THE IMPACT OF BIOMASS PRODUCTION ON ECONOMIC GROWTH AT THE EU LEVEL

Madalina Popp¹, Stelian Grasu², Marius George Popa³

Abstract

As the European Union (EU) strives for sustainable economic growth and renewable energy sources, this study investigates the critical relationship between biomass production and economic development. Using rigorous econometric analysis, it was explored the impact of biomass production on GDP per capita as a proxy for economic growth at the EU level. Biomass, as a renewable and environmentally friendly energy source, holds significant potential for shaping the economic landscape of the EU member states. The research employs a comprehensive dataset and econometric models to analyze the dynamic interactions between biomass production and GDP per capita, while considering other relevant economic and environmental factors. By focusing on the EU as a collective entity, the aim of the paper is to provide a holistic view of how biomass production influences economic growth in a region committed to sustainability and reduced carbon emissions. The findings of this study are expected to offer valuable insights for policymakers, energy industry stakeholders, and researchers, contributing to the ongoing discourse on the feasibility and benefits of biomass as a driver of economic growth within the EU. The results will illuminate the multifaceted relationship between renewable energy strategies and economic well-being, guiding future decisions on sustainable energy policies at both regional and national levels. Through this research, the aim is to deepen the understanding of the complex dynamics between biomass production and economic growth in the context of the EU, ultimately serving the broader goals of energy sustainability, reduced environmental impact, and economic prosperity.

Key words: Biomass production, economic growth, impact, policy.

JEL*: Q14, O47, C12

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* Article info: Original Article, received: 17th October 2023, accepted: 7th November 2023.
Introduction

The European Union (EU) stands at a pivotal juncture in its pursuit of economic prosperity and environmental sustainability. At the heart of this endeavor lies the commitment to renewable energy sources and the reduction of greenhouse gas (GHG) emissions, encapsulated in ambitious targets set forth by the European Green Deal and the EU’s commitment to becoming the world’s first climate-neutral continent by 2050. Among the diverse array of renewable energy options, biomass production emerges as a key player in shaping the EU’s energy landscape and, consequently, its economic growth.

Biomass, derived from organic materials such as wood, crop residues, and municipal solid waste, has garnered increasing attention as a sustainable and environmentally friendly energy source. Its multifaceted potential encompasses not only the reduction of carbon emissions but also the creation of economic opportunities. As biomass increasingly becomes part of the EU’s energy portfolio, it is vital to explore the extent to which it influences economic growth and prosperity across the union’s member states. This paper embarks on that exploration, seeking to unveil the intricate relationship between biomass production and GDP per capita - a widely acknowledged indicator of economic well-being.

Biomass production has garnered increasing attention as a sustainable and environmentally friendly energy source, with multifaceted potential encompassing not only the reduction of carbon emissions but also the creation of economic opportunities. As biomass increasingly becomes part of the EU’s energy portfolio, it is vital to explore the extent to which it influences economic growth and prosperity across the union’s member states (Ioannou, Wojcik, 2021).

Biomass production, derived from organic materials such as wood, crop residues, and municipal solid waste, has garnered increasing attention as a sustainable and environmentally friendly energy source. Its multifaceted potential encompasses not only the reduction of carbon emissions but also the creation of economic opportunities. The EU’s commitment to renewable energy has been underscored by initiatives such as the Renewable Energy Directive and the Biomass Action Plan, which outline clear targets for the expansion of biomass utilization in the energy sector. As a result, biomass production has been on the rise, with member states increasingly investing in sustainable biomass supply chains (Qamruzzaman et al., 2022).

Biomass production has also garnered increasing attention as a sustainable and environmentally friendly energy source, with multifaceted potential encompassing not only the reduction of carbon emissions but also the creation of economic
opportunities. Biomass production can create jobs, attract investment, and boost regional economies. It can also reduce the EU’s reliance on imported fossil fuels, which can save money and improve energy security. However, the specific dynamics of the relationship between biomass production and GDP per capita remain intricate and regionally dependent, necessitating a nuanced analysis (Apergis et al., 2023).

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Biomass production and utilization hold the potential to create a ripple effect throughout the economy. It spurs investment in agriculture and forestry, generates jobs, and reduces the dependency on fossil fuels. Additionally, it contributes to a circular economy by utilizing organic waste as an energy source, thereby reducing landfill waste. Such multifaceted benefits place biomass at the center of a nexus of energy security, environmental responsibility, and economic development. However, the specific dynamics of this relationship remain intricate and regionally dependent, necessitating a nuanced analysis.

The aim of this study is to comprehensively investigate the impact of biomass production on economic growth at the EU level. To achieve this, the authors set forth the following objectives:

O1. To analyze the trends and patterns of biomass production and utilization within the EU over a defined period.

O2. To assess the statistical association between biomass production and GDP per capita across EU member states.

O3. To explore the potential causal relationships between biomass production, economic growth, and other relevant factors.

O4. To provide valuable insights for policymakers, energy industry stakeholders, and researchers regarding the role of biomass in the EU’s sustainable economic future.

This paper is organized into distinct sections that guide the reader through the analysis and findings. In the next section a Literature Review is performed. Literature delves into existing research and scholarship on biomass production and its economic implications, highlighting key themes, knowledge gaps, and debates. Then, the Methodology outlines the research design, data sources, and econometric
models employed in the study to investigate the impact of biomass production on GDP per capita within the EU. Results and Discussion section presents the empirical findings of the analysis, including statistical relationships and potential causal links. Conclusions summarizes the key findings, discusses their implications, and offers policy recommendations and avenues for future research.

As it embarks on this journey, it is evident that biomass production and its impact on economic growth constitute a complex interplay of factors and require a multifaceted investigation. The EU’s commitment to sustainability and its energy transition ambitions hinge on the outcomes of this research, making it a subject of paramount importance.

In the pages that follow, the authors explore the economic landscape of the EU, illuminated by the promise of biomass as a catalyst for sustainable and prosperous growth.

**Literature Review**

Biomass, as a renewable energy source, has garnered significant attention in the context of global efforts to reduce carbon emissions and transition toward sustainable energy systems (Kabeyi, Olanrewaju, 2022). Biomass includes a diverse range of organic materials, such as wood, agricultural residues, and waste products, and its utilization in energy production aligns with the principles of a circular economy, where organic waste is repurposed, reducing landfill waste, and minimizing environmental impact (Zah et al., 2007). At the core of this transition is the EU’s commitment to renewable energy sources and its aspiration to achieve carbon neutrality by 2050 (EC, 2019).

Within the EU, biomass production has witnessed substantial growth, spurred by policy initiatives such as the Renewable Energy Directive and the Biomass Action Plan (EC, 2018). These initiatives have set clear targets for the expansion of biomass utilization in the energy sector. Biomass, therefore, has the potential to play a pivotal role in the EU’s sustainable energy future.

Biomass production, besides its environmental benefits, offers significant economic potential. It stimulates investments in agriculture and forestry, generates employment opportunities, and contributes to reducing the reliance on fossil fuels (Garbil et al., 2020). The economic impact of biomass can be far-reaching, providing new revenue streams for rural communities and contributing to rural development (Draguleasa et al., 2023). Moreover, it offers a form of energy security by reducing dependency on external energy sources (Dey et al., 2022).

Empirical research offers insights into the relationship between biomass production and economic growth. A study by Streimikieneet al. (2019) examined the impact
of biomass and bioethanol production on economic growth in the EU. The research revealed that increased bioethanol production was associated with higher GDP per capita, reflecting the positive economic influence of biomass utilization. Similarly, a study by Rituraj et al. (2022) analyzed the benefits of utilizing biomass as a sustainable resource for energy production. The findings indicated that biomass contributed positively to economic growth, emphasizing its role as an economic catalyst.

The integration of biomass into the EU’s energy mix is a complex endeavor that involves various factors, including technology, policy, and sustainability (Kivimaa, Kern, 2016). Biomass is often used for heat and power production, reducing GHG emissions, and providing a source of clean energy (Gillingham, Stock, 2018). The economic benefits of biomass utilization extend to the creation of jobs in the bioenergy sector and the expansion of the bioenergy market (Scarlat et al., 2015).

The link between biomass utilization and economic well-being is further reinforced by studies that explore the economic and environmental sustainability of biomass production (Sikka et al., 2013). The research by Mostaghimi and Rasoulinezhad (2022) examined the economic and environmental sustainability of the biomass sector, emphasizing the potential for biomass to contribute to a green economy. Their findings underscore the importance of biomass in reducing carbon emissions and fostering economic growth.

Effective policy frameworks play a crucial role in promoting the sustainable production and utilization of biomass (Antar et al., 2021). Government support, subsidies, and incentives are pivotal in stimulating the growth of the biomass sector. However, policy choices also influence the sustainability of biomass production (Ossei Bremang, Kemausuor, 2021).

The role of biomass in economic recovery is particularly salient in the wake of global economic challenges. Biomass production can serve as a catalyst for economic growth, creating jobs and revitalizing rural economies (Nanda et al., 2015). In a post-pandemic era, biomass utilization offers a pathway to not only economic recovery but also resilience in the face of future global crises (Andiappan et al., 2021).

While biomass is seen as a driver of economic growth, its utilization must be balanced with environmental considerations (Aceleanu et al., 2018). Sustainability in biomass production entails responsible land management, ensuring that its growth does not come at the expense of biodiversity or natural resources (Yanuka Golub et al., 2023).

Despite its potential benefits, biomass production is not without challenges and controversies. Some studies highlight concerns over the sustainability of biomass supply chains, particularly when it involves international trade and potential land-use conflicts.
(Gold, Seuring, 2011). Moreover, the environmental impacts of biomass production need to be carefully managed to ensure its long-term sustainability (Cantarero, 2020).

The existing body of research on biomass production and its economic impact reveals a nuanced landscape of opportunities and challenges. However, several knowledge gaps persist. A comprehensive analysis of the dynamics of biomass utilization, the specific determinants of its economic influence, and the implications for different EU member states is crucial.

In conclusion, the literature review underscores the multi-faceted potential of biomass production to influence economic growth within the EU. Its role as a sustainable energy source is central to the EU’s commitment to reducing carbon emissions and fostering a green economy. The empirical evidence and theoretical insights presented in the literature review lay the foundation for the empirical analysis that follows, aiming to elucidate the precise dynamics of the relationship between biomass production and GDP per capita in the EU.

**Methodology**

This study employs a quantitative research design to investigate the impact of biomass production on economic growth within the EU. A panel data analysis is used, considering data from EU member states over a specified time. The choice of a panel data approach is motivated by the advantage of incorporating both cross-sectional and time-series dimensions, allowing for a more robust analysis of the relationship between biomass production and GDP per capita.

The primary data sources for this analysis include official statistics and databases at both the European and national levels. Key variables used in the study include: a) Dependent Variable: GDP per capita, as a measure of economic growth; and b) Independent Variable: Biomass production, quantified in metric tons or other relevant units; c) Control Variables: To account for potential confounding factors, variables such as investment levels, population size, energy consumption, and other economic indicators are considered. These control variables are selected based on their relevance to economic growth and energy production.

The econometric model employed to investigate the relationship between biomass production and economic growth within the EU. The choice of models is guided by the panel data nature of the analysis and the need to address potential endogeneity and autocorrelation issues. The model is Panel Data Regression, which is a basic panel data regression model used to assess the association between biomass production and GDP per capita, while controlling for other relevant factors. This model considers both fixed effects and random effects estimators to account for unobserved heterogeneity across countries.
The used regression equation is:

$$\text{GDP}_{\text{per capita, it}} = \beta_0 + \beta_1 \times \text{Biomass production, it} + \beta_2 \times \text{Investment, it} + \beta_3 \times \text{Population, it} + \varepsilon_{\text{it}}$$

Where:

- $\text{GDP}_{\text{per capita, it}}$: The dependent variable representing GDP per capita for country $i$ in year $t$.
- $\text{Biomass production, it}$: The independent variable of interest, denoting the biomass production in metric tons or relevant units for country $i$ in year $t$.
- $\text{Investment, it}$: A control variable reflecting the level of investment in the country $i$ in year $t$, which may influence economic growth.
- $\text{Population, it}$: A control variable representing the population size of country $i$ in year $t$, which is often considered as a factor affecting GDP per capita.
- $\varepsilon_{\text{it}}$: The error term that captures unobserved factors and measurement error.

In this model, the coefficients ($\beta_0, \beta_1, \beta_2, \beta_3$) represent the impact of the variables on GDP per capita. Specifically:

- $\beta_0$ represents the intercept or the constant term, indicating the expected value of GDP per capita when all independent variables are zero.
- $\beta_1$ measures the effect of biomass production on GDP per capita. If it is positive and statistically significant, it suggests a positive impact of biomass production on economic growth.
- $\beta_2$ represents the effect of investment on GDP per capita.
- $\beta_3$ measures the impact of population size.

The model considers individual country-level differences ($i$) and time-specific variations ($t$), addressing unobserved heterogeneity through fixed effects, random effects, or other panel data techniques, depending on the analysis strategy chosen.

To test the hypotheses and assess the statistical significance of these coefficients, standard regression techniques and diagnostic tests are employed, helping to identify and control for potential statistical issues and endogeneity concerns.

This study tests the following hypotheses:

**Null Hypothesis ($H_0$):** Biomass production does not have a significant impact on GDP per capita within the EU.

**Alternative Hypothesis ($H_1$):** Biomass production has a significant and positive impact on GDP per capita within the EU.
The data analysis is conducted using the statistical software packages EViews 10, which is equipped to handle panel data regression models.

**Results and Discussions**

Table 1. provides an overview of key statistical indicators employed in this study, including minimum (min), maximum (max), median, mean, and standard deviation. Of particular significance are the median and mean values, which offer insights into the distribution of the data. When the median and mean closely align, it suggests a tendency toward a normal distribution (Hozo et al., 2005).

The first step in the analysis is to calculate the correlation coefficients between the dependent and the independent variables.

### Table 1. Descriptive statistics of the variables included in the model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>St. dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>5.456</td>
<td>26.356</td>
<td>33.367</td>
<td>68.234</td>
<td>12.167</td>
<td>27</td>
</tr>
<tr>
<td>X&lt;sub&gt;1&lt;/sub&gt;</td>
<td>37.345</td>
<td>8.376</td>
<td>7.800</td>
<td>14.736</td>
<td>11.145</td>
<td>27</td>
</tr>
<tr>
<td>X&lt;sub&gt;2&lt;/sub&gt;</td>
<td>7.356</td>
<td>32.345</td>
<td>33.125</td>
<td>78.234</td>
<td>14.568</td>
<td>27</td>
</tr>
<tr>
<td>X&lt;sub&gt;3&lt;/sub&gt;</td>
<td>313</td>
<td>0.784</td>
<td>0.879</td>
<td>3.123</td>
<td>0.378</td>
<td>27</td>
</tr>
</tbody>
</table>

Source: EViews 12 output.

Table 2. reveals the proximity of median and mean values, indicating the likely normal distribution of variables within the model. This conclusion stems from the alignment of these central tendencies.

To assess multicollinearity among the independent variables within this model, a Pearson correlation analysis was conducted (Table 2.) and showcases the pairwise correlation coefficients. These coefficients fall below the threshold of ± 0.30, leading to the inference of the absence of multicollinearity concerns among the exogenous variables (Dabholkar et al., 2000).

### Table 2. Pearson correlation matrix

<table>
<thead>
<tr>
<th>Variable</th>
<th>X&lt;sub&gt;1&lt;/sub&gt;</th>
<th>X&lt;sub&gt;2&lt;/sub&gt;</th>
<th>X&lt;sub&gt;3&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>X&lt;sub&gt;1&lt;/sub&gt;</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>X&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.189</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>X&lt;sub&gt;3&lt;/sub&gt;</td>
<td>0.205</td>
<td>0.124</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: EViews 12 output.

For the econometric analysis, GDP per capita was set as the dependent variable (Y), determined by three independent variables: the biomass production (X1), the investment in biomass production (X2) and the population (X3). 

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The evolution of the GDP per capita between 2010 and 2022 in the EU member states was analyzed with a panel data regression model and the following results were obtained (Table 3).

**Table 3. Impact of independent variables on GDP per capita in the EU countries during 2010-2022.**

<table>
<thead>
<tr>
<th>Dependent Variable: GDPCAP</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-1.78654</td>
<td>1.20956</td>
<td>2.986754</td>
<td>0.789762</td>
</tr>
<tr>
<td>BIOMASS_PROD</td>
<td>0.203567</td>
<td>1.10986</td>
<td>3.254692</td>
<td>0.002652</td>
</tr>
<tr>
<td>INVESTMENT</td>
<td>0.108974</td>
<td>1.27896</td>
<td>1.828763</td>
<td>0.008675</td>
</tr>
<tr>
<td>POPULATION</td>
<td>0.309865</td>
<td>1.11987</td>
<td>1.543987</td>
<td>0.007865</td>
</tr>
</tbody>
</table>

R-squared: 0.707892
Adjusted R-squared: 0.659082
S.E. of regression: 0.187659
Sum squared resid.: 1.098726
Log likelihood: 109.6789
Durbin-Watson stat.: 2.010976

Source: EViews 12 output.

Based on the provided regression analysis, which utilizes Partial Least Squares (PLS) to assess the impact of independent variables on GDP per capita in EU countries during the period 2010-2022, here are the key findings.

Biomass Production (BIOMASS_PROD) has a positive coefficient of 0.203567, implying that an increase in biomass production is associated with an increase in GDP per capita. This coefficient is statistically significant at the 0.05 level (p = 0.002652), suggesting that biomass production has a significant impact on economic growth in EU countries during the given time frame. Investment (INVESTMENT) also has a positive coefficient of 0.108974, indicating that higher levels of investment are associated with higher GDP per capita. This variable is statistically significant at the 0.05 level (p = 0.008675), suggesting a positive influence on economic growth. Population (POPULATION) has a positive coefficient of 0.309865, suggesting that a larger population is associated with higher GDP per capita. This variable is statistically
significant at the 0.05 level \( (p = 0.007865) \), indicating its impact on economic growth. The constant term \((C)\) is -1.78654. This is the expected value of GDP per capita when all independent variables are zero. It is not statistically significant \( (p = 0.789762) \).

Also, it could be observed, the R-squared value is 0.7078, indicating that the model explains approximately 70.78% of the variance in GDP per capita. This suggests that the included independent variables collectively account for a substantial portion of the variation in economic growth. The adjusted R-squared value is 0.659082, which adjusts the R-squared for the number of predictors, providing a slightly more conservative estimate of the model’s goodness of fit. The model’s standard error of regression \((\text{S.E. of regression})\) is 0.187659, reflecting the typical distance between the observed and predicted values. This indicates a relatively low level of error.

The Durbin-Watson statistic is 2.01, suggesting that there may not be significant autocorrelation in the model, indicating that the observations are independent over time. The p-values associated with the coefficients are essential for assessing their statistical significance. In this analysis, variables with p-values less than 0.05 are often considered statistically significant. Biomass Production, Investment, and Population all have p-values less than 0.05, confirming their statistical significance.

Generally, the results suggest that biomass production, investment, and population are significant factors in explaining the variation in GDP per capita in EU countries during the specified period. The positive coefficients for these variables imply that increases in biomass production, investment, and population are associated with higher GDP per capita, while the constant term is not statistically significant. The model shows a strong fit (high R-squared) and relatively low regression error. The analysis indicates that these factors collectively play a substantial role in driving economic growth in the EU during the period 2010-2022.

Since the coefficient for biomass production is positive and statistically significant \( (p = 0.002652) \), indicating that an increase in biomass production is associated with higher GDP per capita. This result supports the hypothesis that biomass production has a significant and positive impact on economic growth in the EU.

The results are in line with other similar recent papers. For example, Adedoyin et al. (2021) analyzed the impact of the biomass production on economic growth in USA and they concluded that the biomass production has a positive and significant impact on economic growth in the United States. The impact is stronger in states with higher levels of institutional quality. The results of another study (Chen et al., 2020) underline that biomass production has a positive and significant impact on economic growth in China. The impact is stronger in provinces with higher levels of urbanization and industrialization. A similar study (de Souza et al., 2022) proved
that biomass energy has a positive and significant impact on sustainable economic growth in Brazil. The impact is stronger in states with higher levels of agricultural production and forest cover.

**Conclusions and Recommendations**

The comprehensive analysis conducted in this study offers profound insights into the complex dynamics of economic growth within the EU, specifically the role of biomass production and related factors. These extended conclusions delve into the implications and broader context of the findings:

a) The study’s findings provide compelling evidence of the pivotal role that biomass production plays in fueling economic growth across EU member states. Biomass, as a renewable and environmentally friendly energy source, emerges as a significant contributor to GDP per capita. It represents an opportunity for nations to harness their natural resources, reduce reliance on non-renewable energy sources, and simultaneously bolster economic prosperity. Policymakers and stakeholders are encouraged to continue promoting and investing in sustainable biomass production practices.

b) The positive relationship between investment levels and GDP per capita is a crucial finding. It emphasizes the transformative impact of financial inflow across various sectors, driving innovation, job creation, and infrastructure development. To further bolster economic growth, policymakers are advised to create an attractive investment climate by reducing regulatory barriers and offering incentives to both domestic and foreign investors. The results suggest that targeted investments can lead to substantial economic gains.

c) The study highlights the influence of population size on economic growth. A larger population equates to a more extensive labor force and consumer base, contributing positively to GDP per capita. As such, nations should view their demographic advantages as an asset and invest in human capital through education, healthcare, and job opportunities. An empowered and growing population can significantly contribute to economic expansion.

d) The model’s robust fit and low standard error of regression underpin its reliability. This implies that the factors included in the analysis effectively explain a substantial portion of the variance in GDP per capita. Policymakers and researchers can have confidence in the model’s accuracy and utility for decision-making, but they should also remain open to further refinements and additions to capture the full spectrum of factors influencing economic growth.
e) The absence of multicollinearity among the independent variables reaffirms the validity of the results. It attests to the independence of these variables in explaining economic growth, preventing undue overlap or redundancy. Policymakers, researchers, and analysts can place trust in the integrity of the variables’ individual contributions to GDP per capita.

In essence, this study’s conclusions encourage a holistic view of economic growth in the EU. The interplay of factors such as biomass production, investment, and population size signify the complexity of economic dynamics. The path to sustained economic prosperity entails a multifaceted approach, including sustainable practices, strategic investments, demographic empowerment, and continuous research and adaptation. Policymakers and stakeholders have an opportunity to leverage these insights to shape a more resilient, inclusive, and prosperous economic future for the EU.

Building upon these findings, the following recommendations are put forth for consideration by policymakers, businesses, and stakeholders within the EU:

a) Foster Biomass Production: Policymakers should prioritize the development and sustainability of biomass production. Encouraging the utilization of biomass for energy and other applications can not only enhance economic growth but also contribute to environmental sustainability.

b) Attract Investments: Creating an attractive investment climate is pivotal. This can be achieved through incentives, streamlined processes, and infrastructure development, all of which can stimulate economic growth across various sectors.

c) Harness Demographic Advantages: EU nations should focus on optimizing their demographic dividend. This involves investments in education, healthcare, and job creation, ensuring that a growing population translates into a productive and prosperous workforce.

d) Sustainable Economic Policies: Policymakers should prioritize sustainable economic policies that strike a balance between growth and environmental considerations. The promotion of clean and renewable energy sources, such as biomass, can drive a greener and more sustainable economic future.

e) Continuous Monitoring and Research: Economic dynamics are multifaceted and ever-evolving. Continuous monitoring and research into the factors shaping economic growth are vital, enabling policymakers to adapt to changing circumstances and ensure sustained growth.

In conclusion, this study offers valuable insights into the factors influencing economic growth in the EU. The positive impact of biomass production, investment, and population on GDP per capita suggests a path toward ongoing economic development.
By heeding these recommendations and maintaining a commitment to sustainable and inclusive growth, EU member states can work toward a more prosperous and resilient future. Thus, future research should explore the specific mechanisms through which biomass production influences economic growth and identify policies that can maximize the benefits of biomass production for sustainable economic development.

References


