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The Impact of Renewable Energy Sources on the Economic Growth of Poland and Sweden Considering COVID-19 Times

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Abstract: A demonstration of the relationship between the share of renewables in gross marginal energy and selected countries' economic growth is the basis of this research. The paper seeks to investigate mutual correlations between renewable energy sources and economic growth for two EU economies and how it influences their fluctuations (increase and decrease). The comparative analysis of results was carried out for less-income Polish and high-income Swedish economies. This research used a regression model to answer the research questions examining the presence of correlations between renewable energy sources in gross marginal energy consumption and economic growth. This study analyzes data starting from 1991 to 2022. The results indicated a positive correlation (statistical significance) between Gross Domestic Product and Gross National Income variables for Sweden (84.6% and 83.7%, respectively) and Poland (79.9% and 79.2%, respectively), which influence the use of renewable energy sources. The findings also reveal that the higher economic growth caused by the use of renewables is observed for the leading countries but at the same time the risk of a greater recession is much more likely than in other countries. These findings would help government officials and policymakers to better understand the role of renewable energy in the economic growth of these countries. This study has contributed to the literature on renewable energy sources and statistical reports under the EU energy sector framework.

Keywords: economic growth; renewable energy sources (RES); Gross Domestic Product (GDP); Gross National Income (GNI); regression model; Poland; Sweden; COVID-19

Citation: Ślusarczyk, B.; Żegleń, P.; Kluczek, A.; Nizioł, A.; Górka, M. The Impact of Renewable Energy Sources on the Economic Growth of Poland and Sweden Considering COVID-19 Times. *Energies* **2022**, *15*, 332. https://doi.org/10.3390/en15010332

Academic Editor: Ricardo J. Bessa

Received: 30 November 2021
Accepted: 28 December 2021
Published: 4 January 2022

1. Introduction

The growing "green" paradigm to minimalize energy use and its effect on climate change highlights the necessity for shifting from a fossil-based economy to renewables-based economy or bio-based economy [1]. However, the transformation process might go well delivering regular statistical data collection if not for unexpected events such as COVID-19, which disturbs and causes uncertainty in the evaluation of a factor's impact on the economic growth of both developing and developed countries.

The main motivation for writing the paper is to analyze the impact of three key issues regarding renewable energy sources (RES) and its influence on two coefficients, Gross Domestic Product (GDP) and Gross National Income (GNI), of Poland and Sweden. Moreover, because of existing unpredictable phenomena that are called "Black Swans" in the economy, the issues were examined considering the COVID-19 (perceived as the "Black Swan") era. The paper aims to examine correlations between renewable and economic growth in Poland and Sweden, improving the quality of the debate about RES and their

influence on GDP and GNI from a COVID-19 perspective. The authors stated that the higher the share of RES, the better the economic growth and higher the GDP and GNI indicators. This choice of countries was made due to the existence of significant differences between them, not only economically but also related to renewable energy sources; this being the reason why the research concerning Sweden and Poland (no other well-developed and developed countries) is a randomized trial conducted among well-developed and developed European countries. To back the choice up, it is worth underlining that, in Sweden, the share of renewable energy in the gross marginal energy consumption in 2020 was over 92%. In turn, over 82% of the energy production in Poland is the energy obtained from non-renewable sources [2]. Additionally, another reason for choosing these two countries is a similar situation regarding economic growth, as the GDP ratio in 2015–2019 was at the given level. We also selected a variety of methods and research, performed to analyze the relationship between these countries, but mainly to investigate the impact of economic growth on the creation of power plants powered by renewable energy sources.

Over the years, several studies have been undertaken to investigate the correlations between RES and economic growth formulated in GDP and GNI indicators. The interconnections were mostly found as positive relations [3–10], and supported by technological innovations [11].

Similar research was carried out in various countries in terms of economy and policy [12–18], but the problem of influencing RES on the less-income Polish and high-income Swedish economies has not yet been addressed in this considered area. Hence, the authors of the paper tried to formulate a research gap, which is the lack of a casual interconnection between the energy-based economic factors (energy-GDP and energy-GNI) impacting the economic growth of these countries. Then, the relations are compared to each other to reveal the economic welfare gap with emphasis on COVID-19. In this study, the two variables considered are interdependent, but the research was carried out under various configurations of the variables (as per the level of dependency). To extend the current research in the field of RES, the authors put the main research questions as follows: (1) Is there a relationship between the share of RES in gross marginal energy consumption and economic growth? (2) Do the identified variables interact with each other using a regression model? These research questions were determined in relation to the research gap defining the problem statement.

The goal of the study is to examine the impact of the energy-related variables (GDI and GNI) on the level of economic growth in Poland and Sweden. Through the regression model, this research is intended to demonstrate an impact of renewable energy sources on the economic development through countries' economic factor structures. The selection of countries was based on data availability in EUROSTAT, World Bank and Internet reports, to provide a balanced sample and specifically for the environmental and political conditions and their successful establishment in the national markets. In addition, the selected countries to be analyzed should also outline the importance of RES, which is distributed unequally across the European Union countries (Sweden and Poland). According to the ranking of the Responsible Development Index and the 2019 Sustainable Development Report [19,20], Sweden was rated very highly amongst the world's most developed economies. Poland occupies a stagnating position regarding affordable and clean energy, thus not meeting the Sustainable Development Goals from the 2030 Agenda [21].

This article presents a linkage between the significant energy-related factors influencing the economic growth of Poland and Sweden—two distinct countries in terms of economy, policy, tradition, culture, location, etc. The current state of the research conducted in different parts of the world and in various countries has been carefully reviewed [17,22–26]. In the light of the reviewed literature, the authors of this paper derived the inspiration and need to treat/consider the research from a COVID-19 perspective. The perspective seems to be very important because it influenced all the spheres of our lives and made a contribution to decrease the GDP and GNI in all the countries. The paper is an attempt to disseminate the effects on the structure of the energy sector across the last 20 years, also considering the

COVID-19 pandemic, with a particular emphasis on the use of renewable energy sources. To meet the goal set out in the literature review, a regression model was used.

The paper is structured as follows: Section 1 includes introduction, Section 2 outlines the literature review, which explains the relations between the components of energy-based economic growth under constraints such as COVID-19. Section 3 covers the conceptual framework that defines the impact of RES on the economic growth of Poland and Sweden. Section 4 presents the research outcomes, followed by the recommendations implied by these results and the energy policy implication for economic growth. Section 5 states the discussion and Section 6 covers conclusions.

2. COVID-19 and Renewable Energy Sources—Literature Review

The crisis changed consumer behavior, which resulted in a reduction in the level of fossil fuel consumption in favor of an increase in demand for renewable energy. Regarding the energy sector, the impact of the crisis and the associated policy responses are reinforcing the existing trends in renewable energy, with leaders continuing to use renewable energy, while countries heavily dependent on the fossil fuel industry spend government spending on supporting these sectors, which additionally slows down the clean energy transition [27]. Pandemic restrictions in many countries did not affect electricity production from renewable sources. Global renewable energy consumption in all sectors increased by 1.5%, while renewable electricity production increased by almost 3% in the first quarter of 2020 compared to the same period in 2019. It resulted from new wind and solar PV projects completed within the last year and the fact that renewable energy sources have low marginal operating costs. As a result, the share of RES in electricity demand has increased in many regions affected by the pandemic blockade, including parts of Europe and the USA [28]. With the COVID-19 pandemic starting in 2020, RES accounted for as much as 90% of the added energy in the energy sector. The most significant contribution to such a large increase was made by photovoltaics and hydro and wind energy. According to the International Energy Agency (IEA) report [29], if the current trends continue until 2025, renewable energy will become the most significant energy source. It will meet a third of the global energy demand. Moreover, most of the shares of companies related to the sector doubled in value compared to December 2019. However, the COVID-19 pandemic provides unique information on how different societies are coping with emergencies and how the higher share of RES compared to traditional fuels will affect grid infrastructure, energy markets, and related investments [30–32]. Indeed, the lessons learned from the crisis will shape new policies and determine the long-term consequences for a more sustainable future. Achievements in industrial production have contributed to the increased use of fossil fuels on a large scale, making the energy sector a vital sector of most economies in the world. A disturbing phenomenon is the rapid depletion of oil, gas, and coal resources, which has significantly contributed to by the increase in the world's population, which, according to the United Nations forecasts, will reach the level of 10.9 billion by 2100. Moreover, the extraction of these raw materials becomes more complex and requires advanced technological solutions, which translates into an increase in costs and prices. Thanks to the growing awareness of the dangers of a fossil fuel-based energy, humanity has once again turned to solutions that use renewable energy. Extensive analysis of the literature concerning correlations between renewable energy sources and the economic growth of various countries is presented in this paper. Many countries (including Sweden, Finland, and Denmark [33], Bulgaria [34], Croatia [35], Estonia [36], the Czech Republic [37], Greece [18], and others) are changing their energy policy [2] because it has occurred to them that the renewables may (among others) constitute a way to strike a balance between economic growth and the quality of the environment. It is confirmed, among others, by EUROSTAT data, according to which the share of renewable energy sources in the energy policy of most countries from 28 countries has increased, and 12 European Union members have already achieved the target of a 20% share of energy from renewable sources in the gross final energy consumption in the community in 2020. With the growing level of RES use by Euro-

pean countries, an in-depth analysis of the impact of various factors on this phenomenon is present in numerous publications [38–40]. In the group of factors there are listed increases in oil prices caused by geopolitical threats, the necessity of climate changes mitigations, increase in energy security, GDP, and elimination of carbon-intensive fuels. Peculiarly high carbon dioxide (CO2) emissivity as a result of using traditional energy sources as well as economic growth measured in GDP are the main reasons why separate countries change their energy policy and use RES [41–43]. Moreover, the empirical findings show that an ever-greater use of renewable energies may sustain the economic growth process and have a positive significant impact on GDP improvement and economic development, not only in European and well-developed countries, but [44–46] also in SAARC countries (South Asian Association for Regional Cooperation) [47] and Latin American countries [48,49]. This novel empirical research resulted in creating a new energy policy to reach goals in the area of sustainable economic growth in many countries, especially in EU countries. Therefore, RES consumption plays a determining role in improving economic growth in numerous European and non-European countries. Scientists confirm that the exploitation of renewable energy sources brings many benefits, such as reducing environmental pollution, reducing the consumption of fossil fuels, and reducing the costs of energy production and supply [50–52]. In view of the foregoing, Europe is gradually moving away from non-renewable energy sources in favor of "green energy", the share of which in Europe's energy sector is increasing even in the face of the crisis caused by the COVID-19 pandemic. Mandatory quarantine contributed to a significant decrease in environmental pollution by reducing the consumption of fossil fuels in favor of increasing the demand for renewable energy sources [53–56]. The research undertaken by scientists allowed to assess the impact of the coronavirus pandemic on the energy sector, also in terms of investment and use of renewable energy [46–48]. Such an acceleration of activities can offset the harmful effects of the COVID-19 global pandemic. Despite the crisis caused by the COVID-19 pandemic in 2020, which affected many industries, including the energy sector, the increase in renewable energy was observed, especially wind and solar energy [27]. Global power of RES (that constitute almost 30% in all the energy mixture) increased to about 260 GW [57]. The International Energy Agency (IEA) [17] also reports on the excellent condition of RES. Despite the disturbances in the energy sector due to the pandemic, in the first quarter of 2020 (i.e., in the conditions of the ongoing pandemic), only renewable energy sources recorded a 1.5% increase in demand with a parallel decrease in demand for coal, oil, and natural gas. Many authors [57–59] wrote about the essential maintenance of the growth in demand for renewable energy in the conditions of lockdown and pandemic constraints. The most significant decrease in demand by approx. 15% concerned electricity, especially in countries where strict health restrictions were introduced. Forecasts indicate that the demand for fossil fuel sources will continue to decline. Only the demand for renewable energy sources will increase, which means a favorable prognosis for this energy field [19]. The coronavirus pandemic and the global crisis it causes, combined with climate threats, made it necessary to adjust the energy policy to include renewable sources of electricity. The introduction of renewable energy sources into the energy sector by many countries has become a priority in their policy of building energy security. When comparing Poland and Sweden with respect to energy policy, one has to emphasize that Sweden is the undisputed leader in the energy transformation rankings [60]. Unfortunately, Poland is placed 69th (between Bolivia and Indonesia). Sweden was using RES in 33% of its total energy production in 1990, and the aim of using "green energy" in 50% (planned for 2020) was achieved in 2012. Sweden aims to support domestic energy use by total use of RES, and they want to achieve the goal in 2040. The importance and the growing share of renewable energy sources is also one of the sustainable targets for Poland within its energy policy [61]. As an EU target, the energy policy assumes a 21–23% increase in the share of renewable energy sources in the energy mix by 2030 [20]. Additionally, the report addresses the carbon share in energy production (it is going to be decreased up to 60% whereas today it is 80%), and the RES share in the oil and energy sector will equal 28.5% in 2040 [62]. The relationships between

the components of energy-based economic growth under constraints such as COVID-19 is outlined in Figure 1.

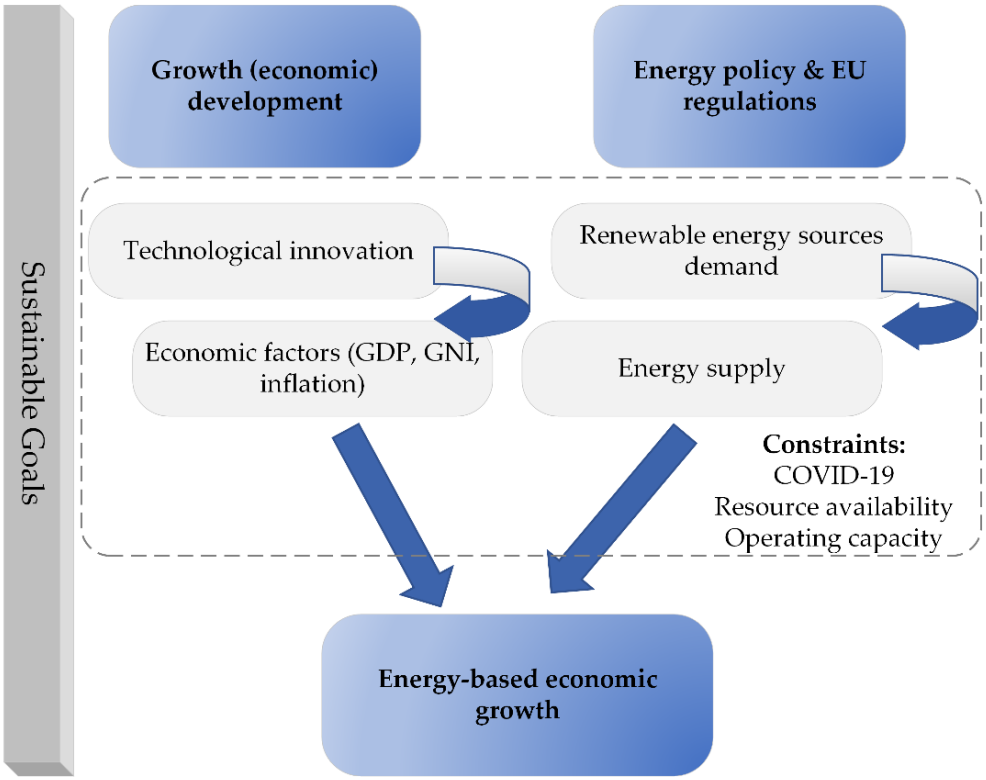

Figure 1. Energy-based economic growth. Source: Own elaboration.

The foregoing literature review concerning correlations between the renewable energy sources and economic growth of various countries regarding the COVID-19 pandemic constitutes a background for the research analyzing two different countries with various energy resource sharing coefficients in their final use of gross energy (Poland and Sweden). These countries were selected considering a highly developed economy against a less-developed one to identify the gross energy consumption disparities between them. Usually, these analyses are being carried out to compare extremely developed countries (with less-income vs. high-income economy) or for developing countries [54]. Data analyses through the use of a regression model will allow solving the problem of an "asymmetrical distribution" of renewable energy sources between both countries.

3. Materials and Methods

The study uses the data from EUROSTAT and the World Bank selected by the researchers. The idea is to show to which extent the impact of RES occurs in developed countries, which are characterized mostly by Gross Domestic Product and Gross National Income.

In this paper, the authors used a conceptual framework for defining the impact of RES on the economic growth of Poland and Sweden, as presented in Figure 2. It consists of the following stages:

1. Problem statement based on the literature review and observations of the economic situation in Europe.
2. Selection of countries using a randomized trial performed by the authors of the paper.
3. Analysis of the energy-related economic variables based on available reports, scientific papers, and statistical data from EUROSTAT and the World Bank, which was a basis for the calculation of a correlation coefficient. For the analysis, GDP, GNI, and RES were taken to calculate the correlation coefficients considering the impact of RES on the

economic growth for the variables for Poland and Sweden. Fundamental indicators, such as standard deviation and coefficient of determination, were also analyzed.

4. Building a regression model, we find the relations between the economic variables, with the use of the time series method. Moreover, to analyze the economic variables in a proper way, the authors have divided the variables into endogenous (RES) and exogenous (GDP, GNI) ones. STASTISTICA 13.1 software was used to obtain the research results. The steps required to carry out and validate the variables are as follows:
    - 4.1. Analysis of various regression models in the literature on the considered topic [16,63,64];
    - 4.2. Linear regression model was applied to find correlations between the analyzed economic variables;
    - 4.3. The regression model used in the study is a kind of panel data fixed-effects regression model denoting the GDP, GNI, and RES variables;
    - 4.4. Responsiveness to changes of the variables' creation was obtained in the final step of analysis.
5. Comparative analysis of the results in terms of the three selected economic variables' correlations for both countries.
6. Results discussion.

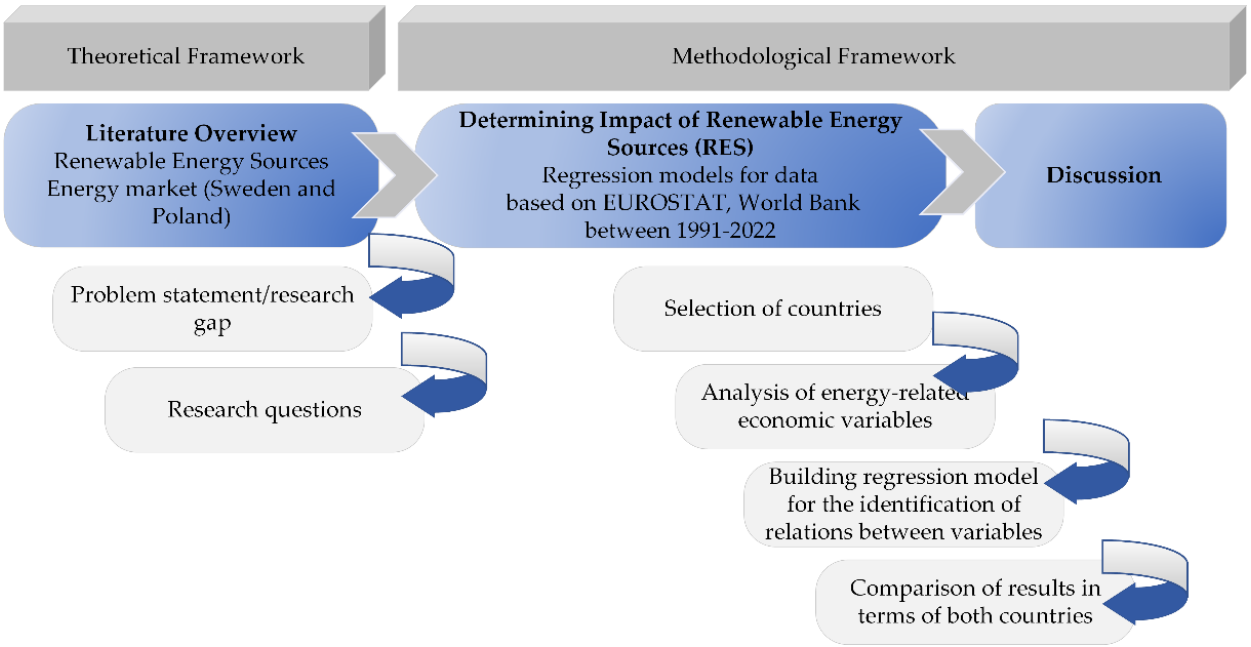

Figure 2. The proposed conceptual framework for determining the impact of RES on the economic growth.

Having this schematic structure of the study, a correlation coefficient between the renewables and economic growth for Sweden and Poland can be investigated. The research uses time interval series data starting from 1991 to 2022.

Having the linear regression model built, the authors could identify the relations between the variables to carry out and validate them. The authors of the paper referred to other works that used similar regression models with a fixed-effects approach in the context of renewables use and its impact on economic growth [16,63,64].

4. Results

The researchers focused their analysis on the relations between three variables (GDP, GNI, and RES), which means that it was investigated whether the changes in the shaping of the X variables (GDP and GNI) influenced the changes in the Y variable (RES).

Table 1 shows the results of the correlation coefficients between the variables GDP, GNI, and RES and gross final energy consumption in Poland and Sweden from 1991 to 2020, as well as the prognosis made for 2021 and 2022.

Table 1. Coefficients of the Gross Domestic Product (GDP), Gross National Income (GNI), and renewable energy resources (RES) share in the final use of gross energy.

% Share of Renewable Energy in Gross Final Energy Consumption			Gross Domestic Product (GDP)			Gross National Income (GNI)		
Years	Poland	Sweden	Years	Poland (Billion Dollars)	Sweden (Billion Dollars)	Years	Poland (Billion Dollars)	Sweden (Billion Dollars)
1991	2.06	32.46	1991	85.50	271.98	1991	82.65	265.72
1992	2.3	33.23	1992	94.34	281.99	1992	90.34	272.06
1993	6.13	34.39	1993	96.05	211.21	1993	92.55	202.59
1994	6.19	31.35	1994	110.80	227.27	1994	109.81	221.47
1995	6.33	33.91	1995	142.14	265.39	1995	140.14	259.83
1996	5.86	31.36	1996	159.94	289.76	1996	158.87	283.99
1997	5.98	35.62	1997	159.12	266.38	1997	157.99	261.16
1998	6.54	35.66	1998	174.39	268.92	1998	173.20	265.02
1999	6.41	34.79	1999	169.72	272.29	1999	168.71	271.86
2000	6.93	40.01	2000	171.89	261.34	2000	171.16	261.50
2001	7.21	37.66	2001	190.52	241.02	2001	189.91	241.20
2002	7.49	36.15	2002	198.68	265.34	2002	198.01	266.10
2003	7.29	34.91	2003	217.51	332.27	2003	215.41	337.90
2004	6.914	38.677	2004	255.10	382.62	2004	246.98	384.80
2005	6.9	40.72	2005	306.12	389.75	2005	300.78	395.09
2006	6.888	42.447	2006	344.75	420,22	2006	337.48	431.20
2007	6.93	43.929	2007	429.06	487.97	2007	414.66	502.69
2008	7.713	44.666	2008	533.82	515.41	2008	524.47	533.27
2009	8.661	47.88	2009	439.80	435.11	2009	426.59	445.35
2010	9.253	46.958	2010	479.32	495.33	2010	462.20	508.80
2011	10.295	48.245	2011	528.83	572.74	2011	509.76	584.48
2012	10.897	50.23	2012	500.36	550.93	2012	481.70	563.58
2013	11.68	50.8	2013	524.23	584.64	2013	506.69	597.82
2014	11.495	51.874	2014	545.39	580.25	2014	525.24	592.53
2015	11.743	53.009	2015	477.58	503.65	2015	460.25	508.19
2016	11.267	53.371	2016	472.03	515.74	2016	453.44	519.29
2017	10.964	54.201	2017	526.22	540.54	2017	504.58	548.71
2018	11.284	54.645	2018	585.66	556.09	2018	560.91	564.72
2019	12.164	56.391	2019	570.78	551.03	2019	546.84	559.08
2020	11.69	59.48	2020	570.04	566.25	2020	531.51	570.64
2021	12.34	61.05	2021	587.16	576.51	2021	548.44	584.42
2022	12.61	61.66	2022	604.27	586.76	2022	565.37	598.20

Source: Own elaboration on the basis of EUROSTAT and World Bank data.

An increasing tendency has been observed in both countries but it is worth it to underline that the share is much higher in Sweden than in Poland. Moreover, the increase

in Poland is not regular and some decreases are noticed (within the period of 2015 to 2020). The correlation between the use of RES, GDP, and GNI show the well-developed country is more advanced in using RES. The forecasts are also optimistic because the use of RES is increasing but the pace of the increase is higher in Sweden again.

Figure 3 presents the correlation between GDP, GNI, and RES for Poland and Sweden within the period of 1991–2022 (with extrapolation).

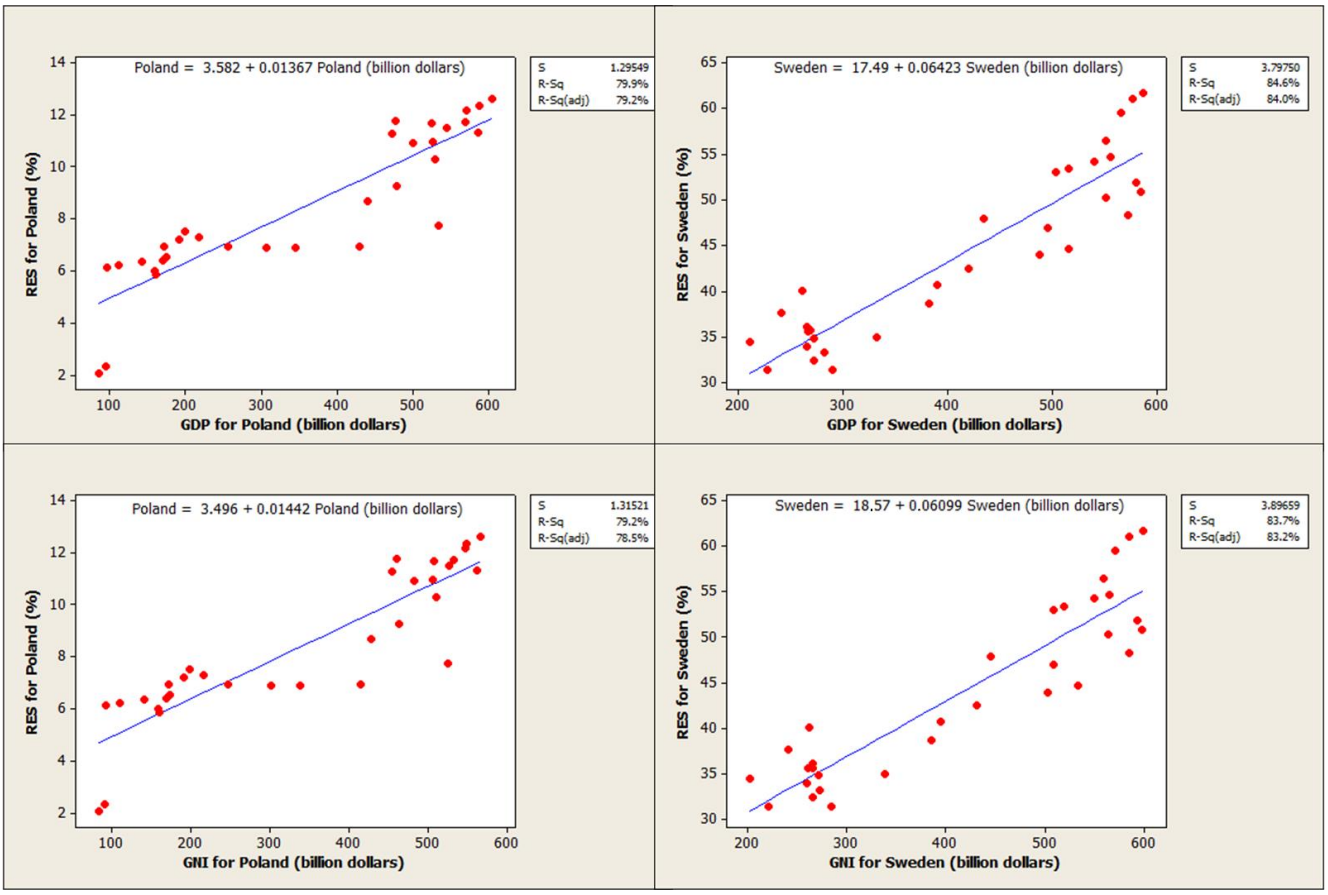

Figure 3. Correlations between GDP, GNI (in billion USD), and RES for Poland and Sweden.

Correlations between GDP, GNI, and RES for both Poland and Sweden are very high. Relations between RES and GDP for Poland and Sweden (79.9% and 84.6%, respectively) indicate a good fit between the analyzed variables. The standard deviation for Poland and Sweden (S = 1.29549 and S = 3.79750, respectively) shows that GDP values are not dispersed widely around its average. Correlations between RES and GNI for Poland and Sweden (79.2% and 83.7% respectively) also point at an accurate fit between the variables. The GNI values for Poland and Sweden are not so dispersed around its average (S = 1.31521 and S = 3.89659, respectively), as is shown in Figure 3.

Figure 4 depicts high values of the coefficient of determination (R-Sq = 84.3%), which means that the model provides a good fit and the authors of the paper can have confidence in its ability to predict the future share of RES for both analyzed countries. It determines the independent variable (RES), which means that the data fit well the regression model. The standard deviation (S) equals 1.14516, which means that the RES values are not dispersed widely around its average. Nevertheless, if R-Sq is high, there is still ambiguity in how large the percentage needs to be in order to be considered a good fit. Based on the statistics generated, linear regression is still an optimal forecasting method. Viewed in terms of prediction, the estimated trend is increasing because a part of the extrapolated series give

the clearest indication of the future movements in the series. Thereupon, the forecast presented in Figure 4 estimates the best fit regression line for the given data.

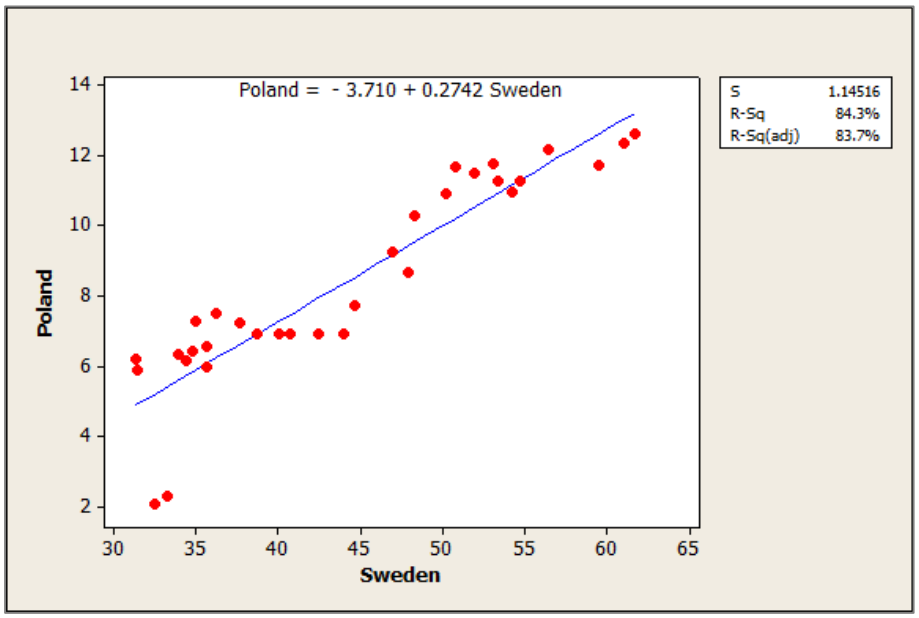

Figure 4. Poland's and Sweden's coefficient of RES.

4.1. Regression Model Based on Variable Y (Renewable) and Variable X (GDP) for Poland

The dependent Y variable (RES) is the share of renewable energy sources in gross energy consumption. In turn, the variables GDP and GNI are the explanatory X variables. The variables are opposite—GDP and GNI are dependent variables, whereas RES is an explanatory variable. The results of modeling the GDP influencing the share of RES in gross marginal energy consumption in Poland within 1991–2022 are presented in Table 2.

Table 2. Results of modeling the share of renewable energy sources in gross marginal energy consumption in Poland in 1991–2022 using a linear econometric model of one variable.

N = 32	**R = 0.89383973, R^2 = 0.79894947, Corr. R^2 = 0.79224778 F(1.30) = 119.22, p < 0.00000, Std Error of Estim. 1.2892**			
	Coefficients	**Standard Error**	**t-Stat**	***p* Value**
Absolute term	3.589947	0.494204	7.26410	0.00000004
GDP (X_1)	0.013618	0.001247	10.91862	0.00000000

The model of the share of renewable energy sources in gross marginal energy consumption in Poland (GDP) is outlined in Equation (1):

$$\hat{Y}_t = 3.58995 + 0.013618\ X_1 \quad (1)$$

The estimated model shows that if the X_1 variable denoting the amount of GDP expressed in USD billion increases by one whole unit (USD 1 billion), the share of renewable energy sources in gross marginal energy consumption will also increase by 13.618%. The intercept is the data that determines the magnitude of the value of Y for the period preceding the analyzed phenomenon. It is a constant and independent value, and its positive value, in this case, means that with each successive period, the variable Y will increase.

The estimated econometric model is relatively well-adjusted to the empirical data and reflects the changes of this phenomenon over time in 79.89%. It is evidenced by the value of the R^2 coefficient = 0.7989. The actual values of the share of renewable energy sources in the gross marginal energy consumption in subsequent years deviate from the estimated model

by 1.2892% on average. On the other hand, the residual deviation, speaking about the average deviation of the theoretical values from the arithmetic mean of empirical values, is S_e = 1.299%.

The last phenomenon presented is the importance of the structural parameters. The hypotheses can be presented as follows: the hypothesis H_0 applies to the situation where it = 0, and the parameter is statistically insignificant. On the other hand, there is the H_1 hypothesis, where it $\neq$ 0 and the parameter is statistically significant. Satisfying the *p*-value inequality implies the rejection of the H_0 hypothesis in favor of the H_1 alternative. In the tested example, α = 0.05, and the value *p*, as shown in Table 2, is a minimal value, and its first number is at the 8th decimal place. This relationship shows that the H_0 hypothesis was rejected, favoring the H_1 alternative, which means that the structural parameter is statistically significant. The variable X_1 has a significant impact on the dependent variable Y.

Another model that concerns the data was developed for Poland, as outlined in Table 3. However, as the previous GDP was used, this section focuses on Gross National Income, as the X_1 variable influences the share of renewable energy sources in the gross marginal energy consumption as the Y variable.

Table 3. Results of modeling the share of renewable energy sources in gross marginal energy consumption in Poland in 1991–2022 using a linear econometric model of one variable.

N = 32	**R = 0.89027206, R^2 = 0.79258435, Corr. R^2 = 0.78567049 F(1.30) = 114.64, *p* < 0.00000, Std Error of Estim. 1.3094**			
	Coefficients	**Standard Error**	**t-Stat**	***p* Value**
Absolute term	3.504782	0.510628	6.86367	0.00000013
GNI (X_1)	0.014364	0.001342	10.70687	0.00000000

The estimated model shows that if the X_1 variable denoting the value of GNI expressed in USD billion increases by one whole unit (USD 1 billion), the share of renewable energy sources in the gross marginal energy consumption will also increase by 14.36%. The estimated econometric model is exceptionally well suited to the empirical data and reflects the changes in this phenomenon over time to be 79.26%. In this case, the H_0 hypothesis also was rejected in favor of the alternative hypothesis H_1, which means that the structural parameter is statistically significant. The variable X_1 has a significant impact on the dependent variable Y. Completing the regression analysis, the model of the share of renewable energy sources in the gross marginal energy consumption in Poland (GNI) is presented below in Equation (2):

$$\hat{Y}_t = 3.5048 + 0.01436\ X_1 \quad (2)$$

4.2. Regression Model Based on Variable Y (Renewable) and Variable X (GDP) for Sweden

The following two regression models were developed for Sweden. To create the current model, Sweden's GDP was used as variable X_1, influencing the share of renewable energy sources in the gross marginal energy consumption as variable Y (Table 4).

Table 4. Results of modeling the share of renewable energy sources in gross marginal energy consumption in Sweden in 1991–2022 using a linear econometric model of one variable.

N = 32	**R = 0.91952560, R^2 = 0.84552732, Corr. R^2 = 0.84037824 F(1.30) = 164.21, *p* < 0.00000, Std Error of Estim. 3.7974**			
	Coefficients	**Standard Error**	**t-Stat**	***p* Value**
Absolute term	17.48746	2.183803	8.00780	0.00000001
GDP (X_1)	0.06423	0.005012	12.81441	0.00000000

The estimated model shows that if the variable X_1, denoting the amount of GDP expressed in USD billion, increases by one whole unit (USD 1 billion), the share of renewable energy sources in gross marginal energy consumption in Sweden would also increase by 64.2%. Such a considerable increase is no longer possible in this country due to the current share of renewable energy sources. Still, it shows how quickly the share of renewable energy in the gross marginal energy consumption grew there. The estimated econometric model is well suited to the empirical data and reflects 84.55% of the changes in this phenomenon over time. It is evidenced by the value of the coefficient $R^2 = 0.8455$. The actual values of the share of renewable energy sources in the gross marginal energy consumption in the following years deviate from the estimated model by 3.797% on average. In turn, the residual deviation, indicating the average deviation of the theoretical values from the arithmetic mean of empirical values, is $S_e = 3.799\%$.

The last phenomenon presented is the importance of the structural parameters. The H_0 hypothesis was rejected in favor of the alternative H_1 hypothesis, which means that the structural parameter is statistically significant. The variable X_1 has a significant impact on the dependent variable Y. Completing the regression analysis, the model of the share of renewable energy sources in the gross marginal energy consumption in Sweden (GDP) is presented below:

$$\hat{Y}t = 17.4875 + 0.06423\ X_1 \quad (3)$$

The second of the Swedish regression models was created using the GNI of Sweden as the variable X_1, influencing the share of renewable energy sources in the gross marginal energy consumption as variable Y (Table 5).

Table 5. Results of modeling the share of renewable energy sources in gross marginal energy consumption in Sweden in 1991–2022 using a linear econometric model of one variable.

N = 32	**R = 0.91507404, R^2 = 0.83736051, Corr. R^2 = 0.83193919 F(1.30) = 154.46, p < 0.00000, Std Error of Estim. 3.8965**			
	Coefficients	**Standard Error**	**t-Stat**	***p* Value**
Absolute term	18.57016	2.167887	8.56602	0.00000001
GNI (X_1)	0.06099	0.004908	12.42807	0.00000000

The estimated model shows that if the X_1 variable denoting the value of GNI expressed in a billion USD increases by one whole unit (USD 1 billion), the share of renewable energy sources in gross marginal energy consumption in Sweden will also increase by 61%. The estimated econometric model is well suited to the empirical data and reflects 83.74% of the changes in this phenomenon over time. The last phenomenon presented shows the importance of the structural parameter α_i. In the tested example, $\alpha = 0.05$, the p value, as shown in Table 5, is a minimal value, and its first number is at the 9th decimal place. This dependence shows that the H_0 hypothesis was rejected, favoring the H1 alternative hypothesis, which means that the structural parameter is statistically significant. The variable X_1 has a significant impact on the dependent variable Y. Completing the regression analysis, the model of the share of renewable energy sources in gross marginal energy consumption in Sweden (GNI) is presented below:

$$\hat{Y}_t = 18.5702 + 0.06099\ X_1 \quad (4)$$

4.3. Regression Model Based on GDP (Variable Y) and Renewable (Variable X_1) for Poland and Sweden

The last analyzed dependence is the opposite situation to the previous two items. The current model was created using the share of renewable energy sources in the gross marginal energy consumption as the X_1 variable influencing the size of the Gross Domestic Product as the dependent variable Y. The model illustrating this situation in both Poland

and Sweden is detailed below. In the analyzed example, all the necessary data for Poland is presented in Table 6 and for Sweden in Table 7.

Table 6. The results of modeling the Gross Domestic Product in Poland in 1991–2022 using a linear econometric model of one variable.

N = 32	R = 0.89383973, R^2 = 0.79894947, Corr. R^2 = 0.79224778 F(1.30) = 119.22, p < 0.00000, Std Error of Estim. 84.617			
	Coefficients	**Standard Error**	**t-Stat**	***p* Value**
Absolute term	−139.929	47.43734	−2.94976	0.006114
RES share (X_1)	58.669	5.37327	10.91862	0.000000

Table 7. The results of modeling the Gross Domestic Product in Sweden in 1991–2022 using a linear econometric model of one variable.

N = 32	R = 0.91952560, R^2 = 0.84552732, Corr. R^2 = 0.84037824 F(1.30) = 164.21, p < 0.00000, Std Error of Estim. 54.363			
	Coefficients	**Standard Error**	**t-Stat**	***p* Value**
Absolute term	−166.160	46.32738	−3.58665	0.001172
RES share (X_1)	13.164	1.02727	12.81441	0.000000

The estimated model shows that if the variable X_1, denoting the share of renewable energy sources in Poland's gross marginal energy consumption expressed in %, increases by one whole unit (1%), GDP will increase by USD 58.67 billion. The estimated econometric model is exceptionally well suited to the empirical data, and at 79.89%, it reflects the change in this phenomenon over time as in the inverse case where GDP was the variable Y. On the other hand, the residual deviation, representing the average deviation of the theoretical values from the arithmetic mean of empirical values, was Se = USD 84.62 billion. The last phenomenon presented is the importance of the structural parameter α_i. The H_0 hypothesis was rejected in favor of the alternative H1 hypothesis, which means that the structural parameter is statistically significant. The variable X_1 has a significant impact on the dependent variable Y. Complementing the regression analysis below, the model of the Gross Domestic Product in Poland, depending on the share of renewable energy sources, is presented in the gross marginal energy consumption (see Equation (5)):

$$\hat{Y}_t = -139.93 + 58.669\ X_1 \quad (5)$$

In turn, the situation in Sweden is mentioned in Table 7.

The estimated model shows that if the variable X_1 representing the share of renewable energy sources in Sweden's gross marginal energy consumption expressed in % increases by one whole unit (1%), GDP would increase by USD 13.16 billion. The estimated econometric model is exceptionally well suited to the empirical data and at 84.55% reflects the change of this phenomenon over time as in the inverse case where GDP was the variable Y. The H_0 hypothesis was rejected in favor of the H1 alternative hypothesis, which means that the structural parameter is statistically significant and the variable X_1 has a significant impact on the dependent variable Y. Completing the regression analysis, the model of Gross Domestic Product in Sweden, depending on the share of renewable energy sources in gross marginal energy consumption, is formulated using Equation (6):

$$\hat{Y}_t = -166.16 + 13.164\ X_1 \quad (6)$$

To sum up, positive correlation between GDP and GNI variables (which is statistically significant) for Sweden (84.6% and 83.7%, respectively) and Poland (79.9% and 79.2%, respectively) influences the use of renewable energy sources. The findings of the study reveal the importance of RES use in the leading countries but simultaneously the paper points that the risk of recession is higher in these economies in comparison to less-income countries.

5. Discussion

The results of this research fill in the research gap concerning the renewables share in highly developed and developed countries. The comparative analysis made it possible to compare the fundamental indicators of economic growth (GDP, GNI) with the use of a regression model. The research conducted by the authors of the paper confirm the need of disseminating the knowledge about RES and its use by different economies. The current state of research concerning the problem still seems to be verified in order to provide evidence on the importance of the problem and correlations between the analyzed coefficients. The research conducted by the authors partially confirm the positive and dynamic impact of renewables on the GDP and GNI of the countries. Additionally, economic recession can constitute a danger for well-developed countries [33]. The higher economic growth caused by the use of renewables is possible but in time the risk of a greater recession is much more possible than in other countries simultaneously.

Answering the first research question, there is a positive relationship between the share of RES in gross marginal energy consumption and economic growth. The higher the economic growth, the more often renewables are used in the countries because they play a significant role in building the economic growth of their economies. In the situation when the GDP and GNI are lower, renewable energy sources are less often used by the government of the country. Another relationship (second question) was to investigate whether the variables interact with each other in the regression model. A critical issue that has been concluded from the analysis of the regression model used in the research is that the more RES-addicted the economy, the worse the situation of the country (in case of any economic crisis and fluctuations). In the situation of economic recession, the country feels the effects of the RES share decrease more often than other less RES-addicted countries. It can be confirmed by the research because it was observed in the results and correlations. Because the study is an attempt to disseminate effects on the structure of the energy sector data, the regression models are presented in a comparative form in Table 8. The bold text indicates the most favorable values. For example, the model for Poland, where the dependent Y variable (RES) distinguished the share of renewable energy sources in gross marginal energy consumption, was compared using the explanatory variable. Concerning GDP (X_1), the model was better adjusted to empirical data, and the reflection of the change of this phenomenon overtime was more favorable. The situation with the standard error of estimation was similarly more favorable because the value was lower than when explaining RES using GNI, which meant that the actual values deviated from the estimated model. On the other hand, in the case of estimating the Y variable with the GNI variable (X_1), there was a higher increase in the Y variable when the X_1 variable increased by one unit (USD billion). However, based on available information, the regression model exhibiting the modeling of the share of renewable energy sources in gross marginal energy consumption in Poland in 1991–2022, with the use of the linear econometric model, is accurately estimated by the Gross Domestic Product due to the lower error.

Table 8. Summary of the regression models.

Summary	Poland					
	Increase of the X_1 Variable by One Unit Causes an Increase in the Dependent Variable by:	**R^2**	**Standard Error of Estimation:**	**Significance of the F Statistics**	**The Importance of Structural Parameters**	**Correlation**
RES (Y), GDP (X_1)	13.618%	0.798949	1.2892%	5.86×10^{-12}	0.00000004	0.8938
RES (Y), GNI (X_1)	14.364%	0.792584	1.3094%	9.11×10^{-12}	0.00000013	0.8903
GDP (Y), RES (X_1)	58.669 billion USD	0.798949	84.617 billion USD	5.86×10^{-12}	0.00611400	0.8938
GNI (Y), RES (X_1)	55.179 billion USD	0.792584	82.763 billion USD	9.11×10^{-12}	0.01117993	0.8903
Summary	**Sweden**					
	Increase of the X_1 Variable by One Unit Causes an Increase in the Dependent Variable by:	**R^2**	**Standard Error of Estimation:**	**Significance of the F Statistics**	**The Importance of Structural Parameters**	**Correlation**
RES (Y), GDP (X_1)	64.23%	0.845527	3.7974%	2.69×10^{-13}	0.00000001	0.9195
RES (Y), GNI (X_1)	60.99%	0.837360	3.8965%	2.31×10^{-13}	0.000000001	0.9151
GDP (Y), RES (X_1)	13.164 billion USD	0.845527	54.363 billion USD	2.69×10^{-13}	0.001172	0.9195
GNI (Y), RES (X_1)	13.729 billion USD	0.837360	58.897 billion USD	2.31×10^{-13}	0.00075493	0.9151

Source: Own study based on EUROSTAT and World Bank data.

Figure 5 depicts the comparison in trend analyses for both countries in terms of the economic indicators, showing their tendency to grow in the next few years. The prognosis of GDP and GNI fluctuations are positive concerning both countries. The regression model is more accurately illustrated when the dependent variable is the GDP indicator than the GNI. The model (linear econometric model of one variable) represents the creation of economic growth and development in Poland within 1991–2022 using the share of RES in the gross marginal energy consumption. The regression that models the share of renewable energy sources in the gross marginal energy consumption in Sweden in 1991–2022 through the application of a linear econometric model of one variable is also better estimated by the GDP. It is argued that there is a minor error and an adjustment of the model to the data, but also the fact that an increase in GDP by one unit (USD billion) causes a greater increase in the share of RES compared to GNI The regression model (linear econometric model of one variable) presenting the creation of economic growth and development in Sweden, with the use of renewable energy sources in the gross marginal energy consumption, is better illustrated when the dependent variable is GDP than GNI. However, despite the above selection between GDP and GNI, both variables affect the RES variable to a similar extent, and RES describe both similarly. The RES variable is statistically significant for the regression model. The positive correlation between the share of renewable energy sources in the gross final energy consumption and GDP in Poland was 0.89384, whereas in Sweden the correlation equaled 0.91953. Considering the correlation between the share of renewable energy sources in the gross final energy consumption and GNI, the research shown that it was a positive correlation in Poland (0.89027) and in Sweden (0.91507). The variable determining the share of renewable energy sources significantly influences the shaping of the variable denoting economic growth (GDP and GNI) in Poland and Sweden. Considering the lower ex-ante error, a better fit is characteristic for the model with the GDP variable. The variable determining economic growth (GDP and GNI) significantly influences the shape of the variable determining the share of renewable energy sources in Poland and Sweden. These results are consistent with the data presented in the Global Renewables Outlook report, which emphasizes that the increase in expenditure on "green" transformation leads to faster global GDP growth—by 2.4% more than with the current

plans (IRENA 2020). Investments in renewable energy sources should increase economic growth and the number of jobs.

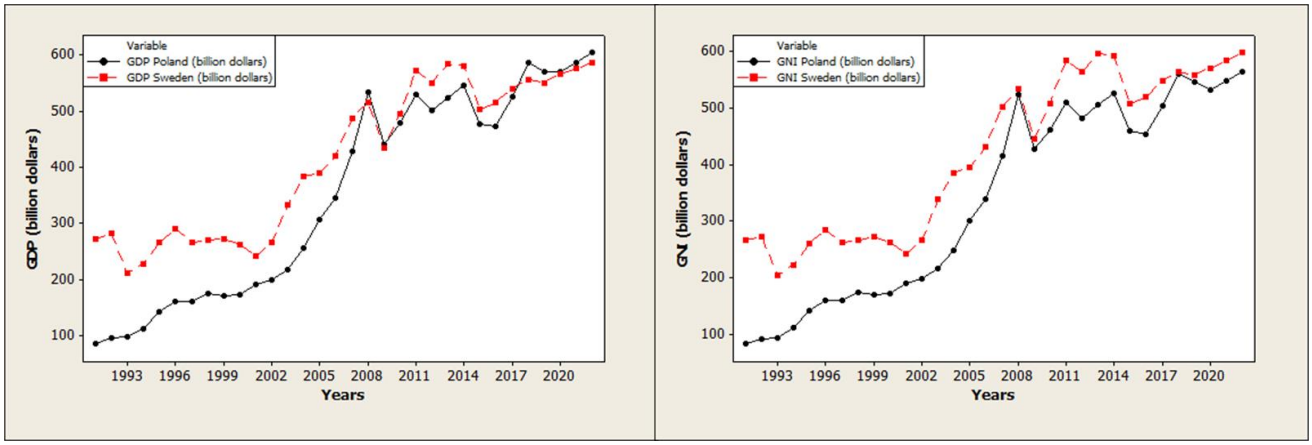

Figure 5. Comparison of GDP vs. GNI for Poland and Sweden between 1991 and 2022.

The analysis of linear regression made it possible to predict the value of one variable (GDP, GNI) on the basis of the other variable (RES). Thanks to this method, the analyzed countries may make optimal decisions concerning RES use and how it influences their economic growth. Moreover, thanks to data analysis and with the use of a linear regression model, the decision-makers of the countries now have an in-depth analysis and presentation of the new models and relations between coefficients.

Energy Policy Implication and Future Agenda for Economic Growth

The statistical differences between countries should be on display by the governments' decision-makers to mainstream this into energy policy within the EU. It should help align these differences in economic values between less-income Polish and high-income Swedish economies. Moreover, those issues will be most significant for small and medium enterprises, which account for the generation for 29% of the added values in Poland [65] versus more than 61% in the Swedish "non-financial business economy" [66]. The consequences of lack of coherence and unified EU energy policy leads to a gap in the relevant literature and prompts to examine forecasting models or tools for applying energy policy in practice. A discussion on energy policy research cannot be separated from the macroeconomic determinants. Therefore, research must be addressed to the factors of unified energy policy to set energy targets for European countries, and then make interventions in order to meet the goals and targets that influence the nation's energy demand. In this context, it would be a crucial agenda of the EU governments by restructuring the content of the current, incoherent energy policy. Element such as economic impact of energy prices and cost-effective investment in RES should be supported adequately by politicians and decision-makers, thereby becoming competitive [67].

In line with the abovementioned finding, some energy policy implications can be recommended for managing the RES energy demand:

- Energy efficiency improvements in the EU countries by implementation of technological innovations. Thanks to that, a balance in the macroeconomic factors between these countries could be maintained.
- Supportive initiatives to promote the reduction dependency on fossil fuels, especially in Poland, and permanent diversification its energy mix by augmenting renewable energy resources.
- Fiscal and tax policies make them particularly essential to examine the negative or positive impact of macroeconomic factors.
- Research models and methods towards facilitating management and evaluation should be able to use existing energy data to generate statistical reports available

for the public institutions. They might be necessary to analyze energy-related trends and provide sufficient indicators for newest technological initiatives.

A transformation into sustainable energy and infrastructure in the post-COVID-19 time through different models is needed in the next few years to provide sustainable economies while ensuring equitable energy planning for economic growth [68].

6. Conclusions

The goal of the study was achieved by depicting the positive correlations between energy-related variables on the level of economic growth in Poland and Sweden. Economic growth and development as well as the share of renewable energy sources in gross marginal energy consumption [69] are the variables between which mutual interaction occurs both these countries. The positive correlations observed between these variables were characterized by the fact that the increase in gross marginal energy consumption contributes to the increase in economic growth. The share of RES could be increased drastically by taking actions to accelerate the economic growth in less-developed countries and promoting national initiatives. The calculation of correlations revealed that in Sweden there was the largest gap (0.44%) between its GDP and GNI compared to Poland (0.35%). In general, in Sweden the impact of RES on GDP is higher by about 2.57% in comparison to Poland, and greater by 2.48% given the RES–GNI analysis.

The results confirm also that the long-term perspective of the economic growth of those developed countries in terms of GDP depends on energy consumption from renewables. The results achieved do not support the research done in [38]. Therefore, developing countries are making more efforts to replace fossil fuels and reduce their dependence by investing in renewable energy resources [6]. The pandemic could change the values of the economic variables only temporarily and in the long run shift to focus on the growth relationship (energy-GDP and energy-GNI). Therefore, the pandemic might result in a significant decrease in all the parameters. The study seems to be unique through mapping of the correlation effects on the structure of the energy sector across the last 20 years, shifting from a traditional fossil-based economy into a renewables-based economy. It, in turn, makes this research different from other studies and fill a gap in the present literature and statistical reports. This paper provides new insight for further research on other countries that are differentiated in terms of economic growth, income, and use of RES. The in-depth analysis could focus on renewable energy sources that impact not only on GDP and GNI but also on other economic quantitative (Net National Income—NNI, inflation rate, GDP per capita, budget deficit, etc.) and qualitative (Human Development Index—HDI, Human Poverty Index—HPI, extent of investments, etc.) indicators.

Moreover, this paper highlights the fundamentals for further research in the area of using renewable energy sources in all European Union countries, taking the abovementioned economic indicators into account.

Author Contributions: Conceptualization, B.Ś., P.Ż. and A.K.; methodology, B.Ś., P.Ż. and A.K.; software, A.K. and P.Ż.; validation, B.Ś., P.Ż., A.K. and A.N.; formal analysis, B.Ś., P.Ż., A.K. and A.N.; investigation, P.Ż., A.K., A.N. and M.G.; resources, B.Ś., P.Ż., A.K., A.N. and M.G.; data curation, B.Ś., P.Ż., A.K. and A.N.; writing—original draft preparation, B.Ś., A.K., P.Ż. and A.N.; writing—review and editing, P.Ż. and A.K.; visualization, P.Ż. and A.K.; supervision, P.Ż. and A.K.; project administration, P.Ż., A.K., A.N. and M.G.; funding acquisition, B.Ś., P.Ż., A.K., A.N. and M.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The study did not report any data.

Conflicts of Interest: The authors declare no conflict of interest.

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