**International Journal of Management Science and Business Administration**

Volume 2, Issue 9, August 2016, Pages 37-46
DOI: 10.18775/ijmsba.1849-5664-5419.2014.29.1004
URL: http://dx.doi.org/10.18775/ijmsba.1849-5664-5419.2014.29.1004

# The Greenhouse Gas Emission in the EU: a VAR Analysis of the Relevant Variables

[1]Filip Kokotovic, [2]Petar Kurecic, [3]Domagoj Cingula
[1]University College of International Relations and Diplomacy Dag Hammarskjold, Zagreb, Ilica 242, Croatia
[2]University North, Department of Business Economics, Varazdin, 104, Brigade 3, Croatia
[3]Varazdin Development and Entrepreneurship Agency, Varazdin, Croatia

**Abstract**: This paper considers the relevance of a nexus of variables relevant to achieving the Sustainable Development Goals (SDGs) of the United Nations, as well as accomplishing the goals of the Paris Agreement. It empirically considers the 28 European Union (EU) member states, dividing them into three panels based upon the time of their accession to full EU membership. The empirical analysis consists of unit root tests, a Vector Autoregressive (VAR) framework, Granger causality test, and diagnostic tests. Based on the empirical results, there are significant differences between the post-transitional and original EU member states. This difference is most notable in the fact that only in the panel of countries that have acceded to the EU after 2004 there is a statistically significant link between energy consumption and the greenhouse gas emission. We, therefore, conclude that while not all EU member states exhibit signs of environmental imbalances, there still are significant differences between the EU 15 and the states that have acceded to full membership after 2004.

**Key words:** Granger causality, VAR analysis, Sustainable Development Goals (SDGs), Greenhouse Gas Emission, the European Union (the EU), Economic Growth

## 1. Introduction

With the signing of the Paris Agreement and its probable ratification during 2016, the focus of the international debate once again slowly shifts back towards sustainable development. The goals set forth in Paris are in no way significantly ambitious towards ensuring long-term sustainable development, yet they seem to be a step in the right direction. Combating climate change in the past several decades has seen several setbacks. The Kyoto Protocol never lived up to its expectations and will probably only ever be mentioned as one of many failed treaties that have tried and failed to address climate change issues. There have been numerous other attempts, although noticeably less in the public eye, such as the Copenhagen Summit of 2009, perhaps far more notably the United Nations (UN) have tried and utterly failed to achieve goals targeted by the Millennium Declaration.

The UN seems to have become a significant figure in attempting to combat climate change and achieve goals necessary to ensure long-term sustainable development. Unfortunately, mainly these goals never been implemented into legislation and strategies of the various UN member-states. The format of a General Assembly resolution for the majority of issues regarding climate change is perhaps acceptable to many UN member-states because these resolutions are not legally binding. It is possible to emphasize moral and political responsibility, yet these concepts seem to have a diminished significance in present-day international relations. Perhaps the most ambitious concept so far devised by the UN are the Sustainable Development Goals (SDGs) (United Nations, 2015). The concept in itself is ambitious, comprehensive and *sui generis* in its approach. While the Millennium Declaration had a comprehensive approach and attempted to deal with issues besides climate change, it did not have such a comprehensive framework that it attempted to deal with all of the relevant issues of the 21st century (Kumar, Kuman, and Vivekadhish, 2016). Members of the scientific community and politicians alike, agree that the SDGs have approached the issue from a human-centered paradigm, were the product of discussion by millions of people and many, including Erna Solberg, the Prime Minister of Norway, emphasize the role of civil society in their development (Solberg, 2015; Kumar, Kuman, and Vivekadhish, 2016).

Many critics question the SDGs implementation (Pogge and Sengputa, 2015). Even the most basic approach to decreasing $CO_2$ and other greenhouse gas emission, as required by the Paris Agreement, will require a substantial change. This paper empirically approaches the issue of relevant factors that cause the increase of greenhouse gas emission. It especially examines the relationship between greenhouse gas emission and environmental taxes, although it also examines a wide range of indicators relevant to sustainable development. The empirical analysis is focused on the European Union (the EU), as a developed region that would be expected to conform easily to both the Paris Agreement and have a long-term role in achieving the SDGs.

A significant amount of studies explores the influence of economic growth and other economic indicators on the emissions of $CO_2$. We conduct this literature review by listing the empirical works that have considered a panel is setting first, while also taking note of several studies that have only examined one particular country. Wagner et al. (2016) conducted a simple ordinary least squares (OLS) regression, using data from 1950–2010 on a global scale, for all countries where data was available, with the following empirical approach:

$$dLn(Energy(t)) = \alpha * dln(GDP(t)) + \beta * dln(pop(t-2)) + \gamma * dln(pop(t-4)) + \varepsilon * \ln(energy(t-1)) + \varphi * \ln(GDP(t-1)) + \rho * \ln(pop(t-1)) \quad (1)$$

Energyproportional change in energy use over time
GDPGross Domestic product
Poppopulation
$\alpha$ , $\beta$, $\gamma$, $\varepsilon$, $\varphi$, $\rho$ coefficients

Based upon their approach, Wagner et al. (2016) concluded that there is a need to switch to renewable energy and that this change should be made as soon as possible. They further conclude that this change will be economically profitable, due to the fact that at some point there will be a drastic rise in fossil fuel prices, especially in developing countries. Lutz and Meyer (2010) believe that there would be a positive effect of increasing taxes on resource use or emission in Europe. Lee and Brahmasrene (2013) conducted several tests on the EU countries, including panel cointegration and concluded that there is a positive long-term relationship between $CO_2$ emission and GDP. Han and Lee (2013) conducted a General Method of Movement (GMM) analysis on a panel of 19 OECD countries that have ratified the Kyoto protocol, and concluded that the effect of $CO_2$ emission on economic growth is declining at a statistically significant trend. Blanco, Gonzalez, and Ruiz (2013) conducted panel Granger causality tests on a sample of 18 Latin American countries and concluded that there was empirical evidence of causality going from FDI in pollution-intensive industries towards $CO_2$ emission per capita.

Srinivasan (2014) used several quantitative analysis methods, including a Vector Error Correction Model (VECM), impulse response functions and cointegration tests on the available data for India and concluded that there is a short-run relationship from $CO_2$ emissions to economic growth. He further finds that there is a long-term relationship between GDP and energy consumption (Srinivasan, 2014: 329). Shaari, Hussain, and Rashid (2014) made a VECM for Malaysia and emphasized that increasing energy consumption in order to increase economic growth may also result in increased $CO_2$ emission. Based on the conducted literature review it seems that there is a statistically significant relationship between $CO_2$ emission and several macroeconomic variables. This paper also acknowledges the divide that was especially noted by Wagner et al. (2016), that there is a division in the economic field regarding the direction of the causal relationship between economic growth and $CO_2$ emission.

## 2. Methodology

In the empirical analysis here, we primarily consider the total environment tax revenue (ENV Tax), measured in millions of Euros and greenhouse gas emission (GG Emis), as $CO_2$ equivalent, in thousands of tons. As additional explanatory variables, employment (Empl), in thousands of persons, total gross inland consumption of all energy (ENCons) in thousands of tons of oil equivalent, primary production of renewable energy (Renew) in thousands of tons of oil equivalent and GDP in millions of Euros are considered. All of the data is extracted from the Eurostat database for the 1995–2013 periods. All of the variables are transformed into the form of their natural logarithm. The panels for which we conduct the statistical tests are as specified: Panel A are the original EU member states at the time of the forming of the


ISSN 1849-5664 (online)http://researchleap.com/category/international-journal-of-management-science-and-business-administration
ISSN 1849-5419 (print) International Journal of Management Science And Business Administration, vol. 2, issue 9, pp. 37-46, August, 2016

European Community for Coal and Steel whereas Panel B consists of countries that have acceded to full membership in the EU from the first enlargement of the EU until the enlargement of 2004, while Panel C consists of countries that have acceded to full membership from 2004. Complete lists of countries, as well as summary statistics for each of the panels, are available in the Appendix.

The first step in the analysis is performing unit root tests; this paper employs the tests originally suggested by Levin, Lin and Chu (2002) and by Im, Peseran and Schin (2003). Both tests have a null hypothesis of non-stationary, meaning that rejection of the null hypothesis is necessary to confirm the absence of a unit root. Following the unit root tests, we perform Vector Auto Regression (VAR) models for each of the panels. Once specifying the correct lag length of the VAR models, diagnostic tests are conducted on the VAR models to ensure that they do not exhibit autocorrelation, homoscedasticity or parameter instability. We conduct Granger causality tests, initially introduced by Granger (1969) in order to establish the significant causal relationships between the variables. When the results of the Granger causality test are significant at the 10% significance level, further Cholesky impulse response functions are conducted to inspect the short-term and long-term effect of an inclusion of one standard deviation of the independent variable on the dependent variable. Based upon the conducted test, it will be possible to conclude whether there is any statistically significant relationship between the considered variables.

# 3. Results and Discussion

The unit root tests are conducted with constant, and with the number of lags determined automatically based upon the Schwarz information criterion. In order to confirm the absence of a unit root, both tests had to reject the null hypothesis of a unit root presence at the 5% significance level.

As can be seen from the results in Table 1, for Panel A all variables are stationary in their first difference, except employment that is I(2). For Panel B, three variables are stationary in level, while three are I(1). In Panel C, two variables are stationary in level, while four are I(1). The very fact that these variables are not integrated into the same level suggests that not all of these variables may have a statistically significant impact, but such conclusions with far greater precision based on the results of the VAR model.

Regarding the specification of the VAR models, for Panel A, the Schwarz information criterion suggested one lag, while the Akaike information criterion suggested six lags. At both lag lengths, there is evidence of parameter instability or autocorrelation. At four lags, the model is both structurally stable and does not exhibit signs of autocorrelation nor homoscedasticity. For Panel B the majority of the criterions suggest two lags, yet at that lag length, the stability condition is not satisfied. Therefore, the model is specified using three lags and at that lag length, the model satisfies the stability condition, as well as all of the other diagnostic tests that are shown in the Appendix. We, therefore, detect the following statistically significant relations at the 10% level of relevance and test the impulse response function. For Panel C the Schwarz information criterion suggested one lag, while the Akaike information criterion suggested eight lags. After conducting tests on both models at one lag, the model rejects the null of heteroscedasticity and rejects the null of no autocorrelation, while at eight lags the model had a higher explanatory value and based on the results of the diagnostic tests is stable and absent of the errors present in the one lag length specification. In Table 2, we display the explanatory value of each model, with the models identified by the dependent variable.

The key statistic clearly displays that especially in Panel A some of the results, based upon the value of the F-statistic, are not statistically significant. Clearly, other factors rather than those selected by the methodology of this paper are crucial for determining greenhouse gas emission. The explanatory value of that model comes close to being adequate only in Panel C. Regarding the environmental tax revenue. Clearly, the chosen variables have a significant impact in Panel C, while in Panels A and B variables that are not considered by this paper have a more statistically significant impact on determining environmental tax revenue. Perhaps surprisingly, the chosen variables have a moderate to high ability to explain two purely macroeconomic variables – GDP and the number of employees. It should be noted that the examined studies either examine the Granger causality or employ panel OLS between usually GDP or GDP per capita and $CO_2$ emission such as Lee and Brahmasrene (2013) while other studies that have included a larger number of variables face difficulties as this paper (Srinivasan, 2014; Wagner et al., 2016).

**Table 1**: Unit root tests

| | Panel A | | Panel B | | Panel C | |
|---|---|---|---|---|---|---|
| | Levin, Lin and Chu t | Im, Peseran and Schin W-stat | Levil, Lin and Chu t | Im, Peseran and Schin W-stat | Levil, Lin and Chu t | Im, Peseran and Schin W-stat |
| ENVTax | -4.002** (0.0000) | -0.365 (0.3576) | -4.31597** (0.0000) | -1.5974 (0.0551) | -5.6522** (0.0000) | -2.2735* (0.0115) |
| In first difference | -5.6623** (0.0000) | -5.0611** (0.0000) | -10.002** (0.0000) | -7.1326** (0.0000) | / | / |
| GGEmis | 2.8196 (0.9976) | 4.3053 (1.000) | 1.3777 (0.9158) | 2.1227 (0.9831) | -0.8697 (0.1922) | -0.2552 (0.3993) |
| In first difference | -10.0789** (0.0000) | -10.2057** (0.0000) | -8.6056** (0.0000) | -8.9611** (0.0000) | -8.3501** (0.0000) | -7.6192** (0.0000) |
| Empl | -3.200** (0.0007) | -1.0264 (0.1523) | -4.311** (0.0000) | -1.8091* (0.0352) | -4.4454** (0.0000) | -3.2715** (0.0000) |
| In first difference | 1.484 (0.0689) | -1.4824 (0.0691) | / | / | / | / |
| In second difference | -5.064** (0.0000) | -5.6051** (0.0000) | / | / | / | / |
| GDP | -5.034** (0.0000) | -1.5763 (0.0575) | -6.401** (0.0000) | -3.519** (0.0002) | -3.6434** (0.0001) | 0.8916 (0.8137) |
| In first difference | -5.7224** (0.0000) | -4.012 (0.0000) | / | / | -6.4687** (0.0000) | -4.2146** (0.0000) |
| ENCons | -1.2198 (0.1113) | -0.8914 (0.1864) | -3.7418** (0.0001) | -2.5179** (0.0059) | -0.9154 (0.18) | -0.2669 (0.3948) |
| In first difference | -7.6515** (0.0000) | -6.3993** (0.0000) | / | / | -12.559** (0.0000) | -10.206** (0.0000) |
| Renew | 1.331 (0.9084) | 4.3053 | 2.2495 (0.9878) | 4.7046 (1.0000) | 1.5228 (0.9361) | 3.855 (0.9999) |
| In first difference | -7.5778** (0.0000) | -6.7513** (0.0000) | -11.127** (0.0000) | -9.1365** (0.0000) | -10.852** (0.0000) | -10.188** (0.0000) |

**Source:** Authors' calculations and E-Views 9.5 output
**Note:** values in the parenthesis represent the p value. * and ** indicate statistical significance at the respected 0.05 and 0.01 levels of significance.

**Table 2**: Key statistics regarding VAR models

| | Panel A | | | | | |
|---|---|---|---|---|---|---|
| | GGEmis | Renew | ENVTax | Empl | ENCons | GDP |
| R-squared | 0.3849 | 0.3916 | 0.5168 | 0.5802 | 0.5181 | 0.6148 |
| Adjusted R-squared | 0.077 | 0.096 | 0.1854 | 0.2924 | 0.1877 | 0.3507 |
| F-statistic | 1.13 | 0.925 | 1.5597 | 2.016 | 1.687 | 2.238 |
| AIC | -3.432 | -1.663 | -3.487 | -6.15 | -3.927 | -4.697 |
| | Panel B | | | | | |
| R-squared | 0.2477 | 0.237 | 0.1528 | 0.99967 | 0.9982 | 0.9991 |
| Adjusted R-squared | 0.1289 | 0.1165 | 0.019 | 0.99961 | 0.9979 | 0.999 |
| F-statistic | 2.085 | 1.967 | 1.142 | 19005.6 | 3572.77 | 7409.048 |
| AIC | -1.546 | -2.02 | -2.59 | -5.171 | -3.585 | -4.395 |
| | Panel C | | | | | |
| R-squared | 0.6357 | 0.6249 | 0.9971 | 0.9996 | 0.6335 | 0.662 |
| Adjusted R-squared | 0.3668 | 0.3479 | 0.9947 | 0.9994 | 0.3628 | 0.412 |
| F-statistic | 2.3635 | 2.256 | 466.593 | 3726.248 | 2.341 | 2.652 |
| AIC | -1.592 | -2.238 | -2.196 | -4.0022 | -3.206 | -2.184 |

**Source:** Authors' calculations and E-Views 9.5 output

**Table 3**: Granger causality test

| Excluded | Dependent variable | Panel A Chi-sq | Panel B Chi-sq | Panel C Chi-sq |
|---|---|---|---|---|
| Renew | GGemis | 4.38 | 4.132 | 4.779 |
| | | (0.357) | (0.2475) | (0.7809) |
| ENVTax | | 1.125 | 0.842 | 6.462 |
| | | (0.8903) | (0.8393) | (0.5956) |
| Empl | | 1.947 | 3.364 | 6.376 |
| | | (0.7455) | (0.3389) | (0.6052) |
| EnConcs | | 6.829 | 3.879 | 27.74*** |
| | | (0.1452) | (0.5045) | (0.0005) |
| GDP | | 3.202 | 1.782 | 10.322 |
| | | (0.5245) | (0.6189) | (0.2431) |
| GGemis | Renew | 4.2802 | 3.065 | 14.68* |
| | | (0.3694) | (0.3817) | (0.0656) |
| ENVTax | | 1.672 | 0.842 | 6.136 |
| | | (0.7959) | (0.8393) | (0.632) |
| Empl | | 0.359 | 3.364 | 9.624 |
| | | (0.9857) | (0.3389) | (0.2924) |
| EnConcs | | 6.337 | 3.879 | 11.075 |
| | | (0.1754) | (0.5045) | (0.1975) |
| GDP | | 1.369 | 5.533 | 15.146* |
| | | (0.8495) | (0.1367) | (0.0564) |
| GGemis | ENVTax | 1.324 | 1.313 | 14.15* |
| | | (0.8573) | (0.726) | (0.0779) |
| Renew | | 7.747 | 5.787 | 10.788 |
| | | (0.1013) | (0.141) | (0.2140) |
| Empl | | 8.14* | 3.652 | 20.314*** |
| | | (0.0659) | (0.3016) | (0.0092) |
| EnConcs | | 4.277 | 0.689 | 17.314** |
| | | (0.3698) | (0.8759) | (0.027) |
| GDP | | 6.086 | 4.176 | 13.059 |
| | | (0.1928) | (0.2431) | (0.1098) |
| GGemis | Empl | 5.238 | 2.3002 | 4.96 |
| | | (0.2638) | (0.5125) | (0.7618) |
| Renew | | 5.389 | 8.343** | 3.75 |
| | | (0.2497) | (0.0394) | (0.8789) |
| ENVTax | | 3.581 | 4.2205 | 9.657 |
| | | (0.4657) | (0.2386) | (0.2899) |
| EnConcs | | 4.658 | 1.312 | 8.153 |
| | | (0.3242) | (0.7263) | (0.4187) |
| GDP | | 3.809 | 16.878** | 11.814 |
| | | (0.4324) | (0.0007) | (0.1597) |
| GGemis | EnConcs | 4.63 | 0.4857 | 8.08 |
| | | (0.3274) | (0.9220) | (0.4257) |
| Renew | | 7.733 | 5.089 | 13.038 |
| | | (0.1019) | (0.1654) | (0.1106) |
| ENVTax | | 1.052 | 0.575 | 14.554* |
| | | (0.9018) | (0.9021) | (0.0684) |
| Empl | | 2.11 | 6.953* | 24.244*** |
| | | (0.7155) | (0.0734) | (0.0021) |
| GDP | | 6.79 | 0.07 | 16.3** |
| | | (0.1474) | (0.9951) | (0.0383) |
| GGemis | GDP | 7.56 | 3.893 | 5.76 |
| | | (0.1091) | (0.2733) | (0.6741) |
| Renew | | 4.061 | 5.113 | 2.198 |
| | | (0.3979) | (0.1637) | (0.9743) |
| ENVTax | | 5.116 | 3.211 | 11.997 |
| | | (0.2756) | (0.3602) | (0.1513) |
| Empl | | 2.991 | 6.813* | 7.164 |
| | | (0.5594) | (0.0781) | (0.519) |
| EnCons | | 11.537** | 3.2662 | 20.94*** |
| | | (0.0211) | (0.3524) | (0.0073) |

**Source:** Authors' calculations and E-Views 9.5 output


ISSN 1849-5664 (online)http://researchleap.com/category/international-journal-of-management-science-and-business-administration
ISSN 1849-5419 (print) International Journal of Management Science And Business Administration, vol. 2, issue 9, pp. 37-46, August, 2016

**Note:** values in the parenthesis represent the p value. *, ** and *** indicate statistical significance at the respected 0.1, 0.05 and 0.01 levels of significance.

Based on the results of the Granger causality test we conduct the impulse response functions where we found evidence that there is a statistically significant relationship between the variables. For Panel A this paper finds there is causality going from energy consumption towards GDP. Based on the results of the impulse response function we find that the initial short-term relationship is positive, but it starts fluctuating after two periods, meaning that the relationship is statistically significant and positive in the short term, but we find no evidence of a long-term relationship. This paper also finds that there is a relationship going from employment towards environmental tax revenue. This may be considered intuitively logical as in periods where there is a stable macroeconomic environment, other factors such as sustainable development indicators become increasingly significant. Thus with the rise of employment, there may be a rise in environmental tax revenue, although this intuitive hypothesis is not confirmed by the impulse response function that suggests that the long-term effects are not statistically significant.

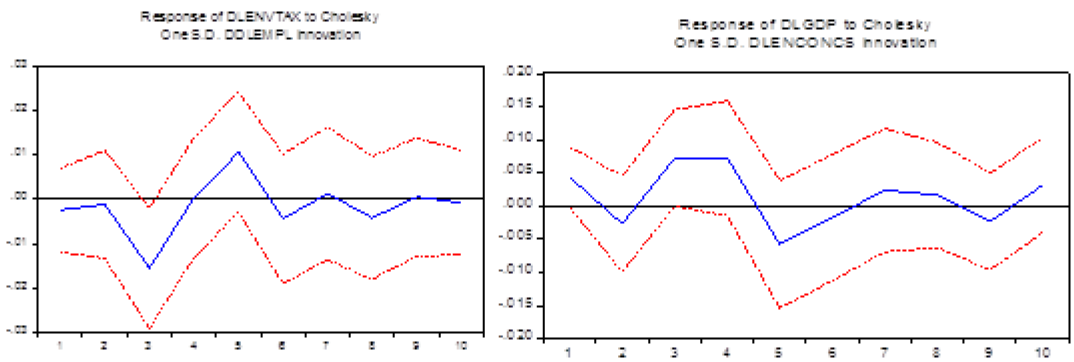


**Figure 1:** Impulse response functions for Panel A
**Source:** Authors' calculations and E-Views 9.5 output

For Panel B there are more statistically significant relationships detected. There is a statistically significant relationship between renewable energy source production and employment. It initially has a positive response, although it seems to be negative in the long-term. Several sets of relationships concern traditionally macroeconomic variables, such as that there is a logically long-term relationship from the number of employees towards GDP growth. The relationship seems to be bidirectional, as there is a positive long-term relationship going from economic growth towards the number of employees. This is confirmed by the impulse response function, as for Panel B there seems to be both a rise in economic growth when the number of employees increases, as well as an increase in the number of employees when there is a period of economic growth. Lastly, there seems to be an increase in energy consumption that follows the rise of employment. This conclusion is also intuitive as several others have noted that an increase in population or employed may lead to increased energy consumption (Wagner et al., 2016).

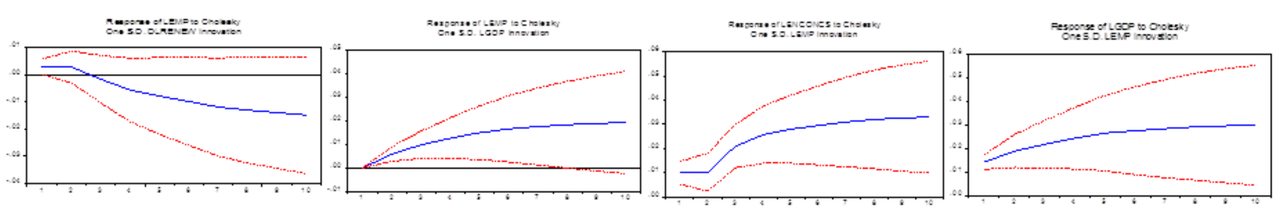

**Figure 2:** Impulse response functions for Panel B
**Source:** Authors' calculations and E-Views 9.5 output

For Panel C a higher number of statistically significant relationships are detected. Notably, there seems to be a significant short-term impact of energy consumption on greenhouse gas emission. Such a relationship is not detected in Panel A or B where we find no statistically significant link going from any of the chosen variables towards greenhouse gas emission. This is perhaps possible to explain by the fact that several of these mostly post-transitional economies still do not have the equal standards to their western counterparts. There is a significant relationship going from GDP towards renewable energy consumption, although based on the results of the impulse results function it mostly seems to fluctuate without definitive patterns. Similarly, without a definitive pattern, this paper finds a significant relationship going from


ISSN 1849-5664 (online)http://researchleap.com/category/international-journal-of-management-science-and-business-administration
ISSN 1849-5419 (print) International Journal of Management Science And Business Administration, vol. 2, issue 9, pp. 37-46, August, 2016

greenhouse gas emission towards renewable energy production. This relationship also seems to have no distinct pattern. The relationship going from greenhouse gas emission towards environmental tax revenue seems initially neutral but is positive in the long-term. Therefore, only with a more significant increase of greenhouse gas emission is there any chance of an increase in environmental taxes to curb the excessive emission.

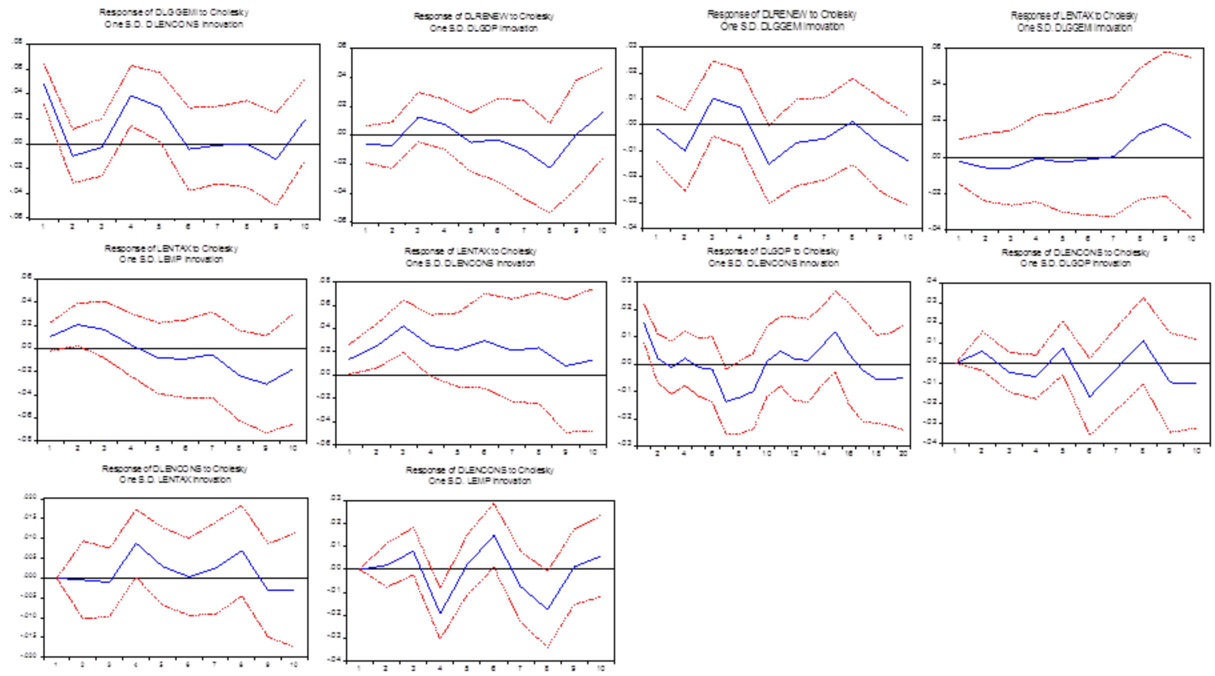

**Figure 3:** Impulse response functions for Panel B
**Source:** Authors' calculations and E-Views 9.5 output

Based upon the Granger causality test, there is a bidirectional relationship going from GDP towards energy consumptions and from energy consumption towards GDP. Both of these relationships seem positive in the short term based on the results of the impulse response function, while they seem to fluctuate without a definitive pattern in the long-term. There seems to be a bidirectional relationship between energy consumption and environmental tax revenue as well. As the results of the Granger causality test imply, the relationship is more significant going from energy consumption towards environmental tax revenue. This finding is conclusive and may be given similar argumentation as with the relevance of greenhouse gas emission on environmental tax revenue. This paper also notes that with the rising number of employees there is a rise in the energy consumption, comparative to Panel B. There is also a significant relationship going from the number of employees towards the environmental tax revenue. A possible argument why there are such some statistically significant relationships in Panel C is that in these post-transitional countries, the economic growth and stability are a necessary condition for advancing sustainable development goals.

# 4. Conclusion

The paper employs a VAR framework on three different panels of EU countries. Before conducting the VAR analysis, the stationary of the variables was tested using standard panel unit root tests. The VAR analysis results signify a rather simple conclusion, for the majority of the EU moving towards the SDGs in regards to greenhouse gas emission and similar goals is already a reality. This paper finds slight differences in the relevance of political stability or economic growth on greenhouse gas emission. Primarily this is because Panel C seems to exhibit signs of relevance of energy consumption on greenhouse gas emission. There is no such relationship detected in Panels A and B, as the chosen variables mostly do not have a statistically significant impact on the determination of greenhouse gas emission.

This clearly displays that further research should be focused on different regions of the world where there may be a significant long-term relationship between greenhouse gas emission and economic growth. In this regard, this paper manages to determine that there are major differences between the countries that have acceded to the EU prior to 2004 and the newly acceded countries. This article still concludes that none of the EU member states has any statistically significant markers that would imply the existence of a significant relationship between further economic growth and


ISSN 1849-5664 (online)http://researchleap.com/category/international-journal-of-management-science-and-business-administration
ISSN 1849-5419 (print) International Journal of Management Science And Business Administration, vol. 2, issue 9, pp. 37-46, August, 2016

greenhouse gas emission. Therefore, the EU, while still not implementing the level of environmental tax revenue necessary to have a statistically significant impact on greenhouse gas emission, is on the right path to achieving the Paris Agreement goals.

# References

- Blanco, L., F. Gonzalez, Ruiz, I. (2013). The Impact of FDI on CO2 Emissions in Latin America. Oxford Development Studies, 41(1), 104-121, CrossRef
- Eurostat data. http://ec.europa.eu/eurostat/data/database (Retrieved 05/05/2016)
- Granger, C.W.J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica, 37(3), 424-438, CrossRef
- Han, C., Lee, H. (2013). Dependence of Economic Growth on CO2 Emissions. Journal of Economic Development, 38(1), 47-57.
- Im, K.S., Pesaran, H.M., Shin, Y. (2003). Testing for Unit Roots in Heterogeneous Panels. Journal of Econometrics, 115(1), 53-74, CrossRef
- Kumar, S, Kumar, N., Vivekadhish, S. (2016). Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs): Addressing Unfinished Agenda and Strengthening Sustainable Development and Partnership. Indian Journal of Community Medicine, 41(1), 1-4, CrossRef
- Lee, J.W., Brahmasrene, T. (2013). Investigating the Influence of Tourism on Economic Growth and Carbon Emissions: Evidence from Panel Analysis of the European Union. Tourism Management, (38), 69-76, CrossRef
- Levin, A., Lin, C.F., Chu, S.J. (2002). Unit Root Tests in Panel Data: Asymptotic and finite-sample properties. Journal of Econometrics, 108(1), 1-24, CrossRef
- Lutz, C., Meyer, B. (2010). Environmental Tax Reform in the European Union: Impact on CO2 Emissions and the Economy. Zeitschrift für Energiewirtschaft, 34(1), 1-10, CrossRef
- Pogge, T., Sengupta, M. (2015). The Sustainable Development Goals (SDGs) as Drafted: Nice Idea, Poor Execution. Washington International Law Journal, 24(3), 571-587.
- Shari, M.S., Hussain, N.E., Rashid, I.M.A. (2014). The Relationship between Energy Use, Economic Growth, and CO2 Emission in Malaysia. Economics, Management, and Financial Markets, 9(2), 41-53.
- Solberg, E. (2015). From MDGs to SDGs: The Political Value of Common Global Goals. Harvard International Review, 37(1), 58-61.
- Srinivasan, P. (2014). Causality among Energy Consumption, CO2, Economic Growth and Trade: A Case of India. Journal of Academic Research in Economics, 6(3), 315-335.
- United Nations, Sustainable Development Goals, http://www.un.org/sustainabledevelopment/sustainable-development-goals/ (Retrieved 04/05/2016)
- Wagner, L. et al. (2016). Trading Off Global Fuel Supply, CO2 Emissions and Sustainable Development. PLoS ONE 11(3), e0149406. doi:10.1371/journal.pone.0149406, CrossRef

# Appendix

The specification for each of the panels is listed in Table A1.

**Table A1**: Panel specifications

| Panel A | Panel B | Panel C | Panel C – continued |
|---|---|---|---|
| Belgium | Denmark | Bulgaria | Romania |
| Germany | Ireland | Czech Republic | Poland |
| France | Greece | Estonia | Slovenia |
| Italy | Spain | Croatia | Slovakia |
| Luxembourg | Austria | Cyprus | |
| Netherlands | Portugal | Latvia | |
| | Finland | Lithuania | |
| | Sweden | Hungary | |
| | United Kingdom | Malta | |

Full summary statistics for each of the panels are provided in Table A2.

**Table A2**: Summary statistics

| | GGEMIS | GDP | ENVTax | ENCons | Empl | Renew |
|---|---|---|---|---|---|---|
| | | | Panel A | | | |
| Mean | 39451.8 | 1182934 | 25830.75 | 167588.7 | 15185.47 | 8534.044 |
| Median | 32438.2 | 1453378 | 26224.5 | 174219.2 | 15524 | 5175.1 |
| Maximum | 1103855 | 2693325 | 58691 | 352857 | 37810 | 33679.5 |
| Minimum | 8466.9 | 30248.2 | 468.77 | 3268.9 | 167.3 | 29.8 |
| Std. Deviation | 325323 | 869652.8 | 19209.15 | 125055.6 | 12337.83 | 8729.405 |
| Skewness | 0.708511 | 1.549504 | 1.639244 | 1.521702 | 1.84504 | 2.57896 |
| Observations | 114 | 109 | 114 | 95 | 109 | 114 |
| | | | Panel B | | | |
| Mean | 167956.7 | 459086.2 | 10985.96 | 61428.5 | 6746.471 | 5776.638 |
| Median | 75343.83 | 23639 | 6248.7 | 31836.4 | 3348.63 | 4785.9 |
| Maximum | 779954.83 | 1911309 | 51053.57 | 234000.9 | 25574 | 18524.4 |
| Minimum | 14222.71 | 76519 | 1565.12 | 11066.5 | 1222.1 | 154.6 |
| Std. Deviation | 205307.5 | 497292.6 | 12400.5 | 65661.47 | 7469.311 | 4576.595 |
| Skewness | 1.8222 | 1.76109 | 2.20661 | 1.67037 | 1.58446 | 0.843335 |
| Observations | 171 | 171 | 171 | 168 | 171 | 171 |
| | | | Panel C | | | |
| Mean | 67626.56 | 66987.12 | 1360.833 | 21475.93 | 2694.994 | 1645.365 |
| Median | 22531.52 | 35287.7 | 731.39 | 9301.4 | 1267.29 | 1138.55 |
| Maximum | 429942.7 | 390673.8 | 9711.090 | 103065.6 | 12260 | 8511.5 |
| Minimum | 2411.39 | 5391.6 | 25.61 | 742.4 | 127.3 | 0.2 |
| Std. Deviation | 98163.82 | 78391.37 | 1790.798 | 25208.58 | 3022.564 | 1608.588 |
| Skewness | 2.3173 | 2.2162 | 2.8886 | 1.9172 | 1.7148 | 1.7299 |
| Observations | 247 | 239 | 240 | 247 | 242 | 240 |

**Source:** Authors' calculations and E-Views 9.5 output

Based upon the results of the LM autocorrelation test in Table A3, we can confirm that the residuals are not serially correlated. The tests are conducted for the lag length selected for each of the respected models, with an initial lag included to confirm adequate model specification.

**Table A3**: Autocorrelation LM test

| Number of lags | Panel A LM-stat | p value | Panel B LM-stat | p value | Panel C LM-stat | p value |
|---|---|---|---|---|---|---|
| 1 | 48.864 | 0.062 | 30.539 | 0.7256 | 36.008 | 0.4683 |
| 2 | 28.848 | 0.7957 | 39.34 | 0.3227 | 42.91 | 0.1992 |
| 3 | 34.465 | 0.5416 | 34.21 | 0.5539 | 47.36 | 0.0974 |
| 4 | 47.156 | 0.0865 | 41.812 | 0.233 | 35.591 | 0.4879 |
| 5 | 36.395 | 0.4503 | | | 44.739 | 0.1506 |
| 6 | | | | | 48.617 | 0.078 |
| 7 | | | | | 28.06 | 0.8251 |
| 8 | | | | | 37.73 | 0.3901 |
| 9 | | | | | 34.892 | 0.5211 |

**Source:** Authors' calculations and E-Views 9.5 output


ISSN 1849-5664 (online)http://researchleap.com/category/international-journal-of-management-science-and-business-administration
ISSN 1849-5419 (print) International Journal of Management Science And Business Administration, vol. 2, issue 9, pp. 37-46, August, 2016

The results in Table A4 clearly confirm that at the 5% significance level we fail to reject the null hypothesis of no heteroscedasticity.

**Table A4**: Heteroscedasticity joint test

| Panel A Chi-sq | Panel B Chi-sq | Panel C Chi-sq |
|---|---|---|
| 1027.102 | 815.3928 | 2060.793 |
| (0.3308) | (0.066) | (0.2386) |

**Source:** Authors' calculations and E-Views 9.5 output
**Note:** values in the parenthesis represent the p value

The final test, presented in Figure A1, confirms that the parameters are structurally stable as none of the unit roots lay outside the stability circle. This concludes that the VAR models satisfy the stability condition.

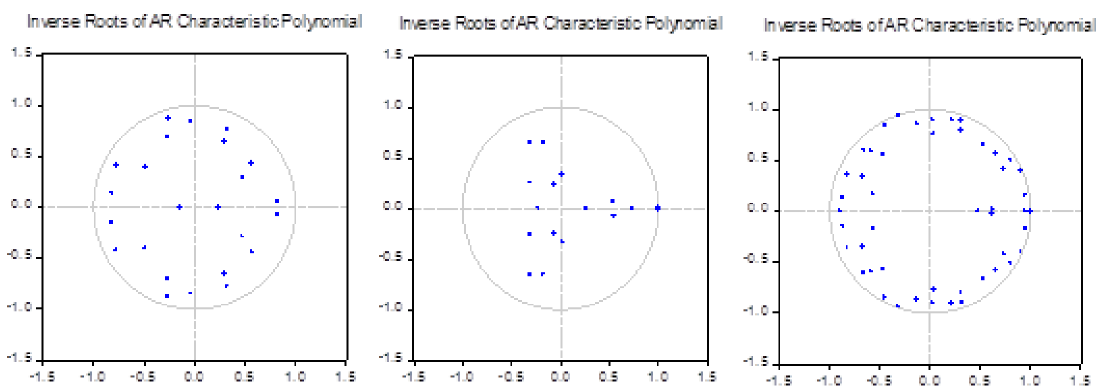


**Figure A1**: Parameter structural stability test