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An Empirical Analysis of Relationships between Forest Resources and Economic and Green Performances in the European Union

Anca Antoaneta Vărzaru [1] and Claudiu George Bocean [2,*]

[1] Department of Economics, Accounting and International Business, Faculty of Economics and Business Administration, University of Craiova, 13 AI Cuza Street, 200585 Craiova, Romania; anca.varzaru@edu.ucv.ro
[2] Department of Management, Marketing and Business Administration, Faculty of Economics and Business Administration, University of Craiova, 200585 Craiova, Romania
* Correspondence: claudiu.bocean@edu.ucv.ro; Tel.: +407-2629-9522

Abstract: The growing concern for environmental sustainability drives efforts toward balancing economic growth with responsible resource management. Forests represent invaluable green assets central to combating climate change and supporting biodiversity. This research investigates the intricate interaction between forest resources and economic and green performances within the European Union (EU). The European Union, as a conglomerate of diverse member states with varying forest endowments and economic contexts, provides a rich framework for examining these connections. This paper applies structural equation modeling (SEM) and cluster analysis to a dataset collected from Eurostat. This study's empirical findings underscore the multidimensional relationship between forest resources and green and economic performances. The findings reveal significant positive relationships between economic and green performances and forest resources and a negative relationship between greenhouse gas (GHG) emissions and forest resources, implying a decline in GHG while green and economic performances increase. Cluster analysis identifies distinct groups of EU countries exhibiting similar profiles concerning forest management and economic and green performances. The cluster analysis results highlight the necessity for tailored strategies and policy benchmarking that acknowledge the heterogeneity of EU member states and their unique combinations of forest resources, economic structures, and ecological commitments.

Keywords: forest resources; economic performance; green performance; GHG; European Union

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1. Introduction

Research on the intricate relationships between forest resources, economic performance, and environmental sustainability has evolved in an era marked by increasingly evident climate changes and growing concerns about environmental conservation. In the current global context, where environmental concerns and sustainable development have become focal points of the international agenda, the European Union (EU) has solidified its commitment to address these issues in an integrated and holistic manner.

Forest resources, with their entire biological and functional diversity, are crucial in maintaining ecological balance at European and global levels [1]. They significantly contribute to carbon dioxide absorption, hydrological regulation, biodiversity conservation, and habitat provision for numerous species. However, alongside these ecological benefits, forests and their resources hold substantial economic significance. The forest industries provide essential raw materials that contribute to job creation and generate substantial revenue within national economies and the global market [2]. Forest resources are vital to terrestrial ecosystems, significantly impacting the environment and the economy. Simultaneously, economic performance and sustainable development are essential objectives

within contemporary societies. Nevertheless, the interdependencies between these aspects have grown increasingly complex and pivotal for our planet.

In the European Union, these interactions have become subjects of intensive research and integrated policies. The EU has adopted ambitious strategies to combat climate change and preserve biodiversity, recognizing the importance of forests in achieving these goals [3]. Consequently, there is a pursuit to create synergy between environmental protection, economic development, and societal well-being. The European Union is actively engaged in a concerted effort to establish a profound synergy among environmental protection, economic progress, and enhancing the quality of life for its citizens. This strategic approach reflects a broader vision of harmonizing environmental stewardship with the imperative of fostering economic growth, all while ensuring the well-being and satisfaction of its diverse population.

EU member states have a remarkable diversity in forest resources, economic circumstances, and ecological commitments. Some countries within the EU possess vast forested areas, while others have limited resources. Economic situations also differ significantly, ranging from highly industrialized economies to those heavily reliant on agriculture and traditional sectors. Furthermore, individual states within the EU may have distinct ecological commitments and priorities.

Sustainable forest management is essential for sustainable development at all levels [4]. Forest resources hold significant importance for economic performance and constitute a vital component concerning the green performance of an economy [5]. In this context, efficient forest management must attain multiple objectives, including maintaining forest production and regeneration capacity and conserving biodiversity and ecology [6]. Sustainable forest management extends beyond economic aspects, involving a holistic approach that accounts for forest ecosystems' manifold functions and benefits [5]. For instance, forests provide timber and materials, regulate hydrological cycles, prevent soil erosion, offer habitats for biodiversity, and contribute to capturing and storing atmospheric carbon. Consequently, sustainable forest management has profound implications for the environment, society, and economy [6].

Ongoing climate changes present a global challenge that has garnered significant attention from governments, leading to the initiation of actions for circular and green economies with reduced emissions. Forest resources are critical in achieving a sustainable economic performance that enables a good green performance [2]. Forest resources, including their carbon capture capacity, play a role in pollution control. They are renewable natural resources of the planet, pivotal in economic development and the conservation of the natural ecosystem [7,8]. Over time, researchers have conducted studies on climate changes affecting forest resources. These resources, in turn, influence significant climate changes due to extensive deforestation worldwide to meet the elevated demand for wood products driven by the economic growth of developed and developing countries and the rapid urbanization of a growing population. Consequently, global forest resources have continually decreased [9–12].

This article aims to explore and analyze these intricate connections in the European Union context, providing robust empirical evidence. This study contributes significantly to understanding the complex relationships between forest resources, the economy, and environmental sustainability within the EU, addressing this research gap. Given this multifaceted landscape, it is imperative to investigate and comprehend these intricate relationships within a comprehensive and adaptable framework. This approach allows for tailored strategies considering each member state's specific characteristics and needs, fostering a harmonious balance between environmental preservation, economic prosperity, and societal well-being across the European Union.

This paper's structure includes a literature review after an introduction. Afterward, this paper exposes the research methodology, and Sections 4 and 5 present results and discussions. The conclusions summarize the findings of the research.

2. Theoretical Framework and Hypothesis Development

Forest resources are a crucial source of production materials, critical in driving economic growth [13–16]. The academics [7,16–20] assert that forest resources are affected by socioeconomic factors, such as economic growth, population growth, the urbanization rate, and environmental protection policies. Pursuing economic performance significantly negatively impacts forest resources, while pursuing green performance influences them positively [21,22]. Balancing forest management sustainably and equitably is crucial to aligning economic needs with conserving the natural environment and protecting biological diversity.

The transformation of industrial structures driven by environmental protection imperatives yields benefits for efficient resource utilization and optimized production technologies [23]. Prevailing research predominantly focuses on the effects of environmental policies or ecological regulations [24–26], while research concerning the relationships between economic and green performances and forest coverage remains relatively limited [27]. Various researchers [28,29] have indicated that environmental protection policies aiming at reducing GHG emissions can lead to increased pollution emissions, as these policies are structured to transfer costs into the future, accelerating fossil energy exploitation and diminishing the effectiveness of GHG reduction [30]. GHG reduction strategies in developed countries can also lead to the offshoring of emissions [31]. This phenomenon highlights the importance of taking a holistic approach to addressing climate change.

The concept of a low-carbon economy is built upon implementing technological innovations and institutional reforms aimed at transforming industrial and energy production processes, reducing dependency on fossil fuels, and promoting a mutually beneficial relationship between economic growth and environmental protection. Forest resources are a crucial vector for achieving circular and green economies, improving quality of life, and combating CO_2 emission pollution through carbon capture functions. Forest resources are essential natural assets that shape sustainable economic growth worldwide [32,33]. Simultaneously, uncontrolled economic growth reduces forest resources, contributing to a pronounced increase in GHG emissions [34].

The potential impact of forest-based carbon sequestration through various forestry-related emission reduction activities, such as afforestation, reforestation, forest conservation, and sustainable forest management, and their efficiency relative to costs could play a significant role in environmental sustainability by reducing global greenhouse gas (GHG) emissions at a lower cost compared to other GHG reduction technologies. This concept is supported by recent studies such as that conducted by Begum et al. [35,36]. Thus, proactive measures in the forestry sector can yield a considerable impact in reducing GHG emissions and subsequently mitigating the impact of climate change.

In examining the relationship between forest resources and economic growth, indicators such as deforestation, the forest area, the forest coverage rate, the timber production or timber stock volume, GDP per capita, geographic characteristics, and political factors have been used as indicators for economic performance [11,16,19,37–39].

This study's first hypothesis is grounded in the relationship between forest resources, represented by the forested area in each EU state, and economic and green performances, represented by the GDP per capita and the SDG Index for each EU state:

Hypothesis 1 (H1). *Economic and green performances and forest resources have a significant positive relationship.*

Economic performance refers to assessing a country, region, or organization's success in achieving its economic objectives and goals. It is typically measured using various economic indicators, with Gross Domestic Product (GDP) being one of the most common. Green performance focuses on evaluating an entity's actions and outcomes regarding environmental responsibility and sustainability. Green performance aims to minimize adverse environmental impacts and enhance ecological sustainability. In our paper, green

performance is represented by the orientation towards sustainability illustrated by the SDG score. The SDGs encompass various economic, social, and environmental objectives to create a more sustainable and equitable world by 2030. The Sustainable Development Goals Index score (SDGi) is a valuable tool to assess a country's progress in achieving the United Nations' 17 Sustainable Development Goals. The SDG Index score involves systematic goal and indicator selection, data collection and processing, and applying statistical and mathematical techniques.

The conceptual model is presented in Figure 1.

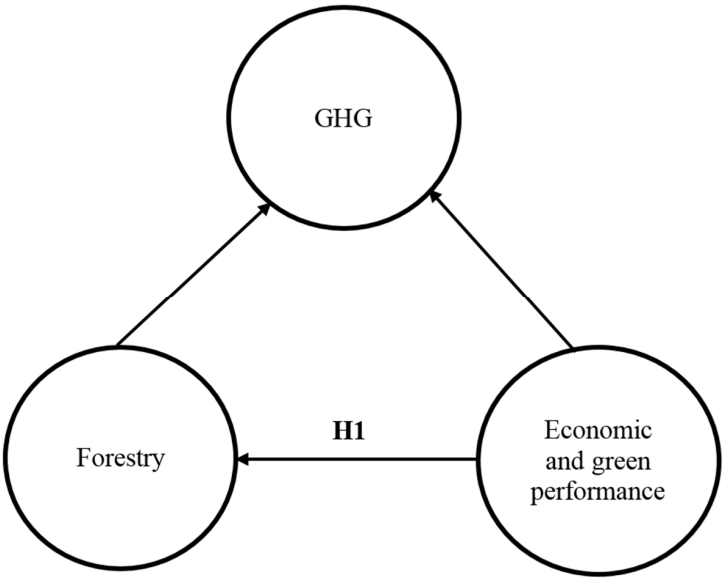

Figure 1. Theoretical model. Source: authors' design.

The paradox of increasing GHG emissions is typically analyzed from the perspective of harm to the biosphere. Halicioglu [40] and Magazzino [41] highlight that the real GDP drives energy consumption and CO_2 emissions, findings validated by recent studies [42–45]. Climate change and environmental degradation impact economic sustainability [3,46–48], generating potential negative implications of climate change on economic activity and affecting the population welfare. Managing climate risks at the EU level necessitates proactive management based on identifying relationships between economic and green performances, GHG emissions reduction, and forest resource coverage—the most significant CO_2 catcher [49]. The literature offers various approaches and hypotheses regarding the relationship between economic growth and environmental pollution [3].

The OECD has proposed decoupling economic growth from resource consumption and environmental pollution to address the challenges of climate change while improving the overall well-being of societies [50–52]. Economic growth places more significant pressure on the environment and resource consumption to achieve sustainable economic growth, allowing good economic and green performances [53]. Sustainable economic growth seeks to harmonize economic and green performances by ensuring economic development is carried out to respect the environment, promote social well-being, and maintain long-term viability. This approach is increasingly seen as a critical strategy for addressing the dual challenges of economic development and environmental sustainability in the modern world.

Though numerous studies analyze the dynamics of the relationship between growth and CO_2 emissions, few focus on the EU countries [3]. Therefore, research is a gap that must be addressed to support the development of specific strategies for each country concerning forest resources and economic and green performances.

Based on the findings of previous empirical research, we formulated the second hypothesis of the study:

Hypothesis 2 (H2). *EU countries can be grouped into homogeneous clusters based on forest area, economic performance, green performance, and GHG emissions variables.*

3. Materials and Methods

The methodology in this study employed a robust and comprehensive analytical approach tailored to identify connections between forest resources, economic performance, and environmental sustainability within the European Union. This multifaceted approach incorporated two essential analytical techniques: structural equation modeling and cluster analysis.

Structural equation modeling (SEM) is a powerful tool for unraveling the intricate relationships between forest resources, economic performance, and environmental sustainability. It provided a systematic framework for identifying and quantifying direct and indirect associations among selected factors. Structural equation modeling has proven to be a valuable and versatile tool, and its application extends to numerous other studies within the field of forestry. Many scholarly articles and research endeavors in forestry have harnessed the power of SEM to explore complex relationships and interactions relevant to forest management and environmental sustainability [54,55]. This method's versatility suits it to analyze the multifaceted dynamics between forest resources, ecological factors, economic considerations, and environmental outcomes [56,57]. Appendix A (Table A1) exposes a literature summary table on the relationships among the key variables used in SEM.

In parallel, cluster analysis added a layer of insight to this study. By applying cluster analysis, this research aimed to discern patterns, similarities, and differences among the diverse member countries of the EU. This approach involved grouping countries with comparable profiles based on various characteristics, including their forest resources, economic performance, and environmental performance. Cluster analysis has demonstrated its relevance and utility in forestry research, and its use extends to numerous other scholarly investigations [58–60]. In forestry research, cluster analysis has proven invaluable for categorizing and understanding the diversity and similarities among forest ecosystems, management practices, and ecological settings. Researchers have found it particularly useful for grouping regions or forests with similar profiles based on various characteristics, such as tree species composition, ecological factors, management strategies, and environmental impacts [58,60].

The results of our analysis can reveal specific peculiarities and nuances in the relationships between forest resources, economic performance, and environmental sustainability within these unique country clusters. They allowed for a comparative examination of how different groups of countries tackled these challenges and capitalized on opportunities, highlighting best practices and policy approaches that might be tailored to each cluster's specific needs. Ultimately, this dual-pronged analytical and spatial approach provided a comprehensive and nuanced understanding of the complex dynamics within the EU, enabling more informed decision making and policy formulation in environmental protection, economic development, and forest management.

Table 1 presents the research variables.

Table 1. Selected variables.

Variable	Dataset	Measure
FOR_AREA	Forest area	Percentage of land area
GHG	Greenhouse gas emissions intensity	Index, 2000 = 100
GDPc	GDP per capita in PPS	Volume indices of real expenditure per capita (in PPS_EU27_2020 = 100)
SDGi	SDG Index score	Aggregate score (1–100)

Source: Authors' design based on collected data from Eurostat.

These data covered the European Union member countries, facilitating a comprehensive analysis at the regional level. Collecting and processing these data revealed the existing patterns and trends concerning the relationships between forest resources, economic performance, and environmental sustainability.

4. Results

Partial Least Squares Structural Equation Modeling was employed using SmartPLS v3.0 (SmartPLS GmbH, Oststeinbek, Germany) to investigate the H1 hypothesis (Figure 2).

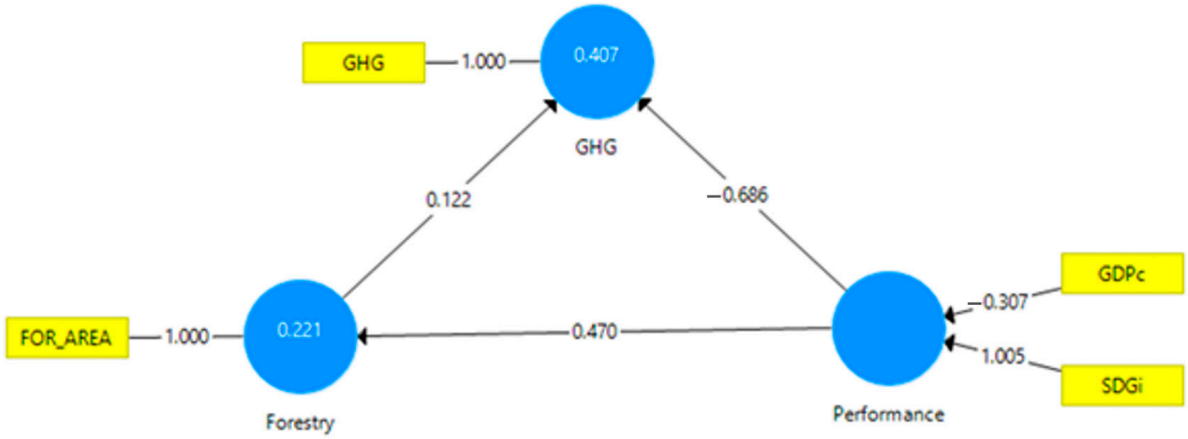

Figure 2. Empirical model. Source: Authors' design based on data using SmartPLS v.3.0.

The latent variables are forestry, economic and green performance, and GHG level. The economic and green performance is a latent variable determined by two observable variables: GDP per capita in PPS and SDG Index score. GHG is a latent variable determined by an observable variable, greenhouse gas emissions intensity, while forestry is a latent variable determined by an observable variable, forest area (% of land area). The model exhibits good fit indices (SRMR 0.037 and NFI 0.980). The formative model should not display excessive multicollinearity of indicator variables, according to Hair et al. [61]. Multicollinearity may be problematic if the variance inflation factor (VIF) exceeds 5 (Table 2).

Table 2. Multicollinearity.

	VIF
FOR_AREA	1.000
GDPc	1.029
GHG	1.000
SDGi	1.029

Source: Authors' design based on data using SmartPLS v3.0.

Table 3 exposes the total effects recorded between latent variables by running a basic bootstrapping procedure with a bias-corrected, two-tailed 0.05 significance level using SmartPLS 3.0.

Table 3. Specific indirect and total effects.

	Original Sample	Sample Mean	Standard Deviation	T Statistics	*p* Values
Forestry → GHG	0.122	0.190	0.257	0.476	0.317
Performance → Forestry	0.470	0.494	0.251	1.876	0.030
Performance → GHG	−0.629	−0.606	0.192	3.268	0.001

Source: Authors' design based on data using SmartPLS v.3.0.

The empirical model confirms the validity of the H1 hypothesis. There is a significant relationship between forest resources and economic performance and countries' orientation towards green performance. While the positive impact of economic and green performance on the GHG level provides robust values, forest resources do not have a significant influence on the GHG level (p-value > 0.05) due to predominant factors, such as industrial activity, transportation, and livestock farming, whose significant effects cannot be countered solely by carbon capture by forested areas. The relationships from Table 3 confirm the validity of the H1 hypothesis. There is a significant relationship between forest resources and economic and green performance.

To investigate the H2 hypothesis, we used cluster analysis. The method used was Ward linkage with a squared Euclidean distance interval. Figure 3 presents the resulting dendrogram (SPSS v.27., IBM Corp., Armonk, NY, USA).

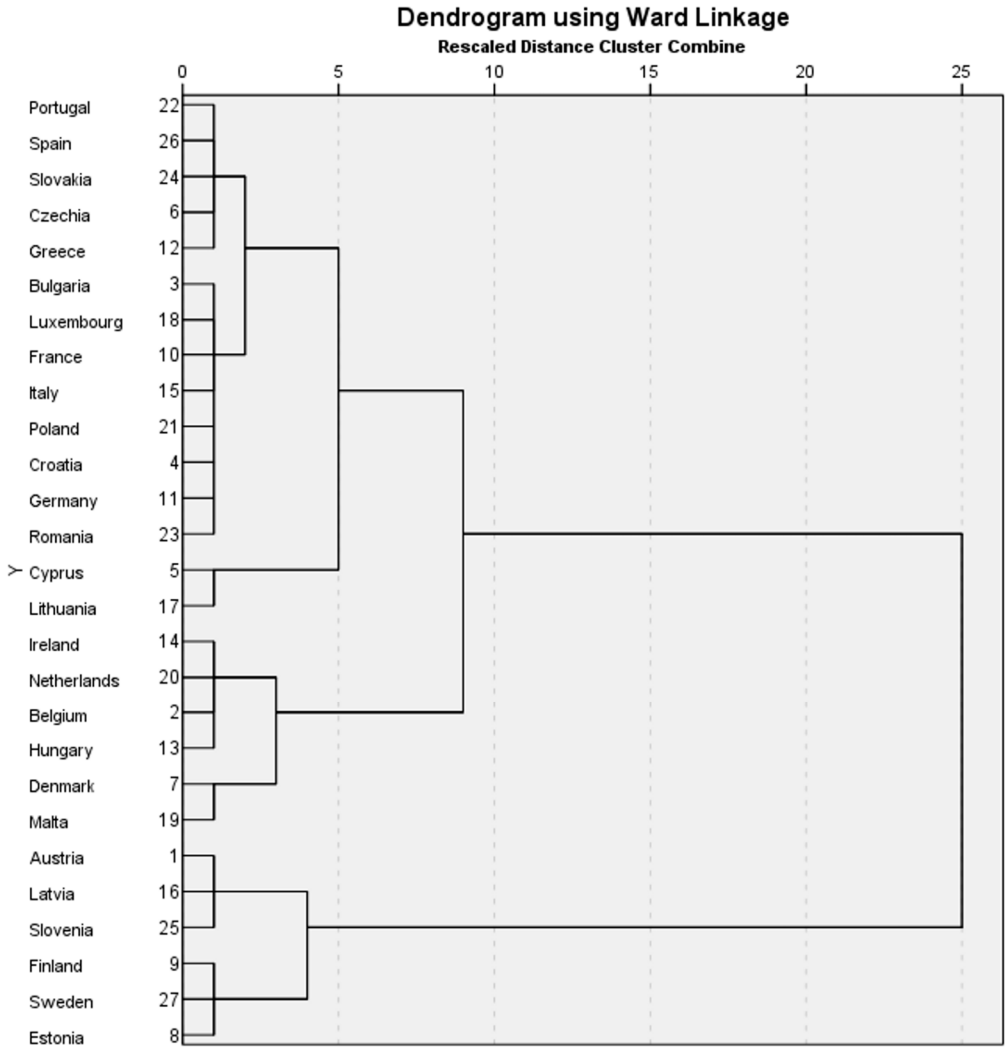

Figure 3. Dendrogram. Source: Authors' design based on data using SPSS v.27.

Cluster A comprises countries with a high level of forest area (Table 4).

The values in this cluster range from 47.25% to 73.73% in forest areas. The forest area mean for these countries is approximately 60.50%, while the EU mean is significantly lower at 39.45%. These data suggest that the countries in the analyzed cluster have a higher forest coverage than the EU mean. Despite their robust economic performance, these countries exhibit lower GHG emissions than the EU mean. The GDP per capita records higher mean values in these countries (101.33) than the EU mean of 90.13. The lower pollution levels and the maintenance of the high forest coverage can also be explained by their orientation

towards sustainability, with these countries achieving values (82.43) above the EU mean (80.05). Countries in this cluster exhibit a higher forest coverage, lower GHG emissions, good economic performance, and relatively strong performance in achieving sustainable development goals compared to the EU mean. These observations can provide relevant insights for assessing the environmental impact, economic development, and progress toward sustainable development goals in that region.

Table 4. Cluster A.

	FOR_AREA	GDPc	GHG	SDGi
Austria	47.25	125	81.6	82
Latvia	54.81	72	81.0	80
Slovenia	61.47	89	87.4	80
Finland	73.73	114	65.3	86
Sweden	68.70	122	69.0	85
Estonia	57.04	86	64.5	81
Cluster A mean	60.50	101.33	74.80	82.43
UE mean	39.45	90.13	79.65	80.05

Source: Authors' design based on data using SPSS v.27.

Cluster B encompasses countries with mean forest area values (Table 5).

Table 5. Cluster B.

	FOR_AREA	GDPc	GHG	SDGi
Portugal	36.15	76	76.3	79
Spain	37.18	83	76.7	80
Slovakia	40.06	72	73.4	79
Czechia	34.68	93	70.3	80
Greece	30.27	62	72.7	77
Bulgaria	35.86	55	88.2	74
Luxembourg	34.45	261	86.8	76
France	31.51	105	79.7	81
Italy	32.35	94	80.3	79
Poland	30.98	76	82.3	80
Croatia	34.65	65	86.9	79
Germany	32.68	123	84.5	82
Romania	30.12	73	85.6	78
Cyprus	18.67	90	101.0	74
Lithuania	35.15	88	104.2	75
Cluster B mean	32.98	94.40	83.26	78.13
UE mean	39.45	90.13	79.65	80.05

Source: Authors' design based on data using SPSS v.27.

The forest area mean for these countries is approximately 32.98%, while the EU mean is 39.45%. These data indicate that most countries in this cluster have lower forest coverage than the EU mean. This cluster is relatively heterogeneous regarding economic performance, including countries with solid performances above the European Union mean (such as Luxembourg, Germany, France, Italy, Spain, and Czechia) and countries with lower economic performances (such as Bulgaria, Croatia, and Greece). GHG emission levels are generally higher in these countries (83.26%) compared to the EU mean of 79.65%. These levels can be explained by lower forest areas and a poor green performance, as the SDG Index score values vary between 74 and 82, with a mean of 78.13, below the EU mean (80.05). Countries in this cluster have a lower forest coverage, relatively good economic performance, higher GHG emissions, and weak green performance.

Cluster C includes countries with the lowest forest area values (Table 6).

Table 6. Cluster C.

	FOR_AREA	GDPc	GHG	SDGi
Ireland	11.35	205	81.5	81
Netherlands	10.97	130	86.5	80
Belgium	22.76	119	84.9	80
Hungary	22.50	74	76.1	79
Denmark	15.71	133	61.6	85
Malta	1.44	98	68.6	77
Cluster C mean	14.12	126.50	76.53	80.20
UE mean	39.45	90.13	79.65	80.05

Source: Authors' design using SPSS v.27.

The forest area values in this cluster spread from 1.44% to 22.76%. The forest area mean for these countries is approximately 14.12%, significantly lower than the EU mean of 39.45%. These data suggest that countries in this cluster have minimal forest coverage compared to the EU mean. The reduced forest coverage in these countries may be attributed to specific geographical factors. These countries achieve excellent economic performances (excluding Hungary). GHG emission levels per production unit are generally moderate in these countries (76.53) compared to the EU mean (79.65), which is potentially explained by their relatively good green performance around the EU mean. Despite having a shallow forest coverage, these countries' good economic and green performance leads to moderate GHG emissions.

The data in Tables 4–6 indicate substantial differences among countries concerning forest areas, economic and green performance, and GHG levels. These differences enable the grouping of countries into relatively homogeneous clusters, which can form the basis for establishing sustainable economic development strategies. In conclusion, the H2 hypothesis is valid, as EU countries can be grouped into homogeneous clusters based on forest area, economic performance, green performance, and GHG emissions.

5. Discussion

In the current context of climate change, forests have become even more relevant as they have the potential to contribute to capturing and storing carbon from the atmosphere significantly. This result can be achieved by implementing effective management practices like afforestation and reforestation, which can counteract carbon emissions and contribute to sustainable climate change mitigation. Forest management supports economic development and promotes environmental conservation and ecological balance to serve current and future generations.

Some researchers argue for a negative correlation between abundant natural resources and economic growth [62,63]. However, there is a positive relationship between forest resources and green performance, enabling the sustainable development of a country [64]. Green economic growth entails harmonizing economic progress with environmental protection [65]. Researchers propose various measures for assessing green performance [66,67]. We used the SDG Index calculated at the country level for the green performance of an EU member state.

This paper aims to explore and analyze these intricate connections within the European Union context, providing robust empirical evidence. In this study, we selected the countries of the European Union that have considerable heterogeneity in terms of forest resources. The investigation of the H1 hypothesis focuses on a significant relationship between forest resources and economic performance and green performance in EU member states. This hypothesis suggests an interconnection between the efficient management of forest resources, a country's economic performance, and its contributions to environmental sustainability and ecological protection. Following the investigation of the H1 hypothesis, we can assert a positive relationship between forest resources and economic performance ($\beta = 0.470$, p-value < 0.05), given that forests provide essential resources for the timber industry and related economic activities.

Thus, countries with a strong foundation of forest resources could benefit from sustainable economic development, generating employment, GDP growth, and exports. Sustainable forest management can contribute to economic growth through the timber industry, eco-tourism, and non-timber forest products. While not strictly causal, there is a clear link between the two, influenced by how forest resources are managed. Our findings are in line with those of Martinho and Ferreira [5], Wu et al. [11], and Barañano et al. [2]. An enhanced understanding of the relationships between forest resources and economic and green performance can guide governmental decisions regarding forest conservation and sustainable management and promote their efficient utilization to maximize economic and ecological benefits [34]. Countries with a strong SDG orientation often prioritize the conservation and sustainable management of their forest resources as part of their broader development strategy.

Forests are crucial in carbon sequestration, maintaining balance in the global carbon cycle [49,51]. Adequate afforestation and reforestation efforts can counterbalance the loss of natural forests and contribute to increased biodiversity and the protection of species' natural habitats. Conserving existing forests and their sustainable management encourage carbon sequestration and prevent deforestation and degradation, reducing GHG emissions. Forest resources are essential in combating climate change and promoting environmental sustainability. Through carbon sequestration activities like afforestation, reforestation, and forest conservation, it is possible to reduce global GHG emissions with relatively low costs, contributing to global environmental protection efforts and climate change mitigation.

While forest resources can play a crucial role in carbon absorption and GHG emissions reduction, it is essential to understand that addressing these issues cannot be limited solely to this aspect. A comprehensive approach is needed to address all economic sectors responsible for GHG emissions and promote sustainable economic development aligned with environmental protection objectives.

The empirical model used in this study confirms the H1 hypothesis, underscoring the importance of the relationships between economic performance, green performance, and GHG emissions levels ($\beta = -0.629$, p-value < 0.05) within the European Union. Although economic and green performance notably contributes to lowering greenhouse gas (GHG) emissions, forest resources, in contrast, do not exert a significant influence on GHG levels (p-value > 0.05). This lack of significant impact is attributed to dominant factors, like industrial activity, transportation, and livestock farming, which outweigh the capacity of forested areas to counteract their significant emissions.

The investigation of the H2 hypothesis explores the possibility of clustering EU member countries into homogeneous groups based on key features, like forest area, economic performance, green performance, and greenhouse gas emissions (GHG). The cluster analysis results confirm this hypothesis by identifying distinct groups of countries with similar characteristics in these domains, consistent with the findings of other researchers [3,5,42,49]. Cluster A comprises countries with high forest coverage (60.50%). This aspect is associated with lower GHG emissions (74.80), as forests absorb carbon. While the economic performance (GDPc = 101.33) is strong, pollution levels are low. These countries excel in achieving sustainable development goals (SDGi = 82.43). Cluster B encompasses countries with moderate forest area values (32.98). This cluster exhibits greater diversity in terms of economic performance, including countries with above-mean performances (such as Luxembourg, Germany, France, Italy, Spain, and Czechia) and those with weaker economic performances (such as Bulgaria, Croatia, and Greece). GHG emissions (83.26) are generally higher in these countries than the EU mean, possibly due to a lower forest coverage and weak green performance. Cluster C includes countries with the lowest forest area values (14.12). This cluster presents an excellent economic performance (GDPc = 126.50), excluding Hungary and Malta. Moderate levels of GHG emissions (76.53) can be explained by a relatively good green performance. While Cluster C is characterized by a shallow forest coverage, its economically solid and relatively good green performance (SDGi = 80.20) contributes to moderate GHG emissions.

In conclusion, the results validate the H2 hypothesis. This study demonstrates that EU countries can be grouped into homogeneous clusters based on forest area, economic performance, green performance, and greenhouse gas emissions. These findings can provide crucial insights for assessing the environmental impact, economic development, and progress toward sustainable development goals in the region [12]. The significant differences among the identified clusters provide the foundation for formulating strategies for sustainable economic development. By identifying homogeneous clusters, this approach can offer new perspectives and guidance for sustainable development in the region.

As climate change poses a significant challenge, forests are becoming increasingly vital in mitigation efforts. Forests play a crucial role in sequestering carbon dioxide, a significant GHG. When forests are cleared or degraded, carbon stored in trees is released into the atmosphere, contributing to higher GHG emissions. Their capacity to capture and store atmospheric carbon through photosynthesis and incorporate carbon into biomass is critical in reducing greenhouse gas concentrations [40–43,68]. Forest management activities, such as afforestation, reforestation, and conservation, can significantly contribute to climate change mitigation by creating carbon-neutral or carbon-negative sources. Thus, besides its economic and social benefits, sustainable forest management is essential in environmental conservation and climate change mitigation [7,26]. Furthermore, it necessitates close collaboration among decision makers, local communities, the forestry industry, and researchers to find innovative and efficient solutions for forest management that balance developmental requirements with environmental protection, leading to reduced GHG emissions.

5.1. Theoretical Implications

Our study significantly contributes to forest resource–economic and green performance relationships at the European level. By applying structural equation modeling and cluster analysis to European Union data, we highlight relevant theoretical aspects regarding the complex interdependencies between these critical factors. The results underscore the need for an integrated approach to evaluate the relationships between natural resources, economic development, and environmental sustainability. This finding confirms the importance of theories advocating that the long-term success of an economy is closely tied to responsible natural resource management.

This study highlights that the relationship between forest resources and economic and green performance is not unidirectional. Forest resources can influence economic performance through multiple pathways, and a focus on sustainable performance leads to increased forest resources, adding theoretical complexity to understanding the connections between these variables. Our research emphasizes the importance of tailoring strategies to each country's particularities. This theoretical perspective recognizes the diversity of national contexts and the need for customized approaches to managing forest resources and promote sustainable development. The theoretical implications of this study extend beyond empirical analysis, providing a solid theoretical foundation for understanding the complex interactions between forest resources, economic performance, and environmental sustainability. These implications have the potential to influence the evolution of theories and approaches in the fields of sustainable development and green economics.

5.2. Practical and Managerial Implications

This study highlights significant practical implications for policymakers, decision makers, and practitioners in sustainable development and environmental conservation within and beyond the European Union. These implications can guide the direction of decision making and future strategies.

Our findings emphasize the need to tailor policies according to the specificities of each EU member country. Development policies and strategies must account for the diversity of local contexts, available forest resources, and specific economic characteristics. This tailored approach is essential to ensure that policies are relevant and effective in addressing each member state's unique challenges and opportunities. Moreover, this study

underscores the multifunctional potential of forests, which can simultaneously support economic growth and environmental conservation where geographical characteristics allow. Forests are pivotal in carbon sequestration and biodiversity preservation, making them critical assets in achieving sustainability goals. Responsible forest resource management can help mitigate climate change by reducing greenhouse gas emissions and positively impacting economic performance.

The practical implications suggest fostering collaboration between economic sectors and academia to create sustainable development models that leverage forest resources for the expected benefits to communities and the environment. By bringing together various stakeholders, including associations of producers, researchers, and policymakers, we can develop comprehensive strategies that harness forests' full potential in advancing economic and environmental objectives.

This study's results offer valuable insights for designing and implementing policies that address the unique challenges faced by each EU member country, promote sustainable forest resource management, and facilitate cross-sector collaboration to achieve the dual goals of economic growth and environmental conservation.

5.3. Limitations and Future Research

This study provides empirical insights to guide more efficient and sustainable stakeholder decision making. However, certain limitations were identified during this study. Our analysis relied on European-level data, and the level of data detail can vary between countries. This study is exploratory, and the potential for generalizability is limited. The findings of our paper can serve as a foundation for more targeted research that delves deeper into the specific relationships within distinct country clusters or regions, thereby yielding more nuanced insights.

While we used structural equation modeling and cluster analysis to examine relationships between forest resources and economic and green performance, we can explore other statistical methods and analytical approaches to validate and extend our results. As for future research, conducting more detailed comparative analyses among EU member countries could provide a better understanding of differences in approaches and the impact of local factors on the investigated relationships. Further research could consider other variables that illustrate economic and green performances (not only GDP per capita and SDG Index) and explore how socio-cultural and legislative factors influence the relationships between forest resources and economic and green performances. Such research could contribute to a deeper understanding of these relationships and offer more detailed insights for sustainable development and environmental conservation decision making.

While forests are a significant natural-based solution for carbon absorption, other essential ecosystems, including various forms of land use and oceans, play essential roles in carbon sequestration and can be the subject of future research.

6. Conclusions

This empirical study concludes that, at the country level, green performance exhibits a positive influence on forest resources, while economic performance negatively affects forest resources, reaffirming the presence of a national-level inhibiting effect. This conclusion is in line with existing research and underscores the critical need for sustainable economic growth that enables a substantial green performance, thereby balancing economic progress with forest conservation. Increases in forested areas play a pivotal role in capturing greenhouse gas emissions, collectively contributing to the mitigation of climate change's rapid pace.

The delicate balance between economic growth and environmental conservation is a challenge that requires tailored strategies for each member country within the European Union. These strategies should consider the unique characteristics and circumstances of each nation, ensuring that economic benefits are optimized while green performance is maximized within their specific contexts. The research findings highlight the role of

forest resources in achieving sustainable development goals. Forests contribute not only to economic growth but also to environmental protection. In this regard, integrated forest management policies should be elevated to a top priority for EU member states.

The empirical approach adopted in this study serves as a robust foundation for informed and sustainable decision making, providing a deeper understanding of the relationships between green and economic performances. While this research emphasizes these essential connections, it also highlights the potential for further investigations and the development of more efficient strategies for responsible resource management. The need for ongoing research and the pursuit of innovative strategies are vital to promoting a green and sustainable future within the European Union.

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Appendix A

Table A1. Summary table on the relationships between forest resources and economic and green performances in the literature review.

	Economic and Green Performances
Forestry	Forestry assets play a pivotal role in achieving a sustainable economic performance and fostering environmentally responsible practices [2].
	The sustainable management of forests can contribute to economic expansion through the activities of the timber industry, eco-tourism, and the utilization of non-timber forest products [2,5,11].
	Forest resources, classified as renewable natural assets on a global scale, play a central role in both economic development and the preservation of the natural ecosystem [7,8].
	Forest resources, serving as vital raw materials for production, significantly contribute to propelling economic growth [13–16].
	The pursuit of a good economic performance exerts a notably negative impact on forest resources, whereas the pursuit of a good green performance has a positive influence on these kinds of resources [21,22].
	Forest resources play a critical role in shaping sustainable economic growth on a global scale, being recognized as essential natural assets [32,33].
	GHG

Table A1. *Cont.*

	Economic and Green Performances
Forestry	Unrestrained economic growth has been identified as a factor contributing to the depletion of forest resources, leading to a substantial rise in GHG emissions [34].
	The potential impact of forest-based carbon sequestration, facilitated through various forestry-related emission reduction activities, such as afforestation, reforestation, forest conservation, and sustainable forest management, is crucial [35]. Assessing the efficiency of these activities in relation to costs could play a significant role in promoting environmental sustainability. These measures have the potential to reduce global greenhouse gas (GHG) emissions at a lower cost compared to other GHG reduction technologies [36].
	Forests' capacity to capture and store atmospheric carbon through photosynthesis, incorporating carbon into biomass, is pivotal for diminishing greenhouse gas concentrations [40–43,68].
	Forests play a critical role in carbon sequestration, maintaining equilibrium in the global carbon cycle [49,51].
	Beyond its economic and social advantages, sustainable forest management is indispensable for environmental conservation and the mitigation of climate change [7,26].
	Economic and green performances
GHG	Several researchers [28,29] have suggested that environmental protection policies designed to decrease greenhouse gas (GHG) emissions may inadvertently increase pollution emissions. This unintended consequence occurs because these policies are often structured to shift costs into the future, thereby expediting the exploitation of fossil energy and diminishing the effectiveness of GHG reduction efforts [30].
	The paradox of increasing greenhouse gas (GHG) emissions is commonly analyzed in terms of its impact on the biosphere. Halicioglu [40] and Magazzino [41] emphasize that the real GDP drives both energy consumption and CO_2 emissions, a conclusion corroborated by recent studies [42–45].
	The repercussions of climate change and environmental degradation (including GHG growth) extend to economic sustainability [3,46–48], with potential adverse effects on economic activity and overall population welfare.
	Effectively managing climate risks at the EU level requires proactive strategies founded on understanding the relationships between economic and green performances, GHG emissions reduction, and forest resource coverage—a paramount CO_2 sink [49].
	Decoupling economic growth from resource consumption and environmental pollution (including GHG growth) is a strategy to address the challenges of climate change while enhancing societal well-being [50–52].
	Economic growth, while integral to achieving sustainable economic development and facilitating good economic and green performances, exerts considerable pressure on the environment (including GHG growth) and resource consumption [53].
	Green economic growth, in essence, involves the synchronization of economic progress with proactive environmental protection [65].

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