*energies*

MDPI

*Article*

# Regression Analysis of the Impact of Foreign Direct Investments, Adjusted Net Savings, and Environmental Tax Revenues on the Consumption of Renewable Energy Sources in EU Countries

**Valentyna Kukharets [1], Rasa Čingiene [2], Dalia Juočiūnienė [1], Savelii Kukharets [3,4], Egidijus Blažauskas [2], Szymon Szufa [5,*], Andrii Muzychenko [6], Svitlana Belei [7], Nazar Lahodyn [7] and Taras Hutsol [8,9,*]**

1 Department of Applied Economics, Finance and Accounting, Agriculture Academy, Vytautas Magnus University, Universiteto g. 10, Akademija, LT-53361 Kaunas, Lithuania; valentyna.kukharets@vdu.lt (V.K.); dalia.juociuniene@vdu.lt (D.J.)
2 Department of Agricultural Engineering and Safety, Agriculture Academy, Vytautas Magnus University, Studentu Str. 15A, LT-44248 Kaunas, Lithuania; rasa.cingiene@vdu.lt (R.Č.); egidijus7609@gmail.com (E.B.)
3 Department of Mechanical, Energy and Biotechnology Engineering, Agriculture Academy, Vytautas Magnus University, Studentų Str. 11, Akademija, LT-53362 Kaunas, Lithuania; savelii.kukharets@vdu.lt
4 Department of Agricultural Engineering, Odesa State Agrarian University, Panteleimonivska St, 65-012 Odesa, Ukraine
5 Faculty of Process and Environmental Engineering, Lodz University of Technology, Wolczanska 213, 90-924 Lodz, Poland
6 Department of Statistics and Economic Analysis, National University of Life and Enviromental Sciences of Ukraine, 03-041 Kyiv, Ukraine; andriimuzychenko@gmail.com
7 Department of Business Economics and Human Resource Management Chernivtsi National University Chernivtsi, Ukraine Yury Fedkovich Chernivtsi National University, Str. 2 Cathedral, 58-000 Chernivtsi, Ukraine; s.belei@chnu.edu.ua (S.B.); lahodyn.nazar@chnu.edu.ua (N.L.)
8 Ukrainian University in Europe—Foundation, Balicka 116, 30-149 Krakow, Poland
9 Department of Mechanics and Agroecosystems Engineering, Polissia National University, 10-008 Zhytomyr, Ukraine
* Correspondence: szymon.szufa@p.lodz.pl (S.S.); wte.inter@gmail.com (T.H.)

check for updates

**Citation:** Kukharets, V.; Čingiene, R.; Juočiūnienė, D.; Kukharets, S.; Blažauskas, E.; Szufa, S.; Muzychenko, A.; Belei, S.; Lahodyn, N.; Hutsol, T. Regression Analysis of the Impact of Foreign Direct Investments, Adjusted Net Savings, and Environmental Tax Revenues on the Consumption of Renewable Energy Sources in EU Countries. *Energies* **2024**, *17*, 4465. https://doi.org/10.3390/en17174465

Received: 31 July 2024
Revised: 2 September 2024
Accepted: 4 September 2024
Published: 5 September 2024



**Abstract:** It is very important for EU countries to achieve energy independence. But this is actually impossible without a high level of use or consumption of renewable energy (RE) sources. Important parameters affecting the consumption of RE sources are as follows: foreign direct investments (FDI), adjusted net savings (ANS), and environmental tax revenues. In the presented work, the likely impact of the above indicators on the level of use of RE sources was estimated using a second-order regression equation. As a result, it was established that the growth of the adjusted net savings indicator and an increase in environmental tax revenues (ETR) have a positive effect on the level of use of RE sources. With significant FDI, the level of ANS does not have a very obvious effect on the growth of the level of use of RE sources. An increase in the level of ANS allows for an increase in ETR, which in turn contributes to an increase in the level of consumption of RE sources. It was also established that an increase in the level of ANS contributes to a more complete realization of the potential of FDI for the development of RE. It has been empirically established that a consistently high consumption of renewable energy sources is actually possible in the countries with a high level of adjusted net savings, high environmental tax revenues, and active attraction of foreign direct investments.

**Keywords:** energy independence; regression equation; coefficients; parameters; indicators

## 1. Introduction

One of the main tasks of today for every country in the world is to achieve energy independence. In addition, a long-term strategy to reduce harmful impacts on the climate and the environment is one of the priorities included in the development of a society, as was stated at the World Economic Forum [1]. That is why the sustainable development of

renewable energy is important. But at the same time, several problems arise. In particular, access to modern clean energy is limited, because about 90% of the increase in energy production from renewable (green) sources is in the countries with strong economies [2].

For the sustainable development of renewable energy, it is important that this development takes place fairly and inclusively. In particular, a significant number of studies confirm that economic growth has a positive effect on the consumption of renewable energy sources [3–8].

On the contrary, a balanced development of renewable energy can help reduce the global unevenness of the economic development of countries and ensure the stability of the world economy. The introduction of policies by countries aiming at reducing energy dependence on traditional energy sources and increasing the level of use of renewable energy sources leads to the repurposing of global economic development factors. In particular, such repurposing involves a change in the proportions of the distribution of financial and human resources between various spheres of the economy and the economic growth of the country in general [9–14]. In the process of such repurposing, inevitably there is a transition of industrial production to "clean" technologies and the economical use of non-renewable resources, furthering the reduction in emissions in the environment [15–17]. Increasing the level of use of renewable energy sources is a powerful social aspect for increasing the number of new jobs, improving the level of energy availability, etc. [18]. Also, reducing energy importation dependence in countries improves the energy security of these countries [19,20]. It should be noted that economic efficiency and energy security can be both potential and real. And the development of clean technologies and social factors have the potential to cause a strong economic effect in the future. Therefore, it is quite difficult to immediately reflect environmental and social efficiency in cost form.

It should be noted that the growth of the share of renewable "green" energy in the total energy consumption of countries is impossible without active international cooperation. Cooperation between countries should be based on scientific cooperation, technology transfer, joint investment in renewable energy, and ecology projects. Thanks to international cooperation, the EU countries introduced a "green course", significantly diversified energy resources, reduced the consumption of traditional types of fuel and improved their energy independence [21,22]. The development strategies of the EU countries envisage further growth in the use of renewable energy sources. In particular, the directive of the European Parliament and the Council on promoting the use of energy from renewable sources (2009/28/EU) envisages an increase in the share of renewable energy sources by 45% of the level of energy consumption in EU countries by 2030 [23–27].

However, different European countries have different opportunities to achieve a share of renewable energy in the final consumption set by the directive. After all, EU member states have different levels of economic stability, different opportunities for investing in renewable energy sources, and different potentials for renewable resources. That is why international cooperation will make it possible to smooth out different capabilities of countries and achieve the planned level of use of renewable energy sources in the European Union.

In scientific studies, economic, technical, ecological, and political factors determining the consumption of renewable energy sources are singled out [28–31]. For example, investment and financing as factors for improving energy independence are considered in a significant number of studies. It is believed that the successful use of renewable energy is based on the growth of annual investments and financing in renewable energy systems [32,33]. Active attraction of investments has a significant impact on increasing the share of renewable energy in total energy consumption [34]. Favorable conditions for foreign and public–private investment, financial and environmental incentives form the vector of development of renewable energy sources.

However, it is necessary to take into account that each individual aspect (factor) of the use of renewable energy sources can have both positive and negative effects. And the

interaction of aspects (factors) can have a significant impact on the formation of policy regarding the use of renewable energy sources.

One of the important options for the interaction of factors are the influence of foreign investments (% GDP), adjusted net savings (% GNP), and environmental tax revenues (% GDP) on the consumption of renewable energy sources (% of total energy consumption). Therefore, in the present study, we tried to evaluate and analyze the relationship of the above indicators and their ability to influence the growth in the use of renewable energy sources in 27 EU countries.

## 2. Literature Review

A significant number of the scientific studies we analyzed were aimed at determining the mutual influence between the consumption of renewable energy sources and various indicators of economic development in countries, as well as some environmental performance indicators in those same countries. This study was conducted for different groups of countries, for different time periods, and for different directions (factors, aspects) of mutual influence. In particular, scientists [35] used an empirical analysis of the outflow of foreign direct investment on the level of consumption of renewable energy sources in 39 countries of the world, taking into account the RECAL index of attractiveness of countries to renewable energy.

The results of the study confirm the existence of a correlation between the model parameters in the presence of cross-sectional dependence and structural breaks. The authors noted that there is a positive effect of foreign direct investments and demand on the level of use of renewable energy sources. However, for the countries in which the average consumption of renewable energy sources is less than the average global energy consumption over the past 20 years, the growth of foreign direct investments has practically no effect on the growth of the level of use of renewable energy sources. Also, it was noted that an increase in foreign direct investments does not contribute to an increase in the introduction of green technologies.

Researchers [36] studied the effects of various factors (aspects) (including foreign direct investments) on the consumption of renewable energy sources in 31 African countries south of the Sahara for the period of 2002–2019. As a result of the research, it was established that the impact of the amount of foreign direct investments on the consumption of renewable energy sources was insignificant. The authors indicated that such results may be a consequence of the predicted creditor risk for the given countries.

An analytical study of the dependences between the investments and consumption of renewable energy sources for BIMESTEC countries (countries of the Bay of Bengal) [37] was also conducted. In the study, the authors took into account the outflow of public–private investments, globalization, and urbanization. Energy consumption was reflected by three indicators: total energy consumption and energy consumption, renewable energy sources, and consumption of traditional (fossil) energy. The researchers established a statistically significant and positive relationship between the above indicators. Specifically, a 1% increase in investment leads to a 0.013% increase in renewable energy demand in the Bay of Bengal. However, this study was more focused on cooperation between public and private investments in the consumption of renewable energy sources.

An assessment of foreign direct investments and globalization in relation to energy diversification in some BRICS countries (Brazil, India, China, and South Africa) was carried out in scientific papers [38,39]. The authors of the papers suggested using the energy diversification index. As a result of research, the positive impact of foreign investments on the energy security of Brazil and South Africa was established. Conversely, for China and India, the negative influence of foreign investments on the energy diversification of their countries was established. The researchers concluded that the impact of foreign direct investments on renewable energy depends on the structure of the economy of the country and its energy policy. Factors affecting the amount of electricity from renewable sources in the total energy consumption and their relationships were investigated for the conditions of

China [30]. The research was conducted on the basis of data for the period from 1980 to 2011 using the vector error correlation model. As a result of the research, a long-term relationship was established between the consumption of electricity from renewable sources and the gross domestic product per capita. The authors of the study also established a negative relationship between foreign direct investments and the share of renewable energy sources in the total electricity consumption in China.

The work by [28] describes a study on the influence of certain factors on the growth of the use of renewable energy sources for 38 countries. The study was conducted for both developed economies and developing countries. Special attention was paid to the countries with significant reserves of traditional (fossil) energy sources. The scientists established that in some countries, the state energy policy significantly hinders investments in renewable energy, and, accordingly, investments in renewable energy have a small impact on the country's energy security.

The study of the relationship between innovations, foreign direct investments, economic growth, and the consumption of renewable energy sources was described in a scientific paper [40]. The study was conducted for a sample of factors for 60 countries.

The results were obtained, indicating the presence of a bidirectional (mutual) connection of the investigated indicators. The results of the research made it possible to draw a conclusion about the importance of investing in renewable energy sources. A two-way connection between the receipt of foreign direct investments and the consumption of renewable energy sources was established. It was stated that an increase in foreign direct investments will contribute to the sustainable development of projects in the field of renewable energy, as foreign investors recognize the potential of sustainable development of renewable energy sources. Conversely, the growth of production and consumption of renewable energy sources can make the country more attractive to foreign investors interested in environmental initiatives. In this study, the scientists emphasized the influence of the abovementioned factors on the economic growth of the countries under study.

The authors [41] investigated how investments in renewable energy and the country's financial structure and environmental regulation affect the sustainability of the transition to renewable energy in the countries with highly developed economies (G7 countries). The researchers applied the CS-ARDL model and obtained results characterizing the influence of the abovementioned factors on stimulating the transition to the use of renewable energy sources in the long term. The paper described the results of a study on the impact of both individual factors and their mutual influence on the sustainable transition to the use of renewable energy sources, which was reflected as a percentage of the consumption of renewable energy sources in the total energy consumption.

The paper states that investments have a significant impact on the development of renewable energy, and this impact can be described by a wide range of mathematical models. The researchers found that an increase in foreign direct investments by 1% can lead to an increase in the use of renewable energy sources by 0.1%. The authors indicated that environmental regulation is an effective tool for the sustainable development of renewable energy in G7 countries. An analysis of the obtained mathematical models was carried out, and it was established that all models indicate the importance of environmental regulations for the growth of the use of renewable energy sources, which is reflected as environmental tax revenues as a % of the total tax revenue.

The study by [42] analyzed the impact of environmental tax revenues together with other factors on the transition of renewable energy in 32 countries with high income. The researchers applied the Method of Moments Quantile Regression. As a result of the analysis of the obtained models, a long-term relationship of the studied factors with the energy transition index was revealed. The presence of U-shaped impact factors at the first stages of the energy transition was established. Scientists noted that environmental tax revenues, combined with other factors, have a favorable influence on selected quantiles regarding the stability of the transition to the use of renewable energy.

In the scientific paper by [43], the causal relationship between environmental tax revenues and the consumption of renewable energy sources in 15 countries along the Belt and Road (including developed countries and developing ones) was investigated. As a result of the study, the non-linear influence of environmental tax revenues on the consumption of renewable energy sources was established. A positive impact was established in the long term, i.e., an increase in environmental tax revenues contributed to a growth in the consumption of renewable energy sources in the long term. But in the short term, the increase in environmental tax revenues did not contribute to a growth in the use of renewable energy sources.

In the study by [44], it was found that an increase in the receipt of foreign direct investments causes an increase in the consumption of renewable energy sources only in the countries with a high level of income. In a number of studies, it was established that an increase in the receipt of foreign direct investments is related to the increase in the consumption of renewable energy sources due to the transfer of clean energy technologies [35].

It should be noted that in the information sources analyzed by us, there is no clear consensus regarding the impact of foreign direct investments and environmental tax revenues on the consumption or production of renewable energy sources. In most of the studies analyzed by us, a favorable relationship between the sustainable development of renewable energy and the abovementioned factors was found; however, some researchers had conclusions about the lack of an adequate connection between the specified factors. In addition, the mathematical models used by the researchers are quite complex and not universal. The mathematical models we analyzed give fairly accurate results only for limited ranges of values. Therefore, it is necessary to conduct further research in order to build an adequate statistical model.

## 3. Materials and Methods

This study examines the influence of factors such as foreign direct investments (FDI) [45], adjusted net savings (ANS) [46], and environmental tax revenues (ETR) [47] on the use or consumption of renewable energy (RE) sources [48] in the countries of the European Union. In this study, we consider the consumption of RE sources as a share of the consumption of RE sources in the country's gross final energy consumption [48] and present this indicator as a dependent variable. The independent variables—FDI and ETR—are expressed as a percentage of gross domestic product (% of GDP) to account for the differences in the sizes of the economies being studied. The independent variable ANS reflects gross national savings, adjusted for profits and losses (consumption of fixed capital, depletion of natural resources and forests, pollution damage), and is expressed as a percentage of gross national income (% of GNI). The data source for FDI was the World Bank Group's Economy section [45]. For ANS, the data source was also the World Bank Group, specifically the World Development Indicators section [46]. For ETR, the data source was the Eurostat portal, Data Browser section [47]. The data on RE was also obtained from the Eurostat portal, Data Browser section [48]. The dataset covers all EU countries for the period from 2011 to 2021.

A second-order regression equation was used to express the probable analytical relationship between the above indicators:

$$y = b_1 + b_2x_1 + b_3x_2 + b_4x_3 + b_5x_1^2 + b_6x_2^2 + b_7x_3^2 + b_8x_1x_2 + b_9x_1x_3 + b_{10}x_2x_3, \quad (1)$$

where

$y$—renewable energy (RE) sources, % of gross energy consumption;
$x_1$—foreign direct investments (FDI), % of gross domestic product;
$x_2$—adjusted net savings (ANS), % of gross national income;
$x_3$—environmental tax revenues (ETR), % of gross domestic product;
$b_i$—equation coefficients.

It is important to note that a second-order regression equation was selected for the statistical analysis. In another article, the authors suggest that equations of this type correctly account for the mutual influence between independent parameters and dependent variable values [49]. To increase the significance level of the equation, the coefficients of the obtained equations were analyzed, and statistically insignificant indicators were identified and excluded from further analysis [50,51].

We also evaluated the adequacy of the equations and the coefficients of the corresponding equation. The assessment was performed based on a comparison of the actual and theoretical values of the F-test (Fisher's test) and the *t*-test (Student's test) [50,51]. The values of the criteria were obtained using Microsoft Excel v.16 (Microsoft Corporation, Redmond, WA, USA) using the Data Analysis package v.16 (Microsoft Corporation, Redmond, WA, USA).

## 4. Results

Statistical analysis of the studied indicators is given in Table 1.

**Table 1.** Statistical analysis of the studied indicators.

| Indicator | $y$ | $x_1$ | $x_2$ | $x_3$ |
|---|---|---|---|---|
| Mean | 21.30135 | 8.51811 | 9.23715 | 2.595175 |
| Median | 18.0255 | 2.706378 | 9.415058 | 2.52 |
| Minimum | 2.855 | −117.42 | −11.3918 | 1.16 |
| Maximum | 62.573 | 279.3473 | 21.79146 | 4.14 |
| Sum | 6092.186 | 2436.179 | 2641.825 | 742.22 |
| Count | 286 | 286 | 286 | 286 |

The regression analysis of the indicators made it possible to obtain preliminary values of the coefficients of Equation (1); these values are listed in Table 2.

**Table 2.** Preliminary values of the coefficients of the regression equation.

| | Coefficient | *t* Stat | *p*-Value |
|---|---|---|---|
| $b_1$ | −15.490 | −1.095 | 0.045 |
| $b_2$ | 0.272 | 1.703 | 0.040 |
| $b_3$ | 0.165 | 0.228 | 0.819 |
| $b_4$ | 23.565 | 2.550 | 0.011 |
| $b_5$ | 0.000 | 0.511 | 0.610 |
| $b_6$ | 0.027 | 1.718 | 0.047 |
| $b_7$ | −3.696 | −2.373 | 0.018 |
| $b_8$ | −0.013 | −2.476 | 0.014 |
| $b_9$ | −0.103 | −1.878 | 0.049 |
| $b_{10}$ | −0.082 | −0.431 | 0.667 |

Analyzing the obtained *p*-Value, we can conclude that some coefficients ($b_3$, $b_5$, $b_{10}$) do not meet the t-criterion (Student's *t*-test for the confidence level of 95%—*p*-Value < 0.05). Therefore, we remove them, and for the remaining coefficients, we make an appropriate adjustment (Table 3).

**Table 3.** Adjusted values of coefficients of the regression equation ($R^2$ = 0.63).

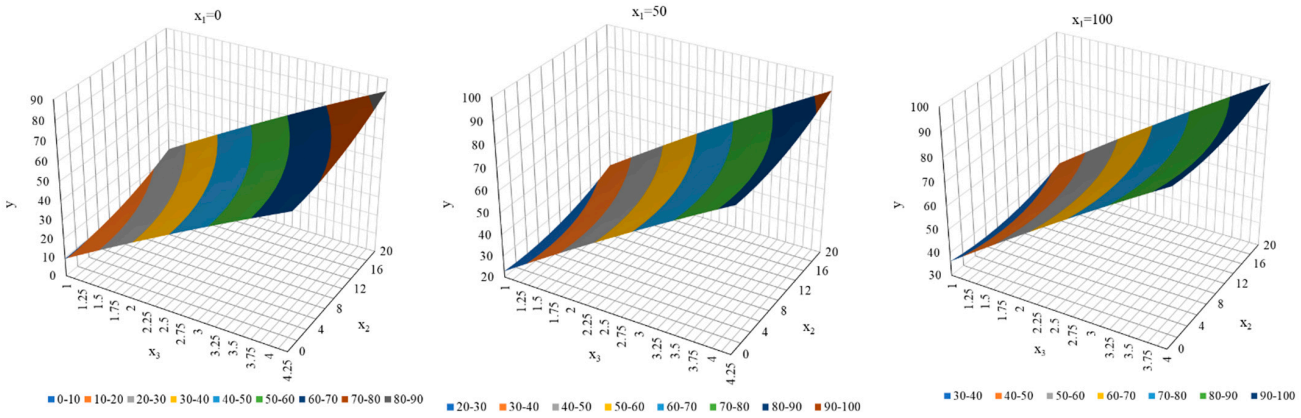
| | Coefficient | *t* Stat | *p*-Value |
|---|---|---|---|
| $b_1$ | −11.061 | −1.018 | 0.031 |
| $b_2$ | 0.261 | 1.653 | 0.039 |
| $b_4$ | 20.843 | 2.595 | 0.010 |
| $b_6$ | 0.038 | 3.573 | 0.000 |
| $b_7$ | −0.471 | −2.293 | 0.023 |
| $b_8$ | −0.005 | −2.417 | 0.016 |
| $b_9$ | 0.008 | −1.808 | 0.042 |

Thus, Equation (1) takes the following form:

$$y = -11.061 + 0.261x_1 + 20.843x_3 + 0.038x_2^2 - 0.471x_3^2 - 0.005x_1x_2 + 0.008x_1x_3. \quad (2)$$

As for the coefficients of the obtained equation, the following should be noted. The values of the coefficients $b_2$ = 0.261 and $b_4$ = 20.843 indicate a positive impact of FDI and ETR on the use of RE sources. Regarding the coefficient $b_6$ = 0.38, it can be noted that there is a positive effect of the square (second degree) of ANS on the use of RE sources. It can also be argued that there is a positive relationship between FDI and ETR, as evidenced by the value of the coefficient $b_9$ = 0.008. However, the values of the coefficients $b_7$ = −0.471 and $b_8$= −0.005 indicate that the influence of the square (second degree) of ETR and the interaction of FDI and ANS may be negative on the use of RE sources, and therefore the careful study and balancing of the above indicators is necessary.

The analysis of Equation (2) for extrema made it possible to construct the corresponding response surfaces. Further analyses of the response surfaces made it possible to make several interesting assumptions. To begin with, we will analyze three surfaces describing the likely impact of ANS ($x_2$, %) and ETR ($x_3$, %) on the consumption of RE sources ($y$, %) at three values of FDI ($x_1$, %): low 0% (Figure 1a), medium 50% (Figure 1b), and high 100% (Figure 1c).




(**a**) (**b**) (**c**)

**Figure 1.** Probable influence of ANS ($x_2$, %) and ETR ($x_3$, %) on the consumption of RE sources ($y$, %). Low 0% (**a**), medium 50% (**b**), and high 100% (**c**).

It is obvious that the growth of the adjusted net saving indicator and the increase in ETR have a positive effect on the level of use of RE sources. Moreover, the relationship between the increase in ETR and the growth in the use of RE sources is actually linear (Figure 2). It should also be noted that with a significant foreign direct investment (about 100% and above), the effect of the level of ANS does not have a very obvious effect on the growth of the level of use of RE sources (Figure 3).

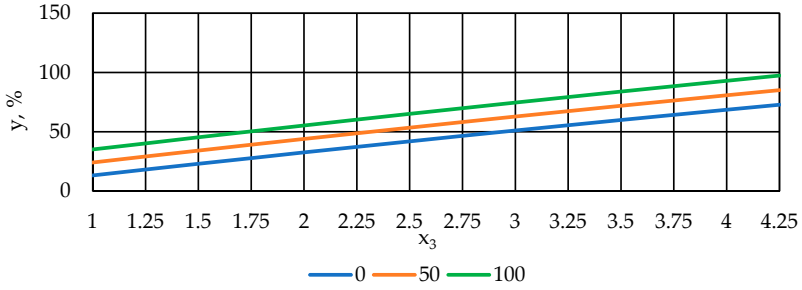



**Figure 2.** Variants in the relationship between the increase in ETR ($x_3$) and the growth in the use of RE sources ($y$) for three values of FDI ($x_1$)—0, 50, and 100%—and the level of ANS ($x_2$)—10%.

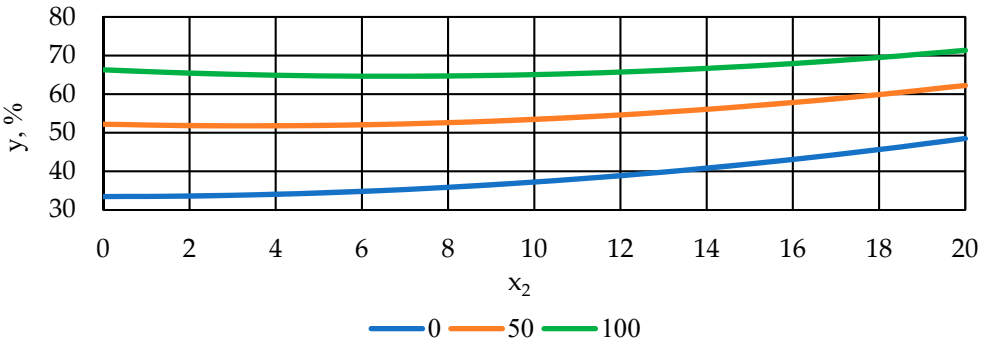



**Figure 3.** Variants in the relationship between the increase in the level of ANS ($x_2$) and the growth in the use of RE sources ($y$) for three values of FDI ($x_1$)—0, 50, 100%—and ETR ($x_3$)—2.5%.

Next, we considered the three surfaces we obtained, which describe the probable impact of FDI ($x_1$, %) and ETR ($x_3$, %) on the consumption of RE sources ($y$, %) at three values of ANS ($x_2$, %): low 0% (Figure 4a), medium 10% (Figure 4b), and high 20% (Figure 4c).

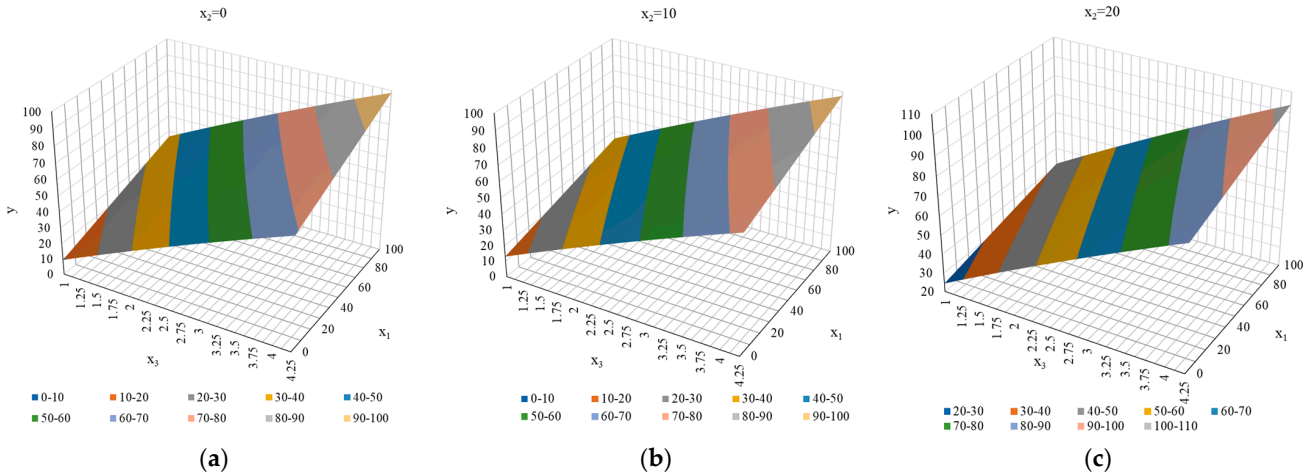



**Figure 4.** Probable influence of FDI ($x_1$, %) and ETR ($x_3$, %) on the consumption of RE sources ($y$, %). Low 0% (**a**), medium 10% (**b**), and high 20% (**c**).

According to our proposed model, an increase in the level of ANS allows for an increase in environmental tax revenues, which in turn will contribute to an increase in the level of consumption of the RE sources (Figure 5).

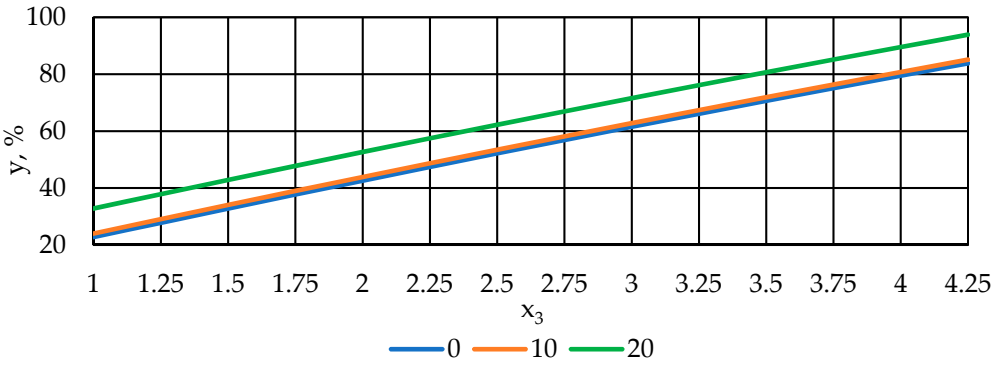



**Figure 5.** Variants in the relationship between the increase in ETR ($x_3$) and the growth in the use of RE sources ($y$) for three values of ANS ($x_2$)—0, 10, 20%—and FDI ($x_1$)—50%.

In addition, according to our proposed model, an increase in the level of ANS will contribute to a more complete realization of the potential of FDI for the development of RE

(Figure 6). Moreover, the abovementioned effects become more noticeable at the level of ANS of 10%.

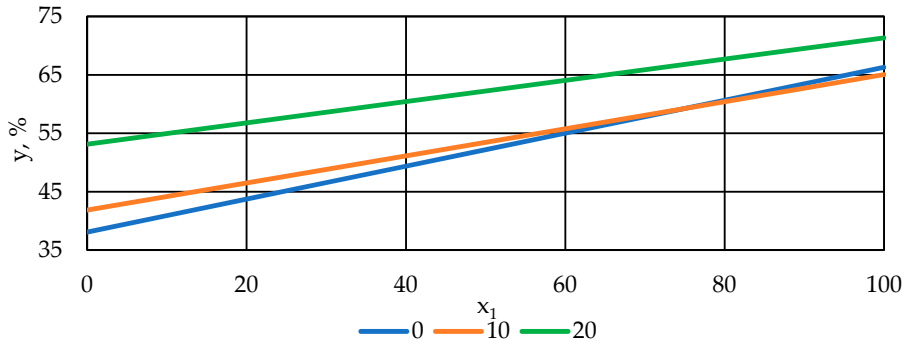
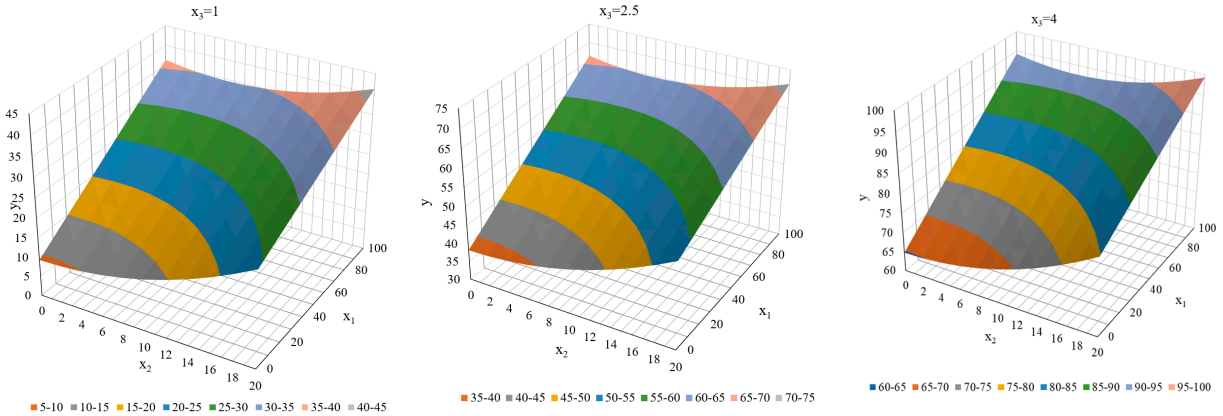



**Figure 6.** Variants in the relationship between the increase in FDI ($x_1$) and the growth in the use of RE sources ($y$) for three values of the level of ANS ($x_2$)—0, 10, 20%—and ETR ($x_3$)—2.5%.

Also, based on the analysis of Equation (2), we constructed surfaces that describe the likely impact of FDI ($x_1$, %) and ANS ($x_2$, %) for the consumption of RE sources ($y$, %) at three values of ETR ($x_3$, %): low 1% (Figure 7a), medium 2.5% (Figure 7b), and high 4% (Figure 7c).




(**a**) (**b**) (**c**)

**Figure 7.** Probable impact of FDI ($x_1$, %) and ANS ($x_2$, %) on consumption of RE sources ($y$, %). Low 1% (**a**), medium 2.5% (**b**), and high 4% (**c**).

Further analysis of the cross-sections of the obtained surfaces allows us to conclude that an increase in ETR will contribute to a growth in the consumption of RE sources, and such growth is typical for the entire range of positive values of ANS (Figure 8).

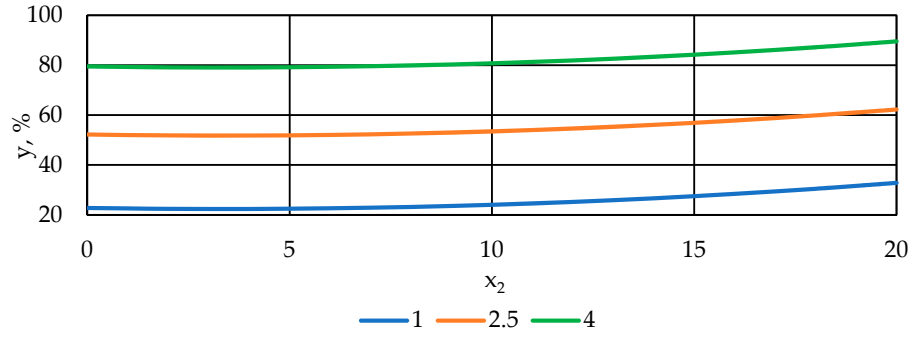



**Figure 8.** Variants in the relationship between the increase in the level of ANS ($x_2$) and the growth in the use of RE sources ($y$) for three values of ETR ($x_3$)—1, 2.5, 4%—and FDI ($x_1$)—50%.

In addition, an increase in ETR will also contribute to a more complete realization of the potential of FDI for the development of RE (Figure 9).

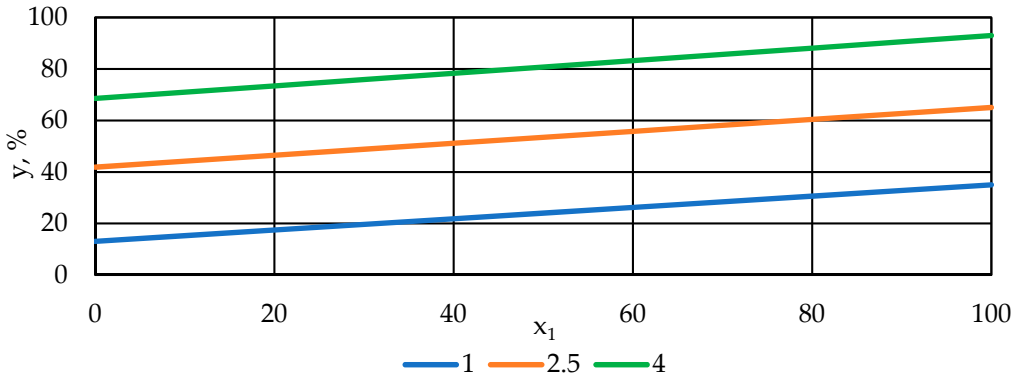



**Figure 9.** Variants in the relationship between the increase in FDI ($x_1$) and the growth in the use of RE sources ($y$) for three values of ETR ($x_3$)—1, 2.5, 4%—and the level of ANS ($x_2$)—10%.

Thus, as a result of the analysis of the regression equation obtained by us, it can be stated that an increase in ETR and the growth of FDI have a positive effect on the growth of the consumption of RE sources, and this effect is characteristically expressed when the value of ANS is more than 10%.

The empirical results we obtained are preliminary; they merely confirm the appropriateness of applying regression analysis to similar datasets. Therefore, to apply these empirical results to a specific country, it may be necessary to adjust these results, taking into account its political and economic situation.

## 5. Discussion

The conclusions made by us regarding the positive impact of any high-adjusted net-saving value on the level of use of RE sources are confirmed in the paper by [4]. In this scientific publication, the authors state that in the countries with high economic development, RE sources are used more efficiently than in the countries with a low level of economic development [12]. It is also indicated that a higher level of economic prosperity provides more funds for projects in the field of renewable energy, but also the consumption of RE sources stimulates economic growth due to the increased demand for new funds, which are necessary for investing in objects that practice renewable energy. And in the study by [14], it was found that an increase in the consumption of RE sources by 1% accelerates the economic growth of Germany by 0.22%, which correlates quite well with our research.

In a paper by [5], the authors confirm the statement that FDI and the demand for RE have a positive relationship. This conclusion corresponds to our statement that the growth of direct foreign investments has a positive effect on the growth of consumption of RE sources. The scientific publication by [36] also talks about the importance of FDI in terms of its impact on the development of renewable energy, in particular for the countries with a low level of economic development.

The scientific paper by [5] gives empirical results that show that financial development and FDI have a positive effect on the consumption of RE sources. However, this is a somewhat idealized case, because in order to have a stable positive impact from the investments on the development of the renewable energy, one more important condition is necessary, namely, an appropriate state energy policy, as stated in the paper by [28].

Our conclusion regarding the fact that with significant FDI (about 100% and above), the effect of the level of ANS does not have a very obvious effect on the growth of the level of use of RE sources, is partially confirmed by the authors of the paper [10]. In the abovementioned publication, it is said that under some conditions, economic growth and an increase in investment do not always lead to an increase in the use of RE sources, which

is typical, in particular, for economically developed countries such as Germany, Italy, Great Britain, and the USA.

In the study by [43], it is said that with an increase in ETR by 1%, the share of consumption of RE sources will increase by 0,021%. This study was conducted for 15 typical countries along the Belt and Road (Bulgaria, China, Czech Republic, Hungary, India, Latvia, Lithuania, Malaysia, Philippines, Poland, Romania, Singapore, Slovak Republic, and Slovenia). Our research shows that a 1% increase in ETR can lead to a more significant increase in the use of RE sources. However, this statement requires further thorough research on the impact of the amount of the ETR on the use of RE sources.

Research [40] substantiates the bidirectional relationship between innovation and economic growth, receipt and growth of foreign direct investments, and consumption of RE sources and economic growth.

Our regression analysis of the dataset allowed us to construct a second-order regression equation, which quite accurately describes the influence of factors such as foreign direct investments, adjusted net savings, and environmental tax revenues on the use or consumption of renewable energy sources in the countries of the European Union.

## 6. Conclusions

To assess the influence of foreign direct investments, adjusted net savings, and environmental tax revenues on the level of consumption of renewable energy sources, we proposed a non-linear model of the interaction of parameters, which is expressed by using a second-order regression equation.

According to the model presented by us, the growth of the adjusted net savings indicator with a simultaneous increase in environmental tax revenues has a positive effect on the level of use of renewable energy sources. Moreover, the relationship between the increase in environmental tax revenues and the growth in the use of renewable energy sources is actually linear. In addition, with significant foreign direct investment (about 100% and more), the level of adjusted net savings does not have a very obvious effect on the growth of the level of use of renewable energy sources.

We have also established that, with an increase in the level of adjusted net savings, in order to increase the level of consumption of renewable energy sources, it is necessary to increase environmental tax revenues. An increase in environmental tax revenues will contribute to the growth of the consumption of renewable energy sources, and such growth is characteristic of the entire range of positive values of adjusted net savings. An increase in the level of adjusted net savings contributes to a more complete realization of the potential of foreign direct investments in view of the development of renewable energy. Moreover, the abovementioned effects become more noticeable when the level of adjusted net savings is more than 10%.

It has been empirically established that a consistently high consumption of renewable energy sources (over 70%) is actually possible in the countries with a high level of adjusted net savings (over 10%) with active foreign direct investments and high environmental tax revenues (over 4%).

The found interdependences highlight the complex and complementary nature of these critical variables. We also note the complex nature of the indicators we are studying. In addition, it should be noted that we evaluated the abovementioned relationships with a step of 1–2 years, but we plan to conduct research on the nature of these relationships in a longer period of time with a step of 3.5 years and more.

**Author Contributions:** Conceptualization, V.K. and R.Č.; methodology, V.K., S.K. and S.S.; software, S.K. and T.H.; validation, D.J., T.H. and A.M.; formal analysis, E.B. and S.B.; investigation, S.K. and A.M.; resources, S.B. and N.L.; data curation, V.K. and R.Č.; writing—original draft preparation, V.K., R.Č. and E.B.; writing—review and editing, D.J.; visualization, S.K. and N.L.; project administration, T.H; funding acquisition, S.S.; supervision, V.K. and T.H. All authors have read and agreed to the published version of the manuscript.

**Funding:** This publication was partially founded from BioTrainValue (BIOmass Valorisation via Superheated Steam Torrefaction, Pyrolysis, Gasification Amplified by Multidisciplinary Researchers TRAINing for Multiple Energy and Products' Added VALUEs), with project number: 101086411, funded under Horizon Europe's Maria Skłodowska-Curie Staff Exchange program.

**Data Availability Statement:** All data generated or analyzed during this study are included in this published article.

**Acknowledgments:** Anonymous reviewers are gratefully acknowledged for their constructive review that significantly improved this manuscript, International Visegrad Fund (www.visegradfund.org), Capitol Award named after Ivan Vykhovskyi (www.studium.uw.edu.pl) and Ukrainian University in Europe (universityuue.com).

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

1. Davos 2024: 4 Things to Know. Available online: https://www.weforum.org/agenda/2024/01/davos-2024-highlights-ai-growth-climate-security/ (accessed on 11 February 2024).
2. Building Trust Through an Equitable and Inclusive Energy Transition. Available online: https://www.weforum.org/publications/building-trust-through-an-equitable-and-inclusive-energy-transition/ (accessed on 11 February 2024).
3. Simionescu, M.; Strielkowski, W.; Tvaronavičienė, M. Renewable Energy in Final Energy Consumption and Income in the EU-28 Countries. *Energies* **2020**, *13*, 2280. [CrossRef]
4. 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. [CrossRef]
5. Bekun, F.V.; Alola, A.A. Determinants of renewable energy consumption in agrarian Sub-Sahara African economies. *Energy Ecol. Environ.* **2022**, *7*, 227–235. [CrossRef]
6. Yue, S.H.; Lu, R.; Shen, Y.; Chen, H. How does financial development affect energy consumption? Evidence from 21 transitional countries. *Energy Policy* **2019**, *130*, 253–262. [CrossRef]
7. Das, N.; Bera, P.; Panda, D. Can economic development & environmental sustainability promote renewable energy consumption in India?? Findings from novel dynamic ARDL simulations approach. *Renew. Energy* **2022**, *189*, 221–230. [CrossRef]
8. Aslan, A.; Ocal, O. The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renew. Sustain. Energy Rev.* **2016**, *60*, 953–959. [CrossRef]
9. Chen, C.; Pinar, M.; Stengos, T. Renewable energy consumption and economic growth nexus: Evidence from a threshold model. *Energy Policy* **2020**, *139*, 111295. [CrossRef]
10. Chang, T.; Gupta, R.; Inglesi-Lotz, R.; Simo-Kengne, B.; Smithers, D.; Trembling, A. Renewable energy and growth: Evidence from heterogeneous panel of G7 countries using granger causality. *Renew. Sustain. Energy Rev.* **2015**, *52*, 1405–1412. [CrossRef]
11. Shahbaz, M.; Raghutla, C.; Chittedi, K.R.; Jiao, Z.; Vo, X.V. The effect of renewable energy consumption on economic growth: Evidence from the renewable energy country attractive index. *Energy* **2020**, *207*, 118162. [CrossRef]
12. Eren, B.M.; Taspinar, N.; Gokmenoglu, K.K. The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. *Sci. Total Environ.* **2019**, *663*, 189–197. [CrossRef]
13. Chang, C.; Fang, M. Renewable energy-led growth hypothesis: New insights from BRICS and N-11 economies. *Renew. Energy* **2022**, *188*, 788–800. [CrossRef]
14. Rafindadi, A.A.; Ozturk, I. Impacts of renewable energy consumption on the German economic growth: Evidence from combined cointegration test. *Renew. Sustain. Energy Rev.* **2017**, *75*, 1130–1141. [CrossRef]
15. Akan, T. Can renewable energy mitigate the impacts of inflation and policy interest on climate change? *Renew. Energy* **2023**, *214*, 255–289. [CrossRef]
16. Ali, A.; Audi, M.; Roussel, Y. Natural Resources Depletion, Renewable Energy Consumption and Environmental Degradation: A Comparative Analysis of Developed and Developing World. *MPRA* **2021**. Available online: https://mpra.ub.uni-muenchen.de/105277/ (accessed on 11 February 2024). [CrossRef]
17. Tiba, S.; Belaid, F. Modeling the Nexus Between Sustainable Development and Renewable Energy: The African Perspectives. *J. Econ. Surv.* **2021**, *35*, 307–329. [CrossRef]
18. Halkos, G.; Gkampoura, E.-C. Assessing Fossil Fuels and Renewables Impact on Energy Poverty Conditions in Europe. *Energies* **2023**, *16*, 560. [CrossRef]
19. De Rosa, M.; Gainsford, K.; Pallonetto, F.; Finn, D.P. Diversification, concentration and renewability of the energy supply in the European Union. *Energy* **2022**, *253*, 124097. [CrossRef]
20. Kukharets, V.; Hutsol, T.; Kukharets, S.; Glowacki, S.; Nurek, T.; Sorokin, D. European Green Deal: The Impact of the Level of Renewable Energy Source and Gross Domestic Product per Capita on Energy Import Dependency. *Sustainability* **2023**, *15*, 11817. [CrossRef]
21. Over 50 Heads of State and Government Attended Davos 2024. Here's What They Had to Say. Available online: https://www.weforum.org/agenda/2024/01/heads-of-state-davos-2024-wef-politics/ (accessed on 17 February 2024).

22. Kukharets, V.; Juočiūnienė, D.; Hutsol, T.; Sukmaniuk, O.; Čėsna, J.; Kukharets, S.; Piersa, P.; Szufa, S.; Horetska, I.; Shevtsova, A. An Algorithm for Managerial Actions on the Rational Use of Renewable Sources of Energy: Determination of the Energy Potential of Biomass in Lithuania. *Energies* **2023**, *16*, 548. [CrossRef]
23. Kukharets, S.; Hutsol, T.; Glowacki, S.; Sukmaniuk, O.; Rozkosz, A.; Tkach, O. Concept of Biohydrogen Production by Agricultural Enterprises. *Agric. Eng.* **2021**, *25*, 63–72. [CrossRef]
24. Directive 2009/28/EC of the European Parliament and of the Council. Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:en:PDF (accessed on 11 June 2024).
25. European Energy Security Strategy. Available online: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52014DC0330&qid=1407855611566 (accessed on 5 June 2024).
26. Directive (EU) 2018/2001 of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32018L2001 (accessed on 5 June 2024).
27. Renewables. Available online: https://www.iea.org/reports/renewable-electricity (accessed on 15 June 2024).
28. Aguirre, M.; Ibikunle, G. Determinants of renewable energy growth: A global sample analysis. *Energy Policy* **2014**, *69*, 374–384. [CrossRef]
29. Papież, M.; Śmiech, S.; Frodyma, K. Determinants of renewable energy development in the EU countries. A 20-year perspective. *Renew. Sustain. Energy Rev.* **2018**, *91*, 918–934. [CrossRef]
30. Lin, B.; Omoju, O.E.; Okonkwo, J.U. Factors influencing renewable electricity consumption in China. *Renew. Sustain. Energy Rev.* **2016**, *55*, 687–696. [CrossRef]
31. Omri, A.; Nguyen, D.K. On the determinants of renewable energy consumption: International evidence. *Energy* **2014**, *72*, 554–560. [CrossRef]
32. Here Are 3 Ways to Speed Up Europes Energy Transition. Available online: https://www.weforum.org/agenda/2023/12/here-are-3-ways-to-speed-up-europes-energy-transition/ (accessed on 1 February 2024).
33. 5 Ways to Fast-Track the Energy Transition in 2024. Available online: https://www.weforum.org/agenda/2024/01/5-ways-fast-track-energy-transition/ (accessed on 10 February 2024).
34. Simionescu, M.; Radulescu, M.; Cifuentes-Faura, J.; Balsalobre-Lorente, D. The role of renewable energy policies in tackling energy poverty in the European Union. *Energy Policy* **2023**, *183*, 113826. [CrossRef]
35. Shahbaz, M.; Sinha, A.; Raghutla, C.; Vo, X.V. Decomposing scale and technique effects of financial development and foreign direct investment on renewable energy consumption. *Energy* **2022**, *238*, 121758. [CrossRef]
36. Nawaz, A.; Rahman, M.M. Renewable energy consumption in sub-saharan africa: The role of human capital, foreign direct investment, financial development, and institutional quality. *Energy Rep.* **2023**, *10*, 3383–3393. [CrossRef]
37. Qamruzzaman, M.; Karim, S. Does public-private investment augment renewable energy consumption in BIMSTEC nations? Evidence from symmetric and asymmetric assessment. *Energy Strategy Rev.* **2023**, *49*, 101169. [CrossRef]
38. Qamruzzaman, M. Nexus between FDI and Globalization-Led Energy Diversification in BRICS: Fresh Evidence from a Newly Constructed Energy Diversification Index. *Energy Strategy Rev.* **2022**, *44*, 100997. [CrossRef]
39. Zhang, Y.; Qamruzzaman, M.; Karim, S.; Jahan, I. Nexus between Economic Policy Uncertainty and Renewable Energy Consumption in BRIC Nations: The Mediating Role of Foreign Direct Investment and Financial Development. *Energies* **2021**, *14*, 4687. [CrossRef]
40. Hoa, P.X.; Xuan, V.N.; Thu, N.T.P.; Huong, L.M. Nexus of innovation, foreign direct investment, economic growth and renewable energy: New insights from 60 countries. *Energy Rep.* **2024**, *11*, 1834–1845. [CrossRef]
41. Liu, W.; Shen, Y.; Razzaq, A. How renewable energy investment, environmental regulations, and financial development derive renewable energy transition: Evidence from G7 countries. *Renew. Energy* **2023**, *206*, 118897. [CrossRef]
42. Chu, L.K. Towards achieving energy transition goal: How do green financial policy, environmental tax, economic complexity, and globalization matter? *Renew. Energy* **2024**, *222*, 119933. [CrossRef]
43. Fang, G.; Yang, K.; Tian, L.; Ma, Y. Can environmental tax promote renewable energy consumption?—An empirical study from the typical countries along the Belt and Road. *Energy* **2022**, *260*, 125193. [CrossRef]
44. Doytch, N.; Narayan, S. Does FDI influence renewable energy consumption? An analysis of sectoral FDI impact on renewable and non-renewable industrial energy consumption. *Energy Econ.* **2016**, *54*, 291–301, ISSN 0140-9883. [CrossRef]
45. Foreign direct investment, World Development Indicators. Available online: https://datatopics.worldbank.org/world-development-indicators/themes/economy.html (accessed on 11 June 2024).
46. Adjusted Net Savings, Including Particulate Emission Damage (% of GNI), World Development Indicators. Available online: https://databank.worldbank.org/reports.aspx?source=2&series=NY.ADJ.SVNG.GN.ZS&country=WLD (accessed on 10 June 2024).
47. Environmental Tax Revenues. Available online: https://ec.europa.eu/eurostat/databrowser/view/env_ac_tax/default/table?lang=en&category=env.env_eta (accessed on 11 June 2024).
48. Share of Renewable Energy in Gross Final Energy Consumption. Available online: https://ec.europa.eu/eurostat/databrowser/view/sdg_07_40/default/table?lang=en (accessed on 11 June 2024).
49. Kissell, R.L. Nonlinear Regression Models. In *Algorithmic Trading Methods*; Fordham University: New York, NY, USA, 2021; pp. 197–219. [CrossRef]

50. Kong, Q.; Siauw, T.; Bayen, A.M. Least Squares Regression. In *Python Programming and Numerical Methods*; Academic Press: Cambridge, MA, USA, 2021; pp. 279–293. [CrossRef]
51. Romeo, G. Data Analysis for Business and Economics. In *Elements of Numerical Mathematical Economics with Excel*; Academic Press: Cambridge, MA, USA, 2020; pp. 695–761. [CrossRef]