Studying Different Factors that May Impact the Emission of Dioxide Carbon and the Economic Growth in Algeria: Using SVAR Model

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Abstract :
Algeria is mainly depending on fossil energy to secure its economic situation and government stability, but such energy can have dangerous consequences on environment. In this topic, we shall study per capita (GDP) representing the economic growth factor, per capita carbon dioxide emission (Coe) and other exogenous variables with structured vector autoregressive model and granger causality for the period of 1995-2016 in Algeria. We found unidirectional causality running from (Gdp) to (Coe), and the same result was found in Svar estimation and structured impulse response.
Keywords: Economic growth, carbon dioxide emission, structured VAR, Granger causality, structured impulsion response.
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1. Introduction :

Algeria is considered as one of the major exporters and producer of oil and natural gas in Africa and in the World. This country is mainly depending on two main energy sources which are crude oil (49.5%) and natural gas (50.4%). However, such energy has a negative impact on the environment in the long-term, and can force the country to look after renewable energy programs, especially with the difficulty to include shale gas in the energy system and the increase of greenhouse gas from oil and natural gas production. In 1999, the cost of environment degradation has been estimated at 3.6% of GDP of the country which it means 97 billion annually of Algerian Dinars (1.7 billion US dollars) and the global environment damage was costing 1.2% of GDP (World Bank).

Moreover, the impact of soil degradation was gauged on the basis of losses in agricultural productivity resulting from water and wind erosion. Water erosion influenced negatively 12 million hectare in northern and western of the country and the wind erosion menaced more than 7 million hectare of arid and semi-arid land. The urban air pollution was caused generally by the transport sector in the large cities of Algiers, Oran and Constantine, by burning municipal waste (Oued Smar in Algiers, Oran) and by the big industries (energy production) in Annaba, Skikda, and Gazaouet. Such pollution has triggered on a yearly basis 353,000 cases of bronchitis, 544,000 asthma attacks and could be the cause of the 1,500 cases of lung cancer. Also, the lack of potable water and sanitation as well as poor water quality and hygienic practices causes mortality in children under the age of 5, because of serious diarrheal diseases and it is estimated at 205,500 DALYs (Disability Adjusted Life Years) to be lost per year. In addition, the water resources degradation was due to dam silting which is estimated at 0.09% of GDP.

The objective of this topic is to try to build a model that supports the economic growth, and the reduction of carbon dioxide emission in the atmosphere. This work will be divided into 5 sections, introduction, literature review, data and the model, empirical result and conclusion, plus reference, tables and annex.

2. Literature Review :

Attiaoui. I et al. (2017) examined the relationship between carbon dioxide, renewable energy and economy growth for the case of 22 African countries over the period of 1990-2011. The variables were (GDP) per capita, (CO_2) emission per capita, renewable energy consumption per capita and non-renewable energy consumption per capita. They showed a positive and significant relationship among (CO_2) emission, (GDP), and non-renewable energy consumption in both short and long-term. Consequently, a 1% increase in (GDP) increases (CO_2) emissions by 0.19 in the long-term and by 0.015% in short-term, an increase by 1% in non-renewable energy consumption increases (CO_2) emissions by 0.23% in the long-term and by 0.35% in the short-term. However, the renewable energy consumption has a negative impact on (CO_2) emission in the both long and short-term, a 1% increase in renewable energy consumption decreases (CO_2) emissions by 0.22% in the long-term and by 0.07% in the short-term. Moreover, when (GDP) is the dependent variable, only carbon dioxide has a negative and significant effect on real (GDP) in the long-term. Although renewable and non-renewable energy consumption positively affect real (GDP) in the long run, a 1% increase in (REC) increases real (GDP) by 0.38%, and 1% increase in non-renewable energy consumption will increase real (GDP) by 1.57%. From this result, they suggested

that the most African countries are still not use renewable energy in their energy production.

Mirza. F.M and Kanwal. A (2017) investigated the relationship between carbon emission, energy consumption and economic growth in Pakistan over the period of 1971 to 2009. They worked with ARDL, VECM models and Granger causality on the variables of income per capita, energy consumption and (CO2) emission. They concluded that there's a bidirectional relationship between economic growth and (CO_2) emissions, so an increase in (CO_2) emissions is related with higher consumption of coal, oil, fertilizers and other energy intensive economic activities. These energy resources are primary inputs to agriculture and industry which will lead to stimulate economic growth if their usage and (CO_2) emission increases. Also, there's bidirectional causality between energy consumption and (CO_2) emission. The high dependence of economic growth on energy resources and the (CO_2) emission reflect that the economic growth in Pakistan is not possible without the availability of adequate energy resources.

Ben Mbarek. M et al. (2017) analysed with VECM procedure the factors that may affect the environmental deterioration (per capita CO_2 emission) and economic growth (per capita GDP) with the use of per capita renewable and non-renewable energy for the case of Tunisia over the period of 1990-2015. They found the existence of long run relationship between variables and an increase of 1% in (GDP) can permit an increase in renewable energy consumption, energy use and (CO_2) emission by 1.33%, 0.36% and 1.12%, respectively. Also, a 1% increase in (CO_2) and renewable energy decreases and increases (GDP) by 0.28% and 0.16%, respectively. The Granger causality revealed the existence of unidirectional relationship running from (GDP) to the renewable energy consumption and from energy consumption to (GDP). Also, there's bidirectional causality between (CO_2) emission and (GDP) and between (CO_2) emission and energy consumption.

Dogan. E and Ozturk. I (2017) studied the contribution of renewable and non-renewable energy and the economic growth on aspect of climate change in the USA over the period of 1980-2014. They used the variables of (CO_2) emission, (GDP), (GDP^2), renewable energy consumption and non-renewable energy consumption. They employed unit root tests with structural break of Zivot-Andrews and Clemente-Montanes-Reyes and applied the cointegration test with structural break of Gregory-Hansen and estimate the model with ARDL procedure. They found that an increase in the use of renewable energy consumption by 1% will negatively affect the levels of (CO_2) emission by 0.09% and a rise in non-renewable energy consumption by 1% will increase the air pollution in the atmosphere by 1.04%. Consequently, an obvious action towards the low levels of emissions is to increase the use of energy from renewable sources and decrease the use of energy from non-renewable sources in energy mix in the USA. The coefficient of (GDP) was negative by 4.66% and the sign of (GDP^2) was positive by 0.08% on (CO_2) emission. Consequently, the (EKC) hypothesis is not validated, because the expansion in production level won't stop the USA growth and will create a collapse to the environment.

Shahbaz. M et al (2014) analysed the Environment Kuznets Curve (EKC) hypothesis and the causal relationship between (CO_2) emission per capita, (GDP) per capita, energy consumption and trade openness for Tunisia case with using ARDL procedure and innovative accounting approach over the period of 1971-

2010. The variables were composed of energy emission per capita, real (GDP) per capita, energy consumption per capita and trade openness per capita. They found an evidence of the (EKC) hypothesis between economic growth and (CO_2) emission. Also, the causal analysis reveals that the overall results point out that economic growth causes (CO_2) emission and energy consumption.

Apergis. N and Payne. J.E (2014) studied the factors of renewable energy consumption per person for a panel of 7 Central American countries for the period of 1980 to 2010 with using nonlinear panel smooth transition vector error correction model and granger causality. They made a structural break in the cointegrating relation for the year of 2002 which is due the establishment of the Energy and Environment Partnership with Central America and they used the variables of renewable energy consumption per capita, real (GDP) per capita, carbon emission per capita, real coal prices and real oil prices. They found that the real (GDP) per capita, carbon emissions per capita, real oil and coal prices have a positive and statistically significant impact on renewable energy consumption per capita, but in the long-run, the elasticity estimates has lesser impact on renewable energy consumption.

Marques. A.C and Fuinhas. J.A (2012) did a study about how to encourage the introduction of renewable energy in 24 European countries with using panel data and dynamic estimator over the period of 1990–2007. The variables were the contribution of renewables to energy supply, (CO_2) emission per capita, energy use per capita, importance of oil, gas, coal and nuclear to electricity generation with proportion, real (GDP), oil, natural gas, and coal price. They concluded that the prices of fossil-based fuels were not statistically significant in explaining of renewable energy use for all models, and they provided strong evidence that the level of renewable energy use in the previous period has a high significant, positive effect and similar magnitude. They found also that the (CO_2) emissions are correlated with lower renewable energy use, and the effect of (CO_2) emissions on renewables was statistically significant and negative. They showed too that the effects of all forms of energy source were highly significant and consistent, which is in line with a lower renewable energy deployment.

Fodha. M and Zaghdoud. O (2010) investigated the relationship between economic growth and pollutant emission (CO_2) and (SO_2) for the case of Tunisia with using a cointegration analysis and causality test over the period of 1961-2004. They used the variables of carbon dioxide emission (CO_2) per capita, sulfuric dioxide emission (SO_2) per capita and (GDP) per capita. They found that there is a robust indication of income growth and which is causing the emissions growth for each environmental indicator, and they found only unidirectional relationship and no feedback relationship between economic growth and environmental degradation.

Huang. W.M et al. (2008) investigated the relationship between greenhouse gas emission and economic growth with using the Environmental Kuznets Curve Hypothesis. They used greenhouse gas (GHG) emission per capita as dependent variable, (GDP) per capita and the external variable as independent variable over the period of 1990 - 2003. They divided their data into two categories, one-sample with 24 countries and second-sample that define the economies in transition (EIT) with 14 countries. They worked with EIT's hockey-stick-curve equation and (EKC) hypothesis test, as result, they had several interpretations, the (EKC) curve

test and R^2 was statistically significant and accepted for Belgium, Canada, Greece, Iceland, Japan, Netherlands and the US, meanwhile, for the other countries, they show only some possibility of accepting (EKC) hypothesis. United Kingdom has shown a higher linear fitting of R^2 value, in this case, they said that UK is likely to meet its Kyoto goal. However, the revelation of this study was Germany because it was considered as the most favourable country to meet the Kyoto commitment and with the best emissions reduction results.

3. Data and the model:

We have done our study on annual series over the period of 1995-2016 in Algeria, and employed the independent variables as volatility series to study the variation change (except dummy variables). We used also other variables that we created to support our models such as GDP^2 (to examine the environment Kuznets curve hypothesis[1]), Kyoto1, Kyoto2 and Paris Agreement. The data are all in natural logarithm and per capita except dummy variables.

Table 1: Definition of variables

Variables	Unites	Source of Data
Fec: Fossil energy consumption	Million tonne equivalent of petrol	British Petroleum and International Energy Agency
Fep: Fossil energy production	Million tonne equivalent of petrol	Bp and IEA
Rec: Renewable energy consumption	Million tonne equivalent of petrol	Bp
Rep: Renewable energy production	Million tonne equivalent of petrol	Organisation for economic co-operation and development
Coe: Dioxide carbon emission	Million tonne carbon dioxide	Bp
Gdp: Gross domestic product	Current US \$ (10th July of 2017)	World Bank
Gdp^2: Gross domestic product square	Current US \$ (10th July of 2017)	Created with using World Bank
Population	Total of population	World Bank

Source: done by the authors

The Structured Vector Autoregressive model:

$$Gdp_t = a_1 + \sum_{i=1}^{p} b_{1i}\, Gdp_{t-1} + \sum_{i=1}^{p} c_{1i}\, Coe_{t-1} + d_1 Gdp^2{}_t + e_1 Rep_t + f_1 Fep_t + g_1 Rec_t + h_1 Fec_t + j_1 \mathbf{Kyoto1}_t + k_1 \mathbf{Kyoto2}_t + l_1 \mathbf{Paris}_t + \varepsilon_{t1}$$

$$Coe_t = a_2 + \sum_{i=1}^{p} b_{2i}\, Gdp_{t-1} + \sum_{i=1}^{p} c_{2i}\, Co2e_{t-1} + d_2 Gdp^2{}_t + e_2 Rep_t + f_2 Fep_t + g_2 Rec_t + h_2 Fec_t + j_2 \mathbf{Kyoto1}_t + k_2 \mathbf{Kyoto2}_t + l_2 \mathbf{Paris}_t + \varepsilon_{t2}$$

(Coe) indicates the level of dioxide carbon emission as it can represent the factor of environment and pollution which is emitted by economic and industrial sectors.

[1] - Simon Kuznets (1901-1985) was an American economist and statistician who have received the Nobel Prize in economics in 1971 and he suggested this hypothesis which is used to explain the relationship between economic development and the environment deterioration.

(C) is the constant variable that represents all variables which are not included like number of cars, fuel consumption and level of technology introduced which can have an influence on dioxide carbon…etc.

(Gdp) and $(Gdp)^2$ are gross domestic production and Gdp square or income and income square. These variables are used to show the difference in the partial effect of real production on carbon emission between the group of low-income countries (GDP) and the group of high-income countries (GDP^2). **E. Dogan and F. Seker (2016).**

(Kyoto1) represents a dummy variable that indicate the ratification of the Kyoto protocol[2], so we will use Du=1 for the year 1997.

(Kyoto2) is also a dummy variable and it focusses on the 2nd Kyoto protocol which has been applied in 2005.

Paris is a dummy variable for United Nations Paris Climate Conference in 2015.

4. Empirical results:

First, we started with the unit root test to see if the variables are stationary or not, so we concluded from Phillips-Perron and Augmented Dickey Fuller test that the endogenous variables are stationary with the first difference (DS) and the exogenous variables which are taken as volatility series are all stationary on level. We confirmed those results by the probability of Q-statistic from correlogram. Therefore, all probabilities were greater than 5%, so we cannot reject the null hypothesis and we can say that the series have not a stochastic trend or long memory process.

Then, we selected the optimal lag model with AIC, SC and HQ criterion, and we found that the minimum value of these criterions was the model with lag 1, so we estimated the vector autoregressive model with one lagged endogenous variables.

4.1. The model residual and diagnostics analysis:

The autoregressive root graph showed that the model VAR is more or less stationary or stable because we have only one root lie inside the unit circle, so this result can have a serious impact on impulse response function.

We have made several tests on residual models and we found that there's no serial correlation between residual up to lag, also the residuals are normally distributed, and have homoscedasticity variance.

4.2. The coefficient diagnostic:

The R^2 (R-squared) or the determination coefficient were high for both equations of VAR model, so for the first equation the exogenous variables explained 94.3% of the endogenous variable (Co_2e) and for the second equation the exogenous variables explained 69.8% of endogenous variable (Gdp). These statistics showed that there's a strong and positive relationship between variables.

4.2.1. The (Gdp) equation:

The coefficient of (Rep) and (Rec) are positive and negative but insignificant; we can say that the Algerian system is not yet depending on renewable source to develop several goods and services. The coefficient of (Kyoto1) and (Kyoto2) are both positive and insignificant; we can say that Algeria was not concerned by this first Kyoto protocol. The coefficient of the 3rd dummy

[2] -http://unfccc.int/kyoto_protocol/items/2830.php

variable (Paris) is statistically negative, an increase by 1% in (Paris) will decrease the (Gdp) by 0.36, in this circumstances when the country try to change, systematically and rapidly its energy policy, it will impact negatively its economic growth (the change from fossil fuels dependence towards renewable energy dependence and then diminish the deforestation, loss of biodiversity, the carbon emissions and other sources of greenhouse gas that was the aim of Paris Summit).
The variables of (Fep) and (Fec) were statistically negative and positive, respectively, so an increase by 1% in Fep will decrease (Gdp) by 84.78 and a rise by 1% in (Fec) will surge (Gdp) by 167.75, such results are unexpected, because Algeria depends a lot of its fossil energy production, this might reveal that the existence of inefficiency in energy production and it may contribute negatively to the economic growth, while the sign of fossil energy consumption seems to be good and it leads to the growth hypothesis[3]. (**Marques. A.C and Fuinhas. J.A, 2012).**

4.2.2. The (Coe) equation:

The coefficient of (Kyoto1) and (Kyoto2) are both negative and significant; an increase by 1% in (Kyoto1) and (Kyoto2) will reduce (Coe) by 0.07 and by 0.02, respectively; these signs are very good, because the objectives of such conferences are the reduction of greenhouse gas emission in the World.

The coefficient of (Paris) is statistically positive, an increase by 1% in Paris will increase (Coe) by 0.05, this result appears very strange, because the aim of this Summit is the introduction of cleaner energy (renewable energy) and the reduction of carbon dioxide. Such result can confirm that Algeria is using the waste and combustion renewable energy that emit a lot of (Coe), so the country isn't respecting one target of Paris conference.

The variables of (Gdp_{t-1}), (Fep) and (Rec) are statistically positive, so an increase by 1% of each variable will raise the level of carbon dioxide by 0.21, 11.7 and 0.24, respectively. These results indicate that the country in this period was using unclean technology that use the waste and combustible energy that emits a high level of pollution in ecosystem. Consequently, we can say that the energy policy in Algeria is more focusing on supporting the development of its economic growth than the reduction of environment problems. The same suppositions were found in the study of **Apergis. N and Payne. J.E (2014), Mirza. F.M and Kanwal. F (2017), Ben Mbarek. M et al. (2017),** and **Attiaoui. I et al. (2017).**

In this case, the income square was not significant, so the Environment Kuznets Curves Hypothesis is not valid, and we can say that the country is considered as developing country that needs a lot of polluted manufactures and productions to keep its economic growth expansion this result is supported by studies of **Huang. W.M et al. (2008) and Dogan. E and Ozturk. I (2017)**.

4.3. The Granger causality:

We found that the variable (Gdp) cause Granger the variable (Coe) but the variable (Coe) doesn't cause Granger the variable (Gdp), so there's one-way relationship between (Gdp) and (Coe). Therefore, we can conclude for no feedback hypothesis but for the evidence of conservation hypothesis, because there's unidirectional causality running from (Gdp) to (Coe), the same result was found for the studies of **Fodha. M and Zaghdoud. O (2010)** and **Shahbaz. M et al. (2014)**.

[3] - When economic growth is depending on energy consumption.

4.4. Structured vector autoregressive model:

4.4.1. Structured impulse response:

We use the impulse response to indicate the variation between the endogenous variables and their residual series. The hypothesis of this topic is that a variation in gross domestic product has an impact on carbon dioxide emission. A shock on (Coe) variable has not a contemporary effect on (Gdp) variable; however a shock on (Gdp) has contemporary impact on (Coe) (correlation coefficient between residuals series). The shock amplitude of (Gdp) was 0.109 and will immediately be reflecting on (Coe) shock by -0.004, so in the first period, if Algeria increase its economic and industrial production, it will decrease the emission of carbon dioxide suddenly, so we can say that the country is using and producing goods and service without emitting a lot of polluting air, while a shock of (Coe) 0.010 won't have an impact on (Gdp) shock. This result comes to confirm the causality test and our hypothesis.

In the second period, the (Gdp) shock was estimating at -0.123 and will directly affect the (Coe) shock by 0.022, so here, if the country decide to decrease its gross domestic product, it will increase the emission of carbon dioxide and we can say that Algeria is consuming several production that release harmful air. However, a (Coe) shock of 0.002 will affect the shock of (Gdp) by 0.017; a rise in emission of dioxide carbon will have a positive impact on gross domestic product. This result can confirm the current situation of Algeria and many other countries, so the expansion of economic growth of the country may depend on several productions and manufactures that emit a lot of carbon dioxide.

5. Conclusion:

Currently, Algeria is working on new projects that may secure its economies stability and industries development, but, it can't realise it without consuming goods, services, energies or else. Nowadays, any country in the world can't produce or attain a huge economic power without consuming a huge quantity of energy and almost of them are damaging the environment and ecological system.

Moreover, the environment (with social) stability represents the main topic of sustainable development and the challenge to create a new energy policy that will adapt to this term is very hard, especially the energy security due the decrease of some energy sources in the world. Nevertheless, the raise of renewable energies will lessen the emissions of greenhouse gas and carbon dioxide reliable with Kyoto protocol and Paris conference demands. Also, since Algeria is very depended on conventional oil and gas resources, renewable energy sources (now) are seem to be the key supplier to energy security supply and sustainable economic growth.

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Table 02: Unit root test of (Coe)

Coe					
Phillips-Perron			Augmented Dickey-Fuller		
Models	On level	1st difference	Models	On level	1st difference
Model 3	-3.26*	-3.34*	Model 3	-3.26*	-3.48*
Model 2	0.94	-3.18**	Model 2	0.94	-3.26**
Model 1	-2.14**	-2.67***	Model 1	-2.14**	-2.73***

Source: Done by the authors on Eviews 9

Table 03: Unit root test of (Gdp)

Gdp					
Phillips-Perron			Augmented Dickey-Fuller		
Models	On level	1st difference	Models	On level	1st difference
Model 3	-0.62	-3.63*	Model 3	-0.38	-3.63*
Model 2	-1.28	-3.5**	Model 2	-1.29	-3.5**
Model 1	1.38	-3.35***	Model 1	1.5	-3.35***

Source: Done by the authors on Eviews 9

(***), (**), (*) Show that the null hypothesis would be rejected respectively at 1%, 5% or 10%, so there's no existence of unit root.

Table 04: The selection lag criterion

Lag	AIC	SC	HQ
0	-3.29	-2.39	-3.11
1	-6.52*	-5.42*	-6.31*

Source: Done by the authors on Eviews 9

*, indicate the optimal coefficient

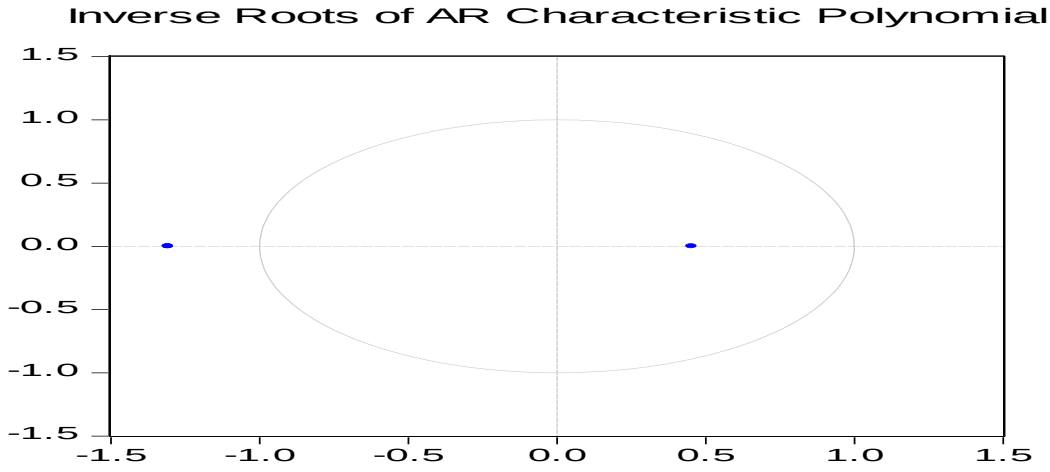
Table 05: The VAR estimation

Variables	Gdp	Co_2e
Gdp_{t-1}	-1.062*	0.217*
t-statistic	-2.241	4.376
Co_2e_{t-1}	1.686	0.212
t-statistic	1.234	1.484
C	0.028	0.007
t-statistic	0.780	1.882
Fep	-87.782	11.705*
t-statistic	-2.081	2.736
Fec	167.756*	5.410
t-statistic	2.432	0.746
Rep	5.604	-0.677
t-statistic	0.989	-1.138
Rec	-0.165	0.243*
t-statistic	-0.167	2.331
Gdp^2	0.0001	$-2.53*10^{-6}$
t-statistic	1.151	-0.261
Kyoto1	0.142	-0.077*
t-statistic	0.968	-4.991
Kyoto2	0.130	-0.029*
t-statistic	1.030	-2.197
Paris	-0.364*	0.053*
t-statistic	-2.127	2.986

Source: Done by the authors with Eviews 9

*, indicate that the variable is significant at level of 5%.

Figure 1: Autoregressive root graph



Source: done on Eviews 9

Table 6: The VAR residual serial correlation LM

Lags	LM-stat	Prob
1	8.419	0.077
2	3.822	0.430
3	1.634	0.802
4	6.444	0.168
5	2.461	0.651

Source: Done by the authors with Eviews 9

Table 7: Multivariate normality tests

Component	Jarque-Bera	Prob
1	0.428	0.807
2	0.437	0.803
Joint	0.865	0.929

Source: Done by the authors with Eviews 9

Table 8: White heteroscedasticity

Chi-square	Prob
52.643	0.410

Source: Done by the authors with Eviews 9

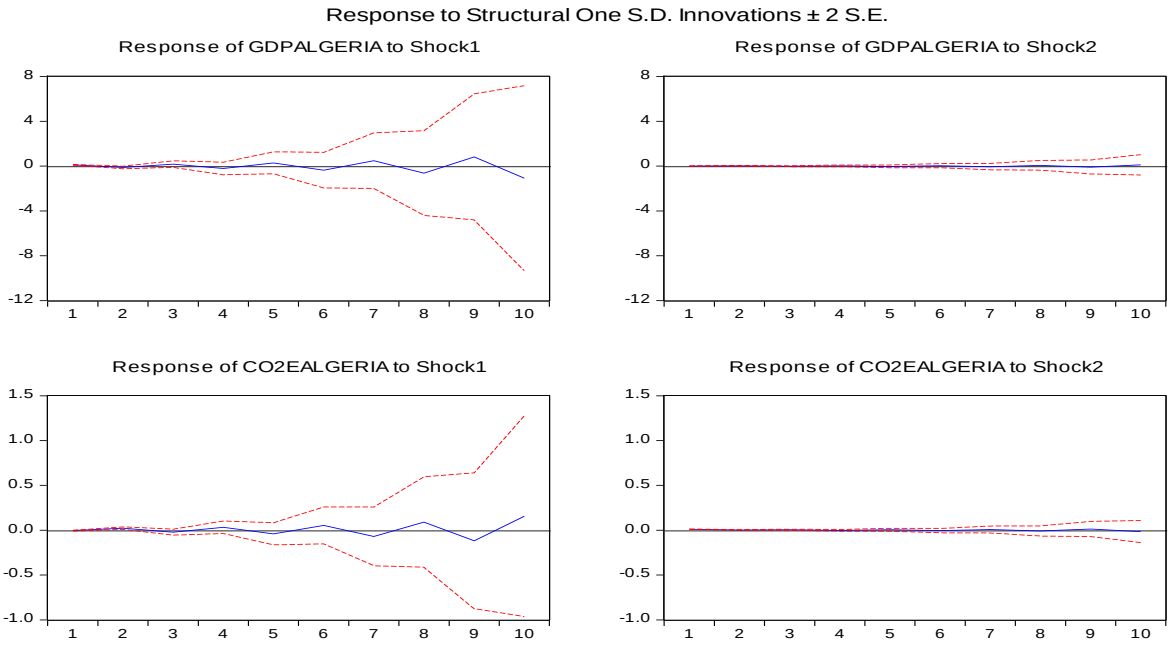
Table 9: Granger Causality

Lag 1	F-statistic	Prob
Co_2e does not Granger cause Gdp	0.089	0.768
Gdp does not Granger cause Co_2e	3.652*	0.073
Lag 2	F-statistic	Prob
Co_2e does not Granger cause Gdp	1.072	0.368
Gdp does not Granger cause Co_2e	12.933***	0
Lag 3	F-statistic	Prob
Co_2e does not Granger cause Gdp	0.529	0.671
Gdp does not Granger cause Co_2e	7.183***	0.006
Lag 4	F-statistic	Prob
Co_2e does not Granger cause Gdp	0.038	0.996
Gdp does not Granger cause Co_2e	10.317***	0.003

Source: Done by the authors with Eviews 9

(***), (**), (*) Show that the alternative hypothesis would be accepted respectively at 1%, 5% or 10%.

Figure 2: Impulse response with structural decomposition



Source: Done by the authors with Eviews 9

Table 10: Structured impulse response of (Gdp)

Period	Shock 1	Shock 2
1	0.109	0
2	-0.123	0.017
3	0.170	-0.015
4	-0.217	0.023
5	0.285	-0.028

Source: Done by the authors with Eviews 9

Table 11: Structured impulse response of (Coe)

Period	Shock 1	Shock 2
1	-0.004	0.010
2	0.022	0.002
3	-0.022	0.004
4	0.032	-0.002
5	-0.040	0.004

Source: Done by the authors with Eviews 9