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Impact of Oil Price Increases on U.S. Economic Growth: Causality Analysis and Study of the Weakening Effects in Relationship

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Abstract: The two oil shocks of the 1970s reduced the GDP growth rate, and since that period, sudden oil price increases have been considered as a major source of economic slowdown in the world. We thus estimate simple linear regression model (SLRM), dynamic regression model (DRM) and VAR model to evaluate the impact of oil price increases on the U.S economic growth. Our results indicate strong weaknesses on the relation between these two factors in what way that the relation has had a low significant effect caused by the existence of breakpoints and the asymmetric effects of the oil price variations.

Keywords: Oil shocks; GDP growth rate; SLRM; DRM; VAR model; Breakpoints; Asymmetrical effects.
JEL Classifications: C22; E31; Q43

1. Introduction

According to the 2012 oil market report[1] published in the Organization for Economic Cooperation and Development (OECD) and the International Energy Agency (IEA, 2012), oil constitutes the more important source of energy and represents an essential factor which spurs the development in the economic sectors (such as electricity, transport, industry, agriculture …) and the noneconomic sectors (such as the military service), too. Moreover, we notice that the oil price has increased significantly during the last decade which may affect the economic situations of the countries which based on the use of huge quantities of oil. This lead to an increase in the oil demand, a decrease in the oil supply which generates, an increase in extraction and refining costs and also an increase of oil importations.

In theoretical studies, the relation between oil price and economic growth has been widely investigated and several transmission channels of the variations of oil price to economic growth have been identified. However, there are distinct differences between historical effects observed during the 1970's crisis and the expected effects predicted by theoretical models.

In the same vein several empirical studies have documented that the relationship between the GPD growth rate and the oil price have been changed after the 1986 oil price collapse. Different theoretical explanations are considered to justify the relationship between economic growth and oil price such as Hamilton (1983, 1996, 2003, 2008) and Hooker (1996, 1999).

Hamilton (1983) concluded that the relationship is asymmetric and that only a high increase in the oil price can affect significantly the economy. In the same paper, the results indicate especially that the weakening of the effects of oil price variations on the GDP growth during the 1986 oil price collapse can be due to the fact that the decrease in the oil price has a low impact on the economy.

To test this theory, we try to estimate separately the effects of increases and decreases of the oil prices on the economy (see: Hamilton, 2008). On another hand, Hooker (1996) examined the existence of breakpoints in the relationship between oil price and GDP Growth rate and he proved that the U.S. economy has been characterized by a regime change around 1973 and because that there is an existence of a significantly different sensitivity to changes in oil prices before and after this date. This hypothesis is being re-examined by Hamilton (1996).

[1] Source: http://omrpublic.iea.org/currentissues/full.pdf

All these considerations show that profound changes in the oil price variations are due to more than one single factor or one single cause. And for this reason, we incite to evaluate the sources, the nature and the importance of the effect of the oil price increases on economic growth.

Thus, in order to investigate the relationship between oil price changes and economic growth, we also propose to answer the following questions:

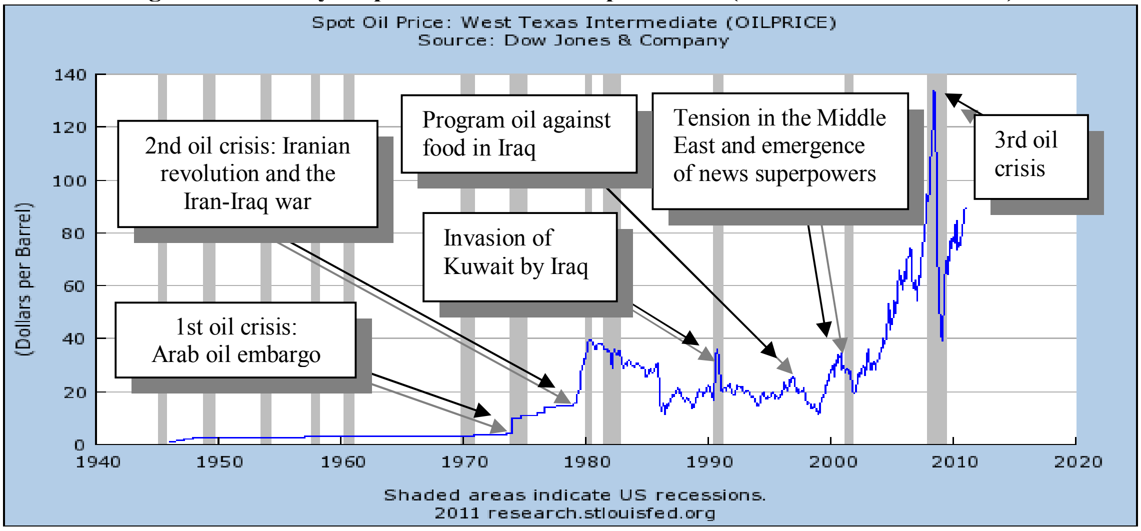
• What are the principal transmission channels of the oil price variations to the economy?
• How can we explain the weakening effects of the oil price variations on the GDP?
• What should be therefore the relationship between oil price and economic growth?

The remainder of this paper proceeds as follows. Section 2 presents the literature review. Section 3 contains the empirical results. Conclusion is provided in the last section.

2. Literature Review

We start with an investigation of the principal transmission channels of the oil price crisis (**Figure 1**) to the economy such they are observed in earlier theoretical studies. In the second stage, we will present the theoretical explanation of the weakening of the relationship between the oil prices variations[2] and the economic growth[3].

Figure 1. Monthly oil price in U.S. dollars per barrel (01/01/1946 – 01/01/2011)



2.1. Principal transmission channels of oil price crisis

In this section, we will study some tests to demonstrate the existence of instability in the relationship between oil price and economic growth. These tests help us to find the best suitable model for such a time series. That is to say we must decide whether to keep the model in its integral form (if the parameters are fixed over the total period), or to divide it (if there is a breakpoint(s)). Several tests of parameters instability have been proposed in the literature with the most known: Chow test, likelihood ratio (LR) test, CUSUM test, CUSUM of squares test, Wald test, Lagrange multiplier (LM) test, etc.

A point of view commonly shared is that six principal transmission channels of oil price variations to the economy can exist and that they help us to comprehend the involvement of the oil price increase.

The first channel mentioned that an increase in the cost of intermediate consumption will be followed by a deceleration of the production and the productivity. This context means to say that the increase in the oil price is due to the increase in the oil demand, the increase in the costs of production and seemingly the decrease in the production growth and the productivity. But this situation has also generated an indication of the oil wells depletion (see: Brown and Yücel, 1999; Abel and Bernanke, 2001).

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[2] The variation means the difference between the current value and the lagged value by one period in logarithmic term.

[3] The economic growth is given by the variation of GDP in logarithmic term.

The second channel tries to develop the point of the transfer of wealth between oil-exporting countries and oil-importing countries. In this vein, the increase in oil price generates a transfer of income from the oil-importing countries towards the oil-exporting countries. This argument is inspired by the work of Dohner (1981), where he considered particularly that the income has an impact on the trade balance because the oil-exporting countries have a propensity to consume less than the oil-importing countries.

The third channel explains what the inflation increase means and why the second-round effects are related to the salary adjustment. In this way, Barlet and Crusson (2009) show that the increase of petroleum products will generate systematically the inflation (means followed by a first-round effects). At this level, the rise in inflation rate will generate a salary adjustment (means followed by a second-round effects on prices) that are related to the agent behavior, in the sense that, when producers may decide to raise production costs by increasing selling prices, workers may demand higher wages in order to compensate for their loss of purchasing power. This effect shows that the wages indexation on prices will be high and that is why the second round effects are mitigated by the development and rising unemployment, and the wage pressures will be reduced.

The fourth channel explains the fall of durable goods and investment consumption by the uncertainty of the economic environment. That is returned to explain that the oil price increases affect the oil consumption, which generates firstly a rise in inflation and which influences thereafter on the households' purchasing power (by the wages). This pressure on the prices, created by the shock, can change the behavior of economic agents because they know that the environment is uncertain. In this case, the consumption of durable goods will decrease because they are directly related to the available incomes. And in another case, the investments in capital are likely to be delayed for not supporting more risk with the companies of investment (see: Hooker, 1996).

The fifth channel incites to investigate the subject of the increase in monetary demand. This idea, inspired by the works of Pierce and Enzler (1974) and Mork (1994), is used to prove that the oil price increase generates an increase in monetary demand, which forces monetary authorities to increase the money supply in order to meet the incapacity, the disability and the insufficiency of the mass. However, Brown and Yücel (2002) explain, in their paper, that this action will involve a rise of interest rates and a slowdown in economic growth.

The last channel talks about the modification of the production structure and how this situation can affect the unemployment rate. This point means that the increase of oil price decreases the profitability in sectors that consume high quantities of oil. And in this case, the current situation can oblige the companies to adopt new strategies and new oil production and oil consumption methods. This conclusion was proved by Loungani (1986). And it helps firstly to have a reallocation of capital and labor between sectors and tries secondly to affect the unemployment rate.

2.2. Explanations of the weakening effects on the relationship

2.2.1. Rupture between GDP and oil price in direct relationship

The presence of a rupture in the relationship between GDP growth rate (GDP in logarithmic variation) and oil price in logarithmic variation is considered as a more important assumption of asymmetrical effects in the recent literature.

In a major way, the presence of a rupture was tested specially, on the American series, per Hooker (1996, 1999) and Hamilton (1996), and recently on the case of France by Barlet and Crusson (2009).

Moreover, for Hooker (1996, 1999), the US economy knew a regime change around 1973. This hypothesis of the existence of rupture is called as question in the paper of Hamilton (1996). He wanted to say that this hypothesis is not convincing over the recent period and changes qualitatively around the average of the mid-Eighties. After this date, the oil price distribution stills rising and it results a significant effect on the economy, but it results also a weakening effect on the relationship between oil price and economic growth.

2.2.2. Asymmetric effects of the oil price variations

It is noted that although majority studies have been proposed to explain this weakening in the relationship between oil price and GDP growth rate by an asymmetric effect of oil price variations, in particular by Hamilton (1983, 1996, 2003, 2008) and Hooker (1996) for the American literature and even recently for the French literature by Jiménez-Rodriguez and Sanchez (2005), Lardic and Mignon (2008) and Barlet and Crusson (2009) and even for some countries of Asia by Prasad et al. (2007).

Thus, it should be noted that the asymmetric effect of the oil price variations is different between studies. For example, Mork (1989), Hamilton (1996, 2008) and Lee et al. (1995) showed, on the American data, that only the rises of the oil price have an impact on the GDP growth rate. In other manner, they want to show that the decrease of the oil price does not have any effect on the economic activity.

In addition, Mork (1989), Lee et al. (1995), Hamilton (1983, 1994, 1996, 2008) and Barlet and Crusson (2009) noted that the relationship between GDP growth rate and oil price variations have weakened, especially during the last three decades, precisely after the 1986 oil price collapse. And they proved that the impact of oil price increases on economic growth is negative.

On another side, Hamilton (1983) privileges the hypothesis of the asymmetric relationship between GDP growth rate and oil price variation. And According to his paper, only the huge increases in oil price have an impact on the economy. In the same paper, Hamilton (1983) showed that nine of the ten American recessions were preceded by a major oil price rising.

Consequently, the weakening effect of the oil price variations on the economic growth during the 1986 oil price collapse is checked by the decreases of the oil prices which have low impact on the economy. And this theory is well tested and checked by Hamilton (2008), where he estimated separately the effects of the increases and the decreases of the oil price on the U.S. GDP growth rate.

At the same, Jiménez-Rodriguez and Sanchez (2005) noted, in their study on the OECD countries, that an oil price increase had a significant impact on GDP more than a case of oil price decrease.

Moreover, Kim and Willett (2000) used panel data to investigate the relationship between oil prices and economic growth in the case of the OECD countries. The results indicate a negative relationship between these two factors. And the same results are confirmed recently by Glasure and Lee (2002) for Korean country.

In another study that was performed on PICs (Pacific Island Countries), Prasad et al., (2007) examined the relationship between oil price and real GDP over the islands of Fiji and have concluded that an increase in oil price has had a positive effect. Hence these results are not consistent with those observed in several developed countries.

3. Methodology and Empirical Results

3.1. Bi-variable relationship: GDP Growth Rate –Oil Price

Earlier studies have documented a negative impact of oil price increase on US economic growth (see: Hamilton 1983, 1996, 2003, 2008 and Hooker, 1996). They consider particularly either a rupture in the relationship between oil price variations and economic growth or asymmetric effects of oil price variations. In this study, we use to combine these two approaches once opposing the results given using the annual data to those found using the quarterly data during the period 1960-2009.

We start to investigate the simultaneous evolution of oil price and economic growth. In order to do, we consider firstly a Linear Regression Model (LRM) between these two factors with, particularly, the GDP growth rate [calculated by using Real GDP measured in constant 2005 U.S. million dollars[4]] as endogenous variable and the oil price [means Real oil price in U.S. dollar per Barrel[5]] as exogenous variable, and we will note that the two variables are measured in natural logarithms to reduce heteroscedasticity. In a second stage, we investigate to conserve the same type of model and we will just change logarithmic oil price by oil price logarithmic variations. In the last stage, we pass to use another model more general than Linear Regression Model (LRM) called Dynamic Regression Model (DRM).

3.1.1. Linear Regression Model (LRM): GDP Growth Rate - Oil Price

In the first stage, we start to propose the distributions of $DLN(GDP_t)$ and $LN(OILPRICE_t)$ using the annual data and the quarterly data during the period 1960-2009 (**Figure 2** and **Figure 3**).

[4] Source: http://research.stlouisfed.org/fred2/series/GDPC96?cid=106
[5] Source: http://research.stlouisfed.org/fred2/series/OILPRICE?cid=98

Figure 2. Annual GDP Growth Rate (DLNGDP)-Oil Price (LNOILPRICE) (1960 - 2009)

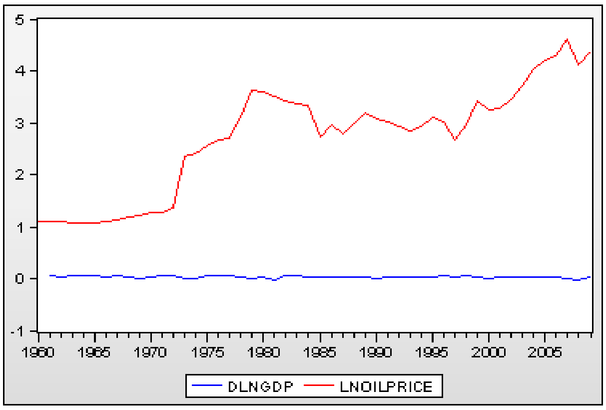
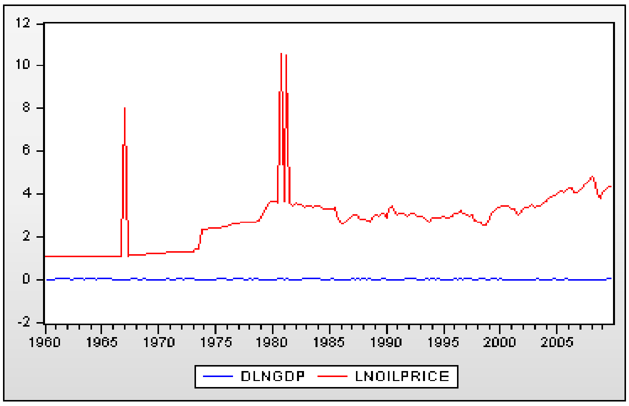


Figure 3. Quarterly GDP Growth Rate (DLNGDP)-Oil Price(LNOILPRICE) (1960Q1 - 2009Q4)



After that, we will examine the simple linear regression model between DLN(GDP_t) and LN($OILPRICE_t$) by using the two following models:

$$DLN(GDP_t) = \alpha + \beta.LN(OILPRICE_t) + \varepsilon_t \quad (1)$$

$$DLN(GDP_t) = \beta.LN(OILPRICE_t) + \varepsilon_t \quad (2)$$

Table 1. Estimation results for model (1) and model (2)

		α	LNOILPRICE	R^2	d	AIC	SC	HQC
Annual Data	**DLNGDP *Model(1)***	0,005536** (6,898912)	-0,008874** (-3,236567)	0,182	1,602	-4,98305	-4,90583	-4,95375
	DLNGDP *Model(2)*		0,008848** (6,576084)	-0,646	0,854	-4,32441	-4,28580	-4,30976
Quarterly Data	**DLNGDP *Model(1)***	0,001054** (7,544426)	-0,001026** (-2,257063)	0,025	1,421	-6,66305	-6,62995	-6,64966
	DLNGDP *Model(2)*		0,002060** (9,169973)	-0,256	1,023	-6,41929	-6,40274	-6,41260

Notes: Model (1) includes an intercept. Model (2) presents without intercept. T-statistics are given in parentheses. ** Indicates the parameters are significant at the 5% level. R^2: coefficient of determination, d: Durbin Watson statistic, AIC: Akaike Information Criterion, SC: Schwarz Criterion, HQC: Hannan-Quinn Criterion.

Table 1 shows the results for the two estimated models (**Model 1** and **Model 2**). These results indicate statistically significant coefficients for the four cases. In fact, all t-statistics are, in absolute value, higher than theoretical value (1.96) at the 5% level. The coefficient of determination, noted R^2, is very low ($R^2 \rightarrow 0$) for the models containing intercept (α), so this indicates a bad adjustment of these models, whereas in the cases of model without intercept (α), the coefficient of determination is completely negative what is impossible because it must be always given by $0 < R^2 < 1$. Moreover, we use to minimize the information criteria, because that we are incited to consider model containing intercept (**Model 1**) when we compare it with model without intercept (**Model 2**). In the same vein, the coefficient of Durbin-Watson (d) can also judge these types of models, as soon as for the four cases, this coefficient, calculated by d=2. (1 -φ), is enough far from 2 (i.e. the coefficient of correlation is far from 0), so we can conclude then the presence of errors autocorrelation. So we can't use a simple linear regression model between DLNDGP (GDP Growth Rate) and LNOILPRICE (Oil Price in natural log).

3.1.2. Linear Regression Model (LRM): GDP Growth Rate - Oil Price Variation

According to the idea indicated in the paper of Rajhi, Benabdallah and Hmissi (2005) and inspired from the study of Bohi (1991), several authors argue that the rupture in the relationship between oil price and macroeconomy is due to the problem of default specification in the term of oil price, rather than the weakening effect in the direct relationship, and because that it is considered a one of the asymmetrical effects in the relationship between these two factors. This argument means that the oil price in level (LNOILPRICE) don't have significant effects on the macroeconomy (economic growth), but rather the oil price variations (DLNOILPRICE). As a result, several researchers have used thereafter the oil price variations (DLNOILPRICE) instead of the oil price (LNOILPRICE).

Considering this implication, we start to propose the distributions of DLN (GDP_t) and DLN($OILPRICE_t$) using the annual data and the quarterly data during the period 1960-2009 (**Figure 4** and **Figure 5**).

Figure 4. Annual GDP Growth Rate (DLNGDP)-Oil Price Variation (DLNOILPRICE) (1960 - 2009)

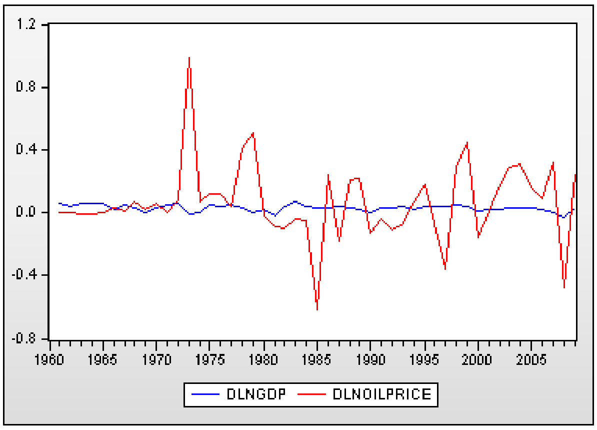
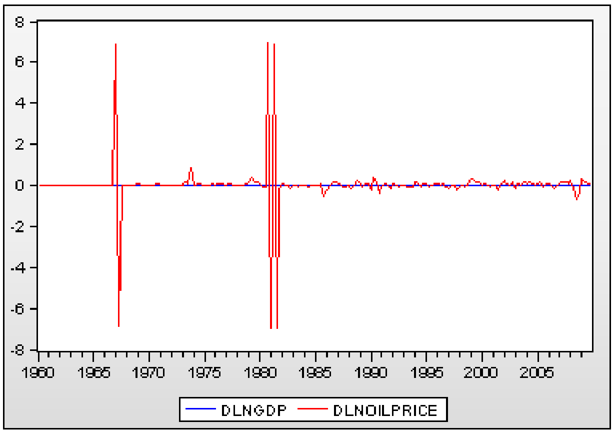


Figure 5. Quarterly GDP Growth Rate (DLNGDP)-Oil Price Variation (DLNOILPRICE) (1960Q1-2009Q4)



After that, we will investigate the simple linear regression model between DLN(GDP_t) and DLN($OILPRICE_t$) by using the two following equations:

$$DLN(GDP_t) = \alpha + \beta.DLN(OILPRICE_t) + \varepsilon_t \tag{3}$$

$$DLN(GDP_t) = \beta.DLN(OILPRICE_t) + \varepsilon_t \tag{4}$$

Table 2. Estimation results for model (3) and model (4)

		α	LNOILPRICE	R^2	d	AIC	SC	HQC
Annual Data	**DLNGDP** ***Model(3)***	0,031625 (0,89231)	-0,008937 (-0,715170)	0,011	1,388	-4,79266	-4,71544	-4,76337
	DLNGDP ***Model(4)***		0,023471 (1,120335)	-2,049	0,486	-3,70787	-3,66927	-3,69323
Quarterly Data	**DLNGDP** ***Model(3)***	0,00769** (12,58991)	0,001085** (2,145618)	0,023	1,296	-6,66062	-6,22752	-6,64722
	DLNGDP ***Model(4)***		0,001172 (1,729492)	-0,763	0,720	-6,08033	-6,06378	-6,07363

Notes: Model (3) includes an intercept. Model (4) presents without intercept. T-statistics are given in parentheses. ** indicates statistical significance at the 5% level. R^2: coefficient of determination, d: Durbin Watson statistic, AIC: Akaike Information Criterion, SC: Schwarz Criterion, HQC: Hannan-Quinn Criterion.

Table 2 shows the results for the two estimated models (**Model 3** and **Model 4**). In this case, it is noticed that only for the quarterly data, the estimation results of the model containing intercept indicate statistically significant coefficients because the t-statistics are, in absolute value, lower than theoretical value (1.96) at the 5% level. But for the remainder of the models, the coefficients are all non significant. In addition, the coefficients of determination "R^2" is very low (R^2 = 0,023→0) so that is indicated a bad adjustment of this model.

So we can conclude that the relation between the economic growth and the oil price cannot be a direct linear regression model and because that we pass to use another model more general than Simple Linear Regression Model (SLRM) called Dynamic Regression Model (DRM).

3.1.3. Dynamic Regression Model (DRM): GDP Growth Rate - Oil Price Variations

The theory of the dynamic regression model is explained very well by Greene (2003) and it is retained in empirical works by several authors such as Rajhi, Benabdallah and Hmissi (2005) and Barlet and Crusson (2009). This model contains an endogenous variable (DLNGDP) which depends on its past values and on regressors namely exogenous variables (DLNOILPRICE). This model is written by the following form:

$$DLN(GDP_t) = \alpha + \sum_{i=1}^{p} \beta_i .DLN(GDP_{t-i}) + \sum_{j=0}^{q} \delta_j .DLN(OILPRICE_{t-j}) + \varepsilon_t \qquad (5)$$

It should be also noted that “p” is the lags number of endogenous variable (DLNGDP) and “q” is the lags number of exgenous variable (DLNOILPRICE). The regressions presented are based on the hypothesis of the exogeneity in oil price. This hypothesis was discussed for the United States case by Barsky and Kilian (2004).

3.1.3.1. ADF Test and choice of lags number

In this line, we apply the strategy which proceeds by the elimination principle, while starting with the tests carried out on the model with intercept and trend. And each time a coefficient is not significant, it will be eliminated in the following sequential stage. This strategy is based on test ADF for rejecting or accepting the hypothesis of the existence of the unit root.

To choose the suitable lags number in the **Model 5**, it comes to retain the lags which minimize joint AIC (Akaike) and SC (Schwarz) criteria. **Table 3** presents summary lags number for annual data and it is noted that the minimization of Akaike and Schwartz criteria leads to a choice of optimal lags number “p = 1; q = 1”.

Table 3. Choice of optimal number of lags « p » and « q » for annual data

Number of lags	AIC	SC	Number of lags	AIC	SC
p=1, q=0	- 4.880493	- 4.763543	**p=2, q=0**	- 4.848296	- 4.690837
p=1, q=1	**- 4.970731**	**- 4.814797**	**p=2, q=1**	- 4.915633	- 4.718809
p=1, q=2	- 4.911336	- 4.714512	**p=2, q=2**	- 4.884264	- 4.648075
p=1, q=3	- 4.869716	- 4.631198	**p=2, q=3**	- 4.862015	- 4.583744
p=1, q=4	- 4.863729	- 4.582693	**p=2, q=4**	- 4.848135	- 4.526951

But in **Table 4** which presents summary lags number for quarterly data, it is clear, whatever the model selected, that the minimization of Akaike Information Criterion (AIC) leads to a choice of optimal lags number “p=2 ; q = 2”, while the Schwartz Criterion (SC) leads to a choice of “p=2; q= 0”. We conclude thus here the presence of a diagnosis divergence in the use of these two criteria, which arrives often in the reality.

Table 4. Choice of optimal number of lags « p » and « q » for quarterly data

Number of lags	AIC	SC	Number of lags	AIC	SC
p=1, q=0	- 6.781279	- 6.731457	**p=2, q=0**	- 6.820669	**- 6.754005**
p=1, q=1	- 6.771215	- 6.704786	**p=2, q=1**	- 6.810629	- 6.727298
p=1, q=2	- 6.797552	- 6.714222	**p=2, q=2**	**- 6.822893**	- 6.722897
p=1, q=3	- 6.785366	- 6.685016	**p=2, q=3**	- 6.809687	- 6.692612
p=1, q=4	- 6.785169	- 6.667677	**p=2, q=4**	- 6.816539	- 6.682262

In this case, it is necessary to understand very well the objective of the study, which consists in general to control the autocorrelation of the innovations. Consequently, we choose the minimal structure which makes possible to achieve this goal. According to a principle of parsimony, it is advisable to estimate the model including the minimum of parameters and which presents absence of residuals autocorrelation. And for that, we thus adopts "p = 2; q = 0".

3.1.3.2. OLS estimation

According to the results presented in **Table 5**, only DLNOILPRICE coefficient, for annual data, is no significant (t-stat < 1.96). The statistical interpretation of two data is as follows:

If the annual DLNOILPRICE(-1) ≡ DLN($OILPRICE_{t-1}$) increases by 1% then the annual GDP growth rate (DLNGDP) decreases by 0.028229%. On the other hand, if the quarterly DLNOILPRICE ≡ DLN($OILPRICE_t$) increases by 1% then the quarterly GDP growth rate (DLNGDP) will increase by 0.001134%.

Table 5. Estimation results for model (5) by OLS

		α	DLNGDP(-1)	DLNGDP(-2)	DLNOILPRICE	DLNOILPRICE(-1)
Annual Data	**DLNGDP**	0,023913** (4,74045)	0,293660** (2,225380)		-0,011839 (-1,046455)	-0,028229** (-2,490781)
Quarterly Data	**DLNGDP**	0,004384** (5,283621)	0,286525** (4,150206)	0,159546** (2,313240)	0,001134** (2,437749)	

** indicates statistical significance at the 5% level. T-statistics are given in parentheses.

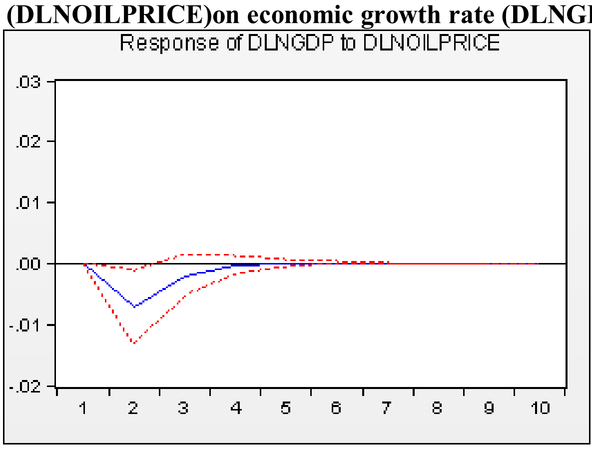
We thus conclude that the annual data presents a weak negative effect in the relationship between GDP and oil price but the quarterly data shows a weak positive effect in relation between these two factors. So the two cases of data always present a weakening in the relationship.

3.1.3.3. Impulse response Functions

Figure 6 helps us to conclude that a one standard deviation shock to the oil price variation weakly decreases the GDP growth rate 2 years after the shock and returns to increase it until to be completely ignored after 7 years.

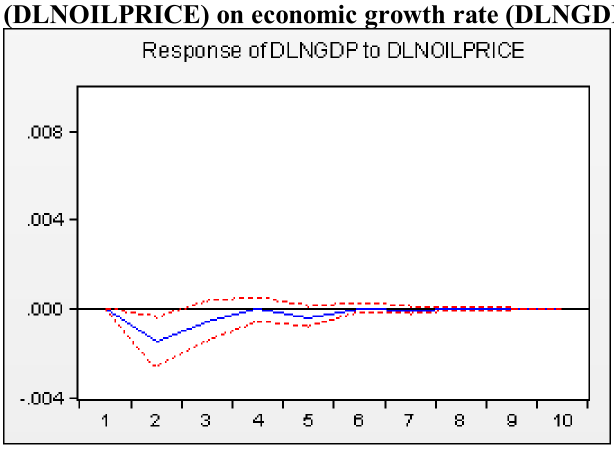
In the same way but for quarterly data, **Figure 7** is investigated to show that a one standard deviation shock to the oil price variation weakly decreases the GDP growth rate 2 quarters after the shock and returns to increase it until to be completely ignored after 9 quarters.

Figure 6. Impact of annual oil price shock (DLNOILPRICE)on economic growth rate (DLNGDP)



* The x-axis gives the year's number after the shock.

Figure 7. Impact of quarterly oil price shock (DLNOILPRICE) on economic growth rate (DLNGDP)



* The x-axis gives the quarter's number after the shock.

3.1.3.4. Break points detection

We choose to work only on quarterly data because we will have, whatever the number of breakpoints, a number of observations before and after break point(s) above 30, which it helps us to estimate any model for each period easily using "***Eviews.7*** software".

In order to test the presence of a rupture in the relationship between GDP growth rate (DLGDP) and oil price variations (DLNOILPRICE) on quarterly data, we will use some of the following tests: Andrews (1993) test, Chow (1960) test and Engle (1984) who studied Wald test, Likelihood Ratio test and Lagrange Multiplier test. These tests provide for testing and estimating the presence of break dates.

A point of view commonly shared is that the best test to use when the breakpoint is unknown is the test of Andrews (1993) and we can verify, after that, by Chow (1960) test. Results in **Table 6** indicate, in accordance with the application of Andrews (1993) test on the quarterly period 1960Q1-2009Q4 for the **model 3** and the **model 5**, that the point which will be selected it is that which has the max of Fischer statistic.

For the **model 3**, the test selected the quarter 2000Q2 as a point of rupture. Whereas for the **model 5**, the test selected the quarter 1978Q4 as a break date. So we must divide our time series for **model 3** (SLRM, Simple Linear Regression Model) into two sub-periods 1960Q1-2000Q1 and 2000Q2-2009Q4, whereas for the **model 5** (DRM, Dynamic Regression Model), we must divide the total period into two sub-periods as follows: 1960Q1-1978Q3 and 1978Q4-2009Q4.

In the **model 3**, all coefficients are significant in two sub-periods but coefficients values always remain very low. So as regards to the same **Table 6**, we will conclude that a 1% point increase in oil price variations (DLNOILPRICE) will generate an increase in GDP growth rate (DLNGDP) by only 0.001012% in the first sub-period (1960Q1-2000Q1) and by only 0.001134% in the second sub-period (2000Q2-2009Q4). According to **model 5**, only the second sub-period (1978Q4-2009Q4) presents a significance in the coefficient of DLNOILPRICE but always still low, because a 1% point increase in oil price variation (DLNOILPRICE) will generate an increase in GDP growth rate (DLNGDP) by only 0.002241%. So in the same way, we can improve our results by repeating to use the Andrews test for detecting break points in the first sub-period.

Table 6. Estimation results for model (3) and model (5) after break points detection

			α	DLNGDP(-1)	DLNGDP(-2)	DLNOILPRICE
model (3)	**1960Q1 – 2000Q1**	**DLNGDP**	0,008606** (12,3440)			0,001012*** (1,9508)
	2000Q2 – 2009Q4	**DLNGDP**	0,004384** (5,28362)			0,001134** (2,437749)
model (5)	**1960Q1 – 1978Q3**	**DLNGDP**	0,007162** (3,99619)	0,178690 (1,541995)	0,129353 (1,123672)	-0,011839 (-1,046455)
	1978Q4 – 2009Q4	**DLNGDP**	0,003095** (3,81270)	0,414791** (4,999785)	0,103707 (1,254531)	0,002241** (4,860215)

, * indicate statistical significance at 5% and 10% levels, respectively. T-statistics are given in parentheses.

We are concluding that the application of the break points tests and the asymmetrical effects can improve the estimation results (means an improvement in coefficients values), but always shows a weakening in the relationship between oil price and economic growth rate. This conclusion requires us to think of a model containing more than two variables for measuring the impact of the oil price on the economic growth such as VAR (Vector Autoregressive) model.

3.2. VAR model

The literature review, studied in the second section, allowed us to establish firstly the possible existence of relationship between GDP growth rate, oil price, inflation, unemployment rate and export of petroleum products and secondly the possible existence of bidirectional causality between these variables. In these circumstances, it is advantageous to test the causality direction without testing endogenous–exogenous hypothesis indicating by Sims (1980). Consequently, the VAR model appears to be an appropriate approach for our study.

3.2.1. Methodology

Identify Variables → ADF Test → Cointegration Test (presence) → VEC Model

Identify Variables → ADF Test → Cointegration Test (absence) → VAR Model

VEC Model / VAR Model → Granger Causality Test; Impulse Response Functions; Variance Decomposition

3.2.2. Identification of variables

The VAR model, that we propose to build, tries to analyze the relationship between GDP growth rate (GDP), oil price (OILPRICE), inflation rate (CPI), unemployment rate (UNRATE) and export of petroleum products (EXPOR). So it takes into account five variables represented by a series covering the quarterly period 1960Q1 - 2009Q4. We will use then Real GDP measured in constant 2005 U.S. million dollars[6], Real oil price in U.S. dollar per Barrel[7], Consumer Index Price[8], Unemployment rate[9] and Export of petroleum products in constant 2005 U.S. million dollars[10]. All variables are measured in natural logarithms expecting UNRATE.

3.2.3. Unit root test (ADF test)

Table 7. Unit root test (ADF test) results

	LNGDP	LNCPI	LNOILPRICE	LNEXPOR	UNRATE
1)**Level** $H_0^3 : \phi = 0$ *Trend & intercept	$t_{\hat{\phi}}$ =(-3,39) (> -3,54) → $\phi = 0$ $t_{\hat{\delta}}$ = 3,22 (> 2,79) → $\delta \neq 0$	$t_{\hat{\phi}}$ =(-1,08)(> -3,54) → $\phi = 0$ $t_{\hat{\delta}}$ = 0,83 (< 2,79) → $\delta = 0$	$t_{\hat{\phi}}$ =(-4,75) (<-3,54) → $\phi \neq 0$ $t_{\hat{\delta}}$ = 3,30 (> 2,79) → $\delta \neq 0$	$t_{\hat{\phi}}$ =(-1,30) (>-3,54) → $\phi = 0$ $t_{\hat{\delta}}$ = 1,10 (< 2,79) → $\delta = 0$	$t_{\hat{\phi}}$ =(-3,31)(>-3,54) → $\phi = 0$ $t_{\hat{\delta}}$ = 0,64 (< 2,79) → $\delta = 0$
$H_0^2 : \phi = 0$ *Intercept		$t_{\hat{\phi}}$ =(-1,41) (>-2,95) → $\phi = 0$ $t_{\hat{c}}$ = 1,95 (<2,54) → c = 0		$t_{\hat{\phi}}$ =(-1,27) (>-2,95) → $\phi = 0$ $t_{\hat{c}}$ = 2,83(> 2,54) → c = 0	$t_{\hat{\phi}}$ =(-3,29)(<-2,95) → $\phi \neq 0$ $t_{\hat{c}}$ = 3.27 (> 2,54) → c = 0
*None		$t_{\hat{\phi}}$ = 1,99 (> -1,95) → $\phi = 0$		$t_{\hat{\phi}}$ = 3,88 (> -1,95) → $\phi = 0$	$t_{\hat{\phi}}$ =(-0,50)(> -1,95) → $\phi = 0$
* Decision	Non-Stationary	Non-Stationary	Non-Stationary	Non-Stationary	Non-Stationary
2)**1st difference** $H_0^3 : \phi = 0$ *Trend & intercept		$t_{\hat{\phi}}$ =(-3,21)(> -3,54) → $\phi = 0$ $t_{\hat{\delta}}$ =(-1,34) (< 2.79) → $\delta = 0$		$t_{\hat{\phi}}$ =(-6,99)(<-3,54) → $\phi \neq 0$ $t_{\hat{\delta}}$ =(-1,14) (< 2,79) → $\delta = 0$	$t_{\hat{\phi}}$ =(-6,22)(<-3,54) → $\phi \neq 0$ $t_{\hat{\delta}}$ = 0,81 (< 2,79) → $\delta = 0$
$H_0^2 : \phi = 0$ *Intercept		$t_{\hat{\phi}}$ =(-2,98)(< -2,95) → $\phi \neq 0$ $t_{\hat{c}}$ = 1,95 (< 2,54) → c = 0		$t_{\hat{\phi}}$ =(-6,89)(< -2,95) → $\phi \neq 0$ $t_{\hat{c}}$ = 4,48 (> 2.54) → c ≠ 0	$t_{\hat{\phi}}$ =(-6,18)(< -2,95) → $\phi \neq 0$ $t_{\hat{c}}$ = 0,14 (< 2.54) → c = 0
*None		$t_{\hat{\phi}}$ =(-2,56)(< -1.95) → $\phi \neq 0$			$t_{\hat{\phi}}$ =(-6,20)(< -1.95) → $\phi \neq 0$
*Decision		Stationary		Stationary	Stationary
*Classification	I(1) + c + Trend	I (1)	I (1)	I (1)	I (1)

6 Source: http://research.stlouisfed.org/fred2/series/GDPC96?cid=106
7 Source: http://research.stlouisfed.org/fred2/series/OILPRICE?cid=98
8 Source: http://research.stlouisfed.org/fred2/series/CPIAUCSL?cid=9
9 Source: http://research.stlouisfed.org/fred2/series/USAURNAA?cid=32284
10 Source: http://research.stlouisfed.org/fred2/categories/16

The ADF (Augmented Dickey-Fuller) test is based on the theory of Said and Dickey (1984) and consists to apply the approach of Dickey and Fuller (1979, 1981). The final results of the stationarity will be found in **Table 7**. Based on the minimization of Akaike information criterion and Schwarz criterion (given directly by ***Eviews.****7* software), we conclude that the first difference of all variables is I(0) so these variables are, in level, I(1).

3.2.4. Johansen cointegration test

Table 8. Identification of optimal number of lags (the length lag equal to 2)

VAR Lag Order Selection Criteria
Endogenous variables: LNGDP LNCPI LNOILPRICE LNEXPOR UNRATE
Sample : 1960:1-2009:4

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-456.1707	NA	7.26E-05	4.658290	4.741327	4.691901
1	1511.053	3815.222	2.19E-13	-14.96013	-14.46191	-14.75847
2	1654.317	270.6096	6.64E-14*	-16.15427*	-15.24131*	-15.78500*

In this test, the first step tries to determine the number of lag used to estimate later the VAR model or VECM. To do this, we estimate a number of autoregressive processes by fixing a length of lag (in our study, the length lag equal to 2) and we will keep only the lag which is minimized by the criteria FPE (Final Prediction Error), AIC (Akaike), SC (Schwarz) and HQ (hannan-Quinn) and which is maximized by the criterion LR (Likelihood Ratio) (see **Table 8**). According to **Table 8**, we conclude that all the criteria lead us to choose the lag number equal to 2 (see the sign * which indicates the lag order selected by the criterion).

Table 9. Unrestricted cointegration rank test (based on Trace statistic)

Sample: 1960:1-2009:4
Trend assumption: Linear deterministic trend
Series: LNGDP LNCPI LNOILPRICE LNEXPOR UNRATE
Lags interval (in first differences): 1 to 2

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None*	0.166200	96.97919	68.52	76.07
At most 1*	0.128078	61.17219	47.21	54.46
At most 2**	0.093166	34.17231	29.68	35.65
At most 3	0.048743	14.90649	15.41	20.04
At most 4**	0.025369	5.062145	03.76	06.65

**(*) denotes rejection of the hypothesis at the 5%(1%)
Trace test indicates 3 cointegrating equation(s) at the 5% level.
Trace test indicates 2 cointegrating equation(s) at the 1% level.

After this step, we pass to investigate the unrestricted cointegration rank test based on the trace statistic (**Table 9**) which helps us to determine the existence of the cointegration relation by using the approach of Johansen (1988). The results presented in **Table 9** reveal the existence of a cointegration relation (means a long-run relation) between the variables of the model (because all the trace statistics are higher than the critical values at the 1% and 5% levels) and lead us to use a VECM (Vector Error Correction Model) by using a number of lag equal to 2.

3.2.5. VECM estimation

The VECM estimation gives us the cointegrated vector which can be written as follows:

$$LNGDP = 10.10535 -0.987758LNCPI +0.205099LNOILPRICE+0.0687106LNEXPOR-0.054235UNRATE$$
$$(2.31988) \quad (-5.32667) \quad (-3.21221) \quad (2.67379) \tag{6}$$

The long-run coefficients are all significant (t-statistics are all higher than 1.96 in absolute value). We can also conclude a negative effect of LNCPI and UNRATE on LNGDP and a positive effect of LNOILPRICE and LNEXPOR on LNGDP. And we can note an improvement in the result of the weakening in the relationship between GDP and oil price when we compare this result with the results finding with SLRM (Simple Linear Regression Model) and DRM (Dynamic Regression Model).

3.2.6. Granger causality test

According to the same lag of number (p = 2), we propose to illustrate **Figure 8** of causality based on Granger (1969) and Engle and Granger (1987) causality tests which conducting to know which variables caused by the other variables. In this step, we will try to apply this test, variable by variable, and the null hypothesis of the reject of the causality test will be acceptable when the probability is higher than 5% (**Table 10**).

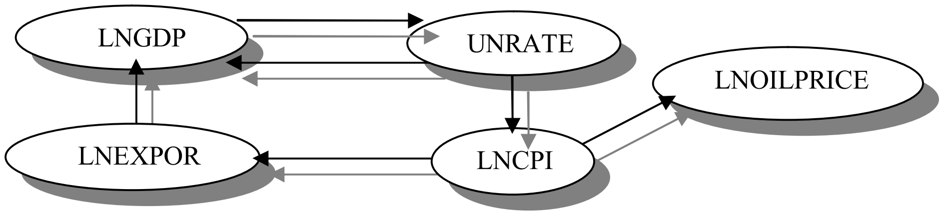
At this level, we can confirm our result which consists to refuse the direct linear relationship between GDP and Oil price because when we returned to this graph, we conclude that the GPD is caused only by unemployment rate and the exports of petroleum products and the Oil price is caused only by the inflation. So we have not a direct causality between these two factors. Because that, it is logical to have a weakening effects in the direct relationship.

Table 10. VEC Pairwise Granger causality

	Dependent Variable				
Independent Variable	**LNGDP**	**LNCPI**	**LNOILPRICE**	**LNEXPOR**	**UNRATE**
LNGDP	#	0.823931	0.045162	3.367894	19.32861**
LNCPI	0.384916	#	5.201661*	26.73864**	0.919210
LNOILPRICE	1.436036	1.819683	#	1.939182	1.377121
LNEXPOR	11.35341**	1.397461	3.225597	#	0.282116
UNRATE	11.72297**	15.33775**	3.406774	4.105173	#
All	29.15346**	21.58725**	18.97498**	41.34955**	25.59511**

**, * indicate statistical significance at the 5% and 10% level, respectively.
Probabilities for Fisher-type tests were computed by using an asymptotic χ^2 distribution.
All variables are in natural logarithms (LN).

Figure 8. Granger causality Graph



3.2.7. Impulse response functions and variance decomposition

The impulse response functions help us to describe the impact of the exogenous variable on the endogenous variables after the shock and how many periods must be passed, to be completely ignored. In the same context, the impulse response functions mean the conditional forecast revision of one variable given an impulse to another variable. According to **Figure 9**, we conclude that the response of LNGDP to LNOILPRICE (first graph, see green line) leads us to conclude that a one standard deviation shock to the oil price variation decreases the GDP growth rate 5 quarters after the shock and returns to increase it weakly after this date.

The variance decomposition study used to confirm the results found by the causality test and the impulse response functions by determining the part of the forecast error variance of exogenous variables on the total variance of the endogenous variable, after the shock. To do this, we start firstly to select horizon and we pass after that to conclude which variables have a high percentage in the total variance of the endogenous variable after the shock and especially at the horizon selected. The results, presented in **Table 11**, indicate that after 10 quarters (horizon H equal to 10):

i) The forecast error variance of LNGDP is due to 73.57841% with its own innovations, 16.67414% to those of LNCPI and small percentage for the remainder of variables. ii) The forecast error variance of LNCPI is due to 92.24229% with its own innovations. iii) The forecast error variance of LNOILPRICE is due to 74.43877% with its own innovations to 22.40046% with those of LNCPI. iv) The forecast error variance of LNEXPOR is due to 34.38012% with its own innovations, 12.63368% with those of LNGDP, to 30.03853% with those of LNCPI and to 20.95836% with those of LNOILPRICE. v) The forecast error variance of UNRATE is due to 22.86484% with its own innovations to 51.26839% with those of LNGDP and to 30.03853% with those of LNCPI.

Figure 9. Impulse response functions

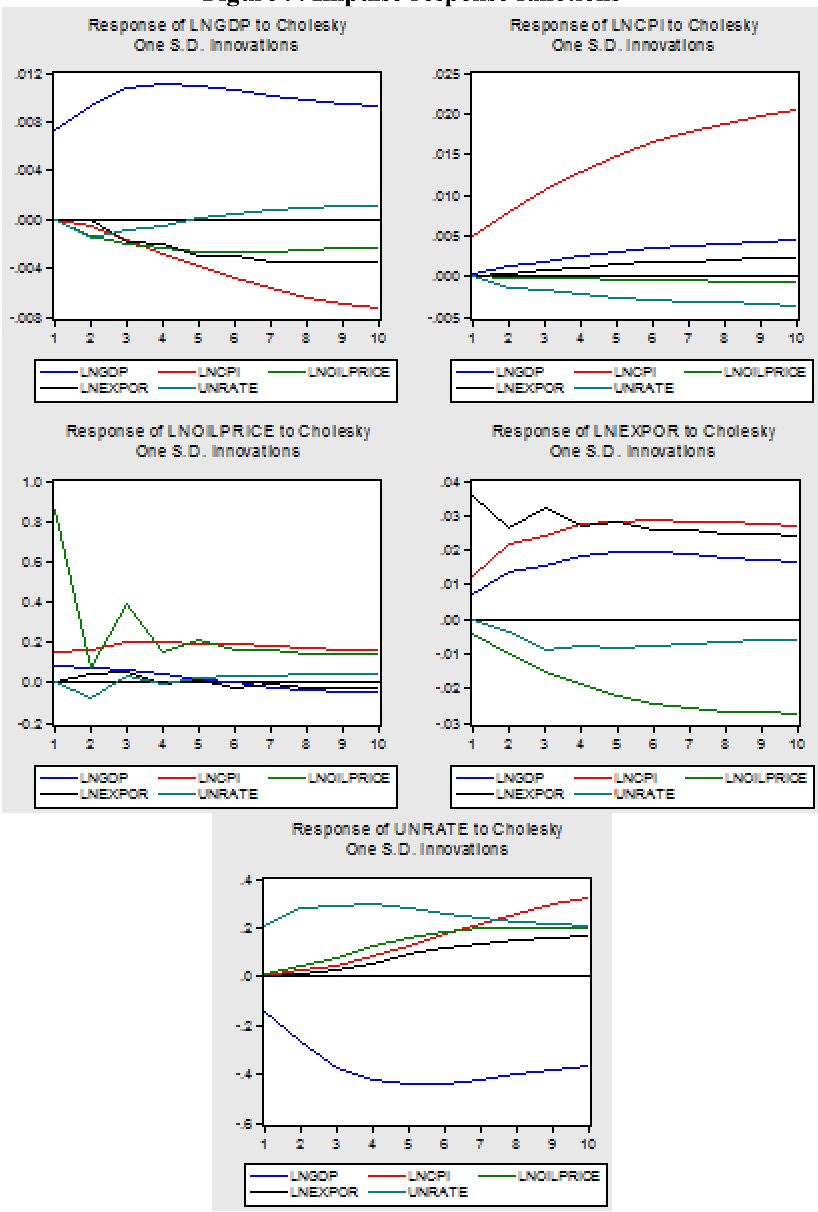


Table 11. Variance decomposition after 10 quarters

Variance decomposition of	S.E.	LNGDP	LNCPI	LNOILPRICE	LNEXPOR	UNRATE
LNGDP	0.036645	**73.57841**	16.67414	3.664345	5.532838	0.550268
LNCPI	0.050264	3.969893	**92.24229**	0.086334	0.950532	2.750953
LNOILPRICE	1.198256	1.683561	**22.40046**	**74.43877**	0.517830	0.959370
LNEXPOR	0.148918	**12.63369**	**30.03853**	**20.95836**	**34.38012**	1.989305
UNRATE	1.668498	**51.26839**	**13.03447**	8.720901	4.291409	**22.68484**

4. Conclusion

The question of the impact of oil price increases on economic growth always presents different results between the models and the variables selected. Because that we developed the question which consists to improve the weakening in the relationship between these two factors by judging firstly the principal transmission channels of oil price crisis and by proving secondly the choice of the appropriate model. Our results showed that the use of SLRM (Simple Linear Regression Model) and DRM (Dynamic regression model) can present a non significant coefficients or a bad adjustment in the direct relationship and they present also a weakening effect in the direct relationship. For this reason, we passed to use firstly a breakpoints detection test and to apply secondly VECM by introducing another factors having a high relationship with the economic growth and the oil price of United States and which may improve our results. So we conclude that the impact of oil price increases on economic growth depends on the best comprehension of this topic and the best manner of the choice of the appropriate model. Because that, the results can be different between work papers and still deserves further attention in future research.

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