

Article

# Does Social Businesses Development Affect Bioenergy Industry Growth under the Pathway of Sustainable Development?

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**Abstract:** The Treaty of European Union (EU) sets out the EU vision for sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment. This led us to ask whether or not social business development stimulates the development of the bioenergy sector in the EU28 countries. Given the increasing rates of energy insecurity, environmental pollution, poverty, and unemployment, countries are switching to alternative energy sources that might promote social business development, climate change, and environmental quality. In this scenario, the bioenergy industry has received the attention of scholars and policymakers alike. The role social business development can play in the growth of the bioenergy industry remains uncertain, therefore, further investigation is necessary. This study, therefore, explores the relationships between the bioenergy industry and social business development indicators related to zero emissions, zero poverty, and zero unemployment for EU28 region countries from 1990 to 2018. Empirical evidence is based on the use of a new economic model, dynamic panel co-integration simulations (Fully Modified Ordinary Least Square, Dynamic Ordinary Least Square, and Pooled Ordinary Least Square). The results reveal a negative relationship between EU28's bioenergy industry growth and carbon dioxide emissions, vulnerable employment, and unemployment rate, suggesting that bioenergy industry growth helps reduce pollution and unemployment. Likewise, bioenergy industry growth increases food supply, economic growth, and female employment and might be the best alternative to fossil fuels. Necessary policy related to bioenergy industry growth can be formulated, especially in achieving the sustainable development goals for social businesses.



**Citation:** Alsaleh, M.; Abdulwakil, M.M.; Abdul-Rahim, A.S. Does Social Businesses Development Affect Bioenergy Industry Growth under the Pathway of Sustainable Development? *Sustainability* **2021**, *13*, 1989. <https://doi.org/10.3390/su13041989>

Academic Editor:

Wadim Strielkowski

Received: 18 January 2021

Accepted: 31 January 2021

Published: 12 February 2021

**Keywords:** bioenergy growth; social business; sustainability; EU-28 region

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## 1. Introduction

### 1.1. Bioenergy Industry Background

The main objectives of Energy policy in the European Union (EU) are characterized as setting up a competitive, yet conducive environment for energy suppliers to improve the accessibility of energy at reasonable and competitive prices, and accomplishing sustainable energy consumption, while guaranteeing a stable energy supply, because of lower emissions and more extensive environmental effects. Also, the region set the following climate and energy targets to be achieved by 2030: a mandatory target to cut greenhouse gas emissions by 40% in 2030, compared to 1990 emissions levels, a binding target to increase the share of renewable energy in final energy consumption and energy efficiency by at least 27% to be reviewed and possibly raising the objective to 30% by 2030, reaching an electricity interconnection goal of 15% in the region by 2030 and advancement in infrastructural projects [1].

Following the communication from the European Commission, “A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy”, the

EU imports 53% of its energy which amount to about EUR400 billion, making the EU the world's largest energy importing region [2]. To tackle the challenges related to supply in the region, the commission has identified a five-pillar strategy to achieve the EU energy union. This strategy includes; energy security solidarity and trust, improved energy efficiency to moderate demand for energy, an integrated energy market in the region, research innovation and competitiveness, as well as decarbonizing the economy. As a benefit, it is also projected that renewable energy businesses in the region have a combined annual turnover of EUR 129 billion and employ over a million people [2].

Bioenergy has significantly contributed to the EU's target of 20% of renewable energy by 2020, and it is expected that bioenergy will contribute immensely to the 2020 long-term target, as bioenergy accounted for 59% of renewable energy (and 10% of total energy) consumption in the EU in 2018. Also, about 96% of bioenergy feedstock is produced in EU-based forests, hence bioenergy contributes to curbing energy insecurity and achieving simultaneous growth in both energy and environmental quality in the region [2,3].

To assess the challenges of biomass imports for the bioenergy industry, the Green-X and ArcGis Network modeling system (See Appendix A) is applied. Imports of solid biomass in the EU are estimated to increase to over 10 MTOE by 2030 compared to the 3.9 MTOE in 2014. Palm kernel shells, straw pellets, and wood pellets from South-East Asia, Ukraine, and Sub-Saharan Africa are expected to contribute 5%, 8%, and 21% of solid biomass import respectively. The US, Canada, and Russia however, remain the biggest suppliers of bioenergy feedstock to the EU, contributing 37%, 10%, and 10% (of total imports) respectively. In the EU, the average investment expectation increased from €53.0 Billion to €65.7 Billion between 2021 and 2030, representing 24% (€12.7 bln per annum) of investment in renewable energy. Also, there is a decline in the investment in biomass installations by 24% (from €22.2 Billion to €16.8 Billion) during this period. The development of the bioenergy industry is however uncertain as a result of the negative investment, political instability, and climate. The decline in investment for biomass to produce bioenergy output is equivalent to the decline in biomass use [2].

### 1.2. Social Businesses Status in EU28 Region

The primary goal of social businesses is to generate a desirable social impact in every European country. They are an integral component of the social economy, where about 13.6 million Europeans work today. Social businesses main focus on delivering essential care services and other societal challenges, such as providing job opportunities for disadvantaged groups and the pursuit of sustainable development goals, identify opportunities, and innovate in areas where both public authorities and mainstream businesses are unable to deliver; thereby contributing to important policy objectives—such as inclusive growth, job creation, equality, fight against poverty, pollution abatement, and sustainability. Social businesses are an excellent example of an “economy that works for people” which remains a priority for the European Commission [4].

Interestingly, only 16 EU Member States have adopted specific legislation in the field and 11 EU Member States have formally created and adopted policies for supporting social business development since the European Commission (EC) adopted its “Social Business Initiative” (SBI) in 2019. This research however takes up the challenge to shed light on this social business's impacts on the bioenergy economy in Europe. It gathers and interprets the main conclusions of 28 member states and portrays a European picture of social enterprises and the growth of the bioenergy industry in which ‘ecosystems’ operate. In particular, new ways are proposed to bring European countries together [4].

In Germany, the emerging sectors include renewable energies, affordable housing, and environmentally friendly and fair products. In addition to the social sector, there are new opportunities for social enterprises to involve the local population in local development, energy, and environmental preservation, for example. The situation in Germany is particularly interesting in this regard, as medium and large non-profit social welfare organizations, which generally have established and sustainable business models, have easy access to

excellent financing options within countries and banks that specialize in financing the non-profit organizations. In the Netherlands, social enterprises have played an increasingly important role in opening up new markets, for example in waste management, recycling, and power generation from biomass and other renewable energies, and business services. As in the Netherlands, social enterprises can even influence the functioning of international markets. In Belgium, the different types of organizations that fall under the EU conceptual and operational definition of social enterprise are not necessarily identified as such. Instead, they usually identify with the area of activity in which they operate (e.g., wellness services, fair trade renewable energies, etc.) and/or the precise forms of organization that they involve [4].

So a crucial question is: does the development of social enterprises in developed and underdeveloped countries in the EU-28 region influence the growth of the bioenergy industry in the EU-28 region? Will the development of social enterprises lead to a world with three zeros (zero emissions, zero unemployment, and zero poverty) on the way to sustainable bioenergy development in the EU28 countries? Due to the significant demand for renewable and sustainable energies and increasing climate change, a better understanding of the causal link between the bioenergy industry and social enterprises at the regional and sub-regional levels in the EU28 is needed. After years of trying to develop bioenergy mainly through major private sector initiatives, EU governments have broadened their focus to provide more support to other actors in the sector. This article aims to assess the role that social enterprise development can play in the growth of the bioenergy sector in developed and underdeveloped countries in the EU28 region for the period 1990–2018. This is the first article to investigate the influence of social enterprises on the bioenergy industry in developed and underdeveloped countries in the EU28 region. It shows that collaborative learning from people across organizational boundaries is essential for the successful implementation of research projects. Bioenergy, which is new in the EU.

This research proposes to investigate the bioenergy economy and the environment at the same time and, tackling huge problems such as carbon dioxide emissions, entrenched poverty, and unemployment in EU28 countries. This paper investigates the capability of social business development to solve economic, human, and environmental problems through bioenergy industry growth rather than exist solely for profit. This study offers several contributions. It supports integrated options for social development in sustainable development in the European zone to develop a clear-cut idea of the relationships between the variables in this study. This study can assist the governments of the EU28 region in mitigating environmental pollution, emissions, climate change, unemployment, poverty, and economic development by understanding the role social business development plays in bioenergy industry growth. The inquiry using the interaction of variables is the first of its kind for the EU28 region. The study also considers bioenergy output and social development framework to find out if it fulfills the sustainability requirement before drawing policies for more implication of social businesses and enterprises into the development of the bioenergy sector.

This study applied the novel approach to estimating cross-sectional data developed by Stock and Watson (1993) [5]. In contrast to the empirical time series and cross-country data tools used in previous studies, such as the widely used panel co-integration model by Phillips and Hansen (1990) [6], the present study uses the recently developed model, analyzing the co-integration methods of dynamic and fully modified panel explaining the significant impacts of regressors on the dependent variable and addressing the complications of behavior and interpretation of the predominant co-integration model of the panel. Finally, this study contributes to knowledge and literature on social enterprise and environmental sustainability and assesses the prevailing relationship between the development of the bioenergy sector and social development in the EU28 members from 1990 to 2018. The originality and novelty of this research lie in the creation of an approach for the deployment of ecosystem services in the planning and design of bioenergy transition. This is useful to advance bioenergy transition by enhancing research methods, by providing

methods useful for planners and designers, and by supporting communities sustainably pursuing bioenergy self-sufficiency.

### 1.3. Paper Organization

We discuss related background and status in Section 1. We review theoretically and empirically the finding of the available work literature in Section 2, and show the applied methodology and data in Section 3. We present results and related discussion in Section 4, and conclude with the implication in Section 5.

## 2. Literature Review

Unlike regular businesses, social businesses do not maximize shareholder value, make profits for themselves, and do not attempt to create whatever will sell. They are however not charity either. Social businesses utilize investors' money for self-sustaining, and return the investors' money plus a one-time percentage fee, thereby resulting in reinvestment in another social business which leads to more social development and economic growth, instead of simply multiplying returns and focusing only on short-term gains [7]. Accordingly, several studies investigate the role of social enterprise and economic growth—such as [8–12]. For example, [13] investigate social entrepreneurship production to promote sustainable social change in communities, arguing institutions, companies, and communities need to perform social innovations to achieve more social development [13].

The energy and climate goals set for 2030 by the European Council will have significant implications for the de-carbonization of Europe's economy and the success of the energy integration project. These targets represent a shift towards a more technology-neutral based EU energy policy and climate than in targets for 2020. Several studies investigate social entrepreneurship and policy interaction for renewable energy targets such as [13–18]. Studies such as [19] examine several regulatory instruments, applied on different government levels to stimulate social entrepreneurship and ecosystems, suggesting that social entrepreneurship is recognized as an important instrument for overcoming social problems and supporting sustainable development. Reference [20] investigates how renewable energy enterprises may improve the social functioning of communities using a quantitative model, referring social enterprise to achieve returns to environmental, financial, and social stakeholders guide funders. Likewise, [21] explores social entrepreneurship in rural Indonesia from environmental, development, and sustainability perspectives, suggesting a lack of financing options for social entrepreneurs and their customers, and limited government support was observed to undermine social enterprise success.

The conventional linear relationship between energy production and consumption is no longer sustainable. A key component in the transition to a more sustainable zero-carbon society is using products longer and developing a culture of recycling and reuse. For example, [22] examines citizens' motivation to start social reuse businesses in Ireland and the factors that help make social reuse businesses sustainable. Reference [22] states that social reuse businesses help solve a range of environmental, economic, and social problems faced by urban areas.

Likewise, [23] investigates the effect of social activities and renewable energy on carbon emissions, pointing to social activities reduced carbon emissions and economic growth reduced carbon emissions only when social activity is controlled. Likewise, [24] strives for ambitious goals to increase renewable energies and provide universal access to energy within the limited social consensus on how to achieve these goals, referring to energy for development. This favors energy as fundamental to long-term economic growth and strategic security. Moreover, for all of this, energy prioritizes the role of energy in basic development and in eradicating poverty in society.

On the other hand, [25] discusses the role of social entrepreneurship in emerging renewable energy communities, pointing biomass energy as an environmentally friendly heating resource that has become a taken-for-granted practice and has been presented as an inspirational example to other communities in the region. Likewise, [26] explores the role of

renewable energy social enterprises accessing government support, suggesting that social enterprises in the renewable energy industry can improve energy policy design significantly. In the same manner, [27] explores the possibility of achieving sustainability through Schumpeterian social entrepreneurship, arguing that social enterprises and sustainable businesses can play a role in achieving sustainable development goals. Identically, [28,29] investigate social sustainability through ecosystems for renewable energy, claiming social entrepreneurship of companies and institutions develops a framework for the formation of innovation ecosystems. The structure is particularly important in creating new renewable energy markets for the rural population and the base of the pyramid (BOP). Reference [30] applies a comparative model of social enterprise and enterprise in the field of new and renewable energies and find that the most notable differences between the models of both groups are in the degree of action orientation and approval of people/groups and the high points of positive engagement in the field of renewable energies.

Bioenergy business development relies on many factors such as the capability of governments at various levels to create enabling conditions for business growth through policy development and policies, efforts to remove barriers to technology implementation beyond the stage of R&D, and issues related to the global diffusion of technology in development. For example, [31] investigates social well-being as an important concept related to the development of bioenergy, suggesting that material well-being illustrates that the relationships between the different dimensions of social well-being should be considered for the development of bioenergy appropriate for the community.

Likewise, [32] explores the role of extractivism and agribusiness of biofuel in social and economic development, pointing that the biofuel industry can add a significant contribution to food security, human health, and employment conditions. Similarly, [33] examines the maturity level of corporate responsibility for the sustainability of the bioenergy business, referred to as the operators of the bioenergy business, which can significantly contribute to the sustainability of bioenergy systems. Reference [34] surveys the promotion of entrepreneurial activities to strengthen the national competitiveness of the bioenergy industry, arguing that small and medium scale entrepreneurs accelerate the evaluation of business opportunities offered by cleaner technologies, such as bioenergy solutions. Many studies investigate the role of businesses and enterprises in developing the bioenergy industry—such as [35–37].

In line with established theoretical and empirical analyses, it seems that no previous work is investigating the impact of social business development on the bioenergy industry development in the EU28 region under the pathway of a world with three zeros (zero emissions, zero poverty, and zero unemployment). Moreover, no prior research has investigated the influence of the development of social enterprises on the growth of the bioenergy industry in the established and emerging economies of the European Union during the period 1990–2018 using the panel's co-integration method. While this approach addresses the research information gap, it also serves as motivation, novelty, and originality of the reason why the present study uses the Fully Modified Ordinary Least Square (FMOLS), Dummy Ordinary Least Square (DOLS), and Pooled Ordinary Least Square (Pooled OLS) methods to regress the correlation between the outgrowth of bioenergy industry and social business development in the EU 28 region, EU15 developed members and EU13 underdeveloped members. This paper conceptualizes the theme of relations and interdependencies between social business development organized in the bioenergy industry in EU countries to empirically determine the sustainability performance of the European bioenergy sector, using the empirical model and various statistical tests that presupposes an innovative contribution to current literature and practice.

### 3. Methodology and Data

The generalised least squares (GLS) estimator of the coefficients of linear regression is a generalisation of the ordinary least squares (OLS) estimator. It is useful to deal with situations in which the OLS estimator is not BLUE (best linear unbiased estimator)

because one of the main assumptions of the Gauss–Markov theorem, namely that of homoskedasticity and absence of serial correlation, is violated as per [38]. In such situations, provided that the other assumptions of the Gauss–Markov theorem are satisfied, the GLS estimator is BLUE. In statistics, generalised least squares (GLS) is a technique for estimating the unknown parameters in a linear regression model. GLS can be used to perform linear regression when there is a certain degree of correlation between the explanatory variables (independent variables) of the regression. In these cases, ordinary least squares and weighted least squares can be statistically inefficient, or even give misleading inferences as forwarded by [38].

Based on earlier research done by [39], in a pooled OLS regression investigations, this research had simply pooled all observations and estimate the grand regression, ignoring the cross-section and time-series nature of the data, in which case the error term captures everything. In this model, as all observations were pooled together it camouflages the heterogeneity or individuality that exists between the variables. Based on [40], the fixed-effects model controls for all time-invariant differences between the individuals, so the estimated coefficients of the fixed-effects models cannot be biased because of omitted time invariant characteristics. Substantively, fixed effects models are designed to study the causes of changes within a person. A time invariant characteristic cannot cause such a change, because it is constant for each country (country effect). According to [41], the rationale behind the random effects model is that the individual-specific effect or variation across entities is assumed to be a random variable that is uncorrelated with the explanatory variables (time effect). The crucial distinction between fixed effect and the random effect is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not. Reference [42] stated the advantage of random effects is that it can include time invariant variables, unlike in fixed effect, where the intercept absorbs all the time invariant variables. Here, the individual's error term is not correlated with the predictors which allow for time invariant variables to play a role as explanatory variables.

According to a prior study [43], the estimation procedure applied followed a statistical evaluation of the pooled OLS regression, GLS random effects (RE) model, and fixed effects (FE) model using the Breusch–Pagan Lagrangian multiplier test (BPLM) and Hausman test approaches. The BPLM test was applied to the RE model estimates to test whether pooled OLS regression was the appropriate model to apply for analysis. The BPLM test (is used to test for heteroskedasticity in a linear regression model) for random effects results rejected the null hypothesis that the Pooled OLS model was appropriate [43]. The FE model was further run to appropriately selected between the RE and FE. The Hausman test (also called the Hausman specification test) detects endogenous regressors (predictor variables) in a regression model. Endogenous variables have values that are determined by other variables in the system. Having endogenous regressors in a model will cause ordinary least squares estimators to fail, as one of the assumptions of OLS is that there is no correlation between a predictor variable and the error term. Reference [43] stated that the Hausman test was applied to select the appropriate model between RE and FE. Interpreting the result from a Hausman test is fairly straightforward: if the  $p$ -value is small (less than 0.05), reject the null hypothesis. Following the results from the Hausman test, the null hypothesis that the random effects model was appropriate was rejected; indicating that the differences between the FE model and the RE model were systematic. Therefore, the coefficients of the FE model were efficient. Based on the results of the FE model.

Over the past decade, thousands of people and organizations embraced Yunus' vision of a new system of capitalism and created innovative social enterprises that focus on the needs of the people rather than raising money [7]. They bring renewable energy to millions of households in Asia, converting thousands of unemployed youth into entrepreneurs, financing women-owned enterprises in North American cities, and providing mobility, housing, and other essential services to the poor in the regions. Rural Europe Create a global support network to help young entrepreneurs start their new businesses. Based on the

concept of three (3) zeros (economics of zero poverty, unemployment, and CO2 emissions), reference [7] developed a new civilized economic system that unleashes altruism as a creative force as powerful as selfishness. Several companies—such as McCain, Essilor, Danone, etc.—have delved into this new business model through their social action groups, by outlining the ingenious new financial instruments that now finance social enterprises and outlining the legal and regulatory changes needed for the next wave of socially oriented innovations [7]. In the present study, the relationship between the factor of bioenergy production and indicators of the degree of development of social enterprise using the Cobb–Douglas production function is analyzed as

$$Y = f(C_{it}, L_{it}) \quad (1)$$

where  $Y$  is production (output),  $C$  represents tangible capital,  $L$  is labor, while  $i$  and  $t$  denote the number of members and years respectively. Equation (1) was transformed into a log-linear form, taking into account all dependent and independent variables in their natural logarithms, and obtaining more accurate experimental results as with previous literature, such as [44–46]. Therefore, Equation (1) is transformed as

$$\ln \text{BIO}_{it} = \beta_0 + \beta_1 \ln \text{FS}_{it} + \beta_2 \ln \text{GDP}_{it} + \beta_3 \ln \text{CO2}_{it} + \beta_4 \ln \text{FML}_{it} + \beta_5 \ln \text{UE}_{it} + \beta_6 \ln \text{VE}_{it} + \varepsilon_{it} \quad (2)$$

where  $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ , and  $\beta_6$  are vectors of coefficients,  $\varepsilon$  is the error term. We used data for the EU28 region from 1990–2018. BIO is the bioenergy prime production in thousand tonnes of oil equivalent (TOE) for country  $i$  across time  $t$ . FS represents food supply indicated by edible food crops supply. Also, the inclusion of food production measure is as a result of excellent data availability, in this case, nutrition production is indicated by the average value of foody supply. GDP is the economic growth indicated by gross domestic product per capita growth annually (%) for country  $i$  across time  $t$ . CO2 refers to the log of carbon dioxide emissions in kiloton of member  $i$  in year  $t$ . The main three selected variables related to social business development are as follows; FML points to the log female labor force participation rate (% of female population ages 15+) of member  $i$  in year  $t$ . UE indicates the percentage of the unemployment labor force of member  $i$  in year  $t$ . VE represents vulnerable employment which denotes contributing family workers and own-account workers (as a percentage of total employment) of member  $i$  in year  $t$ . All relevant data were obtained from the Eurostat and World Bank Database (see Table 1).

**Table 1.** Summary of Variables.

Variable	Abbreviated	Data Source	Statistics/Sign	Unit
Bioenergy Output	BIO	Eurostat	Dependent Variable	Terajoule (TJ)
Food Security	FS	World Bank Datasets	Significant/+	(2004–2006 = 100)
Economic Growth	GDP	World Bank Datasets	Significant/+	GDP per capita growth %
Carbon Dioxide	CO2	Eurostat	Significant/-	CO2 emissions (kiloton)
Female Labor Rate	FML	World Bank Datasets	Significant/+	% of female participation
Unemployment Rate	UE	World Bank Datasets	Significant/-	% of unemployment labor
Vulnerable Employment	VE	World Bank Datasets	Significant/-	% of employment

Firstly, we applied the panel unit root test to establish the stationarity of the determinants. The approach of the panel unit root estimator applied assumes a homogeneity between the cross-sections [47,48]. Following several studies such as [44,46,49], the null hypothesis  $H_0: P_i = 1$  of the unit root analysis that all series contain unit roots or that not all panels are stationary. On the other hand, the alternative hypothesis  $H_1: P_i > 1$  is stationary

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{P_i} \theta_{iL} \Delta y_{it-L} Z'_{it} \gamma + \varepsilon_{it}, \quad m = 1, 2, 3 \quad (3)$$

where  $\varepsilon_{it}$  is unrelated among countries,  $\Delta$  is the first variances,  $\Delta y_{it}$  and  $\Delta y_{it-1}$  have individual estimations with  $\Delta y_{it-L}$ ,  $Z'_{it} \gamma$  presents the countries' parameters, and residuals are

obtained. Hence  $L$  ( $L = 1, 2, 3, 4 \dots, P_i$ ) indicates the highest suitable lag length defined by the information criteria figures.

Secondly, the Pedroni [50] estimation is among the most significant between panel co-integration estimators. It takes into account the heterogeneity through the application of specific parameters that differ between individual countries and cross-sectional dependence [50,51]. The co-integration test was used to obtain the relationship between the variable of interests and control determinants in the panel. Following prior studies such as [52,53], the panel co-integration approach is estimated between the null hypothesis and the alternative hypothesis:

**Hypothesis 0.** *There is no co-integration correlation for all  $i$ .*

**Hypothesis 1.** *There is a co-integration correlation for all  $i$ .*

Thirdly, we applied various panel co-integration strategies to determine the co-integration or the long-term relationship between the variables in this study, also, the fully modified ordinary least squares (FMOLS), the dynamic ordinary least square (DOLS), and the pooled ordinary least Squares (OLS) are used. The FMOLS estimator developed by Pedroni [50,51] is

$$Y_{it} = \alpha_i + \beta_i x_{it} + \sum_{k=-K_i}^{K_i} \gamma_{ik} \Delta x_{it-k} + \varepsilon_{it} \quad (4)$$

The coefficients obtained in Equation (4) are applied across all the cross-sections. The co-integration coefficient for the entire panel is obtained by taking the average of the resulting FMOLS coefficients in each coefficient. In this case, the econometric method of the FMOLS panel is structured as

$$\hat{\beta}_{GFM}^* = N^{-1} \sum_{i=1}^N \hat{\beta}_{FM,i}^* \quad (5)$$

The  $\hat{\beta}_{GFM}^*$  in Equation (5) denotes the FMOLS estimated outcomes given by the panel cross-section that encloses each  $i$ 'th panel. The t-statistic for the importance scale of the parameter for the expanded duration is calculated as

$$t_{\hat{\beta}_{GFM}^*} = N^{-1/2} \sum_{i=1}^N t_{\hat{\beta}_{FM,i}^*} \quad (6)$$

The  $t_{\hat{\beta}_{GFM}^*}$  in Equation (6) is the statistic for the co-integration coefficient scored for the entire panel.

The applied methodology builds upon earlier urban energy approaches such as REAP [54], LES [55], and Energy Potential Mapping [56], but creates a stepped approach that has not been presented and applied to the EU region as a whole yet. As far as the authors know, so far, the bioenergy transition roadmap has never been developed for an entire EU region countries. The study will contribute toward the analysis of the opportunities for adopting social business development and increasing bioenergy sustainability and growth for the EU28 region.

#### 4. Results and Discussion

To begin the estimation process of our panel co-integration, we apply preliminary tests that include descriptive statistics and correlation analysis to ensure the normality and adequacy of the series. Tables 2 and 3 present the results of the descriptive statistics and the correlation matrix, respectively. While the summary descriptive statistics suggest that the series are normally distributed, the correlation matrix shows that there is no high correlation between the explanatory variables included in this study. Thus, the variables can be included in the model without the problem of multi-collinearity since the values are lower than the reference point of 0.80 [57].

**Table 2.** Descriptive Statistics.

Variable	Observations	Mean	Std. Dev.	Min	Max
BIO	765	4.589	0.822	1.690	5.770
FS	765	2.000	0.047	1.850	2.270
CO2	765	4.775	0.619	3.170	5.970
UE	765	0.859	0.221	0.050	1.041
FML	765	1.689	0.068	1.450	1.800
VE	765	1.106	0.204	0.530	1.630
GDP	765	1.250	0.108	0.240	1.600

**Table 3.** Correlation Matrix.

Variables	FS	CO2	UE	FML	VE	GDP
FS	1.000					
CO2	0.047	1.000				
UE	0.023	0.150	1.000			
FML	0.183	0.127	0.029	1.000		
VE	−0.144	0.154	0.231	−0.214	1.000	
GDP	−0.095	−0.141	−0.222	−0.098	−0.040	1.000

The main step in examining the underlying variables is to ensure the order in which the data series are integrated. That is, the dependent variable must be integrated into order I (1). Not all independent variables need to be stationary or have seasonal roots on the first difference. The unit root tests of Levin, Lin, and Chu (LLC), as well as Im, Pesaran, and Shin (IPS) [47,48], are used in this study, and the results presented in Table 4 show that the null hypothesis of a unit root for all variables cannot be rejected at level, but it can be rejected at the first difference with a significance level of 1%. The examined variable has the first-order integration. Therefore, the dynamic panel method like FMOLS is appropriate.

**Table 4.** Panel Unit Root Test Results for the EU-28 Region in 1990–2018.

Variable	Difference		First Difference	
	LLC	IPS	LLC	IPS
BIO	−59.127 *** (0.000)	−34.113 *** (0.000)	−10.826 *** (0.000)	−21.138 *** (0.000)
FS	−22.089 *** (0.000)	−26.115 *** (0.000)	−17.234 *** (0.000)	−23.499 *** (0.000)
CO2	−20.726 *** (0.000)	−21.731 *** (0.000)	−18.552 *** (0.000)	−21.982 *** (0.000)
UE	−12.430 *** (0.000)	−13.099 *** (0.000)	−9.654 *** (0.000)	−10.538 *** (0.000)
FML	−19.896 *** (0.000)	−20.633 *** (0.000)	−19.273 *** (0.000)	−20.646 *** (0.000)
VE	−20.058 *** (0.000)	−19.821 *** (0.000)	−17.923 *** (0.000)	−17.944 *** (0.000)
GDP	−28.308 *** (0.000)	−27.341 *** (0.000)	−24.334 *** (0.000)	−24.604 *** (0.000)

Remark: \*\*\* refer importance at the 1%, scale. Levin, Lin, and Chu test (LLC); and Im, Pesaran, and Shin W-stat test (IPS).

After determining the order in which the determinants were integrated, the research confirmed the presence of a long-term correlation between the determinants. The long-term examination was applied with the Pedroni residual co-integration examination and validated with the Kao residual co-integration validation. The findings of these two validations are presented in Table. Two kinds of residual tests are suggested: within the dimension and between the dimensions [53]. The within dimension has four subtests:

Panel-v, Panel-rho, Panel PP, and ADF Statistics. While the between dimensions comprises of three subtests: group rho, group PP, and group ADF statistics. The null hypotheses of the seven statistics propose that there is no co-integration. Rejection of the null hypothesis indicates the presence of a long-term correlation. Table 5 shows that four of the seven statistics are significant, hence, we reject the null hypothesis. This implies that a long-term relationship exists between the variables. This decision follows the suggestion of Pedroni [53] who argued that the statistics of the ADF panel and group must be signed to conclude the presence of co-integration in the Pedroni test, the statistics of the panel ADF, and the group ADF are consistently highly important. This result is more confirmed by the finding of the Kao residual co-integration validation (see Table 5). The finding proposes long-term correlations between the determinants.

**Table 5.** Panel Cointegration Test Results for the EU-28 Region during 1990–2018.

Dependent Variable: Fish Population		
Table Header	Without Trend	With Trend
Pedroni Residual Co-integration Test		
Alternative hypothesis: common AR coefficients (within dimension):		
Panel v-Statistic	−1.570 (0.941)	−1.704 (0.955)
Panel rho-Statistic	3.715 (0.999)	3.361 (0.999)
Panel PP-Statistic	−3.278 *** (0.000)	−4.397 *** (0.000)
Panel ADF-Statistic	−3.075 *** (0.001)	−4.625 *** (0.000)
Alternative hypothesis: common AR coefficients (between dimension)		
Group rho-Statistic	4.686	1.000
Group PP-Statistic	−8.955 ***	(0.000)
Group ADF-Statistic	−6.235 ***	(0.000)
KAO Residual Cointegration Test		
ADF	−3.140 ***	(0.000)

Remark: \* refer importance at the 1% scale. Values in parentheses are p-values.

In Tables 6–8, panel FMOLS was then estimated, and Models 1, 2, and 3, respectively, display the result along with the results from the DOLS and pooled OLS. However, this research concentrates on the results of the FMOLS. While the findings of DOLS and pooled OLS work as validation tests for models 1, 2, and 3.

**Table 6.** Summary of Panel Regression Model 1 for the EU-28 Region from 1990–2018.

Model 1. Panel Data Analysis Estimation for EU28 Region 1990–2018						
Long-Run Coefficient	Dependent Variable: Bioenergy Production					
	DOLS		FMOLS		Pooled OLS	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
FS	2.341 ***	0.462	2.350 ***	0.444	2.341 ***	0.250
CO2	−0.847 ***	0.059	−0.867 ***	0.056	−0.847 ***	0.032
UE	−0.780 ***	0.169	−0.813 ***	0.162	−0.780 ***	0.091
FML	2.697 ***	0.501	2.800 ***	0.480	2.697 ***	0.271
VE	−0.448 **	0.179	−0.502 ***	0.171	−0.448 ***	0.097
GDP	0.398	0.315	0.229	0.310	0.398 **	0.170

Note: \*\*\* and \*\* indicate significance at the 1% and 5% levels respectively. Values in parentheses are p-values.

**Table 7.** Summary of Panel Regression Model 2 for EU15 Developed Countries from 1990–2018.

<b>Model 2. Panel Data Analysis Estimation for EU15 Developed Countries 1990–2018</b>						
<b>Dependent Variable: Bioenergy Production</b>						
<b>Long-Run Coefficient</b>	<b>DOLS</b>		<b>FMOLS</b>		<b>Pooled OLS</b>	
	<b>Coefficient</b>	<b>Std. Error</b>	<b>Coefficient</b>	<b>Std. Error</b>	<b>Coefficient</b>	<b>Std. Error</b>
FS	0.966 **	0.640	0.988 **	0.502	3.964 ***	0.463
CO2	−1.437 ***	0.352	−1.325 ***	0.259	−0.786 ***	0.050
UE	−0.282 ***	0.125	−0.256 ***	0.086	−0.468 ***	0.132
FML	4.387 ***	0.487	4.946 ***	0.399	4.822 ***	0.411
VE	−0.545 ***	0.292	−7.799 ***	0.232	−0.254 *	0.139
GDP	1.856 **	0.457	0.432 **	0.188	0.052	0.331

Note: \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively. Values in parentheses are *p*-values.

**Table 8.** Summary of Panel Regression Model 3 for Underdeveloped Countries from 1990–2018.

<b>Model 3. Panel Data Analysis Estimation for Underdeveloped Countries 1990–2018</b>						
<b>Dependent Variable: Bioenergy Production</b>						
<b>Long-Run Coefficient</b>	<b>DOLS</b>		<b>FMOLS</b>		<b>Pooled OLS</b>	
	<b>Coefficient</b>	<b>Std. Error</b>	<b>Coefficient</b>	<b>Std. Error</b>	<b>Coefficient</b>	<b>Std. Error</b>
FS	1.513 ***	0.553	1.748 ***	0.495	1.513 ***	0.313
CO2	−1.138 ***	0.098	−1.118 ***	0.088	−1.138 ***	0.055
UE	−0.731 ***	0.235	−0.850 ***	0.211	−0.731 ***	0.133
FML	1.260 *	0.702	1.569 **	0.625	1.260 ***	0.397
VE	−1.131 ***	0.287	−1.133 ***	0.259	−1.131 ***	0.162
GDP	0.643 *	0.341	0.576 *	0.319	0.643 ***	0.193

Note: \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively. Values in parentheses are *p*-values.

In Table 6, the panel FMOLS result suggests that food supply is positively and significantly related to bioenergy production at a 1% level. This means that increasing the food supply increases bioenergy production in the EU-28 region. In particular, an increase in food supply by 1% leads to a decrease in bioenergy production of 2.35%. Given the fundamental role of food production in reducing poverty and improving nutrition, an important recent analysis by [58] has shown that per capita food production and food prices are two of the main drivers of variability in food production poverty especially in the rural area. This close relationship between food production and poverty makes it necessary to understand social enterprise development dynamics to understand changes in the state of bioenergy growth.

The panel FMOLS result suggests that bioenergy is negatively related to carbon dioxide emissions. This implies that increasing bioenergy production reduces carbon dioxide emissions in the EU 28 region members. Precisely, a 0.87% decrease in carbon dioxide emissions will follow a percentage increase in bioenergy production. This result is aligned with [59,60]. It proposes that the EU 28 region has the potential of meeting its sustainable energy aims by expanding the output of bioenergy production and consumption in the region. The ambition to reduce carbon dioxide emissions by the EU 28 region, can be actualized by increasing the quantity of social business development in the bioenergy production processes.

Unemployment yields negative and significant effect on bioenergy output. This suggests that a decrease in the unemployment rate by 1% facilitates bioenergy production by 0.81%. This finding confirms previous bioenergy energy studies such as [61,62]. This finding implies that more social business development reflected in reducing the unemployment rate may assist to an incline in the outgrowth of the bioenergy sector in the EU 28 region.

The female employment rate shows a positive significant coefficient, implying that increasing the female employment rate by 1% will result in a rise in bioenergy growth by

2.80%. This finding validates [63]. It suggests that bioenergy industry growth in the EU 28 region rises with an increase in female employment rate and social business development.

Vulnerable employment, however, appears a negative and significant coefficient. This indicates that a percentage decrease in the vulnerable employment rate will improve bioenergy production by 0.50%. This indicates that more social development in reducing vulnerable employment will lead to more bioenergy production. This result adds empirical advocacy to [64,65]. By implication, bioenergy industry growth in the EU 28 region increases as the last one opens up more for social business development activities to reduce vulnerable employment rate.

In Table 7, the panel FMOLS result suggests that food production is positively related to bioenergy output at a 5% level. This implies that increasing food supply will lead to a corresponding increase in bioenergy output within the EU 15 developed countries. Precisely, a percentage rise in food supply will lead to a 0.98% incline in bioenergy production. Earlier studies, such as [66,67], showed a strong correlation between food production and rural poverty. This relationship between food production and poverty implies that it is necessary to consider the dynamics of social business development in order to understand changes in bioenergy growth status.

The panel FMOLS result reveals that there is a negative relationship between bioenergy and carbon dioxide emissions. This implies that increasing bioenergy production will lead to a decrease in carbon dioxide emissions within the EU 15 developed countries. Specifically, a percentage of the incline in bioenergy production will assist in a 1.32% decrease in carbon dioxide emissions. This result is confirmed by [68]. It points out that EU 15 developed members have the potential of meeting their carbon dioxide emissions targets by increasing the amount of bioenergy output produced which can be achieved by enhancing the development of social businesses in the bioenergy production processes.

Unemployment yields a negative effect on bioenergy output. This suggests that a decrease in the unemployment rate by 1% facilitates bioenergy production by 0.25%. This finding confirms with previous bioenergy-related studies such as [61,68]. The result implies that lowering the unemployment rate, as social business development, can lead to positively influencing the outgrowth of the bioenergy sector in EU 15 developed members. Similarly, the female employment rate has a positive and significant coefficient, implying that increasing the female employment rate by 1% would result in a corresponding increase in bioenergy growth by 4.94%. This finding validates [69,70]. It suggests that bioenergy industry growth in the EU 15 developed countries increase in response to an increase in female employment rate and development of social businesses.

Vulnerable employment yields a negative and significant coefficient. This indicates that more social development in reducing vulnerable employment will lead to more bioenergy production. Specifically, a percentage decrease in the vulnerable employment rate will lead to a 7.79% increase in bioenergy production. This finding conforms with [71,72]. By implication, bioenergy sector growth in the EU 15 developed members increases as the EU 15 opens up more for social business development activities to reduce vulnerable employment rate.

Economic growth shows a positive and significant influence on bioenergy output. This points out that a rise in economic growth by 1 percent inclines bioenergy production by 0.43%. This evidence is aligned with prior energy studies by [68,73]. This result indicates that increasing economic outgrowth through social business development can result in to enhance in the outgrowth of the bioenergy sector in EU 15 members.

In Table 8, the panel FMOLS result suggests that food production influence bioenergy output positively. This implies that increasing the food supply will have a corresponding increase in bioenergy production in the EU 13 underdeveloped countries. Precisely, a percentage increase in food supply will lead to a 1.74% incline in bioenergy production. Recent studies for [67,74] showed a strong correlation between food production and rural poverty. The close relationship between food production and poverty suggests the need to

consider the dynamics of social business development in the region to understand changes in bioenergy growth status.

The panel FMOLS result suggests that bioenergy is negatively related to carbon dioxide emissions. This indicates that an incline in bioenergy output decreases carbon dioxide emissions in the EU 13 underdeveloped members. Precisely, a 1% incline in bioenergy production can lead to a 1.11% decrease in carbon dioxide emissions. This finding is following [75–78]. The result implies that EU 13 underdeveloped countries have the prospect to achieve the stipulated carbon dioxide emissions targets by increasing the amount of bioenergy output produced which can be achieved by enhancing the development of social businesses in the bioenergy production processes.

Unemployment reveals a negative and significant effect on bioenergy output. This finding suggests that a percentage decrease in the unemployment rate will lead to a 0.85% increase in bioenergy production. This result adds empirical evidence to previous bioenergy studies by [61,68]. This finding implies that lowering the unemployment rate, as social business development could stimulate the outgrowth of the bioenergy sector in EU 13 members. On the other hand, the female employment rate has a positive and significant coefficient, which implies that an incline in the female employment rate by 1 percent shows an incline in bioenergy growth by 1.56%. This result validates [69,70]. It suggests that bioenergy industry growth in the EU 13 underdeveloped countries rises with an increase in female employment rate and development of social businesses.

Vulnerable employment has a negative and significant coefficient. This suggests that more social development in reducing vulnerable employment will lead to more bioenergy production. Specifically, a percentage decrease in the vulnerable employment rate will lead to a 1.13% increase in bioenergy production. This finding conforms with [71,72]. By implication, bioenergy industry growth in the EU 13 underdeveloped countries increases as the EU 13 members opens up more for social business development activities to reduce vulnerable employment rate.

We obtained a positive and significant impact of economic outgrowth on bioenergy output. This indicates that a percentage of the incline in economic outgrowth facilitates bioenergy production by 0.57%. This finding adds empirical evidence to earlier bioenergy studies by [62,68,73]. It implies that increasing economic growth activities through social business development can stimulate the outgrowth of the bioenergy sector in EU 13 members [77–80].

The panel FMOLS estimates were robust by the panel DOLS and the pooled OLS. It is noted that the coefficients given by the DOLS have the same sign and scale of significance as those from the FMOLS. This points out that the findings of the FMOLS are validated and may therefore be recognized for conclusions. The pooled OLS coefficients also show the same signs as that of the OLS; however, with a slight variance in the level of significance. In general, however, the estimates of the FMOLS can be considered validated and without problems of endogeneity and serial correlation.

To examine the influence of social business development indicators on bioenergy industry growth in EU 28 region members based on their economic development scales, the members were categorized into two major subgroups—EU 15 members and EU 13 members (see Appendix B). Table 7 presents the estimated results of the impact of social business development indicators on bioenergy industry growth in the EU15 developed countries for the period 1990–2018. While Table 8 shows the finding of the impact of social business development indicators on bioenergy sector outgrowth in the EU13 members during the period 1990–2018. Interestingly, the empirical findings from Tables 7 and 8 both elaborate that social business development has an important influence on bioenergy industry growth.

The findings also point that the negative impact of vulnerable employment and carbon dioxide emissions on bioenergy output is greater in EU 13 members than in the EU 15 members. Specifically, the magnitudes of the effect are  $-1.13$  and  $-7.79$  for vulnerable employment and  $-1.11$  and  $-1.32$  for carbon dioxide in EU13 countries and EU15 developed members, respectively. This implies that a notable decrease in vulnerable employment and

carbon dioxide emissions can lead to EU13 underdeveloped countries to more bioenergy production than in EU15 developed countries.

On the other hand, the findings point out that the impact of the unemployment rate on bioenergy outgrowth is greater in EU 15 members than in the EU 13 members, with the magnitudes of the impact of  $-0.25$  and  $-0.85$  for EU15 members and EU13 members, respectively. Implying that a significant reduction in the unemployment rate can give in EU15 developed countries higher growth of the bioenergy industry than in EU13 underdeveloped countries.

Also, the effect of food supply and economic growth on bioenergy production is higher in EU 13 underdeveloped members than in the EU 15 developed members, with the magnitudes of the impact of  $1.74$  and  $0.98$  for food supply and  $0.57$  and  $0.43$  for economic growth in EU13 underdeveloped countries and EU15 developed members, respectively. Implying that an important development in food supply and economic growth would have a greater influence on the bioenergy industry of the EU13 members than that of the EU15 members. On the other hand, the effect of the female employment rate on bioenergy outgrowth is bigger in EU 15 members than in the EU 13 members, with the magnitudes of impact at  $4.94$  and  $1.56$  for EU15 members and EU13 members, respectively. This implies that a notable enhancement in the female employment rate can give in EU15 members higher outgrowth of the bioenergy sector than in EU13 members.

## 5. Conclusions and Implication

This research investigated the influence of social business development indicators on the outgrowth of the bioenergy sector in the EU28 area from 1990 to 2018. The FMOLS regressor was implemented to achieve the goal, while the DOLS and pooled OLS regressions serve as validation tests. The empirical results indicate that the growth of the bioenergy industry can be significantly increased by improving social business development in EU28 members, particularly in EU13 members. Food supply and economic growth are found to be increasing more the growth of the bioenergy sector in EU13 members compared with EU15 members. While carbon dioxide and vulnerable employment are found to be decreasing more the growth of the bioenergy sector in EU13 members compared with EU 15 members. On the other hand, the female employment participation rate is found to be enhancing more the outgrowth of the bioenergy sector in EU15 members compared with EU13 members. While unemployment is found to be decreasing more the outgrowth of the bioenergy sector in EU15 members compared with EU13 members. As revealed in our results, the bioenergy industry in the EU13 underdeveloped countries is expected to grow faster than the bioenergy industry in the EU15 developed countries. This is due to the high demand on conventional fuel in these countries, which may be easily substituted by the production of bioenergy through the development of inputs of social businesses.

Based on the research findings, recommendations were developed on possible actions to foster cooperation between the social business development and bioenergy industry at EU 28, national, and regional levels. These are presented here in the order of appearance in the main study. Social business development can play a vital to achieve EU28's ambition to simultaneously increase the growth of the bioenergy industry and reduce carbon dioxide emissions. Therefore, the authorities of EU28 region countries should prioritize developing the resources, efficacy, and sustainability of social business development to mitigate emissions, poverty, and unemployment. This research implicates more financing to social business development to maximize the growth of the bioenergy industry. This will help achieve energy security, lower unemployment, fight poverty, and reduce polluting emissions. It is also important to cut the consumption of fossil fuels since it a major factor influencing carbon dioxide emissions and then substitute it with bioenergy in the generation of products and services to mitigate emissions, fight poverty, and lower unemployment. There should also be an emphasis on increasing the efficacy and development of social business development to stimulate bioenergy growth and decrease the

reliance on conventional fuels which will also help to diversify EU28's social business development strategy.

Competition in the development of social business refers to the ability to respond to opportunities and ideas and convert them into values for the societies. It is therefore worth noting that, while struggling to develop the bioenergy sector by improving social business development, the concept of a world of the three zeros (zero emissions, zero poverty, and zero unemployment) can save humankind and the planet. This is because the growth of the bioenergy industry can meet human needs instead of accumulating wealth by launching innovative social businesses. They bring bioenergy to millions of households in EU28 countries; turn thousands of unemployed youth into entrepreneurs through capital investments; financing female entrepreneurs across the region; creating a global support scheme that helps young entrepreneurs start a new business; and providing mobility, housing, and other essential services to the rural area across the underdeveloped countries.

The observed trend is that in the different stages different roles are played by the EU countries as it aims at shifting from subsidy funds to profit-making. In the process of becoming efficient and starting to upscale, it seems harder to ensure the implementation of the social and environmental objectives. Therefore, public actors will have to play a more active role in capacity building and market regulation, and additional funding has to be made available for ensuring social and environmental benefits. Innovations in governance and new ways of linking actors may be part of the solution.

The sustainable development from social businesses development to produce renewable and sustainable energy output are not limited to bioenergy industry growth but include other aspects, such as hydropower, solar energy, wind energy, tidal energy, geothermal energy, and biomass energy. Again, specific studies should be carried whenever possible, taking into consideration the impact of social business development on promoting the sustainability of renewable energy sources.

**Author Contributions:** All three authors contributed to writing, estimation, analysis, and revision of the paper. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

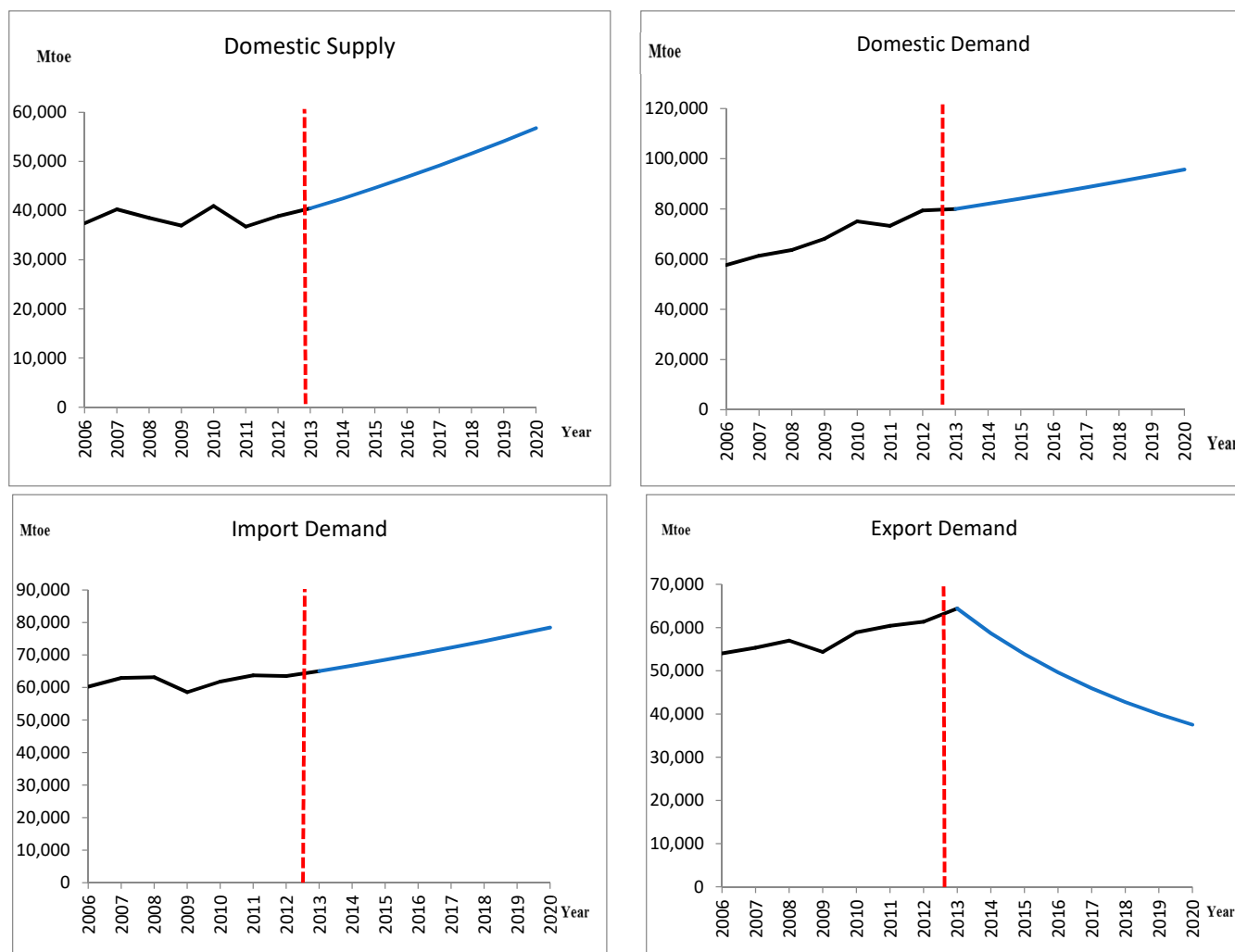
**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Data available in a publicly accessible repository that does not issue DOIs [https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg\\_cb\\_rw&lang=en](https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_cb_rw&lang=en) (accessed on 18 January 2021).

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

## Appendix A



**Figure A1.** Results of Domestic and International Bioenergy Markets in the EU Region from 2014–2020. Note: The black line referred to available data. The vertical line referred to the threshold between historical data and forecasted data. Source: Alsaleh et al. (2017).

## Appendix B

**Table A1.** List of European Union member states by accession.

European Union (EU28) Region			
Developed Countries (EU15)		Underdeveloped Countries (EU13)	
Member Countries	Year	Member Countries	Year
Austria	1995	Bulgaria	2007
Belgium	1958	Croatia	2013
Denmark	1973	Cyprus	2004
Finland	1995	Czech	2004
France	1958	Estonia	2004
Germany	1958	Hungary	2004
Greece	1981	Latvia	2004
Ireland	1973	Lithuania	2004
Italy	1958	Malta	2004
Luxemburg	1958	Poland	2004

Table A1. Cont.

European Union (EU28) Region			
Developed Countries (EU15)		Underdeveloped Countries (EU13)	
Member Countries	Year	Member Countries	Year
Netherlands	1958	Romania	2007
Portugal	1986	Slovakia	2004
Spain	1986	Slovenia	2004
Sweden	1995		
United Kingdom	1973		

Source: European Union Official Website ([www.Europa.eu](http://www.Europa.eu) (accessed on 18 January 2021)).

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