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Green Jobs in the EU Renewable Energy Sector: Quantile Regression Approach

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Abstract: This article explores the ongoing green transition in the energy sector in EU countries. The greening process is brought about by the growth of the Renewable Energy Sources (RES) sector and Green Jobs (GJ). The goal of this paper is to find out how certain factors in the RES sector affect the creation of GJ. This study uses Quantile Regression for Panel Data (QRPD), a method that addresses fixed effects. Based on secondary data from Eurostat and EurObserv'ER reports, the model was made for the EU27 countries for the years 2013–2020. The impact of the adopted variables on GJ generation is heterogeneous. Significantly, the volume of turnover in the RES, across the entire studied cross-section, influences the increase in GJ number. It is also observed that, in the case of economy-wide R&D expenditure, a negative impact on GJ creation is observed. In contrast, interestingly, in the case of R&D expenditure in the business sector, a positive effect on GJ formation is noted. A possible direction for research into the topic of GJ in the RES should be qualitative research, which could provide additional information regarding, for example, the degree of the greening of such jobs.

Keywords: decent employment; green economy; Green Jobs; green transition; Quantile Regression for Panel Data; renewable energy sector

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1. Introduction

Nowadays, the process of the gradual greening of many economic sectors can be observed [1,2]. There are even areas surprisingly impacted by this process [3,4]. Greening involves the implementation of various types of pro-environmental solutions in business processes [5,6]. These practical solutions are expected to contribute to economy decarbonization [7,8] while maintaining continued business growth [9,10] with lower environmental impact [11,12]. The core of the greening process [13,14] is the implementation of current Sustainable Development Goals (SDGs) into business practice [10,15,16]. As a result, there is a green economic transition [8,17,18], sustainable transition [14,19], or transition to a low carbon [20,21], green economy [22,23], or circular economy development [24,25]. These topics are increasingly being addressed in published studies and research [8,26]. Regardless of the indicated area context [27,28], these analyses are performed on the business or country levels, and they often refer to the issue of green transition of the energy sector [29,30] or, simply, clean energy transition [31,32]. Researchers' interest in the energy sector [33,34] stems from its impact on the environment [33,35] and its strategic role in the functioning of each country's economy [36,37]. The development of other sectors of the economy [38,39] depends on the proper functioning of the energy sector [40,41]. Thus, it can be pointed out that, without the decarbonization of the energy sector [42,43], it is impossible to talk about a green economy [44,45]. The energy sector is the backbone of each country's economy, and its transition can be analyzed only on this level [46,47].

The process of decarbonizing the energy sector is complex [38,48]. The transition should be carried out in such a way that it does not contribute to the imbalance of the electricity supply [49,50]. Such imbalance can cause numerous negative consequences [51] not only for households [52,53] but also for business organizations [54,55]. This process requires the commitment of financial outlays [19,56], the implementation of new advanced technologies, and the reduction in barriers to their diffusion and transfer [57,58], as well as time to make the necessary investments aimed at abandoning fossil fuels in the process of electricity generation [59,60]. Some researchers also point out that the energy transition requires broad public acceptance [61,62]. The result of the transformation taking place in the energy sector is a gradual transition to energy derived from renewable sources or nuclear energy [41,63]. From the point of view of the green transition issue, some researchers point out that nuclear energy does not meet the criteria aimed at sustainable development [64,65]. Hence, the issues discussed further in this research refer only to the Renewable Energy Sources (RES) sector [38,66]. Thus, nuclear energy is recognized, in this study, as excluded from the RES sector [46,67].

The observable and widely discussed effect of the greening of the energy sector is, primarily, an increase in renewable energy production [52,68] and a decline in the share of non-renewable energy in gross final energy consumption [27,69]. However, another result of the ongoing green transformation of the energy sector is the Green Jobs (GJ) creation [45,70]. Although the GJ have been the object of scientific consideration for many years [12,71], they are still rather narrowly researched [72,73]. Therefore, the research motivation is to explore the GJ creation determinants and explain their significance, on the country level, among EU27 countries.

Typically, GJ are associated with the positive results of the ongoing green transformation of specific sectors of the economy [74,75]. In the case of the RES sector, there is a clear division between supporters and opponents of identifying GJ in it [5,76]. Due to the scope of the research undertaken in the article, the authors adopt the definition of GJ presented by the European Commission, which defines them as covering all jobs that depend on the environment or are created, substituted, or redefined (in terms of skill sets, work methods, profiles greened, etc.) in the transition process towards a greener economy [77,78]. Hence, the jobs created in the RES sector should be considered as GJ [5,79]. Such a research approach can be encountered in the studies of, among others, Polish researchers dealing with the issue of GJ: namely, Ł. Kozar [5,80], B. Kryk [81], and A. Sulich [82,83].

A fairly general discussion of the factors influencing the creation of GJ is discernible in the literature [24,84]. Hence, joining this discussion, the purpose of this paper the identification the impact of selected factors on the creation of GJ in the renewable energy sector [84,85]. This paper aims to present determinants of the GJ creation in the RES sector based on the variables related to EU27 countries in the years 2013–2020. The primary method assumed in this article is Quantile Regression for Panel Data (QRPD), a method that addresses fixed effects [38,86]. Due to the quality of the results obtained, this method is used, together, with literature review in research of the RES sector [87,88].

Following the logic adopted by the authors for the presentation of the undertaken problem of GJ in the RES sector in the European Union, this article consists of four interrelated sections. After a brief introduction to the considerations undertaken and presented in the introduction section, the reasons for taking up the topic of the article, and explaining the purpose of the work, there is a second chapter. In the second section, called material and methods, there is a detailed description of the research QRPD method. The second part also provides a cross-sectional analysis of the data that was used during the study. The results of the study are presented in the third part. The article concludes with a discussion of the results along with recommendations and directions for future research. The conclusions present theoretical and managerial implications of the presented results. There are also limitations of this study presented, together, with new promising research avenues.

2. Materials and Methods

This section is divided into two subsections. The first is dedicated to the Quantile Regression for Panel Data (QRPD) method [88,89], explained in detail with formulas. The second subsection describes the data source [90] and the meaning of the performed study [87,91]. In this part, the variables' choice and description were presented. Additionally, there is a simplified statistical analysis of the data significance presented in tables and figures [92,93].

2.1. Quantile Regression for Panel Data

This study uses Quantile Regression for Panel Data (QRPD), a method that addresses fixed effects [68,94]. This method was chosen due to a deep understanding of relationships between variables, beyond the mean of the data. This method's advantage is based on the analysis procedure, which explains the data that have non-normal distribution or that have non-linear relationships with predictor variables. However, traditional panel regression techniques, such as ordinary least squares, focus on the effects of the mean, which can lead to under or overestimation of the relevant coefficient or even failure to detect significant relationships. "Therefore, classical ordinary least squares estimates will be biased and non-robust, and quantile regression can be used to overcome this problem" [95]. In addition to this, panel data regression is a powerful way of controlling for unobserved independent variables' impact on the dependent variable [96,97], which overcomes the biased estimators in traditional linear regression models.

Quantile regression is robust to outliers and heavy distributions [98,99]. In addition, this method takes into account distributional heterogeneity [100,101] to provide a detailed description of the relationships between the variables under study [98,102]. The main problem [70,103] with this form of the fixed-effects model is that the inclusion of a large number of fixed effects (α_i) is subject to an incident parameter problem [104,105]. The estimator will be inconsistent when the number of objects described by the data set reaches infinity [100,106], but the number of observations for each cross-sectional unit is constant [89,107]. These methods are based on the assumption that expectations are linear operators, which is not the case with conditional quantiles [89,108]. A solution was proposed by R. Koenker [107,109], who treats the unobservable fixed effects as parameters to be estimated together with the co-variate effects for different quantiles [107].

This paper uses a panel quantile regression model that takes into account unobserved individual heterogeneity [99,108,110]. Based on different quantile points, a more complete description of the underlying conditional distributions is possible [99,102]. Regression estimation on quantiles is semiparametric [101,105], which means that no assumptions are made about the type of random distribution of the vector of residuals in the model [111,112]. We considered the following model for the conditional quantile y_i of given x_i, which is as follows [98]:

$$Q_{y_{it}}(\tau|,\ x_i) = \alpha_i + x_i^T\beta(\tau)\ i = 1,\ \ldots,\ \mathrm{N}, \tag{1}$$

where:

i—is the index of individuals,
N—is the number of observations on the individual,
t—is the index of time,
T—is the ratio of the number of observations per country,
α—have a pure location shift effect on the conditional quantiles of the response,
x_{ij}—are permitted to depend upon the quantile of intere, but the α's do not [107].

To estimate the model (1) for several quantiles simultaneously, we use:

$$\min_{(\alpha,\beta)} \sum\nolimits_{k=1}^{q} \sum\nolimits_{j=1}^{n} \sum\nolimits_{i=1}^{m_i} w_k \rho_{\tau_k}\left(y_{it} - \alpha_i - x_{it}^T\beta(\tau_k)\right)\ i = 1,\ \ldots,\ \mathrm{N};\ t = 1,\ \ldots,\ \mathrm{T} \tag{2}$$

where:

i—is the index of individuals,
N—is the number of observations on the individual,
t—is the index of time,
T—is the ratio of the number of observations per country.

In Formula (2), the parameter α_i has a pure location shift effect on the conditional quantiles of the response [113]. The effects of the covariates x_{it} are permitted to depend upon the quantile t of interest [98].

Following R. Koenker [107,109], the sample mean as the solution to the problem of minimizing a sum of squared residuals was defined. The median, as the solution to the problem of minimizing a sum of absolute residuals, was also defined. The symmetry of the piecewise linear absolute value function implies that the minimization of the sum of absolute residuals must equate to the number of positive and negative residuals, thus assuring that there is the same number of observations above and below the median [109].

Unobservable fixed effects are treated as parameters to be jointly estimated with the covariate effects for different quantiles. A unique characteristic of this method is the introduction of a penalty term in the minimization to address the computational problem of specifically estimating a mass of parameters. Accordingly, parameter estimates are calculated as follows [102,107]:

$$\min_{(\alpha,\beta)} \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{i=1}^{N} w_k \rho_{\tau_k} \left(y_{it} - \alpha_i - x_{it}^T \beta(\tau_k) \right) + \lambda \sum_{i}^{N} |\alpha_i| \; i = 1, \ldots, \mathrm{N}, \; t = 1, \ldots, \mathrm{T}, \tag{3}$$

where:

i—is the index of individual countries,
T—is the ratio of the number of observations per country
K—is the index of quantiles,
x—is the matrix of explanatory variables,
ρ_{τ_k}—is the quantile loss function,
w_k—is the relative weight given to the kth quantile, which controls for the contribution of the kth quantile on the estimation of the fixed effect.

In addition, as with Lamarche [100] and Alexander et al. [101], equally weighted quantiles were used $w_k = 1/K$, and λ is a tuning parameter that improves the efficiency of β estimation by reducing individual effects to zero and takes the value 1 [114].

The model QRPD equation is as follows:

$$\begin{gathered}\mathrm{Log}(Q_{GJ})\ (\tau|\alpha_i,\ x_{it},\ \xi_t) = \alpha_i + \beta_{1\tau}\log(turnover_{it}) + \beta_{2\tau} shares_{\ it} + \beta_{3\tau} hr + \beta_{4\tau} rd\_total + \beta_{5\tau}\mathrm{rd\_bus} + \\ \beta_{6\tau} eas\_p + \beta_{7\tau} tax_{\ it} + \xi_t\end{gathered} \tag{4}$$

where:

i—is the indicator for countries,
t—is the index of time,
α_i—is the fixed effects,
$\log(Q_{GJ})$—is an indicator of the number of people employed in the RES sector,
β—is the estimated vector of coefficients for the given variable,
ξ_t¯is the vector of model residuum at the measurement points,
turnover—the volume of turnover in the RES sector,
shares—share of renewable energy in gross final energy consumption,
hr—share of human resources in science and technology,
rd_total—spending on Research and Development (R&D) in the economy
rd_bus—R&D spending in the business sector,
eas_p—employment and labor force participation in the economy,
tax—environmental tax.

The R Cran package (version 4.1.0) was used to perform the relevant calculations. The necessary step was to install and use the *rqpd-package*. The rqpd package provides quantile regression estimation routines and bootstrap inference for panel (longitudinal) data [115]. The estimation method we used was the penalized fixed-effects model [107].

Using this method, based on panel data with fixed effects, it is possible to demonstrate the determinants affecting GJ across the conditional distribution [24,68]. The use of panel samples for the construction of the econometric model makes it possible to take into account the diversity of the studied units and to observe changes over time in individual sites while aggregating the data [84].

2.2. Data Sources and Data Description

The dataset covers a panel of 27 EU countries over the period 2013–2020 and includes data on the variables indicated in Table 1. The choice of the period was dictated by the availability of data and the date of accession of individual EU member states. The idea was to include as many EU member states as possible in the study [9,116]. The authors decided to exclude the United Kingdom from the study due to the lack of data on employment and *turnover* in the RES sector for the last 3 years, as well as the fact of the UK's withdrawal from EU structures. Table 1 presents the variables and their definitions used in this study along with their sources of the data.

Table 1. Variable definitions and sources.

Variable	Definition	Source
GJ	Number of people employed in the RES sector	EurObserv'ER
turnover	The volume of turnover in the RES sector (in million euros)	EurObserv'ER
shares	Share of renewable energy in gross final energy consumption (in %)	Eurostat
hr	Share of human resources in science and technology (in %)	Eurostat
rd_total	Spending on research and development in the economy (R&D) (as % of GDP)	Eurostat
rd_bus	R&D spending in the business sector (as % of GDP)	Eurostat
eas_p	Employment and labor force participation in the economy (as % of the population)	Eurostat
tax	Environmental tax (as % of tax revenue)	Eurostat

Source: Authors' elaboration based on Eurostat and EurObserv'ER.

The data used in the study is characterized by an annual frequency. They were obtained on 29 March 2022 from the resources of Eurostat and annual reports presented by EurObserv'ER, which are related to the RES sector [117]. Statistical descriptions of all variables in the model are presented in Table 2.

Table 2. Summary of descriptive statistics.

Variable	Min	1st Quartile (Q1)	Median (Q2)	Mean	3rd Quartile (Q3)	Max
GJ	100.00	7275.00	22,675.00	44,754.00	43,250.00	363,100.00
turnover	20.00	677.50	1750.00	5170.56	5926.25	39,180.00
shares	3.49	12.82	17.28	20.75	28.10	55.79
hr	25.10	38.18	46.90	45.91	52.80	65.00
rd_total	0.38	0.90	1.32	1.63	2.23	3.53
rd_bus	0.09	0.44	0.79	1.01	1.53	2.55
eas_p	62.30	74.28	78.70	77.60	80.70	86.80
tax	3.62	5.78	7.39	7.34	8.67	11.75

Source: Authors' elaboration based on EurObserv'ER and Eurostat.

A panel quantile regression model was built to examine the impact of selected variables on GJ creation in the RES sector. The following variables from Eurostat and EurObserv'ER (French: L'Observatoire des Énergies Renouvelables) were included in the study: the volume of *turnover* in the RES sector [117], the share of renewable energy in gross final energy consumption [118], the share of human resources in science and technology [119], R&D expenditures in the economy [120], R&D expenditures in the business sector [120], the share of employed and economically active in the economy [121], and the share of environmental tax in tax revenues [122]. The variable describing *turnover* in the RES sector refers to the liquidity of companies [123] and translates into investment and can translate into an increase in green employment in the sector [124]. The RES share of energy consumption, on the other hand, shows the development of the RES sector compared to the energy sector as a whole [37,125]. The variable share of human resources in science and technology shows access to workers with the right skills. The R&D expenditure variable shows the development of a country [126], which is used in the adopted method for further comparisons between EU countries [116]. On the other hand, the variable R&D expenditure in the business sector was used because there is no data for a variable describing only that in the RES sector or the energy sector in general [127,128]. The variable share of the employed and economically active population was used. The economically active population (labor force) is defined as the sum of the employed and the unemployed [129]. The last variable, on the other hand, reflects the share of environmental taxes [130,131].

These variables are cited by researchers in analyses focused on the issue of GJ creation [84,132] in various sectors of the economy [5,44,85,133]. In the publication using the simple linear regression [24] or Hellwig's taxonomic method [82,134] variables are divided into stimulants, which positively influence the measured phenomenon, and contrary to them are destimulants [135,136]. In this study, all variables have an impact on the GJ creation [137]. The adopted variables in this study (described above and listed in Table 1) are also indicated as statistically important for the economy greening process measured by the GJ number changes [138,139].

In Table 2, there are three quartiles presented, and the 2nd quartile is also the median value for the researched variables. During the study period, the average employment in the RES sector in the cross-section of the studied EU countries was 22,675 people, which the study identifies with GJ. This is an artificial number, showing only the average number of GJ in RES in the years 2013–2020, and can be different for a specific year and countries collected in quantiles.

Before starting the proper analysis, it is worth checking the differentiation of the independent variable, the GJ, because it is not constant over time [94]. To capture the status and dynamics of change for the analyzed variables, a cross-sectional analysis of the data was performed (Appendix A, Tables A1–A4).

The largest number of GJ in the RES sector (considering 2013 and 2020) was characterized by the economies of Germany and France (Table A1). Cyprus, Malta, and Luxembourg, on the other hand, have the lowest number. When comparing the data from the end of 2020 to 2013, the highest growth in the number of GJ in the RES sector was observed in the Netherlands, Poland, Portugal, and Spain.

In 2013, the average number of GJ in the RES sector by a cross-section of countries surveyed was 38,756 (Figure 1). Results above this average were recorded in Austria, France, Germany, Italy, Spain, and Sweden. In 2020, the average number of GJ was 48,641 (Figure 2). The situation has changed compared to that in 2013. Results above the average were again recorded in France, Germany, Italy, Spain, and Sweden but, interestingly, also in the Netherlands, Poland, and Portugal.

Considering the volume of turnover in the RES sector (Table A2), the highest values for 2013 and 2020 are recorded in Germany and France, and the lowest are in Luxembourg, Malta, and Cyprus. In 2020, compared to 2013, turnover in the RES sector increased the most in Malta, Slovenia, and Hungary. On the other hand, referring to the share of renewable energy in gross final energy consumption (Table A2), the leading places, both in 2013 and in 2020, are occupied by Sweden, Latvia, Finland, and Austria. The lowest values of the studied variable can be observed, again, in the case of Luxembourg, Malta, or Cyprus—however, it is in the case of these countries that the highest dynamics of change in the studied variable in 2013–2020 is recorded.

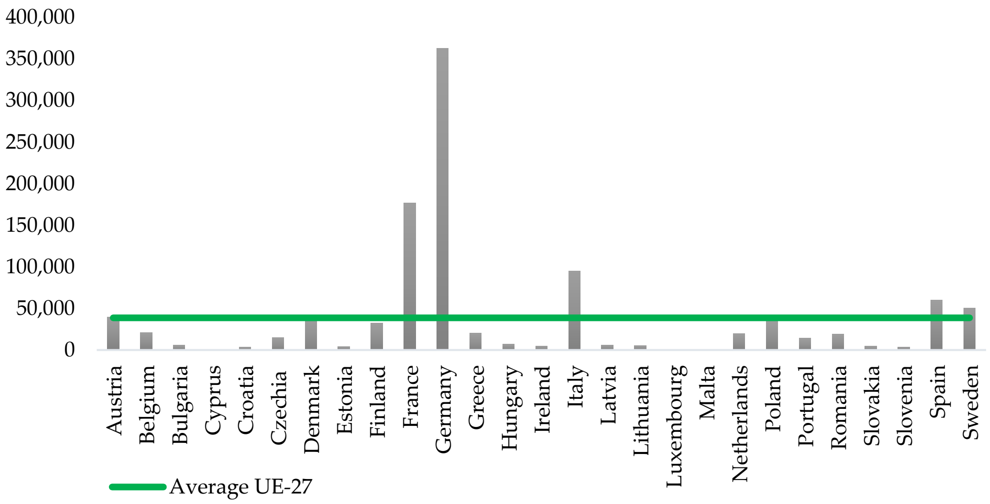

Figure 1. GJ in the RES sector (number of people employed) in EU countries in 2013. Source: Authors' elaboration based on EurObserv'ER data.

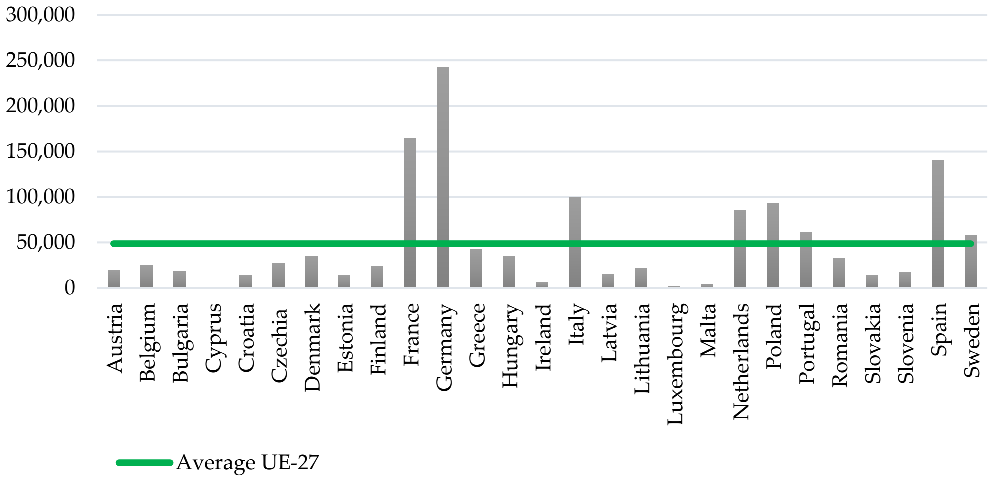

Figure 2. GJ in the RES sector (number of people employed) in EU countries in 2020. Source: Authors' elaboration based on EurObserv'ER data.

In the case of the variable depicting the share of human resources in science and technology, the highest scores were recorded in Luxembourg, Finland, Sweden, Holland, and Denmark, both for 2013 and 2020 (Table A3). On the other hand, the situation is worst for Romania and Slovakia, which also recorded the lowest measures in terms of R&D expenditures (in terms of the entire economy, as well as the business sector). In the case of the variable showing R&D spending in the economy (Table A3), as well as in the business sector, the highest values were recorded in Sweden, Belgium, Austria, Germany, Finland, and Denmark (considering both the situation in 2013 and 2020). In 2020, compared to 2013, R&D spending in the economy increased the most in Greece (nearly double), Cyprus, and Poland (Figure 2). In the case of R&D spending in the business sector, the highest growth was recorded in Cyprus (more than four times), Greece, Romania, and Poland (more than double).

For the variable showing total labor force participation in the population of the surveyed EU-27 countries, the best situations in both 2013 and 2020 are in Sweden, Estonia, and the Netherlands (Table A4). The share of employment and labor force participation in 2020 was lowest in Italy and Romania (below 70%). The largest increase in 2020, compared to 2013, was in Malta, Hungary, and Romania (however, this increase did not ensure that the 70% level was exceeded). Referring to the share of environmental tax in tax revenues (Table A4), the highest is recorded in Bulgaria, Greece, and Latvia (above 9%). The lowest, on the other hand, is found in Luxembourg, Germany, Spain, Sweden, and France (below 5%).

3. Results

There are factors that can influence the formation of GJ represented in numbers in the RES sector employment [34,140]. In line with the existing literature, the variables included in the model are described in detail in Section 2.2 in Table 1. In this method, we use all variables, as opposed to linear regression methods, which often rely on the number of variables reduction. The quantile regression results, based on Equation 4, are shown in Table 3. The estimated coefficients in each quantile are given in the columns labeled quantiles τ for 0.1, 0.25, 0.5, 0.75, 0.9, and 0.99 percentile of the conditional distribution, respectively.

Table 3. Quantile Regression for Panel Data results.

τ / Variable	Quantile Regressions					
	0.1	**0.25**	**0.5**	**0.75**	**0.9**	**0.99**
(Intercept)	−1.52992	−1.22001	−0.55197	2.04316 *	3.19674 **	2.55766 *
log (*turnover*)	0.95845 **	0.975 **	0.99682 **	0.98545 **	0.94993 **	1.00082 **
shares	−0.00242	−0.00381	0.00253	0.00936	0.01068 **	0.00372
hr	−0.01856 **	−0.02342 **	−0.01986 **	−0.01958 **	−0.00797	0.00046
rd_total	−1.48294 **	−1.54765 **	−1.48484 **	−1.4939 **	−1.35431 **	−1.44058 **
rd_bus	1.60837 **	1.68335 **	1.45966 **	1.51513 **	1.27786 **	1.42577 **
eas_p	0.07359 **	0.07268 **	0.06057 **	0.02923 **	0.01519	0.01279
tax	−0.02388	−0.01673	0.00204	−0.00247	−0.0316	0.01387

Statistical significance: ** 0.05, * 0.1. Source: Authors' elaboration based on Eurostat and EurObserv'ER.

Quantiles are the values of the characteristic of the studied EU countries, which divide the ordered statistical population into certain equal parts in terms of the number of statistical units. Starting from this, they were divided every 0.25, 0.5., and 0.75 based on the values of the mean and median (Table 2). A quantile of 0.1 was added to denote the first 10% (there are small values to see how they look and to verify if they are insignificant). However, there is no quantile 0.01, because these are values of little interest and insignificant. Instead, 0.99 has been added, denoting the top 1% of values to see how they behave from the top distribution. Presented in Table 3, the intercept is a constant value that allows for solving equation 4. Its value does not affect the analysis. The representation of its value is important for the consistency of the research, but it does not affect the interpretation of the results of the obtained research. The quantiles collect the countries in a division of the number of GJ. In Table 3, there are results of Quantile Regression for Panel Data analysis presented which identify the statistically significant variables influencing the GJ creation process.

Presented in Table 3 is the model, and its exact procedure is described in Section 2 of this article. The results of the model indicate how the independent variables describe the given phenomenon in each quantile. The quantile is the result of the cross-section analysis of EU countries. In the quantile of 0.75, some countries are significantly affected by positive factors—*turnover*, *shares*, *rd_bus*, and *eas_p*—as well as variables that affect negatively—*hr*, *rd_total*, and *tax*. As the quantiles increase, the amount of negatively influenced variables on GJ creation decreases.

A quantile of 0.1 means that only 10% of cases were analyzed, covering countries where the GJ number was lowest. A negative value indicates that the variable has a negative impact on the GJ creation. In this quantile, the two variables *shares* and *tax* are insignificant and do not affect the creation of GJ. There is no determination of statistical significance. In the same quantile, the variables *turnover*, *rd_bus*, and *eas_p* have a positive effect on the GJ creation in EU countries. On the other hand, the GJ number is negatively influenced by *rd_total* and *hr* variables. In all quantiles presented in Table 3, there is a variable related to the RES sector turnover, which positively influences the GJ formation throughout the cross-section of countries. Better energy sector prosperity influences the need for more workers and implies that the RES sector is also growing.

In contrast, the variable depicting R&D expenditures in the total economy (*rd_total*) across the cross-section of EU countries negatively affects the creation of the number of GJ among all presented in Table 3 quantiles. The variable depicting employment in new technologies (*hr*), except the 0.9 and 0.99 quintiles depicting countries with the highest GJ number, also had a negative impact on GJ creation.

The empirical results obtained from QRPD Formula 4 show that the impact of the adopted variables on the number of GJ is heterogeneous in analyzed quantiles (Table 3). Significantly, the amount of turnover in the RES sector across the studied cross-section affects the increase in the number of GJ (considering a statistical significance level of 0.05). Thus, it can be seen that, in each of the analyzed quantiles, the volume of turnover in the RES sector has a positive impact on GJ creation, which means that the development of the energy sector and the results recorded there contribute to increasing employment in the sector, which is in line with the authors' predictions.

It was also observed that, in the case of R&D expenditures, in terms of the entire economy (variable *rd_total*), a negative impact on the number of GJ is noted. This may indicate that higher research spending in the economy as a whole results in the improvement of certain processes (their greater efficiency), making it unprofitable to increase the number of jobs. On the other hand, interestingly, in the case of R&D expenditures in the business sector (variable *rd_bus*), their positive effect on the number of GJ is noted (Table 3). In this case, R&D spending in the private sector has a positive impact on the GJ formation. What this may prove, for the RES sector, is that the pursuit of development through increased expenditures and better prosperity in the sector also pays off by increasing the number of GJ. This analysis, therefore, provides interesting conclusions about the impact of increased R&D expenditures in the context of employment in the energy industry, which could spur further in-depth research.

In the lower quantiles—0.1, 0.25, 0.5, and 0.75—a positive effect of the number of employees in the whole economy (variable *eas_p*) and on the number of GJ in the RES sector can be observed. Considering the quantile of 0.9 and 0.99 and, respectively, 10% and out of 1% of the surveyed countries with the highest number of GJ in the cross-section of EU countries, the increase in employment in the economy has no statistically significant effect on the GJ formation in the RES sector. This can indicate that, once a certain amount of GJ is reached, this variable does not change under the influence of the other examined factors related to the green labor market.

In the case of the variable depicting employment—to be more exact, human resources in science and technology (variable *hr*)—the results indicate that increasing the share of employment in new technologies and science negatively affects the formation of GJ, except for the quantiles of 0.9 and 0.99. In contrast, for the two highest quantiles of the countries surveyed (where the number of GJ is the highest in the cross-section of EU countries), employment in science and new technologies has no statistically significant effect on GJ creation.

In the case of the variable depicting the share of renewable energy in final energy consumption (variable *shares*), it can be seen that it has a positive effect on the number of

GJ only in the 0.9th percentile (at a significance level of 0.05). For the other quantiles, there was no significant impact of this variable on the formation of GJ.

For each percentile, the variable depicting the share of environmental taxes in total tax revenues (variable *tax*) was found to be statistically insignificant, and it has no effect on the number of GJ in the RES sector in the countries studied. The insignificance of the parameter indicates the neutrality of the environmental tax regarding the development of the volume of employment in the RES sector.

4. Discussion

The results shown in Table 3 imply that, for most EU countries, an increase in the share of employees in new technologies (described by variable *hr*) results in a decrease in GJ. There is a direct and statistically significant relationship with a negative impact between these variables. There is a positive effect on GJ creation when an increase in the share of renewable energy in gross final energy consumption (*shares*) causes an increase in GJ, which may indicate an improvement in the efficiency of the sector. Such an observation is confirmed by the positive impact of the *turnover* variable, which stands for the volume of turnover in the RES sector. Its increase causes an increase in the number of GJ. This is also confirmed by *rd_total*, whose share decreases and affects GJ negatively, decreasing their number. Efficiency is in all sectors of the EU countries, as evidenced by increasing turnover and decreasing R&D expenditures in all sectors. This observed relationship between variables requires further research and explanation in terms of sector profitability. In the private sector, the situation is the opposite, and the variable (*rd_bus*) relation to R&D expenditures implies that employment increases with spending. It has been observed that, when *turnover* and R&D expenditures increase, this can also mean that private business in RES is doing better than the rest of the sectors, and perhaps, it has better know-how, management staff, or better investment of funds. This also requires more detailed qualitative research. The energy sector is not growing organically, so further research is needed in the RES area. The variable *eas_p* also confirms previous observations of growing GJ along with employment and labor activity in the economy. Therefore, the labor market is flexible and growing in this sector throughout the European Union.

In Table 4, these are listed countries in two columns, depending on the meeting or exceeding the threshold of the GJ number. This GJ border value (GJ_bv) is growing in each higher quantile in Table 4, and together with the increase in the quantile, the GJ_bvalso increases. The proportions between EU countries grouped in columns also changes with the quantiles. There are the best performers in the right column in each quantile. In the highest quantile, the best country is Germany (Table 4).

The area of the GJ creation is intertwined with the RES sector because of their deep association with sustainable development ideas. There are three dimensions of the GJ creation: economic, social, and environmental. The economic implication is the positive impact of the GJ, which contributes to economic development and reduces the unemployment rate. According to this research, the average number of people employed in GJ in the years 2013–2020, in EU27 countries was 22,675 in the RES sector (Table 4). Due to the growing expenditures in R&D in RES, new companies and new jobs are created, and this was proved in this study, as well as in similar studies dealing with subject GJ [68,84]. There is the interrelated social implication of the performed research. Growing attention paid to the GJ in the RES sector also influences the environmental awareness in society [141], so social pressure on the business organizations in the energy sector is growing [43]. These companies, then, are forced to change their technologies and get involved in environmental issues. The environmental implication of the GJ creation is also visible when their positive impact on the natural environment is achieved. This environmental implication lies in the nature and definition of the GJ [5,82].

Table 4. Results of quantile analysis for green jobs in EU countries in the years 2013–2020.

Quantile	GJ Border Value GJ_bv	Countries EU ≤GJ_bv	Countries EU >GJ_bv
0.1	2100.00	CY, LU, MT,	AT, BE, BG, CZ, DE, DK, EE, EL, ES, FI, FR, HR, HU, IE, IT, LT, LV, MT, NL, PL, PT, RO, SE, SI, SK
0.25	7225.00	BG, CY, EE, HR, HU, IE, LT, LU, LV, MT, SI, SK	AT, BE, BG, CZ, DE, DK, EL, ES, FI, FR, HR, HU, IT, LV, NL, PL, PT, RO, SE
0.5	22,675.00	AT, BE, BG, CY, CZ, EE, EL, HR, HU, IE, LT, LU, LV, MT, NL, PT, RO, SI, SK	AT, BE, BG, CZ, DE, DK, EL, ES, FI, FR, HR, HU, IT, LV, NL, PL, PT, RO, SE
0.75	43,250.00	AT, BE, BG, CY, CZ, DK, EE, EL, FI, HR, HU, IE, LT, LU, LV, MT, NL, PL, PT, RO, SE, SI, SK	DE, DK, ES, FR, IT, NL, PL, PT, RO, SE
0.9	140,500.00	AT, BE, BG, CY, CZ, DK, EE, EL, ES, FI FR, HR, HU, IE, IT, LT, LU, LV, MT, NL, PL, PT, RO, SE, SI, SK	DE, ES, FR, IT
0.99	343,133.00	AT, BE, BG, CY, CZ, DE, DK, EE, EL, ES FI, FR, HR, HU, IE, IT, LT, LU, LV, MT, NL, PL, PT, RO, SE, SI, SK	DE

Source: Authors' elaboration. The countries' names were abbreviated according to ISO 3166-1 code.

5. Conclusions

The main objective of this paper was to examine the impact of selected variables (presented in Section 2.2) on the creation of GJ in the RES sector among EU27 countries. To achieve the objectives, we used quantile regression for panel data (QRPD), a method that addresses fixed effects. The method, according to the researchers, allows for obtaining much more accurate results compared, for example, to the ordinary least squares regression method [102]. The secondary data from Eurostat and EurObsev'ER databases were used in the calculations of the GJ number. The analyzed period were the years 2013–2020. The novelty of this paper lies in the combination of data sources used in QRPD. The application of the method itself in GJs subject is also a significant novelty, as proven by the slender literature. In this research paper, tables were used to present variables (Table 1), the descriptive statistics of the employed data (Table 2), and to present the QRPD method results (Table 3). Table 4 complemented the obtained results with the direct indication of each EU country's position, which can then be related to each variable meaning (Table 2).

The empirical results of this study indicate that an increase in turnover in the RES sector contributes to an increase in employment in the sector, thus creating GJ. This observation is very important and is supported by statistical significance. This is because it indicates that, in the coming years, there will be a dynamic increase in the number of GJ in the RES sector. Such practical implication confirms the ongoing greening trend in multiple economies [142,143]. Obtained results are related to the current socio-economic situation in Europe and the need for faster diversification of energy sources across economies, including a faster-than-planned transition to Renewable Energy Sources [144]. The observed relationship between *turnover* in the renewable energy sector and the creation of GJ also indicates that specialists should be educated in this direction [83,145]. In addition, the result of the study relates to the findings of other researchers, who indicate, in their deliberations, that the development of the RES sector contributes to increasing the number of GJ in the European Union [24]. The development of the RES sector will continue to be dynamic due to the EU policy directions on zero-emission and building a green economy.

The theoretical contribution of this research paper lies in the explanation of the GJ creation process by the QRDP method. There are determinants, analyzed in this study as variables, which influence both the greening of the economy's sectors and GJ creation. The transition in the energy sector analyzed and presented the salient development determinants. Those variables explored in QRDP method can be translated into managerial practice.

The practical contribution of this study is the observations that an increase in R&D in the RES sector influences positively the number of GJ. The growth in R&D expenditures for the whole economy has a negative impact on the GJ creation process. Thus, such non-aimed sector action proved to be pointless (Table 3). Similar effects can be observed when environmental taxation is implemented. These contra-intuitive observations can interest researchers, scholars, and economic policymakers.

Based on the results, policy guidance was formulated for each country identified in the quantile analysis. These indications have an impact on the creation of green jobs. Countries that want to pursue employment development in the RES sector should choose to support entrepreneurship through favorable legislation and the development of public education. An interesting observation that is relevant to state policy-making is that environmental taxes do not contribute at all to the creation of green jobs in the RES sector and do not contribute to the development of the energy sector. To improve their position in the proposed ranking, states can cooperate in areas that negatively affect the number of green jobs and mitigate their impact.

The creation of green jobs in the RES sector brings EU member states closer to achieving the Sustainable Development Goals. Such a role of green jobs in the green transformation of the entire EU economy can be seen starting with the Europe 2020 strategy [5]. It should be noted that, in the currently implemented SDGs, the labor issue occupies a very important place [24,146]. Green jobs, as recognized by numerous researchers, can be identified with the issue of decent jobs [5,147,148]. The actions of countries grouped in the quartile of 0.75 and above contribute to the creation of environmental attitudes and behavior.

It should be noted that, in the study, the variable that determines the number of GJ in the RES sector is taken through the prism of employment in this sector [84]. This practice is found in the studies conducted to-date [5,68,82]. However, the authors of this article would like to point out that this is a general research approach, which, at the present moment of knowledge and availability of data on GJ, cannot be replaced by another measure, especially in econometric analyses. The GJ are a new scientific subject that warrants further investigation. The future direction of studies on the issue of GJ creation in the RES sector should be a research of a qualitative nature, which will make it possible to ascertain the actual degree of their greening. A possible future research avenue is to determine how much time a given employee actually spends in position on sustainability-oriented work activities [5].

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Appendix A

Table A1. GJ in the RES sector (number of people employed) and the volume of turnover in the RES sector (in million euros)—comparison of 2013 and 2020 in the EU-27 countries.

Specification/ Country	**GJ**			**Position in *C***	**Turnover**			**Position in *G***
	2013	**2020**	**Dynamics [%] *B*/*A* × 100**		**2013**	**2020**	**Dynamics [%] *F*/*G* × 100**	
	A	***B***	***C***	***D***	***E***	***F***	***G***	***H***
Austria	39,750	19,700	49.56	26	5785.00	3850.00	66.55	25
Belgium	21,250	25,000	117.65	20	2130.00	5510.00	258.69	5
Bulgaria	5900	17,900	303.39	9	825.00	890.00	107.88	22
Cyprus	600	1100	183.33	7	70.00	100.00	142.86	15
Croatia	3400	14,000	411.76	16	485.00	670.00	138.14	19
Czechia	14,700	27,500	187.07	15	1650.00	1820.00	110.30	21
Denmark	37,500	35,400	94.40	22	12,450.00	7350.00	59.04	26
Estonia	4400	14,200	322.73	7	545.00	1220.00	223.85	9
Finland	32,350	24,400	75.43	24	3365.00	5370.00	159.58	14
France	176,850	164,400	92.96	23	17,630.00	24,450.00	138.68	18
Germany	363,100	242,100	66.68	25	31,230.00	37,470.00	119.98	20
Greece	20,400	42,300	207.35	14	2185.00	3730.00	170.71	13
Hungary	7050	35,400	502.13	2	640.00	1860.00	290.63	3
Ireland	4700	6200	131.91	18	620.00	880.00	141.94	16
Italy	95,200	99,900	104.94	21	13,850.00	12,860.00	92.85	24
Latvia	6150	15,000	243.90	12	570.00	800.00	140.35	17
Lithuania	5250	22,000	419.05	6	535.00	950.00	177.57	12
Luxembourg	700	1800	257.14	11	120.00	270.00	225.00	8
Malta	100	3700	3700.00	1	20.00	310.00	1550.00	1
Netherlands	19,900	85,800	431.16	4	4840.00	13,050.00	269.63	4
Poland	34,850	92,600	265.71	10	5285.00	5160.00	97.63	23
Portugal	14,500	60,800	419.31	5	1660.00	3910.00	235.54	7
Romania	18,950	32,600	172.03	17	3480.00	1630.00	46.84	27
Slovakia	4450	13,900	312.36	8	600.00	1070.00	178.33	11
Slovenia	3800	17,500	460.53	3	390.00	1480.00	379.49	2
Spain	60,200	140,500	233.39	12	6265.00	15,930.00	254.27	6
Sweden	50,400	57,600	114.29	19	5605.00	10,370.00	185.01	10

Source: Authors compiled on the basis of data from EurObserv'ER [117].

Table A2. Share of renewable energy in gross final energy consumption (in %) and share of human resources in science and technology (in %)—comparison 2013 and 2020 in EU-27 countries.

Specification/ Country	Shares			Position in *C*	Hr			Position in *G*
	2013	2020	Dynamics [%] *B*/*A* × 100		2013	2020	Dynamics [%] *F*/*G* × 100	
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Austria	32.67	34.00	104.09	17	43	52.2	121.40	4
Belgium	7.67	13.00	169.47	5	49.6	56.6	114.11	15
Bulgaria	18.90	16.00	84.67	25	34	38	111.76	19
Cyprus	8.43	13.00	154.25	7	47.9	53	110.65	21
Croatia	28.04	20.00	71.33	27	34.5	40	115.94	9
Czechia	13.93	13.00	93.34	24	37.2	40.6	109.14	24
Denmark	27.17	30.00	110.40	14	53.8	59.3	110.22	22
Estonia	25.36	25.00	98.60	22	48.9	52.8	107.98	26
Finland	36.63	38.00	103.74	18	54.6	61.6	112.82	18
France	13.88	23.00	165.71	6	48.9	55.2	112.88	17
Germany	13.76	18.00	130.81	11	46.8	50.8	108.55	25
Greece	15.33	18.00	117.45	13	35.1	40.7	115.95	8
Hungary	16.21	13.00	80.22	26	36	39.9	110.83	20
Ireland	7.52	16.00	212.74	4	52.8	60.8	115.15	12
Italy	16.74	17.00	101.55	19	34.8	38	109.20	23
Latvia	37.04	40.00	108.00	15	41.2	47.7	115.78	10
Lithuania	22.69	23.00	101.37	20	45.6	52.4	114.91	13
Luxembourg	3.49	11.00	314.83	1	61.1	65	106.38	27
Malta	3.76	10.00	265.96	3	39	47.6	122.05	3
Netherlands	4.69	14.00	298.44	2	52.7	60.8	115.37	11
Poland	11.45	15.00	130.98	10	39	46.6	119.49	5
Portugal	25.70	31.00	120.62	12	30	40.9	136.33	1
Romania	23.89	24.00	100.48	21	25.1	28.4	113.15	16
Slovakia	10.13	14.00	138.16	8	32.5	39.7	122.15	2
Slovenia	23.16	25.00	107.94	16	43.5	50.6	116.32	6
Spain	15.08	20.00	132.62	9	41.2	47.8	116.02	7
Sweden	50.15	49.00	97.70	23	53.8	61.4	114.13	14

Source: Authors compiled on the basis of data from Eurostat [118,119].

Table A3. R&D expenditures in the economy (as % of GDP) and R&D expenditures in the business sector (as % of GDP)—comparison 2013 and 2020 in the EU-27.

Specification/ Country	Rd_total			Position in *C*	Rd_bus			Position in *G*
	2013	2020	Dynamics [%] *B*/*A* × 100		2013	2020	Dynamics [%] *F*/*G* × 100	
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Austria	2.95	3.20	108.47	16	2.09	2.22	106.22	22
Belgium	2.33	3.48	149.36	5	1.62	2.53	156.17	6
Bulgaria	0.63	0.85	134.92	6	0.39	0.58	148.72	8
Cyprus	0.49	0.82	167.35	2	0.09	0.37	411.11	1

Table A3. *Cont.*

Specification/ Country	Rd_total			Position in *C*	Rd_bus			Position in *G*
	2013	2020	Dynamics [%] *B*/*A* × 100		2013	2020	Dynamics [%] *F*/*G* × 100	
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Croatia	0.80	1.25	156.25	4	0.4	0.6	150.00	7
Czechia	1.88	1.99	105.85	19	1.02	1.21	118.63	15
Denmark	2.97	3.03	102.02	22	1.88	1.84	97.87	23
Estonia	1.72	1.79	104.07	21	0.82	0.98	119.51	14
Finland	3.27	2.94	89.91	25	2.25	1.97	87.56	25
France	2.24	2.35	104.91	20	1.44	1.56	108.33	21
Germany	2.84	3.14	110.56	14	1.91	2.11	110.47	19
Greece	0.81	1.50	185.19	1	0.27	0.69	255.56	2
Hungary	1.38	1.61	116.67	11	0.96	1.23	128.13	13
Ireland	1.57	1.23	78.34	27	1.13	0.91	80.53	26
Italy	1.30	1.53	117.69	10	0.71	0.93	130.99	10
Latvia	0.61	0.71	116.39	12	0.17	0.22	129.41	11
Lithuania	0.95	1.16	122.11	8	0.24	0.55	229.17	5
Luxembourg	1.23	1.13	91.87	23	0.65	0.61	93.85	24
Malta	0.74	0.67	90.54	24	0.38	0.43	113.16	18
Netherlands	2.16	2.29	106.02	18	1.41	1.54	109.22	20
Poland	0.88	1.39	157.95	3	0.38	0.88	231.58	4
Portugal	1.32	1.62	122.73	7	0.63	0.92	146.03	9
Romania	0.39	0.47	120.51	9	0.12	0.28	233.33	3
Slovakia	0.82	0.91	110.98	13	0.38	0.49	128.95	12
Slovenia	2.56	2.15	83.98	26	1.96	1.57	80.10	27
Spain	1.28	1.41	110.16	15	0.68	0.78	114.71	16
Sweden	3.26	3.53	108.28	17	2.25	2.55	113.33	17

Source: Authors compiled on the basis of data from Eurostat [120].

Table A4. Size of employment and labor force participation in the economy (in % of population) and share of environmental tax in % of tax revenue)—comparison 2013 and 2020 in the EU-27.

Specification/ Country	Eas_p			Position in *C*	Tax			Position in *G*
	2013	2020	Dynamics [%] *B*/*A* × 100		2013	2020	Dynamics [%] *F*/*G* × 100	
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Austria	78.90	79.50	100.76	23	5.58	5.00	89.61	15
Belgium	73.30	73.80	100.68	24	5.48	5.82	106.20	3
Bulgaria	72.90	77.40	106.17	6	10.15	9.89	97.44	6
Cyprus	79.80	81.10	101.63	19	8.56	7.15	83.53	20
Croatia	68.60	71.90	104.81	10	7.78	8.85	113.75	1
Czechia	77.80	81.80	105.14	9	5.99	5.35	89.32	16
Denmark	79.80	82.10	102.88	14	8.95	6.76	75.53	24
Estonia	81.10	84.90	104.69	11	8.09	7.20	89.00	17
Finland	78.50	81.30	103.57	13	6.71	6.52	97.17	7
France	77.30	78.10	101.03	22	4.45	4.78	107.42	2
Germany	80.20	81.20	101.25	21	5.36	4.27	79.66	23

Table A4. *Cont.*

Specification/ Country	Eas_p			Position in *C*	Tax			Position in *G*
	2013	2020	Dynamics [%] *B*/*A* × 100		2013	2020	Dynamics [%] *F*/*G* × 100	
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Greece	72.60	70.80	97.52	27	10.20	9.69	95.00	10
Hungary	72.20	80.70	111.77	2	6.32	6.01	95.09	9
Ireland	76.70	76.30	99.48	25	8.61	6.04	70.15	26
Italy	67.30	68.20	101.34	20	7.93	7.11	89.66	14
Latvia	78.90	83.80	106.21	5	10.81	9.82	90.84	13
Lithuania	79.30	84.00	105.93	7	6.23	6.26	100.48	5
Luxembourg	75.40	77.10	102.25	16	5.66	3.62	63.96	27
Malta	70.10	80.60	114.98	1	8.24	7.66	92.96	12
Netherlands	82.90	84.30	101.69	17	9.05	7.97	88.07	18
Poland	70.50	75.00	106.38	4	7.55	7.12	94.30	11
Portugal	76.40	79.70	104.32	12	6.49	6.76	104.16	4
Romania	62.30	69.10	110.91	3	7.52	7.30	97.07	8
Slovakia	77.60	79.80	102.84	15	8.16	6.81	83.46	21
Slovenia	74.30	78.70	105.92	8	10.45	7.84	75.02	25
Spain	78.80	77.50	98.35	26	5.80	4.74	81.72	22
Sweden	85.40	86.80	101.64	18	5.46	4.73	86.63	19

Source: Authors compiled on the basis of data from Eurostat [121,122].

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