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PANEL DATA ANALYSIS OF THE CREATION OF GREEN ECONOMY IN THE BALTIC STATES

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Abstract: Greenhouse gases are gases that increase in concentration because of human activity. Carbon dioxide accounts for the largest share of greenhouse gas emissions. The ecological environment can be improved and global warming can be mitigated by reducing carbon dioxide levels. Today, the focus around the world is on CO_2 emissions into the environment. The Baltic countries that produce more electricity, such as Estonia, emit more carbon dioxide into the environment, while countries that produce less electricity, such as Lithuania and Latvia, emit less. Application of the panel data analysis of GDP per capita and CO_2 emissions in millions of tonnes for the years 2000-2021 for the selected countries revealed that the calculated regression constant and coefficient for the independent variable GDP per capita are rather unreliable, which means that there is no common regression function for all these countries, but the differences in the residuals give valuable insight in the specifics of each country.

Keywords: carbon dioxide, fossil fuels, green economy, panel data analysis

JEL Classification: F63, F64

Introduction

The world's largest industries, like energy and transport, create a great number of jobs and boost economic growth. The economy is growing faster in countries with

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advanced energy, transport, technology, health, science, and manufacturing industries. The energy industry is crucial for humanity, as it plays a role in fulfilling many basic needs. Worldwide, the main sources of pollutants and the biggest energy consumers are industry, energy companies, households, agriculture, transport, and the services sector. To protect nature, the following tasks are set for the energy industry: streamlining combustion processes, reducing the use of polluting fuels, and using renewable energy sources (Baublys et al., 2011).

The energy and transport industries pose the greatest risks to human health and the environment. These industries are associated with environmental pollution and the use of natural resources. Not only in the Baltic states, but throughout the world, the transport industry is the largest polluter of the environment. The greatest damage to the environment is caused by airplanes. The energy and transport industries emit the highest levels of pollutants (Gaigalas & Škėma, 2012). There is a lot of research showing the huge potential of energy efficiency in the industry, which is still not yet exploited (Schulze et al., 2016). Today, the focus around the world is on CO_2 emissions into the environment (Porzio et al., 2013).

The topic of 'green economy' discussed by many authors is related to the transport and energy industries. The goal of the green economy is to achieve a harmonious, sustainable economy (Maran, 2017). The green economy could be a means of implementing sustainable development ideas that are related to nature conservation. After reviewing and analysing the scientific literature, it was found that the green economy is a type of economy that focuses on the creation of economic well-being, and that has minimal or no impact on nature (Alekna & Kazlauskienė, 2019; Augustaitė, 2020). Green economy can be a tool to achieve sustainable development. The economy is sustainable if it does not harm nature while meeting human needs (Lorek & Spangenberg, 2014). Most of the energy consumed comes from fossil fuels. The main types of fossil fuels are coal, oil, shale, and natural gas. These are the main sources of energy that are used in the electricity production and transport industry. Most countries around the world strive for sustainable development, which allows to ensure safe life and sustainable nature. "A bold new global agenda to end poverty by 2030 and pursue a sustainable future was unanimously adopted today by the 193 Member States of the United Nations at the start of a three-day Summit on Sustainable Development" (UN Sustainable Development Goals, 2015).

The purpose of this paper is as follows. How efficiently do the countries seek the establishment of a green economy?

Theoretical background and reality

Estonia is energy independent; its energy independence is ensured by shale. In the Baltic states, Estonia is one of the largest electricity producers. Estonia uses the most shale in the world: When producing energy, Estonia burns about 80% of the globally used shale. Estonians have developed the most advanced shale technologies in the world. In Estonia, the biggest air pollutants are old power plants. They emit the highest amount of greenhouse gases into the air. Most carbon dioxide and other pollutants are released into the environment when shale is burnt. About 85% of the

electricity generated in Estonia is produced from shale. The Baltic states are switching to renewable energy sources, such as wind farms and solar power plants. All countries pay great attention to renewable energy sources.

Greenhouse gases are gases that increase in concentration because of human activity. These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other gases. Carbon dioxide accounts for the largest share of greenhouse gas emissions. The burning of fossil fuels related to the development of transport is one of the main causes of the increase in carbon dioxide. It accounts for 80% of greenhouse gas emissions (Bužinskienė & Meškienė, 2016). High emissions of carbon dioxide pose a significant threat and lead to climate change (Zhao et al., 2022). The ecological environment can be improved and global warming can be mitigated by reducing carbon dioxide levels. It is possible to calculate carbon dioxide emissions and determine the factors that contribute to carbon dioxide emissions (Table 1) (Qin & Gong, 2022).

Table 1. Factors contributing to carbon dioxide emissions

Social factors	Economic factors	Environmental factors
– Total population, – Added value – Number of industrial companies	– Foreign investments – Financial revenues of the general budget – Gross domestic product (GDP0	– Climate warming

Source: (Qin & Gong, 2022)

Gross domestic product has important impact on carbon dioxide emissions. The stronger the economies of the countries, the more foreign investments they attract, the greater the number of industrial companies that are created, the more energy is consumed and, as a result, the more carbon dioxide is released into the environment. Climate change began when the Industrial Revolution began (Ali et al., 2022).

Most countries have declared pursuing a sustainable economy (UN Sustainable Development Goals, 2015). An analysis is underway on which countries are more or less green (GreenMatch, 2023). But there is a research gap: How to measure and compare the differences in the progress of countries toward the green economy?

Research and discussion

Of all Baltic countries, Estonia emits the most carbon dioxide into the environment, while Lithuania and Latvia emit much less. Estonia emitted 352 million tonnes of CO_2 in the period from 2000 to 2021, while Lithuania emitted 253 million tonnes and Latvia 158 million tonnes. Estonia emits the most carbon dioxide because it uses an immense amount of shale from which it produces energy.

In the analysis of energy CO_2 emissions, calculations were made using the econometric time series analysis method. Values that a variable takes over time are observed. In the analysis of the time series, it is assumed that there are known values at time points, and all observations are made at equal time intervals (Bartosevičienė, 2001). As shown in Table 2 and Table 3, after the calculations, we see that the period 2008 to

2010 stood out in all Baltic states. This is shown by the absolute change in level (chained) and the rate of change (chained). In 2009, the highest negative rate was obtained in Lithuania, Latvia, and Estonia. This was influenced by the global financial crisis of 2008-2009 and with the deindustrialisation of these countries because of post-soviet restructuring of their economies. In the context of the global financial crisis, consumption, production, and investments decreased significantly, thus resulting in lower emissions of greenhouse gases, i.e., carbon dioxide.

Table 2. Changes in CO_2 emissions in the Baltic states in the period 1990-2021 (absolute in millions of tonnes and chained index to the previous year, percent)

Year	Lithuanian CO_2 emissions, million tonnes	Absolute change per annum, million tonnes	Chained index to the previous year, %	Latvian CO_2 emissions, million tonnes	Absolute change per annum, million tonnes	Chained index to the previous year, %	Estonian CO_2 emissions, million tonnes	Absolute change per annum, million tonnes	Chained index to the previous year, %
1990	32.24			18.64			35.94		
2000	10.39	−21.85	32.23	6.85	−11.79	36.75	14.85	−21.09	41.32
2001	11.06	0.67	106.45	7.25	0.40	105.84	15.23	0.38	102.56
2002	11.09	0.03	100.27	7.25	0.00	100.00	14.90	−0.33	97.83
2003	11.09	0.00	100.00	7.43	0.18	102.48	16.75	1.85	112.42
2004	11.71	0.62	105.59	7.44	0.01	100.13	16.70	−0.05	99.70
2005	12.51	0.80	106.83	7.54	0.10	101.34	16.50	−0.20	98.80
2006	12.57	0.06	100.48	8.02	0.48	106.37	15.83	−0.67	95.94
2007	12.82	0.25	101.99	8.34	0.32	103.99	19.15	3.32	120.97
2008	12.69	−0.13	98.99	7.92	−0.42	94.96	17.00	−2.15	88.77
2009	11.55	−1.14	91.02	7.19	−0.73	90.78	14.10	−2.90	82.94
2010	12.50	0.95	108.23	8.02	0.83	111.54	18.60	4.50	131.91
2011	11.71	−0.79	93.68	7.17	−0.85	89.40	18.47	−0.13	99.30
2012	11.68	−0.03	99.74	6.82	−0.35	95.12	17.05	−1.42	92.31
2013	11.07	−0.61	94.78	6.74	−0.08	98.83	18.86	1.81	110.62
2014	10.65	−0.42	96.21	6.54	−0.20	97.03	18.33	−0.53	97.19
2015	10.59	−0.06	99.44	6.71	0.17	102.60	15.52	−2.81	84.67
2016	10.91	0.32	103.02	6.77	0.06	100.89	17.21	1.69	110.89
2017	10.85	−0.06	99.45	6.69	−0.08	98.82	18.31	1.10	106.39
2018	11.23	0.38	103.50	7.19	0.50	107.47	17.47	−0.84	95.41
2019	11.23	0.00	100.00	6.97	−0.22	96.94	11.91	−5.56	68.17
2020	11.20	−0.03	99.73	6.32	−0.65	90.67	9.11	−2.80	76.49
2021	11.62	0.42	103.75	6.55	0.23	103.64	10.29	1.18	112.95

Source: Authors calculations, Eurostat (2023)

Table 3. Statistical data on GDP per capita in euros and CO_2 emissions in millions of tonnes for the years 2000-2021

Year	Lithuanian GDP per capita, €	Lithuanian CO_2 emissions, million tonnes	Latvian GDP per capita, €	Latvian CO_2 emissions, million tonnes	Estonian GDP per capita, €	Estonian CO_2 emissions, million tonnes
2000	5230	10.39	5250	6.85	7540	14.85
2001	5620	11.06	5050	7.25	8040	15.23
2002	6050	11.09	6120	7.25	8640	14.90
2003	6740	11.09	6700	7.43	9350	16.75
2004	7270	11.71	7340	7.44	10050	16.70
2005	7960	12.51	8210	7.54	11070	16.50
2006	8690	12.57	9280	8.02	12230	15.83
2007	9770	12.82	10280	8.34	13230	19.15
2008	10130	12.69	10050	7.92	12590	17.00
2009	8720	11.55	8760	7.19	10770	14.10
2010	9050	12.50	8550	8.02	11060	18.60
2011	9820	11.71	8940	7.17	11890	18.47
2012	10330	11.68	9680	6.82	12320	17.05
2013	11810	11.07	9980	6.74	12540	18.86
2014	11290	10.65	10270	6.54	12960	18.33
2015	11620	10.59	10760	6.71	13230	15.52
2016	12070	10.91	11110	6.77	13620	17.21
2017	12760	10.85	11590	6.69	14410	18.31
2018	13400	11.23	12140	7.19	14920	17.47
2019	14060	11.23	12540	6.97	15410	11.91
2020	14050	11.20	12330	6.32	15280	9.11
2021	14820	11.62	12980	6.55	16490	10.29

Source: Authors calculations, Eurostat (2023)

For data analysis, we selected the Panel data analysis method (Burkšaitienė & Snieška, 2023). This method allows us to compare the differences between the selected fixed cross-sectional data. As the cross-sections, countries Lithuania, Estonia and Latvia were defined. Also, the data for each country is grouped according to date, yearly. So, the cross sections were fixed by country and by year. The results of the panel data analysis are presented in Table 4.

Table 4. Results of the panel data analysis of GDP per capita and CO_2 emissions in millions of tonnes for the years 2000-2021 for the selected countries

Dependent Variable: CO2MLNT
Method: Panel Least Squares
Date: 08/24/23 Time: 22:44
Sample: 2000 2021
Periods included: 22
Cross-sections included: 3
Total panel (balanced) observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.20724	5.585800	2.185407	0.0346
GDP_C	−0.06185 1	0.528775	−0.116970	0.9075

Effects Specification

Cross-section fixed (dummy variables)
Period fixed (dummy variables)

R-squared	0.907944	Mean dependent var	11.55424
Adjusted R-squared	0.854058	S.D. dependent var	3.978712
S.E. of regression	1.519962	Akaike info criterion	3.956741
Sum squared resid	94.72164	Schwarz criterion	4.786155
Log likelihood	−105.5724	Hannan-Quinn criter.	4.284482
F-statistic	16.84926	Durbin-Watson stat	0.676202
Prob(F-statistic)	0.000000		

These results are based on the application of the Panel Least Squares evaluation method and cross-section and period effects fixed by dummy variables. This has allowed us to use the estimation equation:

CO2MLNT = C(1) + C(2) × GDP_C + [CX = F, PER = F, ESTSMPL = "2000 2021"]

Substituted coefficients: allow us to get the following estimation:

CO2MLNT = 12.207 − 0.061851 × GDP_C + [CX = F, PER = F, ESTSMPL = "2000 2021"]

This equation may be used only cautiously, because, as we can see from Table 3, the standard error for the coefficient C is 5.59 and the standard error for the coefficient before the independent variable GDP_C (GDP per capita) is 0.529. This means t-Statistics, respectively, 2.19 for the constant C and only −0.117 for the independent variable. Consequently, these results mean that there are no unanimous features of CO_2 generation when producing GDP in the analysed Baltic countries.

What is much more interesting are those dummy variables, which ensured rather high general reliability of the model, as described by the adjusted R-squared coefficient, which is as high as 0.854. This method can explain rather close actual and modelled (fitted) results (Figure 1).

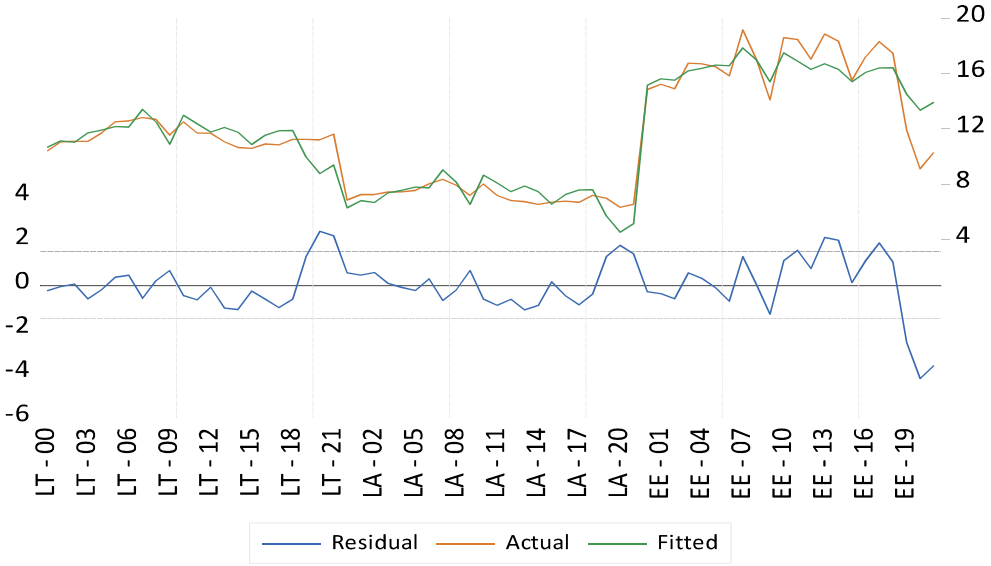

Figure 1. Actual, fitted by the model and residuals of CO_2 emissions in millions of tonnes for the years 2000-2021 (vertical axis) in Lithuania (LT), Latvia (LA) and Estonia (EE)

The results of the residual cross-section dependence test (Table 5) show that there is no cross-section correlation in residuals. This means that each country has specific factors that influence the relationship between GDP growth and CO_2 generation.

Table 5. Residual cross-section dependence test results

Residual Cross-Section Dependence Test
Null hypothesis: No cross-section dependence (correlation) in residuals
Equation: PANEL_CO2_GDP_ESTIMATION
Periods included: 22
Cross-sections included: 3
Total panel observations: 66
Cross-section effects were removed during estimation

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	58.94006	3	0.0000
Pesaran scaled LM	22.83743		0.0000
Bias-corrected scaled LM	22.76601		0.0000
Pesaran CD	−2.854927		0.0043

The application of logarithmic transformation for the panel regression function, as shown in Table 6, allows to obtain better t statistics – 2.95 and 0.606 which is bigger than the previous results – respectively, 2.19 and −0.117.

LOG(CO2MLNT) = C(1) + C(2) × LOG(GDP_C) + [CX = F, PER = F, ESTSMPL = "2000 2021"]

LOG(CO2MLNT) = 1.9807 + 0.17557 × LOG(GDP_C) + [CX = F, PER = F, ESTSMPL = "2000 2021"]

Table 6. Results of the logarithmic transformation-based panel data analysis of GDP per capita and CO_2 emissions in millions of tonnes for the years 2000-2021 for selected countries

Dependent Variable: LOG(CO2MLNT)
Method: Panel Least Squares
Date: 08/24/23 Time: 22:57
Sample: 2000 2021
Periods included: 22
Cross-sections included: 3
Total panel (balanced) observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.980656	0.671665	2.948876	0.0052
LOG(GDP_C)	0.175529	0.289561	0.606188	0.5477

Effects Specification

Cross-section fixed (dummy variables)
Period fixed (dummy variables)

R-squared	0.939105	Mean dependent var	2.387731
Adjusted R-squared	0.903460	S.D. dependent var	0.349369
S.E. of regression	0.108552	Akaike info criterion	−1.321681
Sum squared resid	0.483126	Schwarz criterion	−0.492266
Log likelihood	68.61546	Hannan-Quinn criter.	−0.993939
F-statistic	26.34565	Durbin-Watson stat	0.556869
Prob(F-statistic)	0.000000		

Conclusions

The energy industry is crucial for humanity, as it plays a role in fulfilling many basic needs. Most of the energy consumed comes from fossil fuels. Of all the Baltic states, Estonia produces the most electricity from fossil fuels and therefore emits the most carbon dioxide into the environment. Countries that produce less electricity, such as Lithuania and Latvia, emit less carbon dioxide compared to the GDP produced.

Application of the panel data analysis of GDP per capita and CO_2 emissions in millions of tonnes for the years 2000-2021 for the selected countries revealed that the calculated regression constant and coefficient for the independent variable GDP per capita are rather unreliable, which means that there is no common regression function for all these countries, but the differences in the residuals give valuable insight in the specifics of each country. The logarithmic transformation-based panel data analysis delivers more defined regression coefficients, but without such a transformation, the results of the analysis (Figure 1) are easier for interpretation.

The results of the residual cross-section dependence test (Table 5) show that there is no cross-sectional correlation in residuals. This means that each country has specific factors influencing the relationship between GDP growth and CO_2 generation, and the differences in the residuals give valuable insight into the specifics of each country. This also means that the analysed countries are not very efficient in the achievement of the green economy goals.

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ANALIZA DANYCH PANELOWYCH DOTYCZĄCA TWORZENIA ZIELONEJ GOSPODARKI W KRAJACH BAŁTYCKICH

Streszczenie: Gazy cieplarniane to gazy, których stężenie wzrasta w wyniku działalności człowieka. Dwutlenek węgla ma największy udział w emisji gazów cieplarnianych. Stan środowiska ekologicznego można poprawić, a globalne ocieplenie złagodzić poprzez zmniejszenie poziomu dwutlenku węgla. Obecnie uwaga na całym świecie skupia się na emisji CO_2 do środowiska. Kraje bałtyckie, które produkują więcej energii elektrycznej, takie jak Estonia, emitują do środowiska więcej dwutlenku węgla, natomiast kraje wytwarzające mniej energii elektrycznej, takie jak Litwa i Łotwa, emitują go mniej. Zastosowanie analizy danych panelowych PKB na mieszkańca i emisji CO_2 w milionach ton w latach 2000-2021 dla wybranych krajów wykazało, że obliczona stała regresji i współczynnik dla zmiennej niezależnej PKB na mieszkańca są raczej niewiarygodne, co oznacza, że nie ma wspólnej funkcji regresji dla wszystkich tych krajów, ale różnice w resztach dają cenny wgląd w specyfikę każdego kraju.

Słowa kluczowe: dwutlenek węgla, paliwa kopalne, zielona gospodarka, analiza danych panelowych