Professor Mihai PĂUNICĂ, PhD
E-mail: mihai.paunica@cig.ase.ro
Department of Accounting and Audit
The Bucharest University of Economic Studies
Professor Alexandru MANOLE, PhD
E-mail: amanole@artifex.org.ro
Department of Finances-Accounting
„ARTIFEX" University of Bucharest
Assistant professor Cătălina MOTOFEI, PhD
E-mail: catalina.motofei@cig.ase.ro
Department of Economic-Financial Analysis and Evaluation
The Bucharest University of Economic Studies
Assistant professor Gabriela - Lidia TĂNASE, PhD
E-mail: gabriela.tanase@cig.ase.ro
Department of Accounting and Audit
The Bucharest University of Economic Studies

CAUSALITY ANALYSIS BETWEEN ECONOMIC DEVELOPMENT AND GREENHOUSE GASES EMISSIONS – AN EUROPEAN UNION PERSPECTIVE

Abstract. *Economic development, as a general objective of society, can generate not only benefits but also additional costs and consequences. Along with economic prosperity, there is also a steady increase in pollution and environmental problems. The objective of the present paper is to analyse the causality link (in Granger sense) between economic development, measured through national accounts indicators, and pollution, quantified by the greenhouse gas in the atmosphere. Moreover, by considering the influence of the industry sector in general and of the construction sector in particular on the Gross Domestic Product, we structured our research by evaluating the causality link between the Gross Domestic Product, the value added in industry sector (excluding constructions), and the value added in construction industry and greenhouse gasses. We test for the existence of the links between the greenhouse gases (as dependent variable) and all three variables describing economic outputs, by using the Toda-Yamamoto approach of the Granger causality for 28 countries from the European Union (including UK) and the entire EU28. The results obtained demonstrate that the existence of a Granger causality between greenhouse emissions and the Gross Domestic Product, the value added in constructions, and the value added in industry sector can be confirmed only for a limited number of countries, while for a few cases there is an opposite situation, the reverse causality being demonstrated.*

Keywords*: emissions, economy, industry, construction, causality*

JEL Classification: O44,R15

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1. Introduction

Development. Evolution. Technology. Although the current era in which we are living can be characterized by all these attributes, which are considered steps towards economic development and progress and which in the end are beneficial steps to society and human evolution, we should also take into consideration the less desired effects of our progress, namely the pollution (one form of pollution being the greenhouse gases that are released in to the atmosphere). It seems that in these new times we live in, we realize our economic prosperity to the detriment of our planet and our personal health. Economic development, obtained mainly through industrial developments in all its sectors (construction, energy, mining, manufacturing, chemical, transport, pharmaceutical, health care, electronics, food etc.) contributes to the release of harmful gases in the environment, like carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3) and more. Thus, the authors' choice for industry and constructions sectors from the complex of factors that influence the Gross Domestic Product was determined by the high presence and contribution of technology in the dynamic of those sectors. Fortunately, people are becoming aware of the greenhouse gas problems, and are already adopting mitigating actions and pleading for a green economy. However, in order for these measures to be effective, we have to better understand first the existing connection between economic development, industrial evolution and the greenhouse gas produced, to be able to understand how they influence each other and to learn more about the intensity or strength between them. In this way, we can effectively contribute to the application of useful measures. These perspectives set the premise and objectives of our research.

Theoretically, there is a strong correlation between greenhouse gasses (GGE) and the three key variables, subject of our current paper, namely: gross domestic product (GDP), industry value added (IVA), and construction industry value added to the GDP (CVA). This assumption is based on the observation that countries that have a high level of GDP, which are also the most developed or advanced, are in fact the regions that generate high levels of greenhouse gasses. Hypothetically, with the increase of the GDP, used as a measure for economic development, the volume of greenhouse gas released in to the air should also rise. Moreover, if we further analyse the increase of the GDP (explaining it by the industrial development and also by the construction industry evolution) we believe that the value added to the GDP by the industry sector overall, and by the construction industry in particular, it should also contribute to the increase of the greenhouse gases. Păunică et al. (2017) outlined the role of the final consumption expenditure of households and foreign trade, as extra influencing factors on the evolution of the Gross Domestic Product. But is the growth rate of the greenhouse gases the same or lower than the growth rate of the GDP?

Using the Toda-Yamamoto approach of the Granger causality, we analyse the relationship between greenhouse gasses on one hand, and the three variables on

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the other hand: gross domestic product, industry sector value added, and construction sector value added. Păunică et al. (2019) have used this method to evaluate the Granger Causality between remittances and household consumption for the European Union countries. The rest of the paper is organized as follows: section two presents the previous research result on the topic, section three describes the research methodology and data used, section four details the research result, and the last part of the paper contains the research conclusions.

2. Literature review

In order to study existing connections and their possible direction, shape and intensity, between our research variables (namely between greenhouse gas and GDP, industry sector added value and construction sector added value), we first reviewed the result of the current studies in the field. There are several studies in the international literature that address and interpret the connection between the greenhouse gasses and GDP, or industry/construction sector added value.

Most of the existing studies that were analysed start from the idea that there is a causal connection between economic development and greenhouse gases. For Kumar and Muhuri (2019), the strong link between greenhouse gases and GDP can be easily deducted from the simple fact that the biggest quantity of gases released in the atmosphere are in general produced by the richest countries. The link between the variables is so strong that the authors can use the CO2 emissions to predict the GDP using the Transfer Learning method. The study of Adzawla et al. (2019) also reveals a significant connection between GDP and greenhouse gases. Wang and Feng (2017) find in their study on the case of China that economic activity changes contribute to the increase of the CO2 industrial emissions, while technology development will contribute to their reduction.

The results of Bildirici (2017), from forecast-error variance, outline the effect of petroleum consumption on the economic growth.Although Kumar and Muhuri (2019) recognize the existence of a relationship between greenhouse gases and GDP, they do not believe that this would be a linear one. They considered it to be nonlinear and volatile, because it depends on the technological development and the political measures adopted. In fact, international literature data present the existence of an inverted U shape relation between gases or pollution, and GDP or economic development, which is also known as the Environmental Kuznets Curve (EKC) hypothesis (Kumar and Muhuri, 2019; Lee et al., 2016; Cohen et al., 2019; Vavrek and Chovancova, 2016; Adzawla et al., 2019; Hocaoglu and Karanfil, 2011). This hypothesis states that, if the per capita income or the prosperity increases then the pollution or environmental impact rises, until the per capita income reaches a certain point from which the environmental problems will decrease (Lee et al. 2016; Vavrek and Chovancova, 2016).

Lee et al. (2016) test the Environmental Kuznets Curve for the relationship between waste and GDP in the US using the Granger causality and Toda-Yamamoto test. Although they did not find a causal relationship between GDP and

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waste, implying that if the GDP increase, the waste will not be reduced, they demonstrate that increasing recycling and reducing waste influence in a positive manner the greenhouse gas generated by waste. The analysis of Adzawla et al. (2019) regarding the relationship between GDP and greenhouse gases, based on the Environmental Kuznets Curve (EKC) hypothesis in the sub-Saharan Africa, suggest that emissions will decrease if the GDP increases. The results also indicate that EKC inverted U shape is more evident in the relationship between GDP and CO_2.

Cohen et al. (2019) use the Kuznets elasticity to test the influence of GDP on the greenhouse gas in the case of China. Their results reveal the fact that the elasticity increases with the increase of GDP, and then it declines supporting thus the inverted U shape relation and the Environmental Kuznets Curve (EKC) hypothesis. In conclusion, while a region or province becomes richer the Kuznets elasticity decreases, indicating thus a decoupling phenomenon on long term between the two variables (the relation between them becomes weaker). Another important observation is that the Kuznets elasticity is higher in emissions based on production, as opposed of those based on consumption. Vavrek and Chovancova (2016) also find evidence of an elasticity decoupling phenomena between economic growth and greenhouse gases in four countries (Czech Republic, Hungary, Poland and Slovakia), which indicates that if the GDP raises then the greenhouse gas will decrease.

If a relationship between greenhouse gas and GDP exists, then connections between gas emissions and other variables related to the GDP must be considered. If we take into consideration that the gross domestic product is derived (like other elements) from the industry sector, then we can state that the industry sector added value to the GDP has an influence on the greenhouse gases. Also, if we go further in our analysis and view construction sector as a component of industry sector in general, we can also assume that the construction sector added value (to the GDP) will influence the greenhouse gases, because it influences the GDP. Chiang et al. (2015) found a bidirectional causality connection between construction activities and GDP, as a measure of economic development in the particular case of Hong Kong by applying the Granger causality test.

That being said, previous studies also take into account the relationship between industry sector and greenhouse gas emissions. Wang et al. (2016) showed that, even if the energy consumption of industrial value added in Tianjin decreased for the period 2008-2012, the carbon dioxide emissions generated by the industrial energy consumption increased, while the carbon emission intensity decreased. Sun et al. (2019) selected 26 sectors from China's manufacturing and processing industry and analysed the efficiency of the greenhouse gas emissions, which cannot be improved in their opinion without the development of new technologies. Hocaoglu and Karanfil (2011) successfully used the share of industrial production in the GDP to predict the CO_2 per capita, using the hidden Markov models for six countries (France, Germany, Italy, Japan, UK and USA) out of seven (the model

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fails for Canada, only for the year 1990). Wu et al. (2019) study the decoupling effect in China, which states that gas emissions from industrial waste will decrease as we face economic growth. They found strong decoupling of gas emissions from industrial waste and industrial added value or industrial GDP for industrial sulphur dioxide, nitrogen oxide and soot dust, and also for provinces that have a fast-economic development.

The impact of the construction sector on the gases released into the atmosphere also presents importance in the international literature. Akan et al. (2017) consider that in Turkey the civil construction sector has a negative effect on the greenhouse gases from the atmosphere, focusing in their study on the influence of concrete used in construction on the gas emission. Du et al. (2019) also recognize that in China the construction sector has a significant impact on carbon emissions; they demonstrate that the emissions increase when the industrial GDP increases, even if the carbon intensity will decrease when the GDP rate increases. The same perspective is considered by Chen et al. (2017), who view the construction sector from China as being a main contributor to the carbon dioxide gases freed in to the atmosphere (especially indirect emissions- over 95%). They suggested that although the CO2 emission in the construction sector increases, the carbon intensity for the construction sector decreases. Zhang et al. (2019) also state that the construction sector, alongside with the manufacturing sector influence the carbon dioxide emissions. Li et al. (2019) demonstrated that building construction influence the greenhouse gases emissions, by analysing the particular case of Beijing, China at an urban, national and global level. The study of Hong et al. (2015) indicates that during the construction phase in China the greenhouse gases are emitted, 97% from all gases being emitted especially as indirect gas emissions. Zhang et al. (2019) validates the Environmental Kuznets Curve (EKC) hypothesis for CO2 emissions from the manufacturing and construction industry for 95 countries out of the 121 countries that were analysed.

But even if the construction sector contributes to the increase of harmful gases released into the atmosphere, solutions can still be found. Sandanayake et al. (2013) compares the greenhouse gases emitted during the construction of building realized from timber and concrete, demonstrating that the use of timber can reduce the gas emission. Other factors can also be considered.

3. Research methodology. Data

The aim of the current study is to evaluate the existence of a possible causality in Granger sense between greenhouse gas emissions (GGE) as dependent variable on one side, and the three macroeconomic indicators: the Gross Domestic Product (GDP), value added in constructions (CVA) and value added in industry sector (without constructions, IVA), on the other hand.

Three research hypotheses were defined:

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– H1. Gross Domestic Product Granger causes Greenhouse gas emissions;

– H2. Value added in constructions Granger causes Greenhouse gas emissions;

– H3. Value added in Industry sector Granger causes Greenhouse gas emissions.

Since almost all variables proved to be integrated (despite the authors' initial assumption that GGE might present a different situation, the unit root tests reporting presence of a degree of integration in the majority of cases), the chosen approach towards the assessment of Granger causality was the Toda-Yamamoto method. This observation on the unit root tests' values also ruled out the regression or other methods applied on stationary variables, as potential analysis tools.

The source datasets were drawn from the Eurostat online database, for the EU members and the Union as a whole (European Union - 28 countries), with the following coordinates:

– Greenhouse gas emissions: "Greenhouse gas emissions by source sector (source: European Environment Agency EEA) [env_air_gge]", measured in "Thousand tonnes", which includes, according to Eurostat classification, "Greenhouse gases (CO2, N2O in CO2 equivalent, CH4 in CO2 equivalent, HFC in CO2 equivalent, PFC in CO2 equivalent, SF6 in CO2 equivalent, NF3 in CO2 equivalent)", for "all sectors", last updated on 11.06.19, extracted on 14.09.19. The data are annual. (Eurostat metadata).

– Gross Domestic Product: "Gross domestic product at market prices", dataset "GDP and main components (output, expenditure and income) [nama_10_gdp]", measured in "Current prices, million euro", last updated on 19.09.19, extracted on 21.09.19. Also, the data are annual. (Eurostat metadata).

– Value Added in Industry: dataset "National accounts aggregates by industry (up to NACE A*64) [nama_10_a64]", section "Value added, gross", NACE_R2 dimension member: "Industry (except construction)" , measured in "Current prices, million euro", last update on 10.09.19, retrieved on 20.09.19. Data frequency: annual. (Eurostat metadata).

– Value Added in Constructions: dataset "National accounts aggregates by industry (up to NACE A*64) [nama_10_a64]", section "Value added, gross", NACE_R2 dimension member: "Construction" , measured in "Current prices, million euro", last update on 10.09.19, retrieved on 20.09.19. Data frequency: annual. (Eurostat metadata).

All datasets were initially processed by logarithm; therefore, the processed series represent the natural logarithms of the original data.

The steps pursued for the application of the Toda-Yamamoto method followed the guidelines presented by Giles (2011), implemented (in Eviews) as follows:

- Establishing, via unit root tests, the degree of integration, for each variable in the pair and of the maximum degree of integration (DOI) between them. For this purpose, the following tests have been applied: Advanced Dickey-Fueller,

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with the parameters Exogenous: Constant, Linear Trend, Automatic - based on SIC, maxlag=4, Phillips-Perron (Exogenous: Constant, Linear Trend, Newey-West automatic using Bartlett kernel), Kwiatkowski, Phillips, Schmidt, And Shin (Exogenous: Constant, Linear Trend, Newey-West automatic using Bartlett kernel). Where the tests display the same degree of integration, that value is considered. If the results are not the same, the authors applied some criteria to choose the order of integration (first, same value by KPSS and either ADF or PP tests, second, same value by ADF and PP and third, the minimum value was chosen, in order to avoid overfitting the final configuration of the VAR by a large lag length);

- Configuring a VAR model between the two variables, at the optimum lag length. The lag length criteria were applied against a maximum lag of 6, for all models. As the tests for a maximum of 8 revealed an insufficient number of observations, and for some models an error message describing log of non-positive number was obtained. As the data are not negative, this led to a maximum lag length of 6 in the analysis. In case of contradictory results, as Eviews offers five criteria, the value shown by the majority was preferred, and, if the results do not fit this assumption, the Schwarz Info Criterion is chosen to provide the optimum lag length because, according to Chirilă and Chirilă (2017), „it privileges the models with a reduced number of parameters".

- Testing the VAR models with the standard tests (serial correlation and stability, and extension of the lag length, as suggested by Giles, 2011), if the results are not valid. However, the models that displayed problems of normality and heteroskedasticity were not tested for Granger causality, the authors considering the suggestion of Hatemi-J (2004), who states "(…) Hacker and Hatemi-J(2003) demonstrate by means of Monte Carlo simulations that the inference based on the Toda-Yamamoto test statistic is misleading if non-normality exists or if ARCH effects are present." The tests were applied in the following configurations in Eviews: stability (AR roots test), autocorrelation (Autocorrelation LM test, up to the lag suggested by the Eviews interface, as the number of observations is 19), heteroskedasticity (White VAR Residual Heteroskedasticity Tests: No Cross Terms, only levels and squares), normality (orthogonalization method: Cholesky of covariance-Lutkepohl);

- Inclusion of additional lags (as exogenous variables), equal to maximum degree of integration, for test-complaint country-specific models;

- Assessing the existence of Granger Causality in the basis of re-configured models;

- If two variables have the same order of integration, and the VAR is well-specified, they will be tested for cointegration based on the VAR model without exogenous variables (Johansen test). The results will be cross-checked with the Granger Causality results, based on the criteria stated by Giles (2011): "If two or more time-series are cointegrated, then there must be Granger causality between them - either one-way or in both directions. However, the converse is not true". To

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be consistent with the test for unit roots, only the cases where linear deterministic trend is allowed (cases 3 and 4 in the software interface) are to be considered in evaluating the presence of cointegration.

4. Results and discussions

4.1. Granger Causality between CVA and GGE

First, as described in the research methodology section, the variables were tested for unit root presence, in order to outline their individual degree of integration, and the maximum degree. The results are presented in Table 1.

Table 1. Maximum degree of integration (oi_{max} for CVA and *GGE*)

Country	oi_{max}	Country	oi_{max}	Country	oi_{max}	Country	oi_{max}
AUT	**1**	FIN	**2**	ITA	**2**	POR	**2**
BEL	**2**	FRA	**2**	LIT	**2**	ROM	**2**
BGR	**1**	GER	**2**	LTV	**1**	SLO	**2**
CYP	**2**	GRE	**1**	LUX	**2**	SPA	**3**
CZR	**1**	HRV	**3**	MAL	**2**	SVK	**1**
DNK	**1**	HUN	**1**	NTN	**2**	SWE	**1**
EST	**2**	IRL	**2**	POL	**1**	UK	**1**
EUR	**2**						

Source: Authors' calculations, by using EViews.

The maximum degree of integration, as seen in Table 1, is 1, 2 or 3. No value of 0, and the *GGE* is I (0) only in three cases. However, the degree of integration of *GDP* prohibits the application of regression, as stated before.

After estimating the 29 individual (country-based) VAR models, each VAR was tested for the optimum lag length. As specified, the next step involved the tests of the VAR models, and the well-specified models were updated by extending the lag length with the quota specified as Max DOI in Table 1, then tested for Granger Causality by applying the specific test.

The Austrian model is stable and has no autocorrelation, the normality of residuals is satisfied, but does not pass the heteroskedasticity test, therefore the model will not be used to test Granger Causality. In the cases of Cyprus, Latvia and Lithuania, the heteroskedasticity check is also not passed, even if all other tests display proper results.

The Bulgarian model, stable at the original lag length, does not pass the autocorrelation test. This issue is solved if lag length is increased to 3, the model is stable, residuals are multivariate normal and the heteroskedasticity test is compliant, therefore this model (with l=3) will be tested for Granger Causality. The Wald test results do not allow the rejection of null hypothesis; therefore, Granger Causality cannot be proven. The Czech model passes all tests at the original lag length, and the Wald test for Granger Causality shows that value added in constructions sector influences, in Granger sense, the greenhouse gas emissions. At

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l=1, the Greek model does not pass stability tests, when *l* is extended by one unit there is autocorrelation in residuals, while VAR (3) is properly specified, according to all test results. Upon applying the Wald test on the updated model, it can be observed that *CVA* Granger causes *GGE*.

The Belgian model is not stable, even if *l* is extended to 7 (a higher lag length is not accepted because of the insufficient number of observations); the same observation applies in the Estonian, German, Irish, Italian, Maltese, Dutch, Polish, Portuguese, Slovenian, Spanish, Swedish cases. A stable Romanian VAR(6) model has autocorrelation issues, but the VAR(7) is not stable. VAR(2) for the United Kingdom fails the AR roots test, this persists up until *l* is extended to 7.

Even if the Danish, EU, Finnish, French, Croatian, Hungarian, Luxemburgish and Slovak models pass all tests (at their original setting, but updated according to the procedure), no Granger Causality is present in the case of the two variables.

The synthesis of the results is displayed in Table 2.

Table 2. Granger Causality test results (dependent variable: GGE)

Country	***Chi-sq***	***Prob.***	**Country**	***Chi-sq***	***Prob.***
AUT	-	-	ITA	-	-
BEL	-	-	LIT	-	-
BGR	2.704851	0.4394	LTV	-	-
CYP	-	-	LUX	0.000153	0.9901
CZR	*12.35792*	*0.0063*	MAL	-	-
DNK	0.507420	0.9173	NTN	-	-
EST			POL	-	-
EUR	0.104814	0.7461	POR	-	-
FIN	3.359368	0.3395	ROM	-	-
FRA	3.136658	0.2084	SLO	-	-
GER	-	-	SPA	-	-
GRE	*24.33509*	*0.0000*	SVK	0.222731	0.6370
HRV	0.224211	0.6358	SWE	-	-
HUN	0.461097	0.4971	UK	-	-
IRL	-	-			

Source: Authors' representation, by using EViews.

There are twelve pairs of variables having the same order of integration (*AUT, ITA, LTV, CZR, DNK, GRE, POL, POR, SWE, SVK, UK, HUN*). The models designed for Austria, Italy, Latvia, Poland, Portugal, Sweden, and United Kingdom are not properly specified.

The Czech model has testified for Granger causality. The Johansen cointegration test for the Czech VAR(3) shows no cointegration equations

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For Denmark, as stated before, the VAR(3) is well specified, but the Wald test displays no Granger causality. The Johansen cointegration test (both Trace and Max-Eigen values) show the presence of cointegration for the linear trend case. Therefore, the results are conflicting (the dimension of the dataset might be insufficient for the proper application of those tests, as specified by Giles, 2011).

For the Greek model, cointegration is found only on the assumption “No Intercept, No Trend”, this result will not be considered and does not confirm or denies the fact that *CVA_GRE* causes, in Granger sense, the greenhouse gas emissions.In the case of Hungary, there is evidence of cointegration only when omitting both trend and intercept, while for Slovakia cointegration is accepted only for quadratic trend, not for the linear one. As no Granger causality hypothesis was validated, the results are not contradictory.

4.2. Granger Causality between GDP and GGE

Table 3 displays the individual and maximum degrees of integration calculated following the application of the unit root tests.

Table 3. Maximum degree of integration ($oi_{max}$for GDP and GGE)

Country	oi_{max}	Country	oi_{max}	Country	oi_{max}	Country	oi_{max}
AUT	**1**	FIN	**1**	ITA	**2**	POR	**2**
BEL	**1**	FRA	**1**	LIT	**1**	ROM	**2**
BGR	**1**	GER	**1**	LTV	**1**	SLO	**2**
CYP	**2**	GRE	**2**	LUX	**2**	SPA	**2**
CZR	**1**	HRV	**2**	MAL	**2**	SVK	**2**
DNK	**1**	HUN	**1**	NTN	**2**	SWE	**1**
EST	**1**	IRL	**2**	POL	**1**	UK	**1**
EUR	**1**						

Source: Authors’ calculations, by using EViews.

All pairs of variables present a maximum DOI of 1 or 2, the same situation as in the previous section.

The initial VAR models required by the methodology were estimated at the optimum lag lengths, then the models thus configured were tested for correct specification. Similar to the previous analysis, the same tests were applied; for models with AR roots and autocorrelation problems their lag length was extended by unit and, after those issues were passed, the normality and heteroskedasticity criteria were valuated. Only the models proving to be well specified by all tests have been considered eligible for Wald Granger Causality test, and Johansen Cointegration test.

The Austrian, Croatian, Hungarian, Latvian and EU models, stable and free from autocorrelation at the optimum *l*, fail the normality test. The Bulgarian, French, Italian, Greek, Lithuanian, Maltese (updated to *l*=2 due to stability issues),

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Romanian, and Finnish models do not pass the heteroskedasticity test. For *l* up to 7, the VARs for Germany and United Kingdom are not stable.

Some models encounter issues with the AR roots test (configured initially at *l*=6, the test is not passed when *l* is extended to 7), the models for: Belgium, Estonia, Ireland, Netherlands, Slovenia, Spain, Slovakia.

There was possible to test for Granger Causality only in some cases. For Cyprus, the causality is observed for the reverse of the research hypothesis (*GGE* Granger causes the Gross Domestic Product, for a *Chi-sq* = 7.792940 and *Prob*= 0.0203). As the variables have different orders of integration, the cointegration test is not to be considered. The Czech VAR(3) model is also usable for Granger Causality testing (no cointegration exists between the two variables), which reveals the same conclusion observed for Cyprus: *GGE* Granger causes *GDP*, with *Chi-sq*=7.955637 and Prob.= 0.0469).

For the Danish model, lag length was updated to 3 to eliminate the serial correlation in residuals, and VAR(3) is properly specified, but no Granger causality exists. Johansen test applied to this model shows evidence of cointegration.

Since the test for Granger Causality accepts the null hypothesis, the results are conflicting (the same conclusion as in the previous section). As more data will become available, the authors hope that converging results will be achieved, to enforce the relationship between the two variables.

The Luxemburg VAR(1) is well specified, after the inclusion of the exogenous variables, the Granger Causality test does not reveal any such impact between the two variables. For Poland and Portugal, the small values of the Wald statistic (*Chi-sq*) also indicate the absence of Granger Causality (however, the existence of cointegration leads to the fact that the analysed dataset cannot provide a valid conclusion).

The cointegration test for Portugal indicates the absence of cointegration.

The Swedish model responds well to all models with the original lag length. However, the hypothesis of no Granger causality is validated by the test, and the variables do not have the same order of integration. The summary of the test results is presented in Table 4.

Table 4. Granger Causality test results (dependent variable: GGE)

Country	***Chi-sq***	***Prob.***	**Country**	***Chi-sq***	***Prob.***
AUT	-	-	ITA	-	-
BEL	-	-	LIT	-	-
BGR	-	-	LTV	-	-
CYP	0.710380	0.7010	LUX	0.616839	0.4322
CZR	5.507492	0.1382	MAL	-	-
DNK	1.502675	0.6817	NTN	-	-
EST	-	-	POL	0.079519	0.7780
EUR	-	-	POR	0.550894	0.4580
FIN	-	-	ROM	-	-

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Country	*Chi-sq*	*Prob.*	Country	*Chi-sq*	*Prob.*
FRA	-	-	SLO	-	-
GER	-	-	SPA	-	-
GRE	-	-	SVK	-	-
HRV	-	-	SWE	0.526507	0.4681
HUN	-	-	UK	-	-
IRL	-	-			

Source: Authors' representation, by using EViews.

4.3. Granger Causality between IVA and GGE

All variables were tested, consistent with the previous sections, for integration, and the results of the tests (as degrees of integration) are presented in Table 5.

Table 5. Maximum degree of integration (oi_{max} for IVA and GGE)

Country	oi_{max}	Country	oi_{max}	Country	oi_{max}	Country	oi_{max}
AUT	**1**	FIN	**1**	ITA	**2**	POR	**2**
BEL	**1**	FRA	**2**	LIT	**1**	ROM	**1**
BGR	**2**	GER	**1**	LTV	**1**	SLO	**1**
CYP	**1**	GRE	**2**	LUX	**2**	SPA	**2**
CZR	**1**	HRV	**2**	MAL	**1**	SVK	**1**
DNK	**1**	HUN	**1**	NTN	**1**	SWE	**1**
EST	**1**	IRL	**1**	POL	**1**	UK	1
EUR	**1**						

Source: Authors' calculations, by using EViews.

All pairs of variables were grouped into country-based VAR models. As in the previous cases, the initial lag lengths were estimated by applying the Schwarz Info Criterion.

Tested at the available lags, the Austrian, Danish, EU, Finnish, Greek, Irish, Croatian, Spanish and Belgian models are unstable, while for the Estonian, French, Slovenian, Latvian models the residuals are not normally distributed. For Bulgaria, VAR(3) can be tested for Granger Causality, but the *Chi-sq* value involves the validation of the null hypothesis (no causality, and the variables cannot be used for cointegration). German model becomes stable as VAR(2), but does not pass normality test (the same observation applies to the Hungarian, Maltese and Lithuanian VARs, at l=1). No acceptable lag length led to a stable VAR for Italy. The Netherland VAR(l=5), Romanian and Portuguese models fail heteroskedasticity tests. The British model is unstable at l up to 6, while at 7 there is no stability. The synthetic results of Granger Causality tests are detailed in Table 6.

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Table 6. Granger Causality test results (dependent variable: *GGE*)

Country	*Chi-sq*	*Prob.*	Country	*Chi-sq*	*Prob.*
AUT	-	-	ITA	-	-
BEL	-	-	LIT	-	-
BGR	1.803032	0.4060	LTV	-	-
CYP	2.382765	0.1227	LUX	0.268115	0.6046
CZR	0.100558	0.7512	MAL	-	-
DNK	-	-	NTN	-	-
EST	-	-	POL	0.901690	0.6371
EUR	-	-	POR	-	-
FIN	-	-	ROM	-	-
FRA	-	-	SLO	-	-
GER	-	-	SPA	-	-
GRE	-	-	SVK	1.596370	0.2064
HRV	-	-	SWE	0.773309	0.3792
HUN	-	-	UK	-	-
IRL	-	-			

Source: Authors' representation, by using EViews.

In the case of Cyprus, the model is well specified as VAR(1). The GC test results reveal no causality with *GGE* as dependent variable, but outline the reverse impact, that is *IVA* is Granger caused by *GGE* (Chi-sq= 4.262315, p= 0.0390), for the Czech VAR(1) the same conclusion is reached (Chi-sq= 5.970603, p= 0.0145). The VAR(1) for Luxemburg passes all specification tests, but no Granger Causality exists. When *l* is extended to 2, the Polish model becomes properly specified and was updated with one lag as additional variable. The results for the Granger Causality test do not allow the rejection of the null hypothesis of no causality (the result is contradicted by the cointegration). No Granger causality is also demonstrated for the Slovak model (the variables are not cointegrated) and for Sweden the variables have different degrees of integration.

The cointegration test was applied according to the same principles as used in the previous cases. For Cyprus, no cointegration and no causality do not represent conflicting results. The same conclusion applies to the Czech model, where the intercept cases show no presence of cointegration, by either of the two linear cases.

Conclusions

Although economic prosperity is essential for the development of a country, it can also generate environmental problems and an increase in pollution. It can be argued that all countries are achieving their economic prosperity at the expense of our planet. Economic development, mainly obtained by industrial

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evolution in all its forms, contributes to the release of harmful gases in the environment. In this context, the main objective of our paper is to analyse the causality relationship between economic development, measured through the gross domestic product (GDP) and pollution, quantified by the greenhouse gas in the atmosphere, and also between the industry sector added value, and the construction sector added value and greenhouse gasses, considering the influence of the industry sector and also of the construction sector in particular on the GDP.

The causality link analyses between the greenhouse gases and all three variables analysed, namely GDP, industry sector added value and construction sector added value were done with the help of the EViews specialized software by using the Toda-Yamamoto approach of the Granger causality for 29 countries form the European Union (including UK).

The existence of a Granger causality between greenhouse emissions and value added in constructions can be validated only a very small number of cases (2 countries) namely for: *Czech Republic* and*Greece*, where the Value Added in Construction fields does Granger cause the greenhouse gas emissions.

In regard to the existence of a causality between greenhouse emissions and the Gross Domestic Product, the GDP (economic growth) Granger was not proven as a factor that Granger causes the greenhouse gases emissions. Similarly, no Granger causality was observed for value added in industry sector as independent variable. However, the reverse causality was demonstrated in some cases, for example Cyprus, and Czech Republic: *GGE* Granger causes *GDP*.

Many models were not usable for testing the causality because of the restrictions assumed by the authors. Moreover, in some cases, there is cointegration between the two variables tested, but no kind of causality. The authors hope that the availability of more data in the future could lead to a much wider analysis and with more trustworthy results.

The result of the study demonstrate that the existence of a Granger causality between greenhouse emissions and the Gross Domestic Product, the value added in constructions, and the value added in industry sector can be confirmed only for a limited number of countries, and that the direction of the relationship differs from a country to another. The results are consistent with the mixt results presented by previous studies in the field.

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