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Renewable Energy Consumption in the Context of Economic Development, CO_2 Emissions and Implications for Public Administration: The Case of Visegrad Group Countries

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Abstract
Renewable energy consumption has gained growing importance in the world energy consumption portfolio over recent years. One of the reasons is the increasingly negative development of climate change. The research carried out in this paper aims to discern whether the examined economic indicator (GDP per capita) and the environmental indicator (CO_2 emissions per capita) affect the renewable energy consumption in the region of the Visegrad Group (V4 – Czech Republic, Hungary, Poland, and Slovak Republic) countries, and to draw implications for public administration in the given issue. The fixed effects panel regression model was used to verify the mentioned relationships between variables from 1990-2020. The results show that the level of the share of renewable energy consumption on the total energy consumption in the region of the V4 countries can be affected by the GDP per capita (positive relationship validated) and the CO_2 emissions per capita (negative relationship validated). These results are mostly in line with the findings of other researchers conducted on different samples of countries, although some differences can be noted, especially regarding the direction of the relationship. The implications of the research results are presented on three levels: practical implications for the business sector, emphasis placed on political implications for public administration, and theoretical implications that lay the foundation for further research. The main limitation of the research results comes from the sample used in V4 countries and, thus, from the limited possibilities of generalizing the results. The direction of further research in the addressed issue will include a larger number of countries in the research and the use of various quantitative and qualitative research methods.

Keywords
renewable energy consumption, economic development, CO_2 emissions, climate change, public administration management, Visegrad Group countries

Introduction

With the growing concerns over the environmental consequences of greenhouse gas emissions from fossil fuels and the geopolitical climate surrounding fossil fuel production, renewable energy sources have emerged as an important component in the world energy consumption mix (Apergis and Payne, 2012; Simionescu et al. 2021). Renewable energy sources have gained growing importance in the world energy consumption portfolio over recent years due to the increasingly negative consequences of climate change, high and volatile energy prices, and favorable government policies towards renewable energy use (Chen et al., 2020; Škare et al. 2024a). China proposed that non-fossil energy consumption accounts for 20% of total energy consumption. In its plans in the past, the EU planned to increase the target of renewable energy consumption (REC) share from 27% to 35% in 2030 (Shaozhou and Yang, 2017). The target from 2018 set the share of renewable resources at 32 percent. A new EU directive from October 2023 envisages increasing this target to 42.5 percent by 2030, with member states recommended to reach up to 45 percent. The agreement on the directive means doubling the share of renewable energy sources in the European energy mix. According to Union statistics, this is currently at 22.1 percent. Energy transformation and increasing renewable energy consumption are important energy strategies for all countries at present. Then, the question is: Is the relationship between renewable energy consumption and economic development (represented by GDP per capita) positive or negative? Also, is there really a relationship between the share of renewable energy consumption and CO2 emissions per capita?

The determinants of REC can either be general or based on country specifics. Aguirre and Ibikunle (2014) stated that certain energy-related government policies inhibit renewable energy investments. A relative diversity of renewable energy development, energy mix, GDP per capita, supply of energy concentration, and the cost of fossil-fuel energy consumption are some of the factors that determine renewable energy development in the European Union countries (Papiez et al., 2018; Škare et al. 2023; Simionescu and Gavurova, 2023).

This paper aims to examine the relationships between the share of renewable energy consumption (REC), the GDP per capita, and the CO_2 emissions per capita in the Visegrad Group (V4) countries. Data from the freely available Word Bank database were used. The territories of the Visegrad Group (V4) countries (Czech Republic, Hungary, Poland, and Slovakia) share geographical proximity, as well as cultural and historical development. The V4 countries also share similar experiences in the field of economic transformation and the challenges of joining international structures.

In recent decades, there has been a significant increase in the combined share of wind, solar, and hydropower, indicating a gradual transition to cleaner energy sources. This is also indicated by the example of the Visegrad Group countries (see Figure 1). The rising significance of plummeting CO_2 emissions to combat worldwide environmental change encourages economies to endorse environmental protection and to adopt more renewable energy sources (Saidi and Hammami, 2015; Chen et al., 2021; Skare et al. 2024b). Bamati and Raoofi (2020) claim that GDP per capita exerts a different impact on renewable energy consumption depending on their level of development.

The content of this paper includes a literature review, which contains an overview of the theoretical background and research results of the topic concerning the ties explored in this article. The Material and Methods section specifies the materials and methods to fulfill the established research objective. The results section shows the results of the fixed effects panel regression model. It is followed by their critical discussion and evaluation. The last part of the paper is the conclusions.

Literature Review

Existing studies have considered the concerns regarding renewable energy demand and subsequent consumption (Lei et al., 2021; Murshed, 2021; Suhányiová et al., 2023; Majeed et al., 2022). Although GDP and CO_2 emissions are closely linked with renewable energy consumption (REC), Jianhua (2022) claims in his study that their impact has not yet been discovered sufficiently in the existing literature. Due to the changes in global energy demand, it is essential to discuss the concept of climate change. This is because of occurring events such as increasing global temperature, rising sea level, decreasing snow cover, and natural disasters (Somoye et al., 2022).

The authors Anton and Nucu (2020) concluded in their research on a sample of EU countries that financial development promotes renewable energy consumption, and another research by Omri and Nguyen (2014) established that CO_2 emissions also determine REC. The consumption of renewable energy is also connected with the sustainability of the development, which was also confirmed in the research of Güney (2020) performed on a sample of 20 high-income countries and concluded that a 1% increase in renewable energy consumption increases sustainable development by 0.326%.

Several researchers are dealing with the topic of the connection between REC, GDP, and CO_2 emissions. One of them, the research of Lu (2017), finds that a long-run equilibrium exists between renewable energy consumption, carbon emission, and GDP. Based on the results of this research, CO_2 emissions positively affect

renewable energy consumption in the Philippines, Pakistan, China, Iraq, Yemen, and Saudi Arabia. He concluded that a 1% increase in GDP will increase renewable energy consumption by 0.64%. GDP significantly determines renewable energy in India, Sri Lanka, the Philippines, Thailand, Turkey, Malaysia, Jordan, the United Arab Emirates, Saudi Arabia, and Mongolia. Two bidirectional causal relationships were found between CO_2 emissions and renewable energy consumption and between renewable energy consumption and GDP.

Another research study by Saidi and Mbarek (2016) aimed to investigate the causal relationship between nuclear energy consumption, CO_2 emissions, renewable energy, and real GDP per capita for nine developed countries over the period 1990-2013. Results show that there is a unidirectional causality running from renewable energy consumption to real GDP per capita in the short run. They also concluded that in the long run, a bidirectional causality exists between renewable energy consumption and real GDP per capita, which complains that renewable energy is crucial for economic growth.

Within the article of Belaïd and Zrelli (2019), an empirical model was developed to investigate the causal relationship between renewable energy consumption, GDP and carbon emissions by using a panel of 9 Mediterranean countries from 1980 to 2014. The results provide panel empirical evidence that short-term bidirectional causality exists between GDP, renewable energy consumption, and CO_2 emissions. From a long-term perspective, there is evidence of unidirectional causal relationships between renewable energy consumption and CO_2 emissions. The findings imply that renewable energy consumption reduces CO_2 emissions in southern and northern Mediterranean countries while economic growth stimulates them.

The study of Banday and Aneja (2020) aimed to find the causal relationship among energy consumption (renewable energy and non-renewable energy), GDP growth, and CO_2 emission for Brazil, Russia, India, China, and South Africa for the period of 1990-2017. The causality results from renewable energy consumption to GDP show that there is evidence of feedback hypothesis for China and Brazil, growth hypothesis for Russia, conservation hypothesis for South Africa, and neutrality hypothesis for India. In the case of renewable energy and non-renewable energy consumption compared to CO_2 emission, the results show convergence in India, Russia, and South Africa and divergence in China and Brazil.

The issue was also examined several years ago by the author Tiwari (2011), whose study has attempted to analyze the dynamics of renewable energy consumption, economic growth, and CO_2 emissions. He used the structural VAR approach and revealed that a positive shock on the consumption of renewable energy source increases GDP and decreases CO_2 emissions, and a positive shock on GDP has a very high positive impact on CO_2 emissions.

The study by Salari et al. (2021) investigates the relationship between carbon dioxide (CO_2) emissions, energy consumption, and economic growth (GDP) in the United States at the state level during 1997-2016. Results show that a long-run relationship exists among various types of energy consumption and CO_2 emissions at the state level for both static and dynamic models. Total, non-renewable, industrial, and residential energy consumption positively impacts CO_2 emissions, while renewable energy consumption has a negative relationship with CO_2 emissions.

Another geographical example where the issue was investigated was the case of Iran between 1975-2017. The study of Karimi et al. (2021) examined the relationship between economic growth, renewable energy consumption, and carbon emissions, and the bounds-testing approach to cointegration and the asymmetric method was used. The results reveal that in the long-run perspective, an increase in renewable energy consumption causes an increase in real GDP per capita. Meanwhile, the decrease in renewable energy has the same effect, but GDP per capita reacts more strongly to the rise in renewable energy than the decline. Besides, in the long run, reducing CO_2 emissions has an insignificant impact on GDP per capita. Furthermore, the results from asymmetric tests suggest that reducing CO_2 emissions and renewable energy consumption are not essential in decreasing growth in the short run. In contrast, an increase in renewable energy consumption and CO_2 emissions contribute to boosting the growth.

Sustainable energy development and its evaluation are key resources in learning and understanding the policies implemented by the European Commission and how they work while comparing countries with sustainable energy indicators in the area of sustainable energy (Streimikiene et al., 2016; Arilla-Llorente et al. 2024). The concept of sustainable energy development has developed since it was first mentioned in the Brundtland Report, called "Our Common Future". It was formulated as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland et al., 1987).

The energy sector is directly related to the competitiveness of countries, as it is key to sustainable development. Energy production and consumption have the greatest impact on the environment in terms of climate change and air pollution. However, it is necessary to realize that not only the business sector contributes to air pollution but also the inhabitants themselves, whose choice of energy source often depends on their income above the subsistence level (Suhányiová and Suhányi, 2017). At the same time, the energy sector is the main driving force of economic growth (Streimikiene et al., 2016). Therefore, the analysis of sustainable energy development can be assessed based on the division into GDP, energy consumption, and air pollution, including emissions.

Material and Methods

Within the scope of the research in this paper, the region of the Visegrad Group (V4) countries, which includes the Czech Republic, Hungary, Poland, and the Slovak Republic, is examined. It is an active regional structure of four member countries of the EU and NATO, which share similar political, socioeconomic, economic, and cultural-historical values. On the official website of the Visegrad Group (Visegrad Group, 2023), it is stated that these grouped countries in the Central European region aim to cooperate in several areas of common interest within the framework of pan-European integration. The V4 countries have always been part of a single civilization sharing cultural and intellectual values and common roots in diverse religious traditions, which they wish to preserve and further strengthen. All V4 activities are aimed towards strengthening stability in the Central European region. The regional cooperation of the V4 is successfully developing even in the current period. This primarily takes the form of sectoral policies, such as the economy, infrastructure, energy, digitization, and innovation (Suhányi et al., 2023).

The data source used in this research is the freely available World Bank Open Data database. World Bank databases are essential tools for supporting critical management decisions and providing key statistical information. The application of internationally accepted standards and norms results in a consistent, reliable source of information (The World Bank, 2023).

The time period examined in the research was from 1990 to 2020. Data were collected yearly. The justification for the selected examined period is mainly the availability of data in the World Bank database and the authors' effort to examine the longest possible relevant period in the four examined countries. The above shows that the maximum theoretical possible number of cases for the 11 years of the examined period was 124 (31 for each country). This would be the case if each of the variables under study were available in each of the years under study. In reality, however, it was necessary to omit three cases in the study when one of the investigated variables was not available. This is specifically the case of Hungary in 1990 and two cases of the Slovak Republic in 1990 and 1991. The resulting number of examined cases in this research study was 121.

The rationale for the variables used in this study follows from the research studies and literature review presented in the previous sections of this paper. The following variables were included in this research study (with their description given by the World Bank definition):

- **REC – Renewable Energy Consumption**
  Renewable energy consumption is the share (expressed as %) of renewable energy in total final energy consumption in the country.
  The ID of the indicator in the World Bank Open Data database: EG.FEC.RNEW.ZS
  Source organization: IEA, IRENA, UNSD, World Bank, WHO. 2023. Tracking SDG 7: The Energy Progress Report.
- **GDP per capita**
  This indicator provides per capita values for gross domestic product (GDP) expressed in thousands of current international dollars converted by purchasing power parity (PPP) conversion factor.
  GDP is the sum of gross value added by all resident producers in the country plus any product taxes and minus any subsidies not included in the value of the products. The conversion factor is a spatial price deflator and currency converter that controls price level differences between countries. The total population is a mid-year population based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.
  The indicator is converted to thousands of dollars by the authors.
  The ID of the indicator in the World Bank Open Data database: NY.GDP.PCAP.PP.CD
  Source organization: International Comparison Program, World Bank | World Development Indicators database, World Bank | Eurostat-OECD PPP Programme.
- **CO_2 emissions** (metric tons per capita)
  Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.
  The ID of the indicator in the World Bank Open Data database: EN.ATM.CO2E.PC
  Source organization: Emissions data are sourced from Climate Watch Historical GHG Emissions (1990-2020). 2023. Washington, DC: World Resources Institute. Available online at: https://www.climatewatchdata.org/ghg-emissions.

The paper aims to determine how the selected variables (economic indicator – GDP and environmental indicator – CO2 emissions) could affect the share of renewable energy consumption in the V4 region. The evaluation of the influence of the selected identifiers (indicators) in this study is based on the validation of the following working hypothesis:

H: *The level of the share of renewable energy consumption on the total energy consumption in the region of the Visegrad Group (V4) countries can be affected by the GDP per capita (positive relationship assumed) and the CO_2 emissions per capita (negative relationship assumed).*

This study uses the fixed Effects Panel Regression Model to validate the hypothesis. Fixed effects play a fundamental role in statistical analysis, providing a way to account for specific variables or factors that remain constant across observations. These effects allow us to capture the individual characteristics of entities under study and control for their impact on the outcome of interest.

The fixed effect model can be used to study the relationship between time-varying predictors and outcomes. In general, time-invariant predictors are not utilized in these models (except for certain cases where there is an interest in testing for possible interactions between time-invariant and time-varying predictors) (Allison, 2009). With fixed effects models, individual cases serve as their own controls since they are measured over time. Moreover, there is no concern over omitted-variable bias due to differences between cases, as all time-invariant differences are controlled for. The only possibility for omitted-variable bias is when there is a failure to consider other time-varying predictors of an outcome.

A statistical software application, IBM SPSS Statistics version no. 29.0.2.0 (20) was used to apply the fixed effects panel regression model.

Results

In the research in this article, the consumption of renewable energies is monitored as their share of total energy consumption in the given country. Their development in all four countries of the Visegrad Group in the analyzed period is shown in Figure 1.

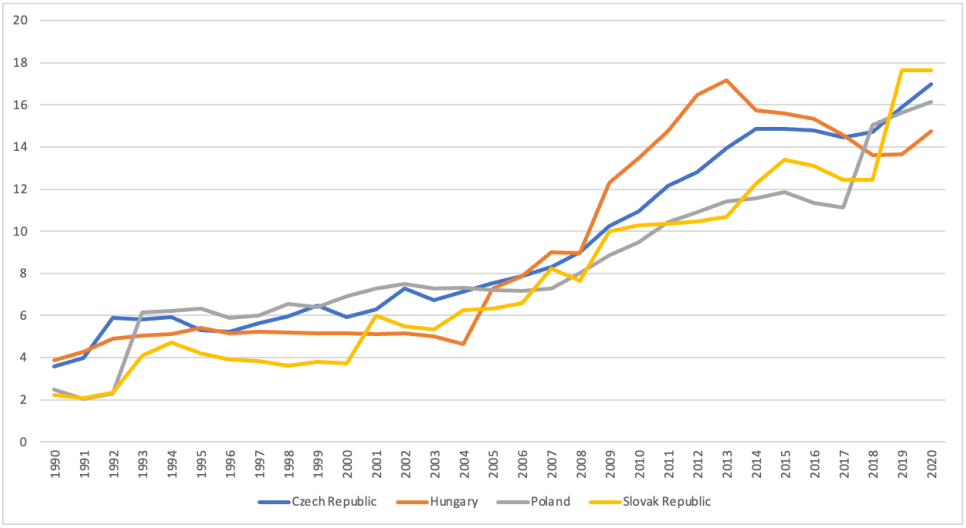

Fig. 1. Development of renewable energy consumption (% of total final energy consumption) in the countries of Visegrad Group (V4)

In general, it is possible to state an increasing trend in the share of energy consumption from renewable sources in all four countries of the Visegrad Group. The indicator represents the share of total energy consumption in the country, which should contribute to reducing dependence on fossil fuels. In the past decade, however, there has been a noticeable medium-term decline in the share of renewable energy in total consumption in all four countries. In the case of the Czech Republic, Poland, and the Slovak Republic, this decline was shorter and only very moderate to moderate, while these countries very quickly reached levels significantly higher than before the decline. On the other hand, Hungary experienced a significant decline in 2013 and lasted until 2019. At the end of the monitored period, Hungary achieved the lowest shares of renewable energy consumption of all four countries of the Visegrad Group, while it previously belonged to the leaders.

In the fixed effects regression model used in this study, GDP per capita (in thousands of current international dollars converted by purchasing power parity conversion factor) and CO_2 emissions (in metric tons per capita) appear as independent variables. Their development in all four countries of the Visegrad Group in the analyzed period is shown in Figure 2.

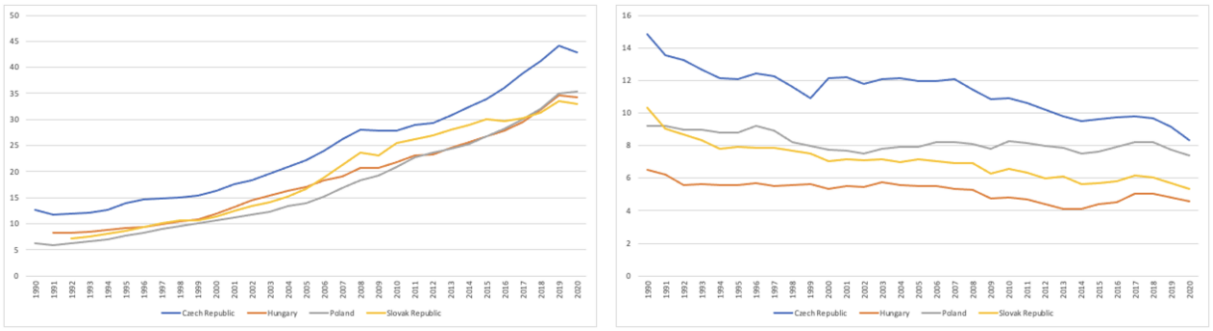

Fig. 2. Development GDP per capita (on the left) and the CO_2 emissions (on the right) in the countries of the Visegrad Group (V4)

The proximity of the Visegrad Group countries is also visible on the graphs showing the GDP and CO_2 emissions development in Figure 2. Both indicators show a very similar development in all four countries in the monitored period of 31 years. The only thing worth mentioning is that the Czech Republic shows the highest values in both indicators throughout the monitored period without exception.

The paper deals with the use of a fixed-effect panel regression model. The dependent variable is the Renewable Energy Consumption (REC). The stated results serve as a basis for validating the hypothesis presented in the Materials and Methods section. The hypothesis assumes a relationship between the mentioned dependent variable and time-varying independent variables (GDP and CO_2 emissions) in the Visegrad Group – V4 counties (Czech Republic, Hungary, Poland, and Slovak Republic). Table 1 shows the results of the descriptive statistics of the time-varying variables.

Tab. 1. Descriptive Statistics

	Mean	Std. Deviation	N
REC	8.7969	4.14195	121
GDP_th_PPP	19.708731614778700	9.441376272596320	121
CO2_em	7.932998428056270	2.456558633324180	121

It was possible to evaluate 121 observations out of 124 cases, for which the data were available for every single examined variable. This was caused by the character of the data that were collected for four countries of the Visegrad Group in the case of three time-varying variables. If any variable was not available for a country in a certain year, that case was excluded from the panel regression model.

Tab. 2. Model Summary

Regression Statistics	
Multiple R	0.938
R Square	0.880409403905254
Adjusted R Square	0.8752098127707
Standard Error of Estimate	1.46317216934868
p	< 0.001
No. of cases	121

The resulting regression statistics show (Table 2) that the Multiple R-value (correlation coefficient) is equal to 0.938. The closer this value is to 1, the stronger the dependence. In the examined case, there is a high degree of intensity of dependence between the variables. The value of R square (value of the coefficient of determination) is at the level of 0.880. After multiplication by 100, this value indicates that the selected regression model explains the variability of REC in the V4 region to approximately 88%, and the remaining part represents unexplained variability, the influence of random variables, and other unspecified influences. The adjusted R square (adjusted coefficient of determination) also considers the number of estimated parameters and the number of measurements, after which the values are still at 87.5%. The Standard Error (standard error of the mean) should be as small as possible.

Tab. 3. Fixed Effects Panel Regression Model – Selected Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t Stat	Sig. (p)	Correlations		
	B	Std. Error	Beta			Zero-order	Partial	Part
(Constant)	12.853	3.167		4.058	0.000			
GDP_th_PPP	0.337	0.024	0.769	14.003	0.000	0.898	0.794	0.452
CO2_em	-1.030	0.236	-0.611	-4.358	0.000	-0.292	-0.376	-0.141

The results of the fixed effects panel regression model show (Table 3) that at the set level of α (*p*-value should be equal to or less than 0.05), a significant relationship is confirmed in the case of both examined time-varying independent variables.

Considering the Renewable Energy Consumption (REC) as a dependent variable in the model, there is a positive predictive relationship with the GDP and a negative predictive relationship with the CO_2 emissions. It follows from the above that if we were to consider the other time-dependent variables unchanged, then the model would assume that with an increase in the country's GDP level, the value of the REC would also increase. Analogously, it can also be assumed that, with other time-dependent variables unchanged, the value of the REC should decrease with increased CO_2 emissions. The regression coefficients of the panel regression model are calculated for the Visegrad Group countries (Czech Republic, Hungary, Poland, and Slovak Republic), where the fixed effects of the countries are assumed in the model. When looking at the coefficients of B, the value of the intercept coefficient (the constant) is at the level of 12.853. The final estimation of regression coefficients shows that if the GDP of the country increases by one unit, the renewable energy consumption will increase by 0.337 units. Also, if the level of CO_2 emissions in the country decreases by one unit, it is accompanied by an increase in the indicator of renewable energy consumption by 1.03 units. These results cannot be quantified entirely in this way, but it appears that there is a link between the REC and the GDP and CO_2 emissions that needs to be taken into account in decision-making. Another thing that needs to be considered when interpreting the results is the units in which individual time-varying variables are included in the model. The basic unit of REC is the percentage of total final energy consumption in the country; the basic unit of GDP (calculated per capita) is expressed in thousands of current international dollars converted by purchasing power parity conversion factor; the basic unit of CO_2 emissions is given in metric tons per capita.

Based on the results, the following hypothesis stated within the present study can be validated:
The level of the share of renewable energy consumption on the total energy consumption in the region of the Visegrad Group (V4) countries can be affected by the GDP per capita (positive relationship validated) and the CO_2 emissions per capita (negative relationship validated).

Next, the appropriateness of the selected fixed-effect panel regression models is tested (Table 4). In accordance with the information in the Material and Methods section, the mentioned testing is carried out using the Analysis of Variance method.

Tab. 4. Testing the suitability of the model – Analysis of Variance

ANNOVA					
	Sum of Squares	df	Mean Square	F	Sig. (p)
Regression	1812.493	5	362.499	169.323	< 0.001
Residual	246.200	115	2.141		
Total	2058.693	120			

In the ANOVA, the null hypothesis is tested for the hypothesis in this paper, which states that the regression model chosen to explain the relationship is not suitable (the alternative hypothesis states the opposite). The F test is used to evaluate these statements, the *p*-value of which should be lower than 0.05 (the chosen significance level α). The *p*-value in the case of the proposed regression model is below the chosen level of significance. For the stated hypothesis, the H0 is rejected, which means that according to the results, the model was chosen correctly. This result confirms the validation of the hypothesis stated within the research in this paper.

Discussion

The results of this study show that on a sample of Visegrad Group (V4) countries, it is possible to confirm the relationship between the share of renewable energy consumption and between the examined variables, which were GDP per capita and CO_2 emissions per capita.

The novelty of this study lies, among other things, in examining the issue in the case of the countries of the Visegrad Group. As already mentioned in the previous sections, it is a grouping of four countries: the Czech Republic, Hungary, Poland, and the Slovak Republic. These countries share geographical proximity, as well as political, cultural, and historical development. The V4 countries also share similar experiences in the field of economic transformation and the challenges of joining international structures. They are part of the European Union (EU) and the North Atlantic Treaty Organization (NATO). At the same time, they are also member countries of the Organization for Economic Cooperation and Development (OECD), which is a forum whose member countries describe themselves as committed to democracy and the market economy, providing a platform to compare policy experiences, seek answers to common problems, identify good practices, and coordinate domestic and international policies of its members (Suhányi et al., 2021). The leaders of the V4 countries meet regularly and discuss common views and positions in the framework of international politics and economic and cultural issues in order to increase the cumulative bargaining power of the countries in this grouping. All of the above justifies examining the issue in a selected group of countries. In general, the validity of the research on the case of V4 countries is confirmed by several researchers also on topics other than the topic addressed in this article (Belas et al., 2023; Gavurova et al., 2020; Suhányi et al., 2023; Valášková et al., 2020). Several authors of scientific publications have already addressed the issue of investigating the relationship between renewable energy consumption, gross domestic product (or even economic growth), and CO_2 emissions in their research on various different cases.

Based on the results of this research, it can be assumed that in the examined countries, there is a positive relationship between the share of renewable energy consumption and GDP per capita. To get an idea of the strength of this assumed relationship, it could be said in a simplified form (if considering unchanged the CO_2 emissions and other variables not included in the proposed model) that an increase in GDP per capita by 337 dollars will be accompanied by an increase in the share of renewable energy consumption in total energy consumption by 1 percent. Compared the result to other research, it can be said that this result is consistent with the findings of Lu (2017), who concluded in his research sample that GDP significantly determines REC in India, Sri Lanka, the Philippines, Thailand, Turkey, Malaysia, Jordan, United Arab Emirates, Saudi Arabia, and Mongolia. The results are also confirmed by the research of Saidi and Mbarek (2016) on a sample of developed countries, revealing a bidirectional relationship in the long run. However, in the short term, their research contradicts this because it only confirms a unidirectional relationship between REC and GDP. On the other hand, research by Belaïd and Zrelli (2019) on a sample of Mediterranean countries confirmed the short-term bidirectional causality between GDP and REC. Although there are studies when the direction of the relationship between GDP and REC has not always been confirmed (Salari et al., 2021; Banday and Aneja, 2020), on the other hand, the results of research in different countries are mostly consistent with the results of this (Tiwari, 2011; Karimi et al., 2021). At the same time, however, the authors of this study are inclined to the opinion of Jianhua (2022) that the issue is poorly researched in this direction.

Another achieved result of the present study is that it can be assumed that there is a negative relationship between the share of renewable energy consumption and CO_2 emissions per capita in the examined countries. Analogously, as in the previous case, to get an idea of the strength of this assumed relationship, it could be said in a simplified form (if considered unchanged the GDP per capita and other variables not included in the proposed model) that a decrease in CO_2 emissions per capita by 1.03 metric tons will be accompanied by an increase in the share of renewable energy consumption in total energy consumption by 1 percent. Here, it can be concluded that there is a general agreement between the results of this study and the results of other studies on different samples of countries, such as the research of Omri and Nguyen (2014), Saidi and Hammami (2015), Chen et al. (2021), Lu (2017), Salari et al. (2021). However, there are also studies that have been able to confirm this relationship only in the opposite direction as Belaïd and Zrelli (2019) and Banday and Aneja (2020).

The practical implications of the research results can be drawn for companies that have a high degree of environmental responsibility or have an effort to increase an environmentally responsible approach in their activities in the future by increasing the share of renewable energy use in their activities. In such cases, when deciding on the location of their activities or their relocation to the target country, they could also include as decision criteria the expected development of GDP per capita and the situation in the country regarding the development of CO_2 emissions (environmental policy, reduction support, obligations of the countries and communities to which they belong, socio-cultural attitude to the issue in the country).

From the point of view of political implications, based on the results of this study, it can be seen (Figure 1) that none of the countries of the Visegrad Group are yet close to the target set within the framework of the EU

directive for 2030. These countries do not even reach half of the planned share. Therefore, the political implications in public administration can be focused on the main priority that the authors see at the moment. The examined countries of the Visegrad Group are member countries of the European Union. First of all, it is necessary to create a national legislative framework for public administration to fulfill the obligations of the European Directive. The European Directive contains a bold commitment (42.5%) and also a recommendation (45%) for member countries regarding the share of renewable energy consumption. Member countries have at their disposal a time frame for the implementation of the directive into national legislation, which, as practice in the past has shown, is not always met on time. Due to the urgency of the issue and ongoing climate changes, it is necessary to speed up the process in the countries of the Visegrad Group so that they can start planning and implementing specific steps as soon as possible. Subsequently, it will be possible to include its relationship with GDP and CO_2 emissions in decision-making on how to set environmental policy in order to achieve the goal of the share of REC.

The theoretical implications of this research result from the fact that there is a gap in research in the examined direction of relationships. This research suggests that it is worth examining the relationship between the REC and GDP and CO_2 emissions in a wider perspective, meaning examining a wide sample of countries to be able to generalize the results.

Conclusions

The research carried out in the study aimed to discern whether the examined economic indicator (GDP per capita) and the environmental indicator CO_2 emissions per capita affect the level of share of renewable energy consumption. The region of the V4 countries was examined from 1990 to 2020. Czech Republic, Hungary, Poland, and Slovak Republic are countries that share geographical proximity, as well as political, cultural, and historical development. The V4 countries also share similar experiences in the field of economic transformation and the challenges of joining international structures. The examined indicators that were considered as independent variables concerning renewable energy consumption (dependent variable) were: gross domestic product (GDP) per capita expressed in thousands of current international dollars converted by purchasing power parity (PPP) conversion factor; and carbon dioxide (CO_2) emissions in metric tons per capita stemming from the burning of fossil fuels and the manufacture of cement.

The results of this study show that the following hypothesis stated within the research was confirmed by the use of a fixed effect panel regression model: the level of the share of renewable energy consumption on the total energy consumption in the region of the Visegrad Group (V4) countries can be affected by the GDP per capita (positive relationship validated) and the CO_2 emissions per capita (negative relationship validated). The novelty is that the issue is examined specifically in the case of the Visegrad Group countries. The results are mostly in line with the results of other researchers' findings on different samples of countries, although it is possible to state that the impact of GDP and CO2 emissions has not been sufficiently discovered in the existing literature. It is especially worth mentioning the assumption of a positive relationship in the direction from GDP to REC.

Implications are presented in the article on three levels: practical implications for the business sector, political implications for public administration, and theoretical implications that lay the foundation for further research. Due to the urgency of the issue and ongoing climate changes, the emphasis is placed mainly on the political implications for public administration, where the accelerated implementation of the European Directive into national legislation is recommended so that the public authorities can start applying the proposed measures in their decision-making process as soon as possible and as effectively as possible. Including considering the results of the relationship between REC and GDP, respectively, and CO_2 emissions.

Within the limitations of the research, the nature of the renewable energy consumption indicator should be mentioned. This is expressed as the share of renewable energy consumption in the total energy consumption in the country. This means that it is a relative indicator that also changes depending on the development of the total energy consumption in the country, and therefore, its growth may not be caused by an absolute increase in the consumption of renewable energies but also by an explicit decrease in the total consumption. At the same time, it is an internationally recognized indicator and sets the overall goals of the community of nations. Another limitation of the research is the selection of the sample of the Visegrad Group countries; thus, the research results cannot be generalized to a higher level or even to a global level. A limitation is also the use of the fixed effects regression model, which, in essence, only creates the assumption of a relationship based on historical data.

The direction of further research in the addressed issue could include incorporating other countries into the research sample to enable the generalization of the results on a wider scale. It could be, for example, a group of European Union countries or countries grouped by the OECD. Further research progress could be made in the area of using specific quantitative methods that enable the evaluation of the direct impact of individual variables on REC. From the point of view of the use of qualitative research methods, it would be possible to evaluate the impact of specific steps and measures of public administration on the consumption of renewable energies.

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