International Journal of Economic Research, Vol. 6, No. 1, 2009: 109-127

THE IMPACT OF OIL SHOCKS AND INFLATION ACCORDING TO THE PHILIPS CURVE MODEL AND THE VAR APPROACH

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ABSTRACT

This paper deals with the impact of oil price shocks to fundamental macroeconomic variables, namely to inflation, unemployment, and interest rates with the help of the Philips Curve model and cointegrating VAR analysis. The data covers a 10-year period, from January 1997 to April 2007. EU and US economies are separately examined. Results show that oil price shocks tend to have marginally different impacts on inflation on the US and the EU as a whole, according to the Phillips Curve approach, while the VAR approach shows, for the European economy an increased volatility after an oil price shock, unlike the US economy.

Keywords: Oil shocks, inflation, Phillips curve, VAR models.

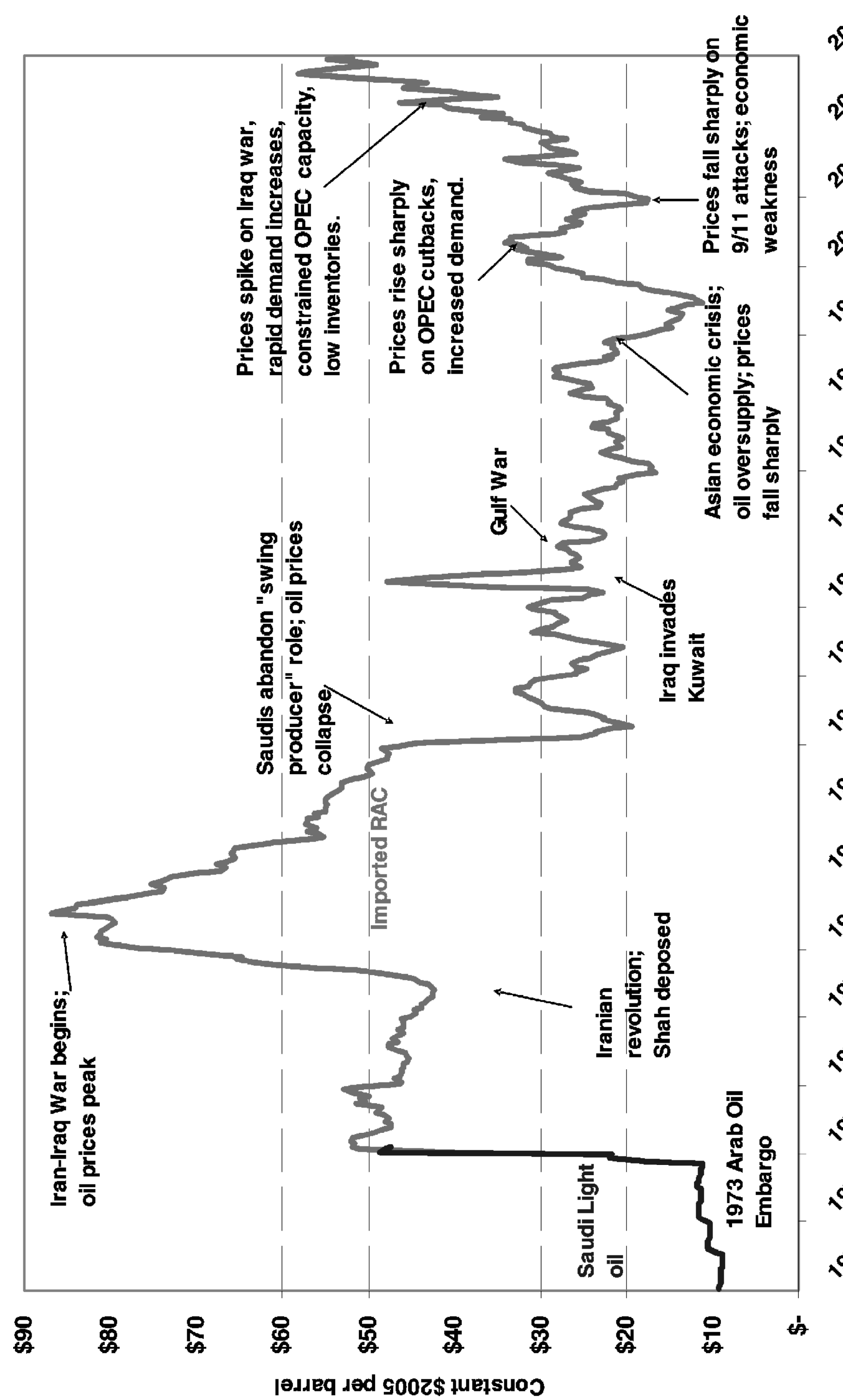
INTRODUCTION

Short-and-long term movements in oil prices have made policymaking and business leaders' tasks more complicated during the last decades. This caused economists to regard oil price shocks as the main factors of macroeconomic performance. Back in the 1970s, the developed world, and mainly the USA, was becoming more and more dependant on imported oil. Adding to that, there were poor macroeconomic expectations. After that period, followed new oil price shocks, namely at the 1986 collapse of oil prices, the unexpected rise in 2000, as well as the positive fluctuations due to the 1990-1991 Gulf War and the 2003 Iraq war. Other incidents accused for oil price shocks are the Iranian revolution (January of 1980), the outbreak of the Iran-Iraq war (July of 1981), and the OPEC meeting in 1999.

There is a general belief that political events in the Middle East exogenously influence booms and recessions in industrialised countries through their effect on oil prices.

Today, the macroeconomic impact of oil price changes is considered one of the most important issues, regarding the impact on inflation, consumption, interest rates, among others. Average GDP figures in countries where oil is an important factor of

Graph 1
Major Events and Real World Oil Price, 1970-2005
(Prices adjusted by Consumer Price Index, 2005))



production, show to have a constant effect from changes in the oil prices. Apart from that, oil price shocks pose a severe problem for central banks. When oil prices increases, so do the firms with the costs of production and the prices they charge for their products. Since non-energy product prices are constant, this tends to boost inflation, and eventually, for a given level of aggregate demand, to lead the economy to a recession. The critical problem, then, for central banks is, to implement a contractionary monetary policy to hold inflation down, while at the same time to implement an expansionary policy to fight recession.

Table 1
Major Oil Price Increases

Oil embargo	1973-1974
Iranian Revolution	1978-1979
Iran-Iraq war	1980
Invasion of Kuwait	1990
OPEC meeting	1999
Afghan war	2001
Iraq war	2003

It is common truth that the effects of oil price shocks differ substantially across countries. This happens due to different levels of importance of energy consumption. For example, the USA and Japan use far more oil per dollar of GDP in production than other developed countries, and therefore, are far more sensitive to oil price shocks. Empirically, a 10% increase in oil prices will result in a less than 0,5% reduction in gross output (Rotemberg and Woodford, 1996). What the paper investigates is the different effects oil price shocks and inflation shocks have on the US and the EU macroeconomic variables.

LITERATURE REVIEW

As Michael LeBlanc and Menzie D.Chinn point out (2004) in their research, after estimating the effects of oil price changes on inflation for the USA, the UK, France, Germany, and Japan using the augmented Philips curve, they concluded that oil prices increased have only a modest impact on the US, European and Japanese inflation. In particular, an increase of 10% in oil prices will lead to a direct inflationary increase of about 0.1-0.8% in the USA and the European Union. Although Europe seems to be more sensitive to oil price changes than the USA, this fact seems to cluster to specific countries only.

Werner Roeger (2005) in his study uses the European Commission's QUEST model. This model is an international macroeconomic one, which stands in the tradition of dynamic equilibrium in the sense that households and firms form optimal intertemporal decisions and wages by maximising an intertemporal utility function subject to a budget constraint and firms decide about labour demand, investment, energy consumption and prices by maximising the net present value of profits subject to a Cobb-Douglas technology, a capital accumulation constraint and additional adjustment constraints for all factors of production. The study's conclusion is that, in principle, oil affects production directly to the extend in which it is used as an intermediate input and it affects consumption directly to the extend in which households use oil as a component of their energy demand. An increase in oil prices increases production costs, whereby the degree to which this happens depends on the degree to which oil can be substituted by other factors of production. On the price side, there are two kinds of effects. The direct effect is the passing on of oil prices to producer prices and Consumer Price Index deflator. The indirect effects are generated by the response of wages to the change in prices as well as effects arising from monetary policy reaction and implied changes of the exchange rate.

Mark A.Hooker (2002) in his study refers to the structural break in core US inflation Phillips curves before 1981 and after that year. Using the typical Phillips curve, he found that oil price changes substantially contributed to inflation before 1981, while monetary policy appears to have displayed smaller responses to oil price changes in the period since 1979, despite a greater sensitivity to changes in inflation.

A helpful historical analysis of the oil price shocks are given by Robert B. Barsky and Lutz Kilian (2004). It is believed that there is a close link from political events in the Middle East to changes in the price of oil, and in turn from oil price changes to macroeconomic performance in developed countries. Political events are only one out of many factors, though, while they differ greatly from one event to the next, in accordance with variations in demand conditions in the oil market and the global macroeconomic conditions. Furthermore, the timing of oil shocks and recessions are consistent, with the notion that oil price shocks may contribute to recessions without necessarily being pivotal.

Using a multivariate vector-autoregression approach, Evangelia Papapetrou (2001) investigates the dynamic relationship among oil prices, real stock prices, interest rates, real economic activity and employment for Greece. After verifying the order of integration of the variables and testing for cointegration, she concludes that oil price shocks explain a significant proportion of the fluctuations in output growth and employment growth. Oil price shocks have an immediate negative effect industrial production and employment. Apart from that, oil prices are important in explaining stock price movements, while interest rates and growth in industrial production are negatively associated, which suggests that a rise in interest rates is likely to be associated with a lower growth in industrial production.

Another interesting note about the relationship between oil prices and macroeconomy comes from Juncal Cunado and Fernando Perez de Gracia (2003), who analysed the impact of oil prices on inflation and industrial production indexes for 13 European countries using quarterly data for the period 1960-1999. What is worth mentioning is that they obtained different results when they used a world oil price index instead of the crude oil price index, and different results, again, when they used a national real price index for each economy. This is because impact is higher when national oil prices are measured in national currency, which is subject to the exchange rates regime. Concluding, the actual oil price is found to increase in 1999, having a greater impact on Europe than in the US, due the weakness of the Euro at that time.

METHODOLOGY AND DATA

Two methods of forecasting, namely the Phillips curve model and the VAR approach, are used, in order to compare their effectiveness.

Phillips Curve Model

In the empirical analysis, we apply in both economies the standard Philips Curve model, as shown below:

$$\pi_t = \alpha + \beta_1 \pi_{t-1} + \beta_2 U_t + \beta_3 O_t + \beta_4 I_t + \varepsilon_t \quad (1)$$

where π is current inflation,

π_{t-1} is lagged inflation,

U_t is the level of unemployment,

O_t denotes the level of oil prices,

I_t is the level of interest rates, and

ε_t is the error term.

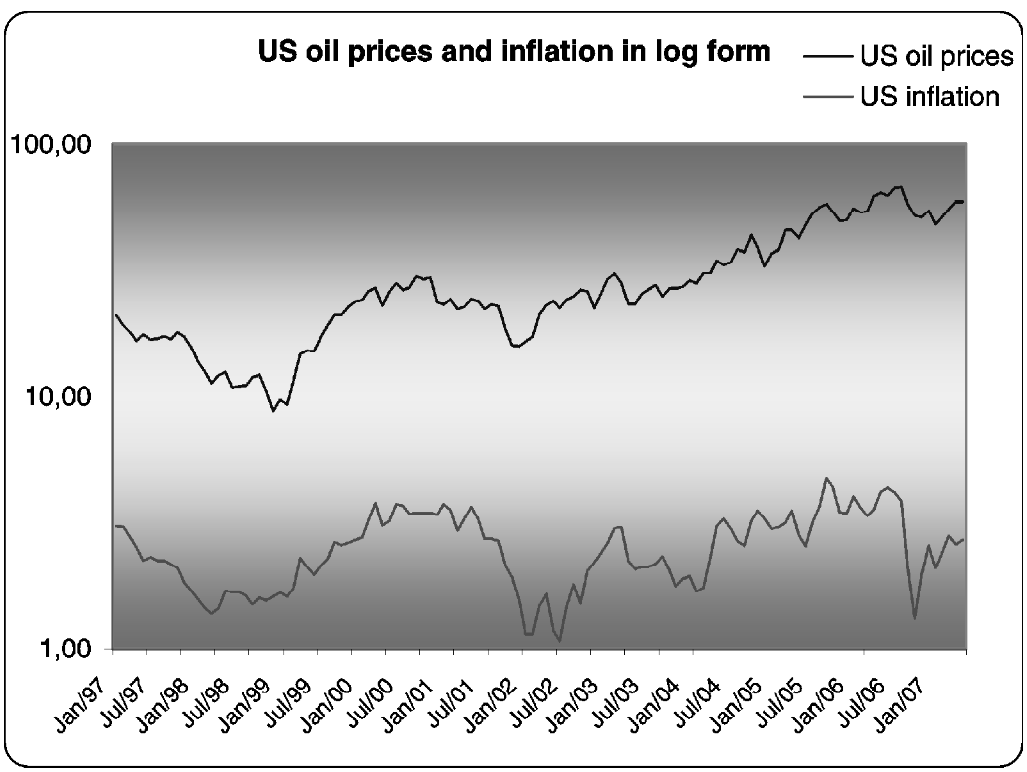
Inflation is measured as the monthly Harmonised Index of Consumer Prices (HICP) for both the US and the EU. Expected inflation and inflation persistence are captured with lags of the dependent variable.

The unemployment gap is measured as the demographically adjusted unemployment rate less the estimated Non-Accelerating Inflation Rate of Unemployment (NAIRU), which varies through time. Interest rates in the EU are taken from the money market, specifically, we account the last traded price of 1-year Euribor (Euro Interbank Offered Rate), as provided by the European Central Bank (ECB). US interest rates are taken from the prime rate charged by US banks. We include interest rates in our model in order to capture monetary policy effects, not forgetting to mention that the assumption that monetary policy works only through interest rates is conservative, as it ignores other options.

As far as the oil prices data is concerned, for the US data we use the US spot price FOB weighted by estimated import volume in dollars per barrel, while for the rest of the world oil prices, we use the crude oil domestic first purchase price. More specifically, world price is defined as the only very long-term price series that exists is the U.S. average wellhead or first purchase price of crude. When discussing long-term price behaviour this presents a problem since the U.S. imposed price controls on domestic production from late 1973 to January 1981. In order to present a consistent series and also reflect the difference between international prices and U.S. prices, a world oil price series was created that was consistent with the U.S. wellhead price, adjusting the wellhead price by adding the difference between the refiners acquisition price of imported crude and the refiners average acquisition price of domestic crude. All of the above variables are in monthly data form, ranging from January 1997 to April 2007. For the EU, we use the crude oil domestic first purchase price in dollars per barrel. Crude oil prices help to test the proposition that petroleum prices are not only important in production, but also as a forerunner of inflationary pressure, which may exceed its importance as a productive input. The Phillips Curve model equation is applied separately for the US and the EU economy for the same period (1997-2007).

The following graph, Graph 2, depicts the common trend between oil price changes, measured as the United States Spot Price FOB Weighted by Estimated Import Volume (Dollars per Barrel), and the US inflation rates, for the period January 1997-May 2007, from monthly data.

Graph 2

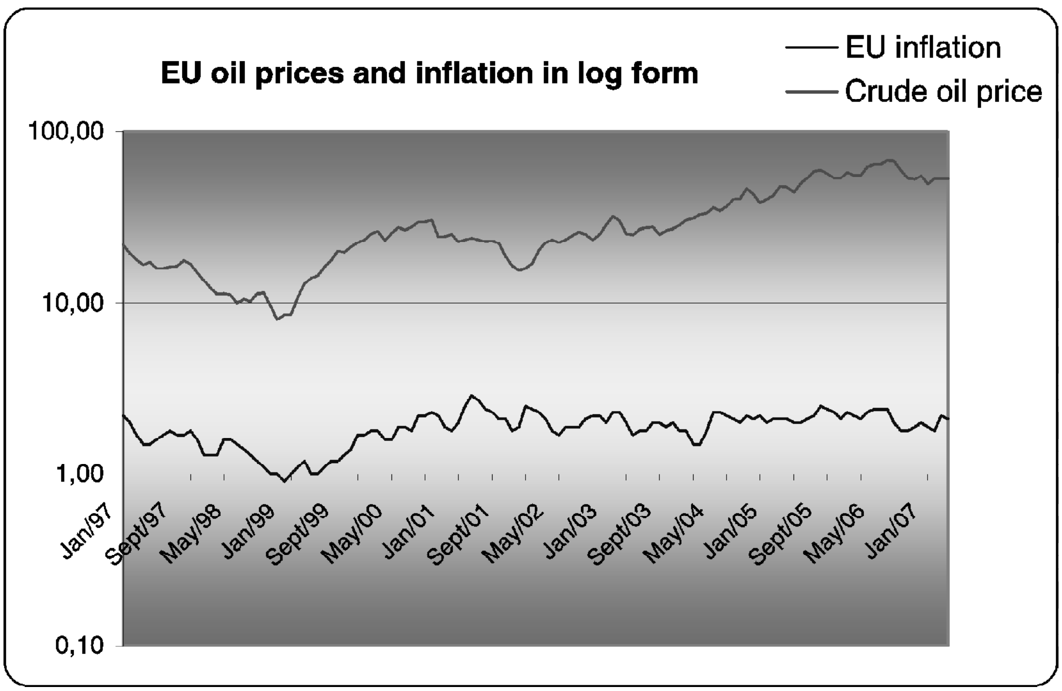


Oil price changes and inflation follow a same trend, slightly upward, with two major low levels in the periods March 1998-February 1999 and January 2002-June 2002. After February 1999, there is an oil price rise due to the OPEC meeting during that year. There have been many OPEC meetings since 1986, but only the one in 1999 was followed by sharp, but substantial, oil price increases. Of course, it takes more than a cartel meeting to drive prices up, but these particular OPEC meeting decisions were far more exogenous and responded to the macroeconomic conditions of that time.

Furthermore, apart from their indirect effects through monopolistic institutions like OPEC, macroeconomic conditions also affect the price of oil by shifting the demand for oil. This connection was more than clear after the Asian crisis in 1997-1998.

The next graph, likewise, depicts the monthly trend of EU inflation according to oil price changes, measured as the crude oil domestic first purchase price (dollars/ barrel).

Graph 3



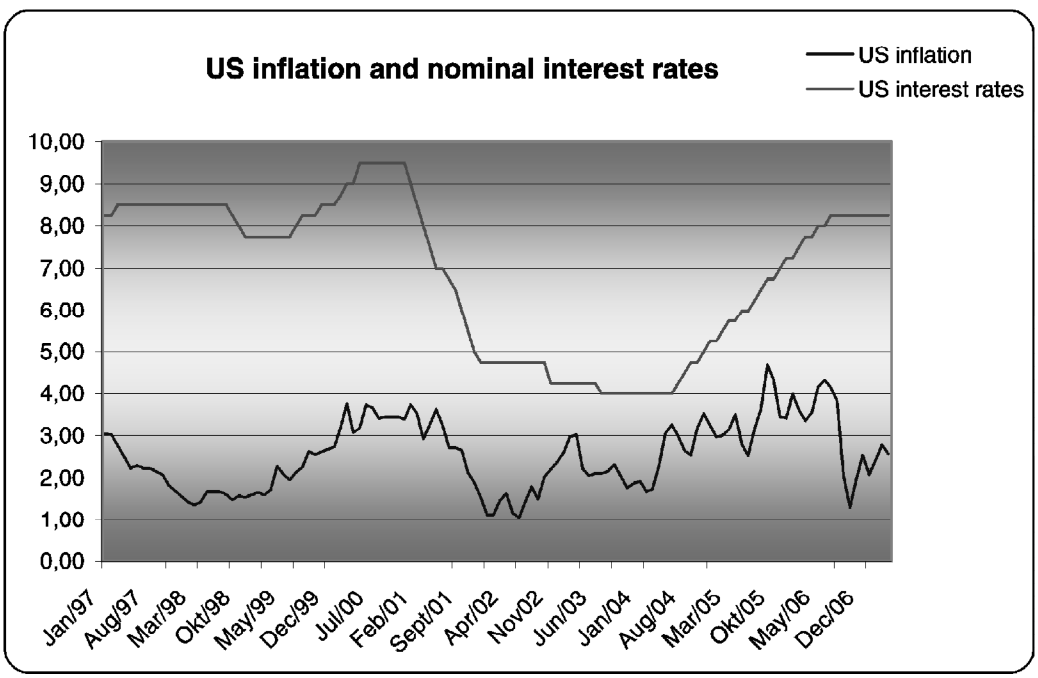
As seen clearly, there is a common trend, up until May 2002. After that, inflation tends to move around 2,4%, while crude oil prices rise constantly. Lower levels are spotted between March 1999 – October 1999. After that, the recessionary effects of the OPEC meeting in 1999 are quite obvious. Namely, there are two main reasons that EU inflation responds faster to oil price changes that US inflation. First, EU labour unions are more powerful than those in the US, and there are likely to extract demand higher wage levels in order to compensate for higher consumer prices for energy. Second, European producers are more likely to pass along higher wage costs to consumers in the form of higher product prices. Therefore, oil price shocks are more likely to initiate a wage-price chain reaction in the EU, whereas in the US workers are likely to absorb higher oil prices through higher prices in energy intensive products.

In order to visualise the relationship between inflation and interest rates, we present the following two graphs, Graph 4 and Graph 5. Generally, when central banks try to reduce inflation, their monetary policy focuses on the increase of nominal interest rates.

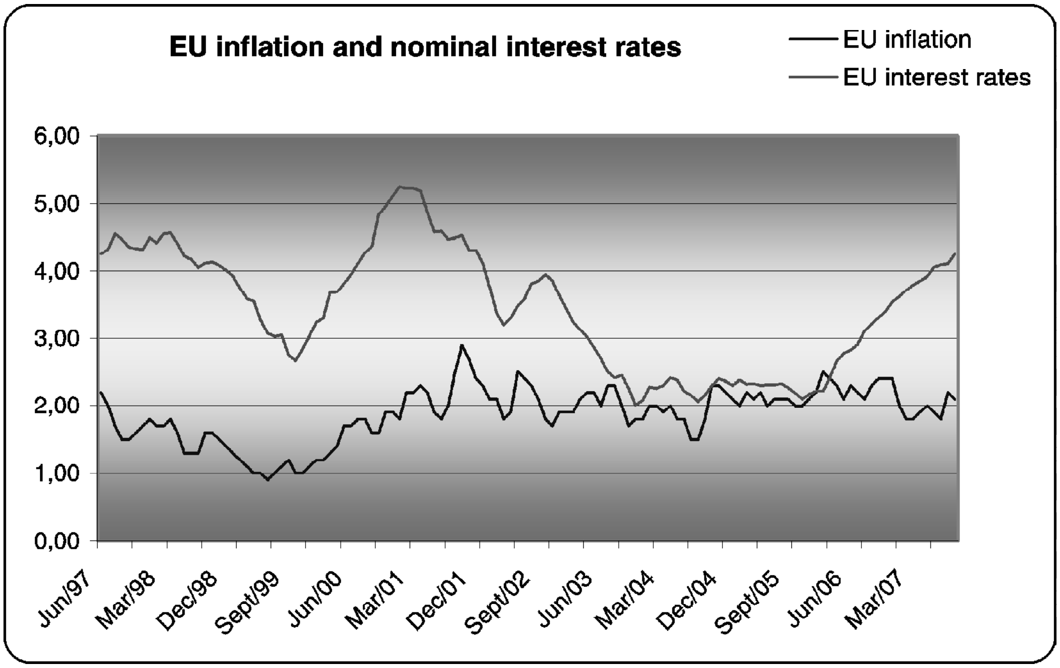
The remarkable exception here is that, increasing or decreasing interest rates are followed by increasing or decreasing inflation levels, both in the US and the EU. This positive relationship between the two variables is carried on until March 2005 for the US and June 2006 for the EU, which shows a substantial connection between interest rates in the US and the EU. In fact, nominal interest rates in the EU seem to be affected by relative movements of nominal interest rates in the US.

There is a similarity to the US and the EU oil price trend, while interest rates tend to be more stable in the US. EU interest rates respond positively to the oil price shocks up until May 2002. After that, there is a significant decline, while oil rises continue to rise.

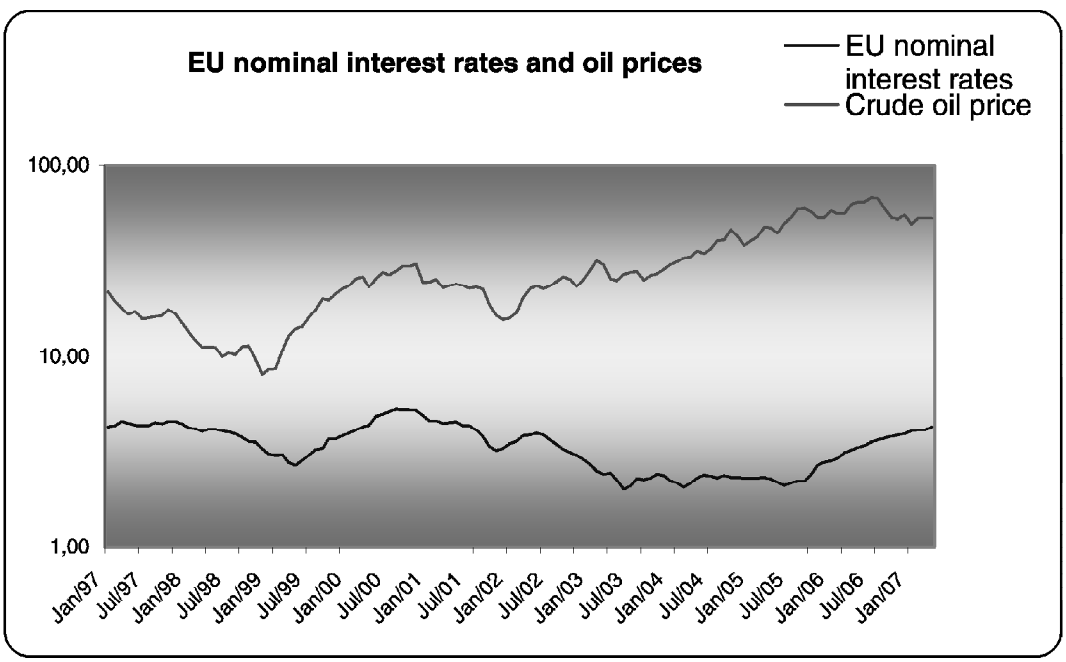
Graph 4



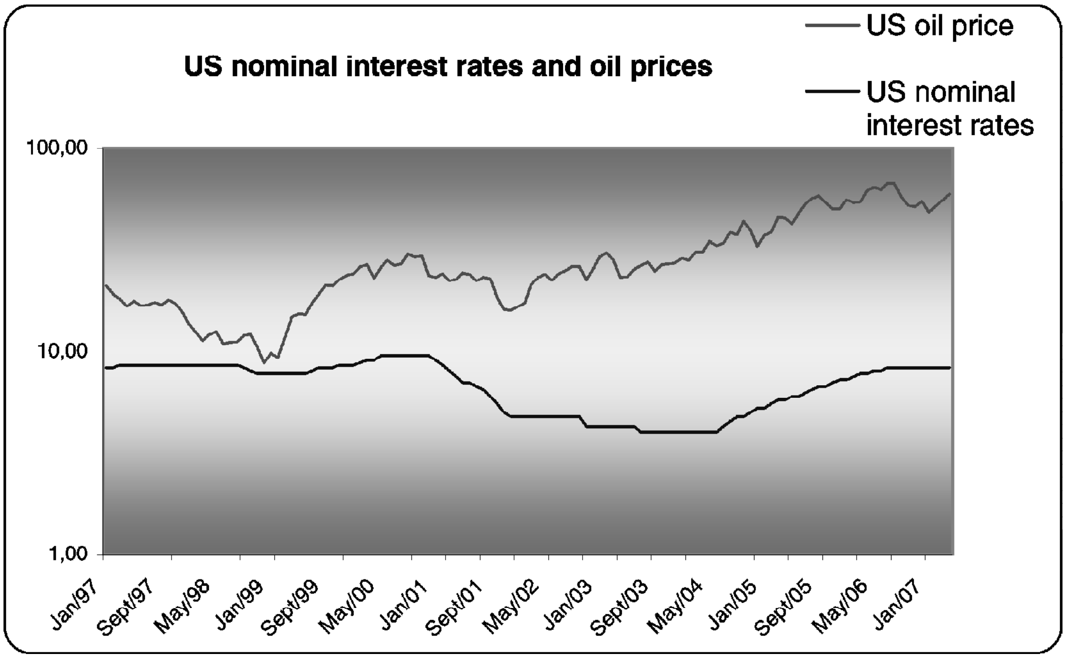
Graph 5



Graph 6



Graph 7



Cointegrating Vector Auto Regression (VAR)

In this part we perform a VAR analysis to explain how oil price shocks and inflation shocks affect both one-the-other and the rest of the variables in our model, namely unemployment levels and interest rate levels, both in the EU and the US economy. This kind of method helps us test for any endogeneity of the variables in the economy and to capture the short-term dynamics of the variables. VAR methodology resembles simultaneous-equation modelling, in which one can consider several endogenous variables together. Each endogenous variable is explained by its lagged values and the lagged values of all other endogenous variables in the model.

In the case of a two-variable model with I_t (inflation) and O_t (oil prices), vector auto-regression is a set of two equations, each of which contains κ lag values of of I_t and O_t:

$$I_t = a + \sum_{j=1}^{k} \beta_j I_{t-j} + \sum_{j=1}^{k} \gamma_j O_{t-j} + u_t \quad (2)$$

and

$$O_t = a' + \sum_{j=1}^{k} \beta_j I_{t-j} + \sum_{j=1}^{k} \gamma_j O_{t-j} + u_t \quad (3)$$

where, I_t and O_t are column vectors of observations at time t on the two variables, the u_t*'s* are the stochastic error terms (or *innovations* or *shocks*).

In our case, we have two sets of vector autoregression. One, containing all four macroeconomic variables of the EU, namely, inflation levels, unemployment levels, oil prices, and interest rates, and a second set of the same variables for the US economy. These sets are regressed in such a way in order to find the impact of inflation shocks and oil price shocks on the rest of the macroeconomic variables.

Testing for cointegration among variables is done as follows:

(i) We use a test for unit root problems in our variables using the Augmented Dickey-Fuller test (ADF test)

The ADF test is supposed to accommodate error autocorrelation by adding lagged differences of the variable (e.g. y_t):

$$\Delta y_t = \alpha + \rho\delta_t - \rho y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t \qquad t = 1, \ldots, n \tag{4}$$

where the H_0 is: $\rho = 0$

(ii) We test for cointegration using the Johansen maximum likelihood approach. This approach is based on the error-correction representation of the VAR model with Gaussian errors.

After steps (i) and (ii), if there is no relationship between the endogenous variables, we carry on with the VAR model. To determine the appropriate number of the model's lag length we employ the likelihood ratio statistic, which follows the x^2 distribution.

EMPIRICAL RESULTS

Phillips Curve model

The results of the EU inflation analysis for the period 1997-2007 according to the Phillips curve model are as follows:

$$\pi_t = 0.7594 + 0.79777\pi_{t-1} - 0.0517\,U_t + 0.001927\,O_t + 0.00293\,I_t$$

t values	(2.83)	(16.29)	(–2.29)	(1.38)	(0.16)
st error	(0.2682)	(0.04899)	(0.02254)	(0.001392)	(0.0188)
p value	(0.005)	(0)	(0.024)	(0.169)	(0.876)
R^2	82.3%				
DW statistic	1.55				

Its clear that current inflation is heavily dependent on its lagged prices. Past inflation levels, therefore, justify future upward trends. The relationship between inflation and unemployment is, as expected, negative, while oil price changes in the EU have, surprisingly enough, the smallest effect on inflation levels (0.001927). This is partly because the European economy is more labour-intensive comparing to the US economy. Furthermore, oil price shocks seem to have smaller effects than interest rates changes (0.00293). This can be explained in the sense that, interest rates' fluctuations tend to follow oil price shocks, and incorporate even more influences from other economic and social events, as in the rise of demand for mortgage loans, which can influence the equilibrium of supply-and-demand for money.

The information we get from R^2 and the Durbin-Watson statistic shows almost no multicollinearity issues and no evidence of either positive or negative first order serial correlation.

Results for the US inflation for the same period, on the other hand, are as follows:

$$\pi_t = 2.0657 + 0.78384\pi_{t-1} - 0.2648\,U_t + 0.008473\,O_t - 0.06786\,I_t$$

t values	(2.32)	(15.29)	(–2.17)	(3.11)	(–1.57)
st error	(0.8921)	(0.05128)	(0.1221)	(0.00272)	(0.04314)
p values	(0.022)	(0)	(0.032)	(0.002)	(0.118)
R^2	82.1%				
DW statistic	1.47				

Although lagged inflation seems to seriously affect future inflation levels, interest rates have a negative effect (–0.06786) on them, unlike the situation in the European economy. This could mean that, a rise in interest rates, except from lowering investment motives, will probably lower consumption as well, which in turn, will lead to a lower supply of money, resulting in lower inflation levels. This is quite the opposite from the case in the European economy. As in the case of the US economy, oil price shocks tend to have a rather discrete effect (0.008473), while unemployment has a negative one (–0.2648). Nevertheless, oil price shocks have a marginally higher effect in the US economy than in Europe. This is due to the fact that the former is more heavily dependant on industrial production that uses oil products. Current inflation levels in the case of the US are much more heavily dependent on unemployment than in the EU. Lagged values of inflation seem to have almost the same level of impact for both the European and the US inflation (0.79777 and 0.78384 respectively). Again, there are no signs for multicollinearity or serial correlation in the model. Comparatively, the US economy is influenced to a larger extent by oil price shocks than Europe, since it is more heavily dependant on oil imports for production and transportation.

Cointegrating VAR

(a) For the EU and the US economy, in order to test for cointegration among variables we follow steps (i) and (ii) discussed in section 3.2. Therefore, firstly, we use the ADF test to check for unit root problems for both economies. After testing for two different model selection criteria, $p = 1$ and $p = 2$, the results of the ADF test are as follows:

Table 1

Variable	*DF test including intercept and linear trend*	*t stat*	*LL*	*AIC*	*SBC*	*HQC*
HICP EU inflation	DF	–3,1829	38,9857	35,9857	31,792	34,2825
	ADF(1)	–3,9032	43,0081	39,0081	33,4165	36,7371
	ADF(2)	–3,3155	43,6902	38,6902	**31,7008**	35,8515
EU oil prices	DF	–2,277	–275,3127	–278,3127	–282,5064	–280,0159
	ADF(1)	–2,5526	–273,045	–277,045	**–282,6365**	–279,3159
	ADF(2)	–2,3247	–271,9445	–276,9445	–283,9339	–279,7831
EU unemployment	DF	–1,3105	149,4252	146,4252	142,2315	144,722
	ADF(1)	–1,3137	152,7894	148,7894	**143,1978**	146,5184
	ADF(2)	–1,3972	156,746	151,746	144,7565	148,9073
EU i/r	DF	0,06511	62,7136	59,7136	55,5199	58,0104
	ADF(1)	–1,1679	81,9714	77,9714	72,3798	75,7004
	ADF(2)	–1,4099	82,6997	77,6997	**70,7102**	74,861
US inflation	DF	–2,8639	–50,7582	–53,7582	–57,9519	–55,4614
	ADF(1)	–3,6224	–45,8987	–49,8987	–55,4903	–52,1697
	ADF(2)	–2,407	–37,8295	–42,8295	**–49,819**	–45,6682
US oil prices	DF	–2,3608	–293,9285	–296,9285	–301,1222	–298,6317
	ADF(1)	–2,5397	–293,1445	–297,1445	**–302,7361**	–299,4155
	ADF(2)	–2,2183	–291,472	–296,472	–303,4615	–299,3107
US unemployment	DF	–0,9899	79,9473	76,9473	72,7536	75,2441
	ADF(1)	–0,8446	80,5982	76,5982	71,0067	74,3273
	ADF(2)	–1,062	82,8564	77,8564	**70,867**	75,0178
US i/r	DF	0,5509	33,5966	30,5966	26,4029	28,8934
	ADF(1)	–0,5895	57,2476	53,2476	**47,656**	50,9766
	ADF(2)	–1,1685	62,5174	57,5174	50,528	54,6787

LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion
99% critical value for the ADF = – 3,9695%
critical value for the ADF = – 3,4190%
critical value for the ADF = – 3,12

(i) The values reported in Table 1 suggest that the correct order for the variables *EU oil prices*, *EU unemployment*, *US oil prices* and *US interest rates* is 1, given by the combination of the lower Schwarz Bayesian criterion and the statistical significance of the t statistic. For the rest of the variables the correct order is 2[1].

(ii) Now, focusing on the EU economy, in order to test for cointegration between the macroeconomic variables of the EU included in the Phillips curve model (that is, inflation level, oil price level, unemployment level and interest rates) we use the Johansen Maximum Likelihood (ML) approach employing both the maximum eigenvalue and trace statistic, as shown in the following Table:

Table 2

	Cointegration LR test based on maximal eigenvalue of the stochastic matrix			
H_0	*H_A*	*Statistic*	*95% Critical value*	*90% Critical value*
$r = 0$	$r = 1$	47,4237	23,92	21,58
$r \leq 1$	$r = 2$	20,6628	17,68	15,57
$r \leq 2$	$r = 3$	8,2496	11,03	9,28
$r \leq 3$	$r = 4$	0,0662	4,16	3,04
	Cointegration LR test based on trace of the stochastic matrix			
H_0	*H_A*	*Statistic*	*95% Critical value*	*90% Critical value*
$r = 0$	$r = 1$	76,4023	39,81	36,69
$r \leq 1$	$r = 2$	28,9786	24,05	21,46
$r \leq 2$	$r = 3$	8,3158	12,36	10,25
$r \leq 3$	$r = 4$	0,0662	4,16	3,04

Note: r indicates the number of cointegrating relationships of the variables, while maximum eigenvalues and trace statistics are compared with Johansen's critical values.

In the first two cases of H_0: $r = 0$ and $r \leq 1$, we reject the null hypothesis, in both the maximal eigenvalue and the trace of the stochastic matrix, since the statistic lies outside the critical values' limits. However, critical values of 95% and 90% show that we cannot reject the hypothesis that $r \leq 2$ in both cases.

The following table indicates cointegrated vectors findings using the Johansen estimation:

Table 3

	Estimated Cointegrated Vectors in Johansen Estimation (Normalized in Brackets)	
	Cointegration with no Intercepts or Trends in the VAR	
	Vector 1	*Vector 2*
HICP EU inflation	0,4809	–0,2064
	(–1)	(–1)
EU oil prices	–0,0123	0,005055
	(–0,2558)	(–0,0245)
EU unemployment	–0,00698	0,05454
	(–0,01451)	(–0,26420)
EU *i/r*	–0,1629	–0,04811
	(–0,3387)	(–0,23314)

The following table, Table 4, includes the levels of cointegration with no intercept or trend in our VAR model using the Johansen method:

Table 4

	Estimated Long Run Matrix in Johansen Estimation			
	EU inflation	*EU oil prices*	*EU unemployment*	*EU i/r*
EU inflation	–0,18922	0,004847	0,001069	0,06793
EU oil prices	1,442	–0,03811	0,264	–1,1409
EU unemployment	0,14356	–0,00362	–0,01275	–0,0242
EU *i/r*	0,09568	–0,00248	0,006144	–0,04965

Since Jonahsen's model does not strictly depend on the normality assumption, it enables us to see at the cross-sectional relations of the model's variables.

After performing various versions of the system in order to determine the appropriate lag length, we came down to the following four:

VAR(1) Akaike Info. Criterion 32,8586 Schwarz Bayesian Criterion 27,2343

VAR(5) Akaike Info. Criterion 39,8342 Schwarz Bayesian Criterion 12,0430

VAR(8) Akaike Info. Criterion 31,3185 Schwarz Bayesian Criterion –12,7389

VAR(12) Akaike Info. Criterion 41,6745 Schwarz Bayesian Criterion –23,5695

Following the rule of the lowest SBC in absolute value, we have to accept the VAR(5) for the EU economy autoregression method.

(b) For the US economy

(i) Estimates of the ADF test are included in Table 1. The values reported in Table 1 suggest that the correct order for US oil prices and US interest rates is 1, while for US unemployment and inflation is 2.

(ii) Testing for cointegration between the macroeconomic variables of the US economy included in the Phillips Curve model we use the same method, the Johansen ML approach:

Table 5

Cointegration LR test based on maximal eigenvalue of the stochastic matrix				
Null	*Alternative*	*Statistic*	*95% Critical value*	*90% Critical value*
$r = 0$	$r = 1$	39,8782	27,42	24,99
$r \leq 1$	$r = 2$	21,3984	21,12	19,02
$r \leq 2$	$r = 3$	3,5079	14,88	12,98
$r \leq 3$	$r = 4$	3,3072	8,07	6,5
Cointegration LR test Based on trace of the stochastic matrix				
Null	*Alternative*	*Statistic*	*95% Critical value*	*90% Critical value*
$r = 0$	$r = 1$	68,0917	48,88	45,7
$r \leq 1$	$r = 2$	31,54	31,54	28,78
$r \leq 2$	$r = 3$	6,8151	17,86	15,75
$r \leq 3$	$r = 4$	3,3072	8,07	6,5

Note: r indicates the number of cointegrating relationships of the variables, while maximum eigenvalues and trace statistics are compared with Johansen's critical values.

Using the maximal eigenvalue statistic we reject the H_0 that $r = 0$ and that $r \leq 1$ both at the 95% and at the 90% level of significance. We can accept, though, the H_0 that $r \leq 2$ at the 95% and at the 90% level of significance.

The following table lists the levels of cointegration of the vectors after the Johansen estimation for the US economy's variables:

Table 6

	Estimated Cointegrated Vectors in Johansen Estimation (Normalized in Brackets) Cointegration with no Intercepts or Trends in the VAR	
	Vector 1	*Vector 2*
HICP US inflation	0,21786	–0,10549
	(–1)	(–1)
US oil prices	0,004343	–0,003882
	(–0,019939)	(–0,00368)
US unemployment	0,013683	–0,80176
	–0,062803	(–7,6004)
US *i/r*	–0,00628	–0,31586
	–0,002891	(–2,9942)

The following table, Table7, includes the levels of cointegration with no intercept or trend in our VAR model using the Johansen method:

Table 7

	Estimated Long Run Matrix in Johansen Estimation			
	HICP US inflation	*US oil prices*	*US unemployment*	*US i/r*
HICP US inflation	–0,28221	–0,00488	–0,36379	–0,13679
US oil prices	–0,77965	–0,0015284	–6,5473	–2,5816
US unemployment	0,038885	0,007977	–0,0079445	–0,0042424
US *i/r*	–0,01621	–0,001884	–0,06353	–0,024811

After performing various versions of the system in order to determine the appropriate lag length, we came down to the following three:

VAR (1) Akaike Info. Criterion -54,9548 Schwarz Bayesian Criterion -60,5792

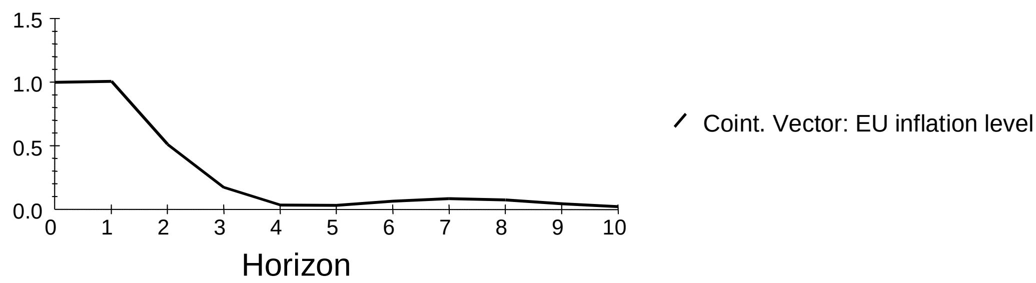
VAR (4) Akaike Info. Criterion -48,1565 Schwarz Bayesian Criterion -70,4565

VAR (6) Akaike Info. Criterion -51,9036 Schwarz Bayesian Criterion -85,1518

Following the rule of the lowest SBC in absolute value, we have to accept the VAR(1) for the US economy variables autoregression method.

Microfit 4.1 enables us to capture multivariate, multi-step ahead forecasts of levels and first-differences of a variable y conditional on other values. We use this ability to evaluate the level of the effect that system-wide shocks have on the cointegrating relations of the variables among them. Therefore, we start by depicting at Graph 8 the persistence profile (i.e. system shocks) for the EU economy, following a VAR(5) and $r = 2$. EU inflation is included in the cointegrating vector, while in VAR the included variables are EU oil prices, EU unemployment, and EU interest rates. We can see the responses of the three variables of the VAR after a disturbance to the inflation levels.

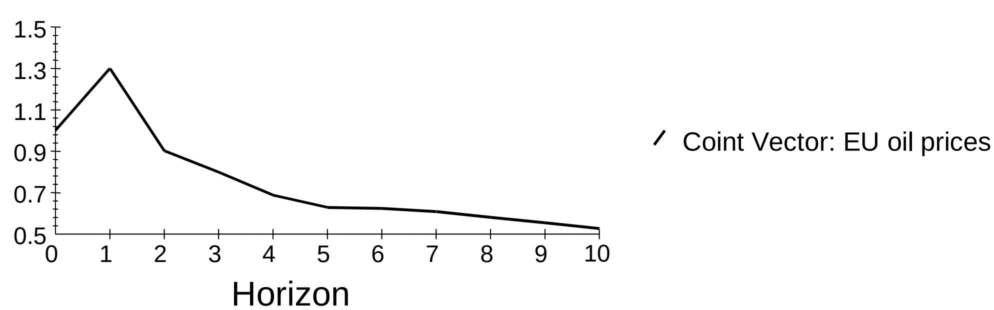
Graph 8



At Graph 8, we see the responses to a one-standard deviation inflation level shock. Clearly, for the first month, there is no actual response from the other variables to an inflation change. Continuing, any positive changes in inflation level will have a cumulative negative to the rest of the variables, up until the 4^{th} month. After that, there is steady positive relationship of 0.01.

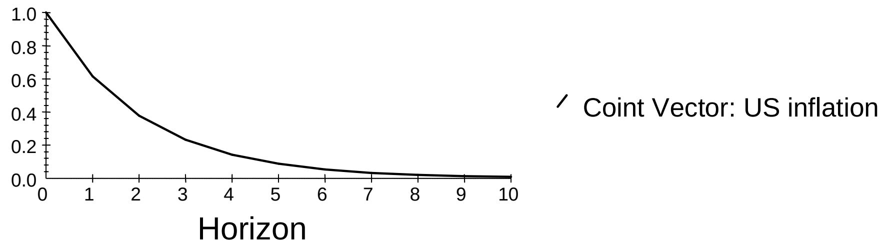
Graph 9 depicts the system-wide shocks for the EU economy, following a VAR(5) and $r = 2$ and including EU oil prices in the cointegrating vector. Variables included in VAR are EU inflation, EU unemployment and EU interest rates. More simply speaking, we can see the responses of the rest of the variables after a disturbance at the EU oil prices level. Obviously, there is increased volatility, unlike the case in the disturbance at the US oil price level (Graph 11). An EU oil prices shock has a positive cumulative effect on unemployment, interest rates, and inflation, for the first month. A steep decline follows, lasting until the second month, and after that, a *smoothening* declination takes place.

Graph 9



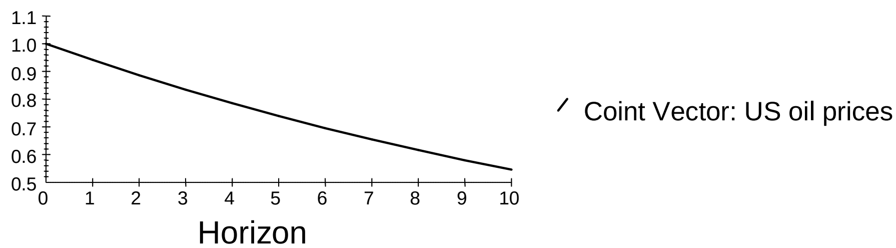
For the US economy, Graph 10 depicts the system-wide shocks, following a VAR(1) and $r = 2$ and including US inflation levels in the cointegrating vector. Variables included in VAR are US oil prices, US unemployment and US interest rates. Therefore, a positive shock to inflation level will result in a decline of the other variables cumulatively. The effect here is smoother than in the EU (Graph 8).

Graph 10



The following graph depicts the system-wide shocks for the US economy, following a VAR(1) and $r = 2$, including US oil prices in the cointegrating vector. Variables included in VAR are US unemployment, US inflation and US interest rates.

Graph 11



Clearly, US oil price shocks tend to smoothly affect the rest of the variables of the VAR model, resulting in an almost straight line. Note that, unlike in the case of the EU, where initially there was a positive effect, there is only a negative effect in the Us economy from the beginning. The economy seems to easily absorb this effect, unlike the EU economy.

CONCLUSIONS

Comparing the two methods, the Phillips curve model shows that oil price shocks tend to have marginally different impacts on inflation on the US and the EU as a whole. More specifically, in the US, every 1% increase of oil prices will positively affect inflation with a 0.0084% increase. Overall, current inflation levels seem to depend more on past inflation levels than anything else. Interest rates in the US negatively affect inflation in combination with oil price shocks, while in the EU they show a modest positive affect.

Inflation in Europe seems to be less sensitive to oil prices than in the US, therefore, the higher energy intensity of the US economy is successfully counterbalanced by the increased inflationary pressures from strong labour union in Europe. On the contrary, the VAR approach shows that in the case of the EU economy, a disturbance at the EU oil prices level leads to increased volatility in the other variables, unlike in the US economy. Overall speaking, the VAR approach seems to capture in more detail the effects of oil price shocks on the rest of the macroeconomic variables than the Phillips curve model, since the latter only examines the linear relationship of the variables.

Further research could take into account the exchange rate effect associated with a dollar denominated oil price. Oil producer and selling countries positively affect their customers' exchange rate levels by increasing the price of their product. This acts as a chain reaction, since exported goods of countries, which are heavily based on oil, tend to become more expensive for importing countries.

NOTE

1. Generally speaking, a result of $r > 2$ leads to no meaningful interpretations when using the Johansen approach. In our case, though, $r \leq 2$, so we encounter no problems whatsoever.

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