Applied Econometrics

BEN HAMOUDA Wael, JOLIVET Nathan, MONGEAUD Nelson, CHAIBI Zidane

Article Name:

Oil price and Greenhouse gas emissions : an investigation on the maritime transport sector.

Question:

What is the impact of OPEC oil prices on Greenhouse Gas Emissions in the maritime transportation sector?

Academic curriculum:

M1 Economie Appliquée - Standard track

Abstract

Working on European countries' variations over time, this paper studies the effect of OPEC oil prices on greenhouse gas emissions in the maritime transportation sector. Through a perilous journey, it is finally find out an ambiguous effect of OPEC oil prices on Greenhouse gas emissions. The investigation turns into a question of countries' oil dependency. In fact, Denmark or Norway that are big oil producers in Europe[1] are considered as "independent" as they do not depend on oil importation from foreign countries. This does not imply that their oil consumption is null. On the other hand, the study includes countries called "dependent" because they face a need of oil importation from foreign exporters to bear their consumption. Finally, "little dependent" countries are nations with very low oil trade balance and usually a pretty high share of renewable energy. In a nutshell, the data suggests that higher OPEC oil prices lead to an increase in greenhouse gas emissions for dependent countries, whereas "independent" and "little dependent" countries decrease their emissions when OPEC oil prices increase.

[1]BP, 2020," BP Statistical Review of World Energy ", p. 17

I - Introduction

While economic growth remained unconditional on environmental cost, the 1970s, mainly with the Stockholm Conference, introduced a new problem into the debate. Up to that time, numerous summits have taken place and should have given reflection and answers to climate urgency that civilisations suffer from.

From quotas to taxes and price policies, loads of solutions were considered by decision-makers. Economically, resolving the dependency and energetic consumption issues by using a price system is a reachable objective. That one could finally have an impact on air pollution. Furthermore, according to the article of Winchester et Ledvina (2017), a higher price level changes agent's behavior by consuming less, and thus reduces the greenhouse gas emissions. Considering greenhouse gas emissions to assess the impact of firms and governments' choices could be the most appropriate way to do so. For instance, thinking about sustainability might mean thinking about the transportation sector because this one captures a big share of the total European greenhouse gas emissions, which is about 28.5% [2]. On top of that, the maritime sector emits more than the road sector for some European countries[3], and it is the way of the investigation: *What is the impact of OPEC oil prices on the greenhouse gas emissions in maritime transportation sector ?*

The investigation has to take into account characteristics of countries that can behave in another way depending on their ability. In fact, Mahmood et al. (2022) states that effects of price variation can be different from one economic situation to another. The oil dependency is thus a major variable of the model because it determines if a country is an importer or exporter. The data currently studied in this paper suggests that in Europe, if maritime companies face higher production costs because of high oil

[2]"Transport emissions as share of the EU's total greenhouse gaz emissions".2019, *European Environment Agency*
[3]"How Maritime Emissions Compare To Cars In Europe". *Statista*

prices, they could be incentivized to consume cheaper but more polluting energies. In addition, the dependency can make countries more vulnerable to oil shocks and it can have a negative impact on their ability to invest in greener technologies.

This is why it is decided to observe in the main analysis the indirect effect of oil price on greenhouse gas emissions by taking into account the oil dependency level of each country. The analysis will be extended by the study of the direct effect of the oil price on GHG (greenhouse gas emissions) by removing the oil dependency variable due to suspicious results. Finally, an extra analysis is conducting returning to the main model and eliminating Norway and Denmark from the database which are supposed to be two outliers in oil dependency.

II - Data

The investigation relies on a self-made panel database. Time series variables from three data banks, namely Eurostat for the intranational variables such as oil consumption, share of renewable energy, oil dependency or GHG emissions. It is also interesting to use the Eurostat data bank due to the fact that it collaborates with the International Energy Agency (IEA) to monitor OPEC decisions, which underlines the reliability of the data. World Bank databases are used in order to provide the real GDP of the countries, and the oil price comes from the OPEC data bank. The pursuit of the study will lead to some issues, that require an instrumental variable, to be solved. This later, that is negative supply shocks, was entirely created from the article “OPEC and the Oil Market” written by Youcef F et al. These combinations lead to a complete database of 520 observations that draws the evolution of 20 European countries over 26 years, from 1995 to 2020.

III - Econometric model

$$GHGperGDP_{i,t} = \alpha_i + \beta_1 \times PriceAdjOil_t + \beta_2 \times PriceAdjOil_t \times OilDep_{i,t}$$
$$+ \beta_3 \times GDPgrowth_{i,t} + \beta_4 \times OilDep_{i,t}$$
$$+ \beta_5 \times GDPperCap_{i,t} + \beta_6 \times OilCperGDP_{i,t} + \beta_7 \times SRE_{i,t} + \epsilon_{i,t} \quad (1)$$

In this model, GHG emissions are divided by the GDP to normalize the observations, which can be interpreted as the carbon intensity and how much countries emit greenhouse gas by unit of GDP. Thus, this new variable allows countries to be more comparable with each other and puts all the countries at scale. The same reasoning is applied to the oil consumption variable, divided by GDP; and to the GDP variable, divided by the population for each country. Notice that price is adjusted from inflation and exchange rate and has only time as index because all countries face the same price in a given year.

In a second part, the oil dependency variable, that corresponds to the difference between exportation and importation divided by the gross available energy, is used to analyse its crossed effect with the oil price, and represents the main part of the analysis. Thereafter it is important to control for variables that, according to the literature, could have an impact on the oil price causal effect on GHG emissions.

Bruvoll and Larsen (2004) show the crucial role of the GDP growth rate. A high level of economic growth might be characterized as an industrialization period, meaning that GHG emissions are important, such as in the Eastern European countries. According to Mirziyoyeva and Salahodjaev (2023), an increase in GDP per capita leads to lower GHG emissions for high-income countries. Harmsen et al. (2011) say in their study that using renewable energies lead to a significant drop on greenhouse gas emissions. Additionally, Yan's study (2021) states that a high level of oil consumption is linked directly with an increase in emissions.

Those variables are essentials to assess the direct impact of the energy mix of a country on GHG emissions. The energy transition could be characterized by environmental policies set by institutions such as IAE, EU or even by national policies in purpose of GHG emissions reduction.

Omitting the oil dependency variable is useful to estimate the direct effect of oil price on emissions, that could be affected by the level of dependence to oil.

$$\begin{aligned} GHGperGDP_{i,t} = \alpha_i + \beta_1 \times PriceAdjOil_t + \beta_2 \times GDPgrowth_{i,t} \\ + \beta_3 \times OilCperGDP_{i,t} + \beta_4 \times SRE_{i,t} + \beta_5 \times GDPperCap_{i,t} + \mathrm{u}_{i,t} \end{aligned} \tag{2}$$

A panel data fixed-effect model is used as estimation method, with the inclusion of an individual fixed-effect for each country that is constant over time, and could impact the dependent variable. These individual effects could take into account characteristics such as the quantity of navigable line and their importance, but also maritime boarders or geographic situations. They could explain the level of oil dependence in the first model. The main objective is to mitigate the individual heterogeneity and then to enhance the efficiency of estimations reducing their variances. The choice of the fixed-effects model instead of a random effect model is comforted by performing an Hausman test, see Table 3.

The within estimation is chosen to estimate the model. See equation (1). That permits to isolate the effects of independent variables by eliminating the fixed effects of individual units and then reduce the bias of the estimations. Furthermore, it allows to analyse the variation through time for a country, and then making it possible to get rid of the variation between countries, and observing institutional policies impact.

The presence of endogeneity is suspected for the treatment variable : oil price. This can be explained by the interaction between supply and demand, implying simultaneity issue. To treat this problem, supply shocks of OPEC members have been chosen as an instrumental variable. Shocks are identified as ”boost” when the shock is positive and ”cut” when the shock is negative. On top of that, it is a dummy variable that takes the value 1 in case of shock. It is important to notice that only ”cut” satisfies the exogeneity and relevance conditions. Indeed, this instrument is directly correlated with the oil price: a negative shock lead to an increase in price for the market to balance, see figure 1. Also, the instrumental variable has an impact on GHG emissions only through the exogenous variable. It verifies the exclusivity assumption because the decision of reducing the oil production affects emissions only by the price adjustment upward.

First Stage of the 2SLS

$$\begin{aligned} PriceAdjOil_t = \gamma_1 \times SupplyShock_{i,t} + \gamma_2 \times OilDep_{i,t} + \gamma_3 \times GDPgrowth_{i,t} \\ + \gamma_4 \times OilCperGDP_{i,t} + \gamma_5 \times SRE_{i,t} + \nu_{i,t} \end{aligned} \tag{3}$$

Finally, the estimates are set robust to take into account the serial correlation that corresponds to the correlation through time of a country to one or more variables and the potential persistence of heteroskedasticity after the within estimation.

IV - Results

After conducting a pooled OLS estimation, oil price is significant at 1% level and its value is about -4.9291, see table 2. Its standard error is quite small with a value of 0.9337. The crossed variable oil price to oil dependency is also significant at 1% level, with a short magnitude about 0.0389, and a standard error that is equal to 0.0040. In addition, GDP per capita, GDP growth rate and share of renewable energy are not significant with pretty high standard errors. It means that the results cannot conclude on whether these variables have an effect on GHG emissions or not.

But this model is not adapted to this study because it doesn't take into account variations over time. In fact, this model doesn't distinguish between individuals and time periods and considers each observation as a different individual. This is why it is decided to conduct a within estimation.

In table 2, results from a within estimation are given and no big changes are observed except that the interaction term of oil price adjusted and oil dependency is no longer significant. The R squared adjusted is about 0.8532 which means that the model explains 85.32% of the total sum of squares which is a strong result on the reliability of the model.This high R squared is mostly due to the variable oil consumption per GDP because a big part of the GHG emissions are directly measured from the total amount of oil consumed in the maritime transportation sector. However, as it results from simultaneous equations from the demand and the supply side of the market, oil price is supposedly endogenous.

After conducting a 2SLS regression in order to correct for endogeneity, using as an instrument the negative supply shocks and thereafter correcting for heteroskedasticity, gives the table 6 's results. It is to notice that the R squared is very high in the model, and explains 85.13% of the dependent variable's sum of squares.

These results finally provides a significant effect of the interaction term between oil price adjusted and oil dependency at 10% level, whereas oil price adjusted is no longer significant. In fact, if the oil price true coefficient is located between -3.3063 and +2.7141 in 95% confidence intervals, which doesn't permit to make any conclusion on whether it has an effect on greenhouse gas emissions. It could be due to the instrument used in the first stage 2SLS estimation, see equation (3), that does not quantify the magnitude of the negative supply shocks. In fact, this variable equals 1 when a negative supply shock occurs but does not express the power of this shock, and may not provide sufficient precision in the oil prices values corrected from endogeneity in the first stage 2SLS regression.

The oil price marginal effect is about -0.2961+0.0126 x Oil Dependency. This means that price has a negative effect on countries that have an oil dependency lower than 23.5%, these countries are called "independent" or "little dependent" from oil's importation. In fact, Denmark and Norway are the only two countries in the data having negative values of oil dependency, which means that they don't need to import oil to meet their energetic need, and can be explained by the fact that these two countries are big oil producers in Europe[4] with pretty high shares of renewable energy in their gross final consumption. For a given oil dependency value below 0, greenhouse gas emissions decrease on average by (-0.2961+0.0126 x Oil Dependency) Kg per million dollars of GDP produced ceteris paribus. For example, Norway in 2020 has an oil dependency of -911%, which means that it exported at least 9 times its gross available energy, and also produced 405,000 of million dollars of GDP in this same year. Then, for Norway in 2020, $1 increase in price leads to a decrease of 4,528.913 Tonnes of greenhouse gas emissions [(-0.2961 + 0.0126 x (-911%)) x 405,000 $million = -4,528,913Kg= -4,528.913Tonnes]. This result could be explained by the fact that an increase in OPEC oil price leads

[4]BP, 2020," BP Statistical Review of World Energy ", p. 17

to an increase in Norway oil price. In fact, when OPEC increases its prices, which might result from a cut in their production, the global oil supply will decline and make oil scarcer. Thereafter, market oil prices directly increase, decreasing as a result the oil consumption in these countries, and finally decreasing greenhouse gas emissions. On the other hand, for countries with an oil dependency greater than 23.5%, price has a positive effect on greenhouse gas emissions. Reciprocally, for countries with positive oil dependency, those that import more than they export oil, which is the case of almost all the countries in the data, $1 increase in price leads to an increase of (-0.2961+0.0126Kg x Oil Dependency) Kg per million dollars of GDP produced. This result seems to be surprising but can be explained as follows : for oil dependent countries, oil consumption is an important energy source that cannot be easily substituable. Thereafter, because of their elasticity to positive price variations, these countries need to move towards cheaper energy sources, but may be using more polluting fuel like fossil fuels and could keep emitting because of this lack of sustainable energy development in the maritime transportation sector.

Finally, neither GDP per capita nor GDP growth rate are significant, which could be potentially explained by the fact that companies are required to comply with environmental standards given by the institutional context and that would therefore not take into account the economic performance of a country.

The other point to emphasize is that the signs of oil consumption and share of renewable energy agree with the literature. As it is said previously, oil consumption is significant due to its specific relation with GHG emisions, unlike the share of renewable energy in which any effect can be concluded. This may be explained by the fact that this variable concerns the share of renewable energy in the whole economy of a country and not specifically from the maritime transportation sector, which could provide imprecise estimates.

It is also important to make an extra analysis estimation, but this time without the oil dependency variable, see equation (2), in order to analyze the direct effect between price and GHG emissions, realized in the table 5. It demonstrates after a correction of endogeneity an expected negative relationship significant at 1 percent level. It is important to highlight the increase in the magnitude of the price from -0.2961 to -9.1032 which confirms that the variable of dependence is very important. This exclusion could lead to an overestimation of the oil price effect of on GHG emissions because this variable allows to take into account the different economic, geographical and political situations of the countries. It can also be noticed that the variable share of renewable energies changes in sign, which is unexpected and goes in contradiction with the literature. All of these results may explain the complexity of this economic model which is impacted by many economic and structural factors. The research carried out by Mahmood et al. (2022) on the Gulf countries shows that the effect of oil price changes on GHG emissions can vary depending on the economic situation of the country, highlighting that oil price fluctuations influence emissions differently depending on the economic specificities of the countries.

Finally, it has been shown in this extra analysis using the main model of the study, see equation (1), the levels of extreme dependence of Norway and Denmark. For this reason, both are eliminated in this last analysis in table 9. It can be seen that the cross effect and the oil price keep the expected signs but become significant at 1% which may question their integration in the model because they are not comparable to other countries of the analysis. Once again in this analysis, the coefficient of our price variable increases drastically until reaching a coefficient close to ”-19”. This increase was expected because the analysis now focuses on a majority of independent countries to oil importation. After correction of heteroskedasticity, the treatment variable and his crossed effect are no longer significant which may be implied by a problem of bias in the new model. An extend to this analysis would be to let these two countries and increase the number of independent countries in the study such as the

United Kingdom in order to balance the number of exporting and importing countries.

V - Conclusion

This research paper examines the impact of oil prices, influenced by OPEC, on the greenhouse gas emissions of European countries. Through an econometric analysis, it identifies a complex relationship between oil dependency, oil prices and GHG emissions.

The marginal effect of the price differentiates three categories of countries presenting different responses and mechanisms to oil price variations. First, for oil independent countries, a higher OPEC oil price, which might result from a decrease in their production, has an indirect effect on the consumption of the independent countries' inhabitants. In fact, their own oil prices would increase too because of oil's scarcity in the market, lowering oil consumption, and finally decreasing greenhouse gas emissions. Secondly, little dependent countries reduce their GHG emissions when the price increases is due to the fact that they are less vulnerable to fluctuations in oil prices, which have potentially enabled them to move towards their renewable energies sources. On the other hand, the dependent countries which had to undergo these shocks, were given a lower share of renewable energy compared to little dependent countries. In fact, these will move towards cheaper but more polluting fuels after an increase in price, and then lead to more GHG emissions. A solution could be to set up public or European policies for the development of cleaner fuels. In particular, it would allow firms to move toward renewable energy sources rather than fossil fuels when prices increase.

Although, the literature review provides valuable insight into the impact of oil prices on greenhouse gas emissions in domestic shipping It has some limitations that could influence the application and interpretation of the results. First, they cover a wide range of sectors and do not focus exclusively on domestic shipping. Second, the data could be short in terms of observations, and as it's said earlier, there is a lack of exporters countries to get powerful estimates that properly measure the impact of OPEC oil prices with respect to their oil dependency levels. A major improvement would be to use a variable measuring the added-value produced from the maritime transport sector. This enables to have estimates' interpretation by unit of added-value produced in the maritime transportation sector rather than by unit of GDP produced economy-wide.

References

Ahmed et al. 2021. "Global Oil Price and Innovation for Sustainability: The Impact of R and D Spending, Oil Price, and Oil Price Volatility on GHG Emissions." *Energies (Basel)*, 2021-03, Vol.14 (6), p.1757.

Bruvoll and Larsen. 2004. "Greenhouse Gas Emissions in Norway: Do Carbon Taxes Work?". *Energy policy*, 2004-03, Vol.32 (4), p.493-505.

Yousef F et al. 2022. "OPEC and the Oil Market." *IMF Working Papers*, September 16, 2022

Harmsen et al. 2011. "The Unrecognized Contribution of Renewable Energy to Europe's Energy Savings Target." *Energy policy*, 2011-06, Vol.39 (6), p.3425-3433.

Mahmood et al. 2022. "Impact of Oil Price, Economic Growth and Urbanization on CO2 Emissions in GCC Countries: Asymmetry Analysis." *Sustainability (Basel, Switzerland)*, 2022-04, Vol.14 (8), p.4562.

Mirziyoyeva and Salahodjaev. 2023. “Renewable energy, GDP and CO2 emissions in high-globalized countries.” *Frontiers in energy research*, 2023-07, Vol.11.

Winchester et al. 2017. ”The Impact of Oil Prices on Bioenergy, Emissions, and Land Use”. *Energy economics*, 2017-06, Vol.65 (C), p.219-227.

Yan and Xinping. 2021. ”Data Analytics for Fuel Consumption Management in Maritime Transportation: Status and Perspectives.” *Transportation research. Part E, Logistics and transportation review*, 2021-11, Vol.155, p.102489, Article 102489.

Appendix

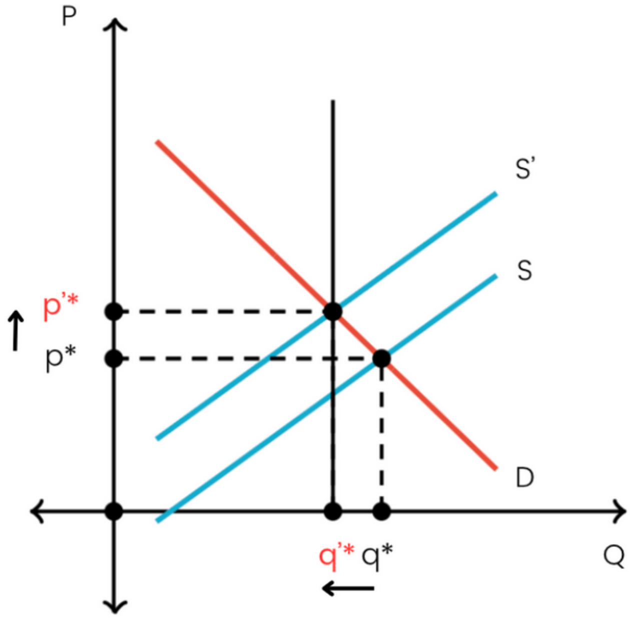


Figure 1: Interpretation of the instrumental variable : negative supply shock
The above graph draws the effect of a negative supply shock. If the market faces a lower level of supply, it means that demand is greater than supply and price should adjust upward in order to balance the market.

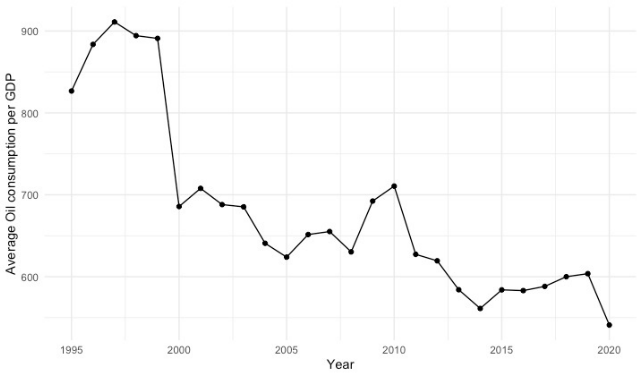


Figure 2: Evolution of the average oil consumption per GDP over time
The graph shows that the average oil consumption per GDP is decreasing over time, especially before 2000. Thereafter, the decrease is smoother even if there is a peak to 700 in 2010.

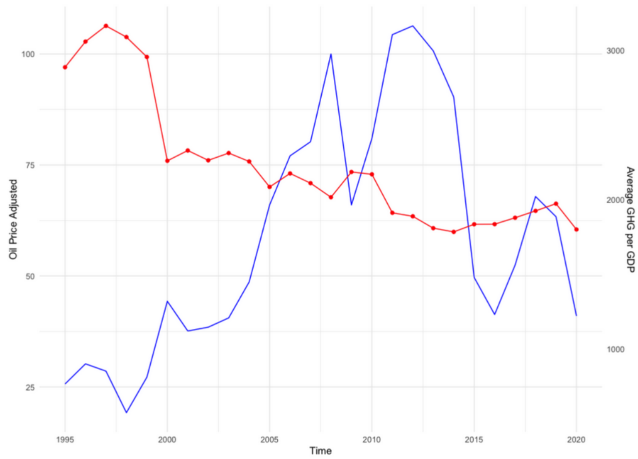


Figure 3: Evolution of oil price ad average GHG emissions over time
The graph represents the effect of the oil price on GHG emissions where the blue line is the price and the red line is the emissions level. Both move simultaneously on the opposite way. In fact, a decrease in price permits to reduce greenhouse gas emissions because oil consumption decrease after an increase in price.

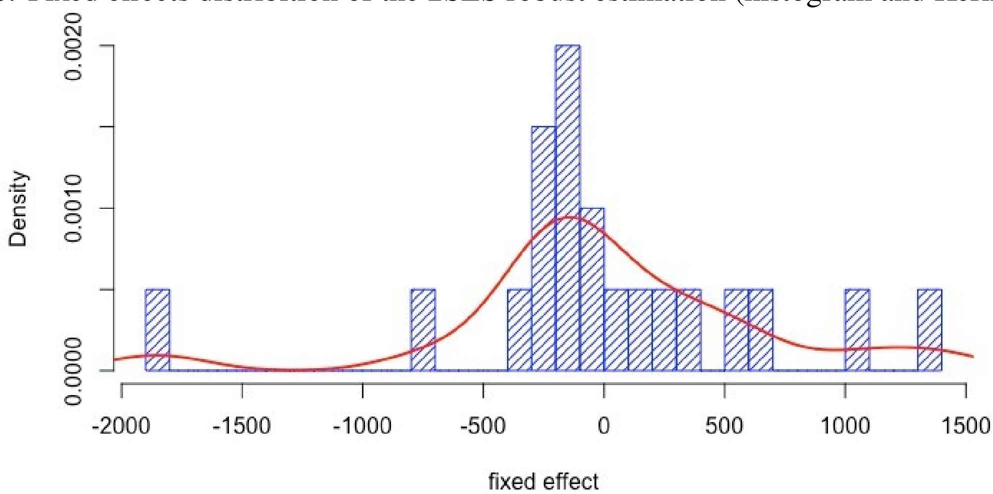
Variable	Dim	Mean	SD	Min	Max	Observations
GHGperGDP	overall	2226.666941	2566.542584	17.182758	15626.797983	N = 520
	between		2465.262926	96.512044	9824.507853	n = 20
	within		895.751668	-549.777093	10628.089554	T = 26

Figure 4: Descriptive statistics of GHG emissions per GDP with respect to the chosen model

Variable	Dim	Mean	SD	Min	Max	Observations
PriceAdjOil	overall	58.766923	26.2835	19.2	106.34	N = 520
	between		0	58.766923	58.766923	n = 20
	within		26.2835	19.2	106.34	T = 26

Figure 5: Descriptive statistics of oil price with respect to the chosen model

Figure 6: Fixed effects distribibition of the 2SLS robust estimation (histogram and Kernel density)



Note : It is noticed in this graph that some countries have extreme values of individual fixed effects, which could translate into possible outliers in the sample.

Table 1: Descriptive Statistics of the variables

Variable	Min	Q25	Median	Mean	SD	Q75	Max
GHGperGDP	17.18276	653.1920	1324.357	2226.667	2566.543	2532.129	15626.80
PriceAdjOil	19.20000	38.46000	51.04500	58.76692	26.28350	80.23000	106.3400
GDPperCap	4454.541	17393.28	34196.39	32541.38	17535.98	44275.72	79522.29
OilCperGDP	1.798348	211.4880	390.3651	679.6058	822.0599	719.7373	4732.219
GDPgrowth	-14.83861	0.7373398	2.192207	2.125778	3.591163	3.914699	24.47525
OilDep	-1746.682	91.00050	96.84500	27.85893	274.8460	99.96875	129.9610
SRE	1.200000	8.700000	17.55000	22.54212	18.05185	30.65000	82.80000
GHG	3090000	90277500	462930000	1047449000	1466265000	1343898000	6320970000
GDP	9144.290	164835.6	291472.6	614035.4	815658.4	552355.5	3597317
Pop	267400.0	4596080	10123000	20130460	23287060	26539710	83161000
OilCons	1000000	24559250	135919500	290702200	389454400	405290500	2000000000

Table 2: Results of pooled, within and random estimations

	Dependent variable: GHGperGDP		
	Pooled model	Within model	Random model
	(1)	(2)	(3)
Constant	352.7951***		848.8787***
	(85.5908)		(135.4434)
PriceAdjOil	−4.9291***	−2.4328***	−3.0811***
	(0.9337)	(0.7308)	(0.7289)
I(PriceAdjOil ∗OilDep)	0.0389***	0.0022	0.0142***
	(0.0040)	(0.0042)	(0.0037)
GDPgrowth	−6.8990	2.1962	2.8475
	(6.6623)	(4.8858)	(4.9870)
GDPperCap	0.0007	0.0013	−0.0044
	(0.0016)	(0.0046)	(0.0036)
OilCperGDP	3.1329***	2.7023***	2.7091***
	(0.0348)	(0.0561)	(0.0509)
SRE	−0.4646	−5.8001	−5.0587
	(1.4957)	(3.9204)	(3.1899)
OilDep	−1.5023***	−2.7056***	−2.2131***
	(0.1960)	(0.1898)	(0.1651)
Observations	520	520	520
R^2	0.9574	0.8532	0.8694
Adjusted R^2	0.9568	0.8455	0.8676
F Statistic	1,644.3760*** (df = 7; 512)	409.3860*** (df = 7; 493)	3,407.0470***

Note: *p<0.1; **p<0.05; ***p<0.01

The pooling model that is equivalent to the OLS model in case of panel study. It gives the first results, but makes the interpretation imprecise because of the complexity of the model. The within model (i.e. fixed effects model) makes the following variables significant at the 1% level: Oil Price, Oil consumption per GDP and Oil dependency. The random effect model makes the following variables significant at the 1% level: Oil Price, Oil consumption per GDP, Oil dependency and the crossing variable between Price and Dependency. So far, it is not possible to choose between both random effect and within model.

Table 3: Hausman test results

	Metric	Value
1	Test statistic	111.54
2	P-value	< 2.2e-16

The table 3 provides the result of the Hausman test performed to choose the right model. The rejection of the null hypothesis suggests that estimations are similar. It is better to pursue the analysis by using a fixed effects model.

Table 4: First stage regression of the 2SLS method with and without positive supply shocks

	Dependent variable:PriceAdjOil	
	Positive and negative supply shocks	Negative supply shocks
	(1)	(2)
PosSupplyShock	−3.0173	
	(2.1959)	
NegSupplyShock	−17.3929***	−17.4179***
	(2.0289)	(2.0307)
GDPgrowth	−0.8061***	−0.8705***
	(0.3026)	(0.2992)
GDPperCap	0.0022***	0.0022***
	(0.0003)	(0.0003)
OilCperGDP	−0.0134***	−0.0133***
	(0.0034)	(0.0034)
SRE	−0.2643	−0.1939
	(0.2538)	(0.2488)
OilDep	0.0254**	0.0261**
	(0.0115)	(0.0115)
Observations	520	520
R^2	0.3505	0.3480
Adjusted R^2	0.3162	0.3150
F Statistic	38.0042*** (df = 7; 493)	43.9446*** (df = 6; 494)
Note:		*p<0.1; **p<0.05; ***p<0.01

Here, it is possible to see that positive supply shock has not a significant impact on the oil price, and then it is better to remove it from the first stage 2SLS and pursue only with one instrumental variable that is negative supply shock. According to the results, it is significant at the 1% level.

Table 5: 2SLS without Oil Dependency

	Dependent variable: GHGperGDP	
	2SLS	Robust
	(1)	(2)
FittedPrice	-9.1032^{***}	-9.1032^{***}
	(2.1115)	(3.0886)
GDPgrowth	0.3492	0.3492
	(6.2047)	(7.9026)
GDPperCap	-0.0007	-0.0007
	(0.0069)	(0.0140)
OilCperGDP	2.4742^{***}	2.4742^{***}
	(0.0697)	(0.1938)
SRE	2.4627	2.4627
	(4.6674)	(12.7625)
Observations	520	
R^2	0.7888	
Adjusted R^2	0.7786	
F Statistic	369.7924^{***} (df = 5; 495)	
Note:		*p<0.1; **p<0.05; ***p<0.01

The table above shows that oil price is significant at 1% level to explain the GHG emissions. Notice that a country could less or more affected by price since it can be highly dependent to oil and so there could be overestimation of the price variable if the oil dependency is omitted.

Table 6: 2SLS with Oil Dependency

	Dependent variable: GHGperGDP	
	2SLS	Robust
	(1)	(2)
FittedPrice	−0.2961	−0.2961
	(1.9308)	(1.5051)
I(FittedPrice $*$OilDep)	0.0126**	0.0126*
	(0.0056)	(0.0073)
GDPgrowth	4.9588	4.9588
	(5.2266)	(6.8357)
GDPperCap	−0.0038	−0.0038
	(0.0058)	(0.0092)
OilCperGDP	2.7314***	2.7314***
	(0.0617)	(0.1363)
SRE	−7.9781**	−7.9781
	(4.0232)	(8.5405)
OilDep	−1.9875***	−1.9875***
	(0.4200)	(0.3892)
Observations	520	
R^2	0.8513	
Adjusted R^2	0.8435	
F Statistic	403.2833*** (df = 7; 493)	
Note:		*p<0.1; **p<0.05; ***p<0.01

This table is the final one and states the result of the estimation after the use of instrumental variable to correct endogeneity and after the correction of heteroskedasticity. Adjusted Oil price is no longer significant unlike the crossed variable PriceAdjOil*OilDep that is significant.

Table 7: Exogeneity verification model of the instrument

	Dependent variable: Residuals 2SLS
NegSupplyShock	0.0000
	(33.0473)
GDPgrowth	0.0000
	(4.8688)
GDPperCap	0.0000
	(0.0045)
OilCperGDP	0.0000
	(0.0556)
SRE	−0.0000
	(4.0488)
OilDep	−0.0000
	(0.1869)
Observations	520
R^2	0.0000
Adjusted R^2	−0.0506
F Statistic	0.0000 (df = 6; 494)
Note:	*p<0.1; **p<0.05; ***p<0.01

In reality, the estimates and the R squared are not equal to 0, but very small and the table 8 above doesn't show a large number of decimals. See table 8 below. In fact, in the 2SLS regression, the R squared is about 85% which means that the model explains very well the dependent variable, and hence provides small residuals (because fitted values are close to the truth). Then, when we regress these residuals on the instrument and the exogenous variables (regressing very small values of Y on very big values of X), it then provides very small estimates which are close to 0, but not equal to 0.

Table 8: Estimates of exogeneity verification model

Term	Estimate
NegSupplyShock	2.9693e-14
GDPgrowth	1.3120e-15
GDPperCap	7.0982e-18
OilCperGDP	6.1695e-17
SRE	-1.9037e-15
OilDep	-1.1264e-16

In fact, the coefficients are different from 0 as the table 7 notices.

Table 9: 2SLS without Norway and Denmark

	Dependent variable: GHGperGDP	
	2SLS	Robust
	(1)	(2)
FittedPrice	-18.7381^{***}	-18.7381
	(6.6517)	(13.0912)
I(FittedPrice ∗OilDep)	0.2079^{***}	0.2079
	(0.0688)	(0.1401)
GDPgrowth	5.1157	5.1157
	(4.5537)	(6.6115)
GDPperCap	-0.0018	-0.0018
	(0.0052)	(0.0092)
OilCperGDP	2.8417^{***}	2.8417^{***}
	(0.0574)	(0.1354)
SRE	-6.9259^{*}	-6.9259
	(3.8448)	(7.8017)
OilDep	1.5439	1.5439
	(3.0159)	(4.5959)
Observations	468	
R^2	0.8966	
Adjusted R^2	0.8910	
F Statistic	548.7889^{***} (df = 7; 443)	
Note:		*p<0.1; **p<0.05; ***p<0.01