocks could difficult the implementation of the unique monetary policy which could be used in response to inflationary concerns attributable to the oil shocks.

The main goal of this paper is to analyze the oil price-macroeconomy relationship by means of applying Granger causality and structural stability tests on the oil price-inflation rate and oil price-production growth rate relationships for most of the European countries using quarterly data for the period 1960-1999. In order to account for the possible non-linear relationship between oil prices and economic activity, we shall use different transformation of oil price data, each of one suggesting a different channel through which oil prices may affect industrial production levels. The major contribution of this paper is the use of four different proxies of oil price shocks in order to measure their impact on inflation and industrial production growth rates for some European countries during the period 1960-1999.

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[2] See Mork (1994) for a further discussion of various mechanisms.

[3] See De los Llanos and Perez (1999).

The plan of the paper is as follows. In Section 2 we briefly present the main features on oil price market in order to justify the proxy variables of oil price shocks we use in the empirical analysis. Section 3 covers the empirical analysis, in which we estimate the differential impact of oil price changes on both inflation and industrial production growth rates for some European countries. Finally, Section 4 provides some concluding remarks.

2. A first look at oil price data

The choice of oil price variables is difficult and, as we shall show later, relevant. National oil prices have been influenced by price-controls, high and varying taxes on petroleum products, exchange rate fluctuations and national price index variations. Such considerations justify the use of the world price of crude oil for all countries both[4] in dollars and converted into each country's currency by means of the market exchange rate. While the world oil price was deflated using the price of all commodities, the national oil prices were deflated using the inflation indicator of each of the country. All these data have been obtained from *the International Financial Statistics (International Monetary Fund)*.[5]

Figure 1 and Table 2 show the evolution of these variables and the correlation coefficients among them. Based on these data, it is worth mentioning the differential evolution of oil prices in United Kingdom and Ireland, which can be explained by the exchange rate behavior of the currencies of these two countries during the mid-seventies.

[Insert Figure 1]

[Insert Table 2]

In this paper we present four possible proxies to oil price shocks: interanual changes of oil prices (Δoil), oil price increases (Δoil^{+}), net oil price increases (NOPI) and scaled oil price increases (SOPI).

Initially we present the evolution of the interanual[6] changes of both world and national oil prices calculated as

$$\Delta oil_t = \ln oil_t - \ln oil_{t-4} \qquad (1)$$

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[4] Most of the papers which analyze this issue for the US case use the world price of crude oil (Hamilton, 1996) or in real terms by means of dividing this variable by a price index for all commodities (Hooker, 1999b). On the other hand, Mork, Orsen and Mysen (1994) use real oil price in national currency when analyzing the case of their 7 OECD countries sample. In this paper we use both of the variables, since we believe that the joint analysis will allow us to filter other variables, such as the exchange rate fluctuations.

[5] See Appendix 1 for details.

[6] In the empirical studies on these subjets, oil price changes are defined either in growth rates or interanual growth rates. In this case, we choose to use interanual growth rates in order to avoid seasonal effects.

where oil_t is the oil price in period t (see Figure 2 and Table 3). As this Figure shows, oil prices were very stable until 1973, when OPEC raised oil prices dramatically in the 1970s. In contrast, the 1980s brought both nominal price decreases and wide swings following market collapse in 1985. From this period on, oil price market is now characterized by large price declines and high volatility, some features that according to some authors should be taken into account (Mork, 1989; Ferderer, 1996; Lee et al., 1995; Hamilton, 1996).[7]

[Insert Figure 2]

[Insert Table 3]

Therefore, and based on the papers by Lee et al. (1995) and Hamilton (1996), we will define three additional proxy variables for oil price shocks. First, a variable that will only consider oil price increases, that is

$$\Delta oil_t^+ = max(0, \Delta oil_t) \tag{2}$$

Second, we define the interanual percentage change in real oil price levels from the past four quarters' high if that is positive and zero otherwise (NOPI). This variable is proposed by Hamilton (1996), who argues that if one wants a measure of how unsettling an increase in the price of oil is likely to be for the spending decisions of consumers and firms, it seems more appropriate to compare the current price of oil with where it has been over the previous years rather than during the previous year alone. Hamilton thus proposes to use the amount by which the log oil price in quarter t exceeds its maximum value over the previous periods; if oil prices are lower that they have been at some point during the most recent years, no oil shock is said to have occurred. In our case, since growth rates are defined as interanual growth rates, we shall calculated

$$NOPI_t = max\left[0, (\ln(oil_t) - \ln(max(oil_{t-4}, oil_{t-8}, oil_{t-12}, oil_{t-16}))\right] \tag{3}$$

In other paper, Lee et al. (1995) focus on volatility arguing that an oil shock is likely to have greater impact in an environment where oil prices have been stable than in an environment where oil price movement has been frequent and erratic because price changes in a volatile environment are likely to be soon reversed. In order to construct this variable, a GARCH(1,1) model is estimated:

[7] According to these authors, the lower correlation between economic activity and oil prices observed after 1985 should be explained by these features and rather than with a weakened relationship (see also Section 3 and Table 7).

$$\Delta oil_t = \alpha + \sum_{j=1}^{k} \beta_j \Delta oil_{t-j} + \varepsilon_t \qquad \varepsilon_t \left| I_t \rightarrow N(0, h_t) \right.$$
$$h_t = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 h_{t-1} \tag{4}$$
$$SOPI_t = max(0, \hat{\varepsilon}_t / \sqrt{\hat{h}_t})$$

[Insert Figure 3]

[Insert Table 4]

The four oil price shock proxies we use in this paper are plotted in Figure 3 and the correlation coefficients among them are calculated in Table 4. From this Figure, we observe the great correlation between oil price increases and NOPI variable. One of the differences between them is their different behavior in 1999, a year in which the NOPI variable takes a lower value than the oil price increases due to the fact that in 1996 oil prices were higher than in 1998. As far as the SOPI is concerned, there is not a great correlation among this variable and the others. This variable considers that oil price increases have a greater impact if they occur in a period of low volatility (as the oil price increase in 1996).

3. Empirical analysis

In this Section we examine the oil price-macroeconomy relationship, by means of estimating the impact of oil price changes on both industrial production indexes and inflation rates for 15 European countries during the period 1960-1999. With this purpose, we use the former defined oil price variables, inflation rates calculated from Consumer Price Indexes (CPI) and Industrial Production Indexes (IPI) for all countries except Greece. In this case, due to the lack of data on that variable, economic activity is proxied by the Manufacturing Production Index. For the cases of Portugal and Denmark, IPI data are only available for the period 1988-1999 and 1968-1999 respectively, so that for the case of Portugal, the empirical analysis is limited to the relationship between oil prices and inflation rates. The temporal evolution of interanual inflation rates and IPI growth rates are plotted in Figures 4 and 5.

[Insert Figures 4 and 5]

a. Unit root and cointegration results

As a first step of the empirical analysis, unit root tests have been carried out for all of the variables. Table 5 shows the results of the Phillips-Perron (1988) unit root tests, which suggest that all the variables exhibit a unit root. However, this test is suspect when the sample period includes some major events, as the four oil shocks we observe in oil price variables. Failure to consider it properly can lead to erroneous conclusions in the case when the null hypothesis is not rejected. To circumvent this problem, Perron and Vogelsang (1992) introduce dummy variables into the estimated equation and recalculate new set of critical values. However, as pointed out by Zivot and Andrews (1992), the choice of breakpoints based on prior observation of the data could introduce pre-testing problems. Consequently, they introduce an alternative formulation to overcome the pre-testing problems:

$$\Delta y_t = \alpha + \beta t + (\rho - 1) y_{t-1} + \gamma DU_t(\lambda) + \sum_{i=1}^{k} \theta_i \Delta y_{t-i} + u_t \qquad (5)$$

where DU(λ)=1 for t>Tλ, and otherwise DU=0; $\lambda = T_B/T$ represents the location where the structural break lies; T is sample size; and T_B is the date when the structural break occurred. In this paper, we also use sequential Augmented Dickey Fuller tests in order to detect structural changes. As in the Phillips-Perron case, the results suggest that the null hypothesis of a unit root in Industrial Production indexes, inflation rates and oil prices cannot be rejected using this approach (see Table 5).

[Insert Table 5]

As all the variables exhibit a unit root, we tested for bivariate cointegration using 3 alternative approaches. First, the Phillips Ouliaris (1990) test based on the analysis of the stationarity of the residuals of the long-run relationship between the variables. Second, we test the stationarity of the cointegration relationship based on Banerjee et al. (1992). However, just as the unit root tests fails to consider problems associated with structural breaks, Gregory and Hansen (1996) apply the similar approach by Zivot and Andrews (1992) and propose a two-stage estimation process of which the first step is to estimate the following regression[8]:

$$y_{1t} = \alpha + \beta t + \gamma DU_t(\lambda) + \theta_1 y_{2t} + u_t \qquad (6)$$

The second step is to test if u_t is I(0) or I(1) via the Augmented Dickey Fuller or Phillips-Perron techniques. Tables 6 and 6' show the results of the bivariate cointegration tests when the world oil price and each of the national oil prices are used as proxy of oil price changes. The general result of this analysis is that there is not a long-run relationship between either oil prices and IPI, or oil prices and inflation rates. When national oil prices are used, a cointegrating relationship is found between these variable and inflation rates for United Kingdom and Ireland. Based on the prior analysis in Section 2, we believe that this long-run relationship should be explained by the evolution of the exchange rates of the currencies of these two countries.

[Insert Tables 6 and 6']

However, when we test for cointegration allowing for structural breaks by means of applying the methodology proposed by Gregory and Hansen (1996), we obtain that a long-run relationship between inflation rates and oil prices exist for most of the countries. As far as the IPI variable is concerned, we do not find evidence of cointegration even when we allow for a structural break, which in most of the cases occurs in mid-eighties, that is with the market collapse occurred in these years, or mid-seventies.

[Insert Table 7]

b. Bivariate Granger causality tests

Since cointegration does not exist between IPI and oil prices, we use the following formulation in order to test the Granger causality from oil prices to IPI growth rates:

$$\Delta IPI_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta IPI_{t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta oil_{t-i} + \varepsilon_t \qquad (7)$$

Failing to reject the null hypothesis $\alpha_{21}=\alpha_{22}=...=\alpha_{2k}=0$ implies that oil prices do not Granger cause or IPI growth rates. Table 8 shows the results of these causality tests. According to the results presented in Table 8, oil price changes cause IPI growth rates for some countries such as Belgium, Luxembourg, United Kingdom, Netherlands and Sweden both when using the world oil price or each of the national oil price level. However, when the positive oil price changes and NOPI variables are used as proxies of oil prices the evidence of causality is much more clear and it affects to most of the countries. Therefore, these results suggest that a non-linear relationship may exist between these two variables and this would explain why the correlation between IPI growth rates and oil price changes decreases after the oil market collapse in mid-eighties (see Table 7 or other studies, such as Hooker (1999b)).

[Insert Table 8]

Since cointegration exists between inflation rates and oil prices, an error correction term is required in testing Granger causality as shown bellow:

$$\Delta \pi_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta \pi_{t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta oil_{t-i} - \gamma z_{t-1} + \varepsilon_t \qquad (8)$$

in which γ denotes the speed of adjustment and z are the residuals of the long run relationship between inflation and oil prices. In this case, failing to reject the null hypothesis $\alpha_{21}=\alpha_{22}=...=\alpha_{2k}=0$ and $\gamma=0$ implies that oil prices do not Granger cause inflation rates.

In this case, oil prices cause inflation rates even when a linear relationship is considered. Furthermore, the impact of oil prices is higher when national oil prices are measured in national currency, which we assume is due to the role of exchanges rates on macroeconomic variables.

[Insert Table 9]

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[8] In our case, IPI and inflation rates (y_{1t}) are regressed on oil prices (y_{2t}).

c. Testing for asymmetries

According to Lee et al. (1995), Hamilton (1996, 2000), Davis and Haltiwanger (1999) and Hooker (1999a) and the results of the former Section, there are evidence that oil prices have asymmetric and non-linear effects on economic activity. In order to test for asymmetries, we enter real oil price increases (and NOPI) and decreases as separate variables. Thus, our bivariate estimation equations for IPI are[9]:

$$\Delta IPI_t = \beta_0 + \sum_{j=1}^{k} \beta_j \Delta IPI_{t-j} + \sum_{j=1}^{k} \gamma_j^+ \Delta oil_{t-j}^+ + \sum_{j=1}^{k} \gamma_j^- \Delta oil_{t-j}^- + \varepsilon_t \qquad (9)$$

$$\Delta IPI_t = \beta_0 + \sum_{j=1}^{k} \beta_j \Delta IPI_{t-j} + \sum_{j=1}^{k} \gamma_j^+ NOPI_{t-j} + \sum_{j=1}^{k} \gamma_j^- \Delta oil_{t-j}^- + \varepsilon_t \qquad (10)$$

Based on the former equations, the following null hypothesis is tested:

$$\sum_{j=1}^{k} \gamma_j^+ = \sum_{j=1}^{k} \gamma_j^- \qquad (11)$$

As observed in Table 10, in most of the cases we find that oil price changes have an asymmetric effect on IPI growth rates. In fact, while oil price increases have a negative and significant effect on IPI growth rates, the opposite result does not hold for oil price decreases. Furthermore, oil price increases are likely to have a greater impact when they follow a period of lower price increases, as the significativity of the NOPI variable suggests.

[Insert Table 10]

d. Trivariate relationship

In this Section a trivariate VAR model is estimated in order to test whether the effect of oil prices on economic activity is through changes in inflation rates or through an additional mechanism. With this purpose, an impulse response function is estimated for each of the country based on the following model (see Figure 6):

$$\Delta IPI_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta IPI_{t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta \pi_{t-i} + \sum_{i=1}^{k} \alpha_{23} NOPI_{t-i} + \varepsilon_t \qquad (12)$$

The results presented in Figure 6 show that a one standard deviation shock on NOPI[10] has a significant negative effect on IPI growth rates even when inflation rate changes are included in

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[9] The analysis for the inflation rates is not presented since according to the former results, we can assume that there is a linear relationship between oil prices and inflation rates. Furthermore, the theoretical papers described in Section 1 consider the possibility that a non-linear relationship may exist between oil prices and economic activity, but not inflation rates.

[10] We use this variable as proxy of oil price shocks since its impact on economic activity is higher than that of the other variables (see Table 8).

the model, which suggest that the economic activity-oil prices relationship cannot be solely explained by the impact of oil prices on inflation rates. Furthermore, when standard deviations are calculated for the response function, we observe that significant differences exist among the impact on each of the analyzed countries, as the case of Luxembourg suggests.

4. Concluding remarks

This paper analyzes the oil prices-macroeconomy relationship by means of studying the impact of oil price changes on both inflation and IPI growth rates for most of the European countries. Besides the relevance of this analysis in the context of the new oil shock occurred in 1999, the major contribution of this paper is the use of different proxys of oil price shocks in order to measure their impact on inflation and IPI growth rates for some European countries.

The main results may be summarized as follows:

First, we obtain different results depending on whether we use a world oil price index (calculated as the ratio between the price of crude oil and a price index for all commodities), or a national real price index for each of the countries measured in the currency of each country. In fact, the impact is higher when national oil prices are measured in national currency, which we assume is due to the role of exchange rates on macroeconomic variables. Based on this result, and as far as the US-Europe relationship is concerned, the actual oil price increases occurred in 1999 are more likely to have a greater impact on Europe than in US due to the weakness of the euro.

Second, there is not a cointegrating long-run relationship between oil prices and economic activity, which suggests that the impact of oil shocks on this variable is limited to the short-run. We do not find evidence of a long-run relationship between these two variables even when we allow for a structural break around mid-eighties in order to capture the oil market collapse occurred around 1985.

In relation to the oil price-inflation relationship, we find evidence of cointegration in the cases of United Kingdom and Ireland solely when oil prices are measured in national currency. This result supports the previous evidence of the relevant role of exchange rates when explaining inflation rates. However, these tests can lead to erroneous conclusions if possible structural breaks are not considered. When Gregory and Hansen (1996) cointegration tests are considered, we find cointegration between inflation rates and oil prices for all countries except Germany, Luxembourg, Netherlands and Sweden.

Third, when analyzing short-run relationships between oil prices and IPI growth rates, oil price changes are found to Granger cause IPI growth rates, although the analyzed data suggests that the correlation between these two variables is not the same over the whole period. According to economic literature and some empirical studies, we test whether or not these differences in the economic activity-oil price relationship could be due to a non-linear relationship between the two variables, by means of defining some transformations of oil price variables. More specifically, this new analysis has been carried out by means of both distinguishing positive and negative movements of oil price changes and defining the two leading proxy variables for oil price shocks proposed in the literature.

Fourth, when these new proxy variables of oil price shocks are used, we find asymmetric effects in the impact of oil prices on economic activity. In fact, while oil price increases have a negative and significant effect on IPI growth rates, the opposite result does not hold for oil price decreases. Furthermore, oil price increases are likely to have a greater impact when they follow a period of lower price increases. However, we do not find evidence enough to assume that the oil price impact on macroeconomic variables depends on the volatility of the oil market.

Fifth, we also study the trivariate relationship among inflation rates, industrial production growth rates and oil prices, finding that oil prices Granger cause economic activity even when inflation rates are included into the regression, which suggests that oil prices affect real activity not only through affecting inflation rates but by some other mechanism.

Sixth, when analyzing the differential effects of oil prices on each of the countries, a relevant issue within the European Monetary Union area, we find significant differences among some of the countries. For instance, the industrial production growth rate in Luxembourg is more vulnerable than the rest of the countries to oil price changes. These differences also exist for the inflation rate responses, as the case of Italy suggests.

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Appendix 1

The data used in this study are obtained from *International Monetary Fund – International Financial Statistics*. The countries includes in the study are Germany, Belgium, Austria, Spain, Finland, France, Ireland, Italy, Luxembourg, Portugal, United Kingdom, Netherlands, Denmark, Greece and Sweden. The data are quarterly from 1960 to 1999. The variables are:

- *Real oil price levels*: the world oil price is calculated as the ratio between the producer price index for crude oil divided by the producer price index for all commodities. The oil prices measured in national currencies are obtained using the exchange rate of each of the countries. These variables are deflated using the inflation indicator of each of the country.
- *Exchange rate* (e): because oil price is expressed in dollars, it was converted to local currencies using the average market exchange rates for the quarter.
- *Inflation rates*, calculated from Consumer Price Index (CPI), seasonally adjusted.
- *Economic activity*, proxied by Industrial Production Index (IPI), seasonally adjusted. We use IPI for all countries except for Greece which is proxied by the Manufacturing Production Index. For the cases of Portugal and Denmark, IPI data are only available for the period 1988-1999 and 1968-1999 respectively.

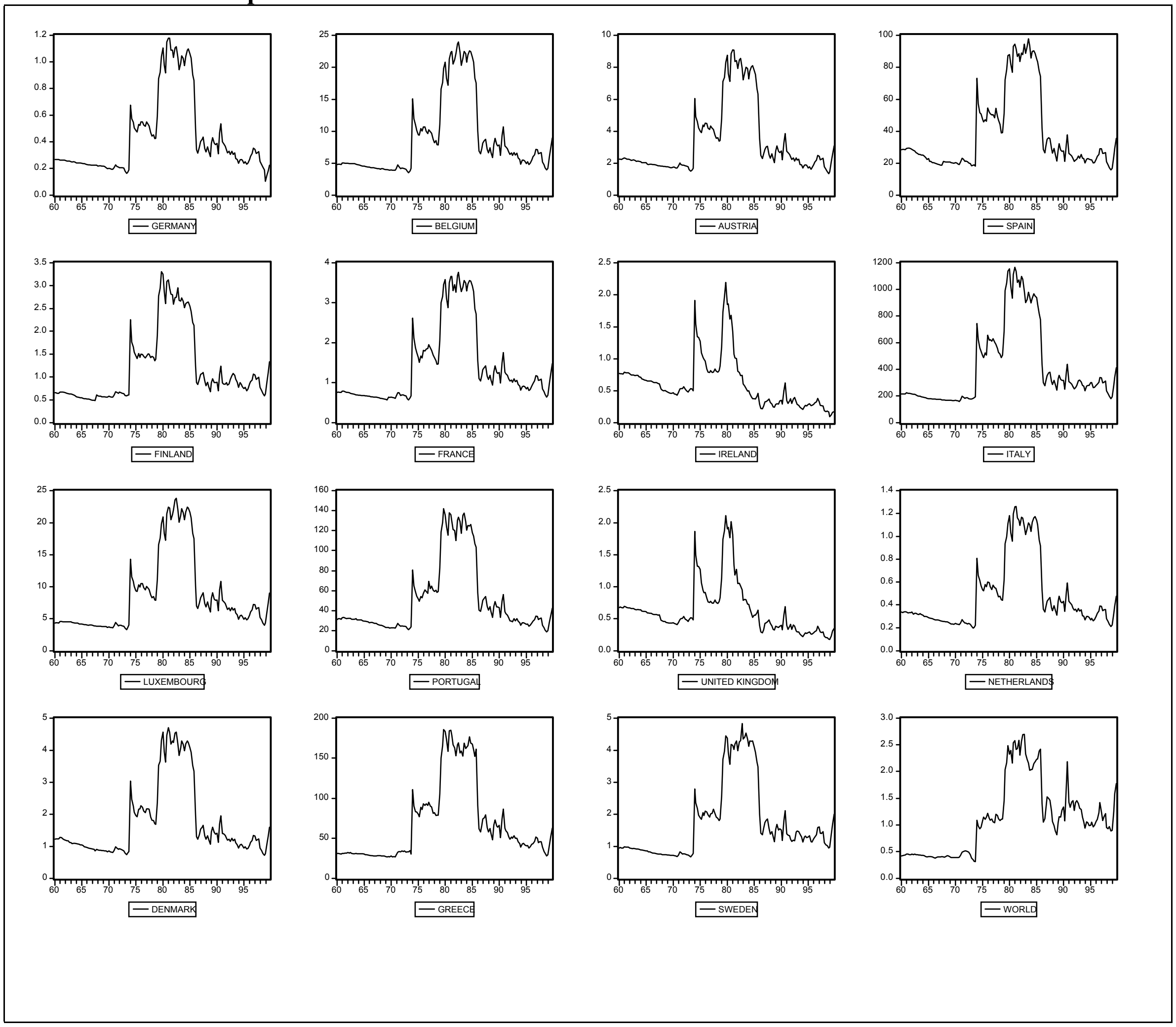
FIGURES AND TABLES

TABLE 1. Differential impact of three oil price shocks

	1973-1974		1978-1979		1990	
	ΔIPI	Δπ	ΔIPI	Δπ	ΔIPI	Δπ
Germany	-10.22	**0.85**	-4.85	2.85	-2.23	-0.20
Belgium	-13.12	8.07	-9.50	2.35	-3.85	0.31
Austria	-9,45	2.92	-2.14	3.12	0.02	0.84
Spain	-7.54	5.87	-2.16	**0.22**	-2.41	-0.34
Finland	-7.07	7.72	2.81	3.73	-10.40	-0.69
France	-10.99	6.22	-2.94	3.20	-0.43	0.13
Ireland	-6.48	8.75	-5.36	7.20	1.11	0.58
Italy	-14.5	11.36	-2.81	6.57	-3.50	0.46
Luxembourg	**-36.05**	4.99	-12.75	2.52	-2.59	0.34
Portugal	--	**16.85**	--	2.98	-2.59	1.94
United Kingdom	-10.74	6.84	-9.92	**9.45**	**-5.01**	2.21
Netherlands	-11.78	2.69	-2.99	2.25	0.27	1.47
Denmark	-16.29	5.92	-6.92	5.84	-1.32	0.21
Greece	-2.31	**21.55**	-4.57	**10.01**	-3.91	**7.15**
Sweden	-4.41	3.76	-3.90	6.73	-6.71	**4.46**

Own elaboration from International Financial Statistic (International Monetary Fund). The numbers represent the highest interanual negative IPI growth rates and inflation growth rates observed in the first six quarters after each of the shocks.

FIGURE 1. Real oil price levels

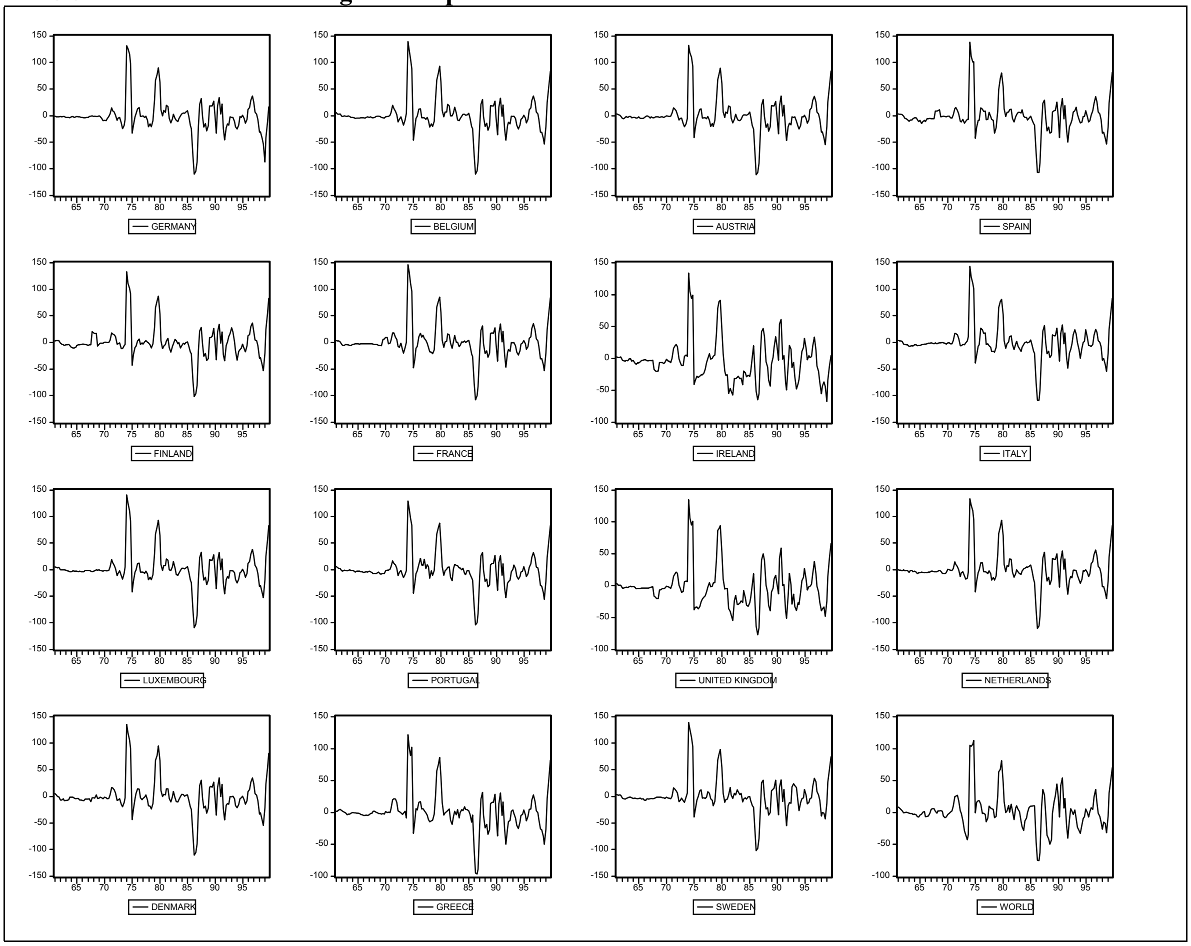


The first 15 variables represent real oil prices in each of the countries' currencies and the last one represents the real oil price in dollars.

TABLE 2. Correlation coefficients among real national oil prices

	Bel	Aus	Spa	Fin	Fra	Ire	Ita	Lux	Por	UK	Net	Den	Gre	Swe	W
Ger	0.99	0.99	0.98	0.96	0.99	0.50	0.98	0.99	0.99	0.67	0.99	0.99	0.99	0.98	0.89
Bel		0.99	0.98	0.97	0.99	0.44	0.97	0.99	0.98	0.63	0.99	0.99	0.98	0.99	0.90
Aus			0.99	0.98	0.99	0.56	0.99	0.99	0.99	0.72	0.99	0.99	0.98	0.98	0.86
Spa				0.98	0.99	0.54	0.98	0.98	0.99	0.70	0.99	0.99	0.98	0.98	0.84
Fin					0.99	0.56	0.99	0.97	0.98	0.73	0.98	0.98	0.98	0.99	0.89
Fra						0.48	0.99	0.99	0.99	0.66	0.99	0.99	0.99	0.99	0.90
Ire							0.56	0.43	0.53	0.97	0.50	0.53	0.49	0.45	**0.26**
Ita								0.98	0.98	0.72	0.98	0.98	0.99	0.98	0.89
Lux									0.98	0.62	0.99	0.99	0.99	0.99	0.91
Por										0.62	0.99	0.99	0.99	0.98	0.87
UK											0.68	0.70	0.67	0.63	**0.46**
Net												0.99	0.99	0.99	0.89
Den													0.98	0.99	0.87
Gre														0.99	0.91
Swe															0.92

FIGURE 2. Interanual changes of oil prices

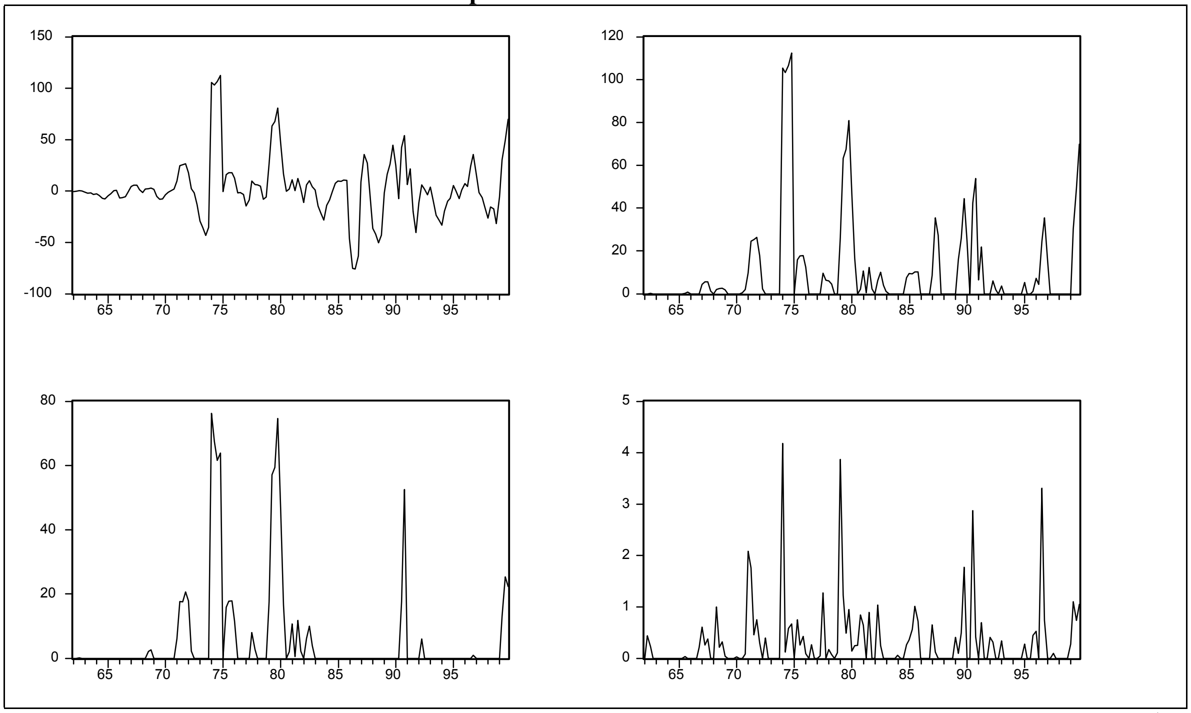


The first 15 variables represent interanual changes in real oil prices in each of the countries' currencies and the last one represents the changes in real oil price in dollars.

TABLE 3. Correlation coefficients among real national interanual oil price changes

	Bel	Aus	Spa	Fin	Fra	Ire	Ita	Lux	Por	UK	Net	Den	Gre	Swe	W
Ger	0.94	0.94	0.92	0.91	0.93	0.78	0.92	0.94	0.92	0.79	0.94	0.94	0.93	0.92	0.85
Bel		0.99	0.98	0.97	0.99	0.74	0.98	0.99	0.98	0.83	0.99	0.99	0.98	0.98	0.89
Aus			0.98	0.97	0.99	0.75	0.98	0.99	0.98	0.84	0.99	0.99	0.98	0.97	0.90
Spa				0.97	0.98	0.72	0.98	0.98	0.97	0.81	0.98	0.98	0.97	0.98	0.89
Fin					0.97	0.76	0.97	0.97	0.97	0.84	0.97	0.97	0.97	0.97	0.90
Fra						0.74	0.98	0.99	0.98	0.83	0.99	0.99	0.98	0.98	0.89
Ire							0.75	0.74	0.75	0.95	0.98	0.74	0.76	0.75	**0.77**
Ita								0.98	0.97	0.84	0.99	0.98	0.98	0.98	0.88
Lux									0.98	0.83	0.99	0.99	0.98	0.98	0.90
Por										0.84	0.98	0.98	0.98	0.98	0.88
UK											0.83	0.83	0.85	0.83	**0.83**
Net												0.99	0.98	0.97	0.90
Den													0.98	0.98	0.90
Gre														0.97	0.90
Swe															0.89

FIGURE 3. Alternative measures of oil price shocks



The first figure represents the oil price changes (Δoil), the second one the positive oil price changes (Δoil^{+}) and the last two figures represent the evolution of NOPI and SOPI variables calculated as described in Section 2.

TABLE 4. Correlation coefficients among oil price proxies

	Δoil	Δoil^{+}	NOPI	SOPI
Δoil		0.88	0.78	0.50
Δoil^{+}			0.91	0.50
NOPI				0.41

FIGURE 4. Interanual inflation rates

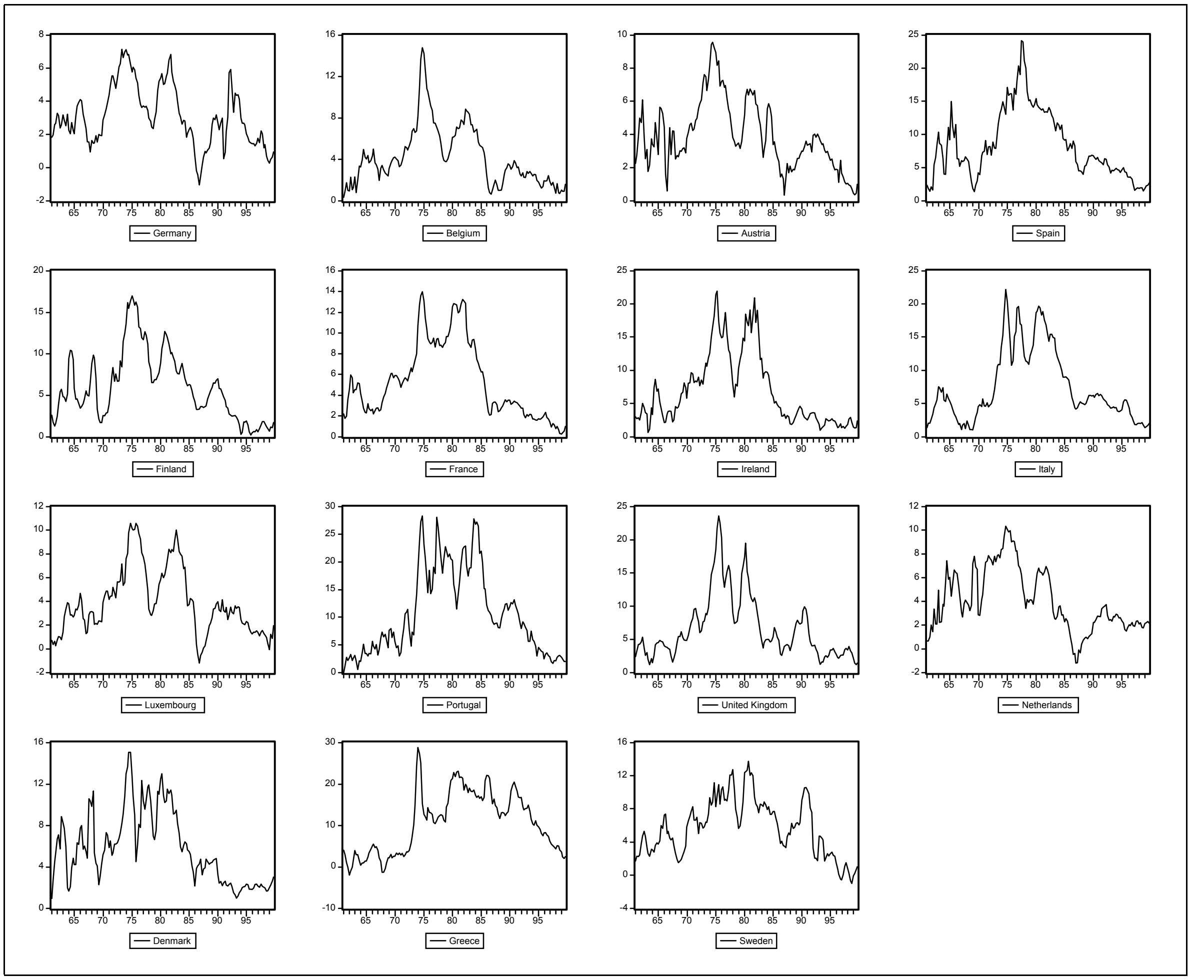


FIGURE 5. Interanual IPI growth rates

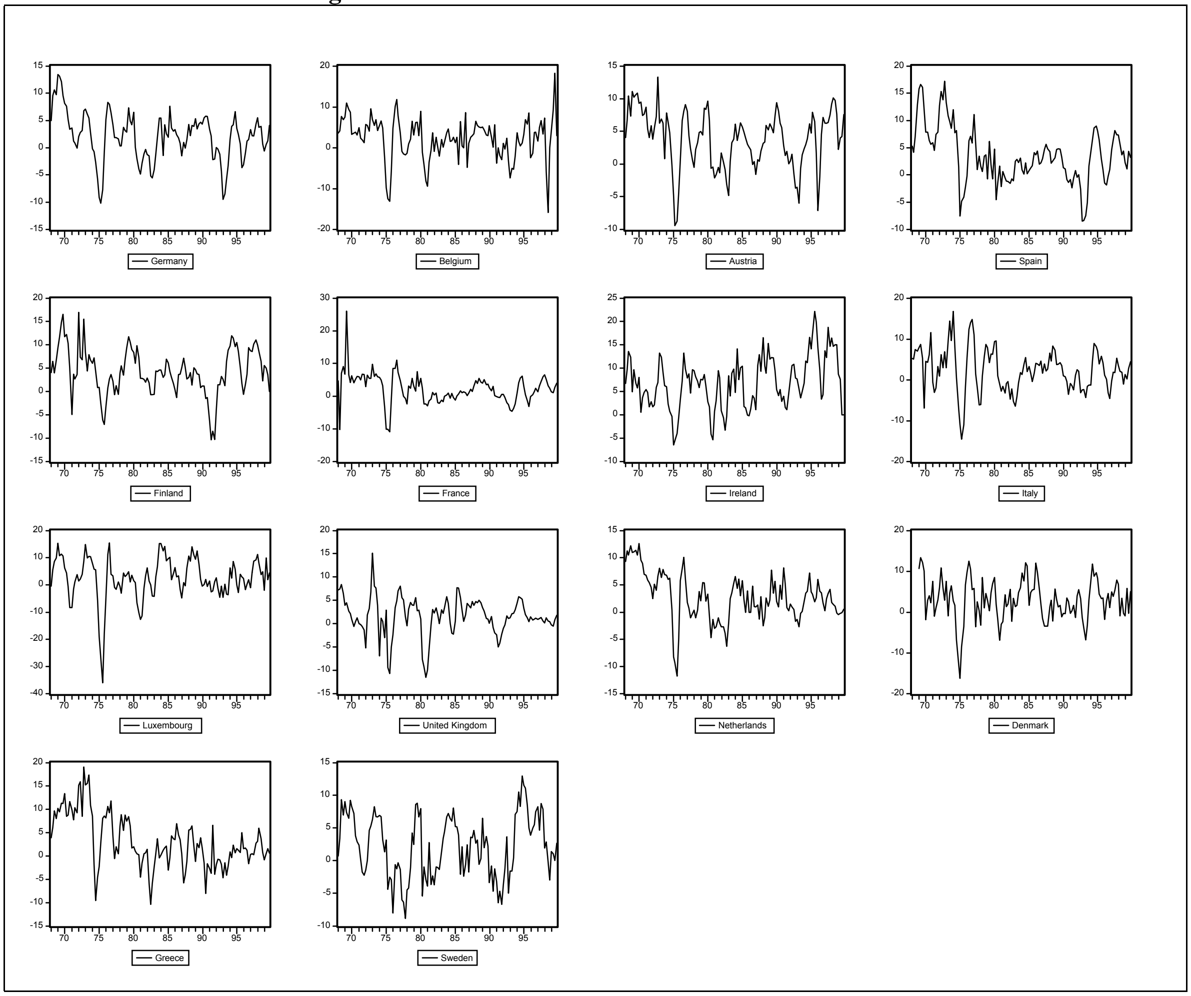


TABLE 5. Unit root tests Phillips Perron (PP) and Zivot and Andrews (ZA)

	Inflation rate		Oil prices		IPI	
	PP	ZA	PP	ZA	PP	ZA
Germany	-2.31	-3.16 (1990:4)	-1.44	-2.55 (1973:4)	-1.90	-2.62 (1982:2)
Belgium	-2.11	-2.25 (1976:4)	-1.59	-2.62 (1973:4)	-1.54	-3.68 (1985:2)
Austria	-2.30	-2.92 (1984:4)	-1.59	-2.61 (1973:4)	0.92	-2.97 (1995:3)
Spain	-1.86	-1.69 (1976:1)	-1.27	-2.52 (1973:4)	-1.40	-1.89 (1995:2)
Finland	-2.00	-1.86 (1975:3)	-1.44	-2.44 (1973:4)	0.75	-2.95 (1970:4)
France	-1.38	-1.76 (1981:3)	-1.54	-2.50 (1973:4)	-1.51	-1.89 (1968:2)
Ireland	-1.80	-2.43 (1982:1)	-1.38	-3.34 (1973:4)	2.22	-1.56 (1987:3)
Italy	-1.79	-1.78 (1976:3)	-1.34	-2.26 (1973:4)	-1.51	-2.70 (1969:4)
Luxembourg	-2.13	-2.60 (1985.1)	-1.45	-2.56 (1973:4)	-0.38	-2.67 (1974.3)
Portugal	-2.06	-1.31 (1976:1)	-1.13	-2.39 (1973:4)	--	--
United Kingdom	-2.16	-2.25 (1975:2)	-1.34	-3.58 (1973:4)	-0.86	-4.07 (1980:1)
Netherlands	-2.20	-2.12 (1967:4)	-1.47	-2.75 (1973:4)	-1.26	-1.93 (1989:4)
Denmark	-2.80	-1.79 (1966:2)	-1.41	-2.62 (1973:4)	-0.39	-2.35 (1996:1)
Greece	-1.93	-2.32 (1972:3)	-1.40	-1.91 (1973:4)	-2.06	-1.89 (1986:4)
Sweden	-2.33	-1.67 (1990:4)	-1.44	-2.24 (1973:4)	0.15	-1.86 (1992:4)
World	--	--	-1.73	-2.62 (1990:4)	--	--

PP: in any of the cases we can reject the null hypothesis of unit root.

ZA: critical values for λ=0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9, the 5% critical values are –3.65, -3.80, -3.87, -3.94, -3.96, -3.95, -3.85, -3.82, -3.68, respectively. The breakpoint (T_B) is calculated multiplying λ by the number of observations (T) and is presented in brackets. In any of the cases we can reject the null hypothesis of unit root.

The same unit root tests have been applied to the first differences of the variables and in all cases we rejected the null hypothesis of unit root.

TABLE 6. Cointegration tests (world oil price)

	Phillips-Ouliaris[#]		Banerjee et al.[&]		Gregory and Hansen[##]	
	Inflation	IPI	Inflation	IPI	Inflation	IPI
Germany	-2.21	-1.64	-0.79	-0.84	-3.42 (1983:4)	-3.05 (1986:4)
Belgium	-1.89	-1.40	-0.65	-0.19	-4.83* (1977:3)	-3.48 (1987:3)
Austria	-2.25	-0.51	-0.08	1.74	-4.87* (1971:2)	-3.10 (1986:3)
Spain	-1.88	-2.15	0.98	0.33	-4.78* (1977:4)	-2.73 (1974:4)
Finland	-1.91	-0.15	1.27	0.93	-5.29** (1978:4)	-2.56 (1993:1)
France	-1.03	-1.70	-0.14	0.04	-4.74* (1978:3)	-3.14 (1987:2)
Ireland	-1.67	3.24	-0.30	0.79	-4.49 (1977:2)	-2.97 (1993:1)
Italy	-1.75	-1.65	0.67	-0.50	-5.39** (1978:3)	-3.54 (1987:2)
Luxembourg	-1.94	-0.07	-1.31	0.27	-4.38 (1978:2)	-3.52 (1986:1)
Portugal	-2.41	-0.50	1.62	--	-4.94* (1979:2)	--
United Kingdom	-1.99	-1.20	-1.15	-0.44	-4.66* (1979:3)	-3.25 (1985:4)
Netherlands	-2.32	-1.43	-1.46	-0.57	-4.08 (1977:1)	-2.75 (1987:4)
Denmark	-2.75	-1.46	0.59	-0.87	-3.60 (1979:4)	-3.50 (1994:1)
Greece	-2.84	-2.31	0.05	-0.40	-6.04** (1980:2)	-3.70 (1973:3)
Sweden	-2.32	-0.86	0.62	-0.27	-4.28 (1975:4)	-2.78 (1992:1)

#The critical value of this statistic at 10% is -3.04, so that we do not reject the null hypothesis of non cointegration in any of the cases.

& In this case, we test if the error correction component is significant in a ECM model.

The critical values are taken from Table 1 in Gregory and Hansen (1996). * and ** indicates that the null hypothesis is rejected at a 10% and 5%, respectively.

TABLE 6'. Cointegration tests (national oil prices)

	Phillips-Ouliaris#		Banerjee et al.&		Gregory and Hansen##	
	Inflation	IPI	Inflation	IPI	Inflation	IPI
Germany	-2.31	-1.13	-0.64	-1.20	-3.37 (1978:4)	-3.31 (1985:2)
Belgium	-2.08	-0.84	-0.90	-0.66	-5.19** (1976:2)	-3.78 (1977:3)
Austria	-2.38	0.25	0.19	1.24	-4.66* (1969:4)	-3.19 (1986:4)
Spain	-2.60	-1.97	1.33	-0.65	-5.55** (1978:2)	-3.16 (1977:2)
Finland	-2.13	1.03	-1.57	0.79	-4.81* (1976:3)	-2.56 (1985:2)
France	-1.52	-1.06	2.37	-0.70	-4.77* (1978:3)	-3.73 (1977:3)
Ireland	-3.43*	-0.13	-2.46**	1.54	-3.87 (1980:3)	-2.84 (1991:1)
Italy	-2.71	-1.07	0.65	-1.26	-5.87** (1977:3)	-4.03 (1985:2)
Luxembourg	-2.15	0.26	-1.27	0.29	-4.25 (1976:1)	-3.84 (1986:2)
Portugal	-3.26*	--	0.16	--	-5.31** (1978:2)	--
United Kingdom	-3.18*	-1.30	-1.77*	-1.45	-3.70 (1978:2)	-3.43 (1984:2)
Netherlands	-2.16	-1.03	-0.78	-1.31	-3.67 (1978:4)	-3.00 (1977:3)
Denmark	-3.16*	--	-1.64	--	-4.79* (1979:4)	-3.50 (1994:4)
Greece	-2.93	-1.53	-0.78	-1.21	-4.20 (1975:2)	-4.04 (1986:2)
Sweden	-2.67	-0.42	0.50	-0.42	-3.70 (1992:4)	-2.68 (1991:1)

#The critical value of this statistic at 10% is -3.04, so that we do not reject the null hypothesis of non cointegration in any of the cases.
& In this case, we test if the error correction component is significant in a ECM model.
The critical values are taken from Table 1 in Gregory and Hansen (1996). * and ** indicates that the null hypothesis is rejected at a 10% and 5%, respectively.

TABLE 7. ΔIPI and oil prices: correlation coefficients before and after 1985

	1961-1999	1961-1985	1986-1999
Germany	-0.18	-0.32	0.03
Belgium	-0.34	-0.54	-0.10
Austria	-0.24	-0.44	0.07
Spain	-0.22	-0.36	-0.20
Finland	-0.23	-0.25	-0.30
France	-0.25	-0.38	-0.07
Ireland	-0.39	-0.49	-0.17
Italy	-0.24	-0.33	-0.18
Luxembourg	-0.43	-0.60	0.06
United Kingdom	-0.36	-0.40	-0.40
Netherlands	-0.34	-0.55	-0.02
Denmark	0.13	-0.01	0.20
Greece	-0.30	-0.35	-0.27
Sweden	-0.22	-0.19	-0.38

The table presents the correlation coefficients between IPI growth rates and the fourth lag of oil price changes. The reason of using the fourth lag is that according to the literature on this subject, the greatest effect of oil prices and macroeconomic variables is observed after 4 quarters (see Table 1 in Hamilton, 2000).

TABLE 8. Granger causality tests (interanual growth rates)

	Δoil	Δ real oil*e	Δoil+	NOPI	SOPI
Germany	0.59	1.27	1.90	2.34**	0.26
Belgium	2.52**	3.63**	4.67**	4.68**	0.98
Austria	1.40	2.24*	2.79**	2.57**	0.13
Spain	1.35	1.38	1.87	1.36	0.28
Finland	2.00	0.75	2.43**	1.57	1.43
France	1.54	2.22**	3.09**	2.79**	0.66
Ireland	2.73**	0.94	2.82**	3.99**	1.51
Italy	0.80	0.82	1.59	1.27	0.84
Luxembourg	4.88**	5.17**	8.69**	8.86**	0.73
United Kingdom	5.86**	5.98**	11.85**	10.59**	1.36
Netherlands	2.67**	3.60**	5.99**	4.91**	0.76
Denmark	2.03	1.54	4.02**	3.11**	0.77
Greece	3.42**	1.77	3.02**	4.22**	1.97
Sweden	3.84**	2.41*	4.55**	4.03**	1.98

The null hypothesis that lag values of oil price shocks are not significant in explaining IPI growth rates is tested (see equation (7)). * and ** indicate significant at 10 and 5% respectively.

TABLE 9. Granger causality tests (changes in inflation rates)

	Δoil	Δoil*e	Δoil+	NOPI	SOPI
Germany	0.41	0.29	0.61	0.09	0.28
Belgium	7.62**	10.62**	8.22**	10.24**	2.59**
Austria	2.34*	3.22**	1.99	1.98	1.23
Spain	1.66	2.25*	0.99	1.14	0.91
Finland	2.20*	4.47**	2.49**	2.67**	1.08
France	2.89**	4.22**	3.55**	2.92**	0.59
Ireland	2.12	3.13**	4.09**	3.48**	1.08
Italy	6.06**	12.92**	8.47**	8.21**	1.86
Luxembourg	3.01**	4.69**	3.68**	2.42*	1.45
United Kingdom	0.61	4.26**	0.61	1.54	1.93
Netherlands	1.45	2.16*	1.49	1.45	1.65
Denmark	2.15	2.78**	3.53**	3.52**	2.34*
Greece	4.48**	5.55**	7.76**	7.25**	1.17
Sweden	1.82	1.50	1.54	2.04	1.17

The null hypothesis that lag values of oil price shocks are not significant in explaining changes in inflation rates is tested (see equation (8)). * and ** indicate significant at 10 and 5% respectively.

TABLE 10. Asymmetric effects

	Δ IPI	
	$\gamma^{+}=\gamma^{-}$	NOPI= γ^{-}
Germany	4.17**	7.25**
Belgium	5.14**	5.78**
Austria	3.66*	3.53*
Spain	3.67*	2.88*
Finland	2.12	1.45
France	5.07**	4.73**
Ireland	0.23	1.98
Italy	1.01	0.71
Luxembourg	0.49	1.45
United Kingdom	2.13	3.87**
Netherlands	9.75**	11.01**
Denmark	8.09**	8.22**
Greece	4.47**	5.40**
Sweden	1.23	1.48

The null hypothesis given by equation (11) is tested. * and ** indicate significant at 10 and 5% respectively.

FIGURE 6. Responses to NOPI (trivariate VAR)