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Entrepreneurial dynamism and sustainability: Unveiling Europe's economic growth patterns through cluster analysis

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Abstract: This paper highlights the complex relationship between entrepreneurship, sustainable development, and economic growth in 41 European countries, using a reliable K-Means cluster analysis. The research thoroughly evaluates three key factors: the SDG Index for sustainable development, GDP per capita for economic well-being, and the New Business Density Rate for entrepreneurial activity. Our methodology reveals three distinct narratives that embody varying degrees of economic vitality and sustainability. Cluster 1 comprises the financially stable and sustainability-oriented countries of Western and Northern Europe. Cluster 2 showcases the variegated economic and sustainability initiatives in Central and Southern Europe. Cluster 3 envelopes the economic titans with noteworthy business expansion but with the potential for better sustainable practices. The analysis reveals a favourable association between economic prosperity and sustainable development within clusters, although with nonlinear intricacies. The research concludes with a series of strategic imperatives specifically crafted for each cluster, promoting economic variation, increased sustainability, invention, and worldwide collaboration. The resulting findings highlight the crucial need for policy-making that considers the specific context and the potential for combined European resilience and sustainability.

Keywords: entrepreneurship; sustainable development; economic growth; economic diversification; policymaking; European countries; K-Means clustering

1. Introduction

At the intersection of entrepreneurship, sustainable development, and economic growth lies a fertile ground for transformative societal progress. This combination is crucial for a prospering economy, however, its complex dynamics, especially in the diverse landscape of European economies, have not been thoroughly examined. This research aims to dissect and explain these interrelated domains within the European context, to the intricacies and complexities that govern them.

Entrepreneurship lies at the intersection of economic growth and innovation, creating a complex fabric that reflects the social, cultural, and economic nuances of different regions. The entrepreneurial journey, dating back to the 20th century when Schumpeter regarded entrepreneurs as the drivers of economic advancement, highlights the significance of "creative destruction" in questioning and reshaping market practices (Mehmood et al., 2019). This narrative presents a diverse range of entrepreneurial intensities and growth patterns in Europe, showcasing its multifaceted impact on job creation, productivity, and economic resilience. Experts such as Amorós and Bosma (2014), Audretsch et al. (2006), and Carree and Thurik (2010) attest to this phenomenon. Entrepreneurship, besides fostering innovation, embodies adaptability and resilience that are crucial for economies to tackle global challenges and seize

opportunities, as argued by Wennekers and Thurik (1999). The empirical evidence linking entrepreneurial activity to economic growth, particularly in developed economies, solidifies its importance as a significant contributor to economic success (Acs and Szerb, 2007). This connection is highlighted by the impact of the digital revolution, which has widened opportunities and disrupted conventional business models, and by a mounting emphasis on sustainable entrepreneurship to synchronize economic growth with environmental and social objectives (Fernandes, et al., 2023; Jawad et al., 2021; Terán-Yépez et al., 2020).

The entrepreneurial landscape varies significantly across regions, influenced by various institutional factors, including business start-up procedures, access to private credit, and human development (Fritsch and Wyrwich, 2017; Głodowska and Pera, 2019; Sternberg and Wennekers, 2005; Urbano et al., 2020). To account for these differences, development economists and policymakers propose a move towards social entrepreneurship, which guarantees sustainable growth and economic benefits. Entrepreneurs are positioned at the forefront of a future in which innovation, technology, and sustainability interconnect, fostering economic growth that is both robust and responsible.

The endorsement of the Sustainable Development Goals (SDGs) by the United Nations in 2015 marked a significant shift in global development strategies, extending beyond poverty reduction to encompass a holistic approach integrating environmental, social, and economic dimensions (Biermann et al., 2022; United Nations, 2015). This study will investigate the implementation of SDGs in Europe, focusing on their economic implications and the role of entrepreneurship in achieving these goals (Weitz et al., 2023).

Studies suggest a mutualistic correlation between sustainability and economic growth, that defies their apparent incompatibility, instead proving their symbiotic relationship (Fonseca et al., 2020; Hall et al., 2010; Sachs et al., 2023; Zhu et al., 2022). The SDGs are increasingly viewed as stimulants for economic innovation, encouraging resource optimisation and market expansion (Fioramonti et al., 2022). Stakeholders, including governments and NGOs, play a crucial role in attaining these objectives, notwithstanding obstacles such as financing and geopolitical matters (Eweje et al., 2021). Central to this discourse is social entrepreneurship, which aligns business with societal improvement to promote sustainable economic growth and a future where profitability is aligned with purpose (Goyal et al., 2021). This union presents a blueprint for a globally prosperous and harmonious future.

The interdependence of entrepreneurship and sustainable development is becoming increasingly acknowledged as a catalyst for economic vitality and societal advancement. Sustainable entrepreneurship, which involves aligning business prospects with environmental and social issues, is thriving, particularly in Europe. This concept has been documented by Dean and McMullen (2007) as well as Cohen and Winn (2007). European countries, with an increased awareness of the environment, have been supporting businesses that not only maintain economic sustainability but also improve environmental and social objectives, aligning with the principles of sustainable entrepreneurship (Farny and Binder, 2021). The European Commission's Green Deal initiative advances the transition towards sustainability by backing green startups and innovations. Empirical evidence shows a significant correlation between

entrepreneurship and the triple bottom line of sustainable development (Gu et al., 2020). In addition, entrepreneurship is often associated with innovation, which can lead to the creation of more sustainable and environmentally friendly products and services (Sahoo et al., 2023). This demonstrates the continent's pledge to integrate entrepreneurship with sustainable development (European Commission, 2019). Research indicates a correlation between European firms with an entrepreneurial mindset and their ability to adopt and implement sustainable practices. This trend contributes to the region's ongoing transformation towards green practices (Hall and Wagner, 2012).

The triangular relationship between entrepreneurship, sustainable development and economic growth is of growing academic interest. However, it has not yet been fully explored. Research is investigating how entrepreneurial ecosystems that support sustainability can contribute to strong economic growth (Alvedalen and Boschma, 2017; Brooks et al., 2019; Guerrero and Martínez-Chávez, 2020). Based on empirical evidence from Europe, the interplay between entrepreneurial activity and growth varies across regions, underscoring the complexity and regional specificity of this nexus (Content et al., 2020). Nevertheless, acknowledging the nuances in this triadic relationship is crucial. Although entrepreneurship may act as a catalyst for growth, it could increase resource consumption, creating challenges to sustainability objectives (Hummels and Argyrou, 2021). This paradox highlights the necessity of a balanced strategy where entrepreneurial ventures serve as both drivers of economic expansion and caretakers of sustainability.

A significant emphasis is placed on the sustainability aspect of entrepreneurship, particularly its role in advancing sustainable national development. Sustainable entrepreneurship transcends traditional business models by embedding environmental and social considerations into the core of entrepreneurial ventures. This approach redefines success, measuring it not only in terms of financial profitability but also in its contribution to ecological preservation and social well-being. Theoretical frameworks such as the Triple Bottom Line (Elkington, 1997) and the concept of 'Creating Shared Value' (Porter and Kramer, 2011) are instrumental in understanding how entrepreneurial activities can align with and promote sustainable national development. In examining the literature, we observe a growing consensus that sustainable entrepreneurship acts as a catalyst for innovative solutions to environmental challenges, driving a shift towards a more circular economy. This shift is characterized by a focus on resource efficiency, waste reduction, and the creation of sustainable products and services, which in turn stimulate economic growth while preserving the environment. Furthermore, the role of entrepreneurs in contributing to social goals, such as community development and social equity, is increasingly recognized. This facet of entrepreneurship contributes to building resilient and inclusive societies, an essential component of sustainable national development.

The interaction between entrepreneurship and sustainable development is also reflected in policy frameworks and national strategies. Governments and international organizations are increasingly fostering environments that encourage sustainable entrepreneurial initiatives. These policies not only provide the necessary support and incentives for entrepreneurs to pursue sustainable goals but also align business practices with national and global sustainable development objectives.

Thus, the supplementing theoretical review underscores the multidimensional impact of sustainable entrepreneurship. It highlights how entrepreneurial ventures, when oriented towards sustainability, can contribute significantly to economic growth, environmental conservation, and social equity, thereby playing a pivotal role in sustainable national development. This enhanced focus on the sustainability dimension of entrepreneurship provides a richer, more comprehensive understanding of its potential and challenges in the context of national development strategies.

Although there is a substantial amount of literature on entrepreneurship, sustainable development, and economic growth, our examination has identified significant gaps. Specifically, there is a lack of research that comprehensively explores the triadic relationship between all three dimensions, particularly within the European context. Instead, many studies concentrate mainly on dyadic relationships, such as entrepreneurship and growth, SDGs and growth, and entrepreneurship and SDGs. This narrow focus has obscured the interconnectivity of these domains, particularly when taking Europe's diversity into account (Schaltegger and Wagner, 2011; Zahra et al., 2014).

Furthermore, several studies have taken a generalized approach, ignoring the subtle nuances and potential variations between countries (Acs et al., 2008; Autio et al., 2014). This discrepancy is particularly evident in the European context, where economies differ vastly in size, development, and institutional structures (Wennekers et al., 2005). Furthermore, despite the literature emphasising the potential synergy across the three domains, there is a dearth of comprehensive research investigating the possible trade-offs and challenges faced by countries striving to promote entrepreneurship, sustainability, and economic growth concurrently (Hall et al., 2010; York and Venkataraman, 2010).

Our investigation is underpinned by five intricately developed hypotheses, each examining a separate aspect of the correlation between entrepreneurship, sustainable development, and economic growth. These hypotheses are devised to simplify the intricate layers of complexity and present a refined comprehension of Europe's economic terrain.

Hypothesis 1 (H1): European countries form distinct clusters based on their performance in entrepreneurship, sustainable development, and economic growth, each demonstrating unique characteristics and developmental paths. This hypothesis investigates how European countries cluster based on their performance in these domains. It explores Europe's diverse economic environment, analysing commonalities and differences in national paths towards entrepreneurship and sustainable development. The distinct economic ecosystems across Europe exhibit diverse trajectories based on their structures and priorities (e.g., Rauhut and Humer, 2020; Schaeffer et al., 2020; Winkelmann et al, 2022). Understanding these clusters can provide valuable insights into both commonalities and differences across Europe, which can help inform policy discussions and strategies.

Hypothesis 2 (H2): There is a positive correlation between high levels of entrepreneurial activity and strong achievement on Sustainable Development Goals (SDGs) and robust GDP growth in European countries. This hypothesis seeks to identify patterns linking high levels of entrepreneurial activity with strong achievement on Sustainable Development Goals (SDGs) and robust GDP growth.

Entrepreneurship plays a critical role in driving economic growth (Abdesselam et al., 2018; Acs et al, 2008), but on the other hand, sustainable development goals and economic prosperity are inextricably linked. Exploring this relationship between the three elements offers a comprehensive understanding of how they interact in the European context. Fritsch and Wyrwich (2017) have highlighted the importance of entrepreneurial legacies for regional economic performance. However, the relationship between SDGs and national economic performance is interdependent (Lafortune et al., 2020). Examining these interrelated dynamics across Europe can reveal complex patterns and implications.

Hypothesis 3 (H3): Specific clusters of European countries demonstrate synchronized progress in entrepreneurship and sustainability, while others exhibit significant trade-offs or discrepancies. This hypothesis investigates the nature of progress in entrepreneurship and sustainability within European clusters, identifying where harmonious development occurs and where potential challenges lie. Identifying and addressing harmonious progress versus potential challenges and exploring how entrepreneurial efforts align with societal benefits is essential (Dacin et al., 2010). Recognizing where divergences occur can guide countries in building on strengths and addressing weaknesses. Exploring synergies between entrepreneurship and sustainability highlights the importance of aligning business practices with sustainable development (Manninen and Huiskonen, 2022). Identifying synchronies and mismatches can provide important insights for policy adjustments, stakeholder collaboration, and strategic interventions.

Hypothesis 4 (H4): Individual country trajectories within Europe vary significantly in terms of their performance in entrepreneurship, sustainable development, and economic growth, reflecting diverse economic, social, and policy contexts. This hypothesis focuses on tracing the unique paths of European countries across these three domains. This detailed analysis aims to reveal the distinct economic, social, and policy frameworks that underlie each country's strategy for balancing entrepreneurship, sustainability, and economic expansion. Our goal is to foster an environment that promotes entrepreneurship, sustainability, and economic growth. A thorough analysis of individual country trajectories provides greater granularity, as context is critical in shaping economic outcomes (Nunn, 2020; Spencer et al., 2010). By analysing European countries, we can identify specific policy recommendations and lessons learned.

Hypothesis 5 (H5): The clustering and performance analysis of European countries can inform the development of effective policy frameworks that integrate entrepreneurship, sustainable development, and economic growth. This hypothesis culminates in translating observed patterns and performances into actionable policy recommendations. The aim is to foster an environment that encourages entrepreneurship and sustainable development to drive inclusive economic growth. These hypotheses work together to build the framework for our study, pursuing not only academic understanding but also practical solutions that resonate with Europe's diverse landscape. The purpose of this study is to provide valuable policy recommendations for the triadic relationship between entrepreneurship, sustainable development, and economic growth. By addressing gaps in the existing literature, this

study aims to contribute substantially towards this area of research, with a particular emphasis on Europe's diverse and rich backdrop.

Central to this study are the following fundamental research questions, each reflecting a critical aspect of the nexus between entrepreneurship, sustainable development, and economic growth within the European context. First, how do various forms of entrepreneurship influence and interact with the sustainable development goals and economic growth across different European countries? Second, what are the patterns and implications of this interaction in terms of regional economic resilience and growth? And third, how can policy frameworks be effectively designed to enhance the synergy between entrepreneurship, sustainable development, and economic growth?

To address these questions, a multi-dimensional research approach will be employed. This approach integrates a comprehensive literature review, quantitative analysis of European economic data, and qualitative case studies. The literature review will provide a theoretical foundation, drawing upon existing research to frame the context and significance of the study. Quantitative analysis will involve examining economic indicators, entrepreneurial activity metrics, and sustainable development outcomes across Europe to identify patterns, correlations, and regional variations. Qualitative case studies will offer in-depth insights into specific examples of successful integration of entrepreneurship with sustainable development and economic growth, highlighting best practices and innovative approaches. This blend of methodologies is designed to ensure a holistic understanding of the complex interplay between entrepreneurship, sustainable development, and economic growth in Europe, thereby not only answering the fundamental research questions but also providing a basis for informed policy recommendations and future research directions.

2. Materials and methods

For the objectives of this study, a robust cluster analysis was employed to unveil underlying structures within our dataset, facilitating an in-depth understanding of the socio-economic and sustainable development positions of various European countries. Our analytical approach comprised two main stages: hierarchical clustering and K-means clustering, each chosen for its distinct advantages in exploring data patterns.

We commenced with hierarchical clustering, a technique lauded for its ability to systematically organize data points into a dendrogram—a tree-like structure revealing hierarchical relationships (Murtagh and Legendre, 2014). Initially, each data point was considered a separate cluster. Iteratively, we merged clusters based on their inherent similarities, utilizing Ward's method and the squared Euclidean distance measure. Ward's method minimizes the total within-cluster variance at each merging step, producing well-separated and compact clusters (Ward, 1963), while the squared Euclidean distance, a widely used metric, measures dissimilarity between data points in our numerical space (Xu and Wunsch, 2009).

For the hierarchical clustering phase, Ward's method was employed, where the calculation of variance minimization is achieved using the formula:

$$Minimize \sum_{i=1}^{k} \Sigma_{x \in S_i} \|x - \mu_i\|^2$$

where k represents the number of clusters, S_i is the set of observations in the i-th cluster, x represents an observation, and μ_i is the mean of the observations in S_i. This method ensures that the total within-cluster variance is minimized at each step of the clustering process.

For the K-means clustering, the decision to identify three clusters was based on a comprehensive analysis of the dataset. This choice was informed by the Elbow Method, a widely used heuristic to determine the optimal number of clusters. By plotting the sum of squared distances from each point to its assigned center for different values of k, we observed a distinct point of inflection at $k = 3$. This suggests that adding more clusters beyond three would result in diminishing returns in terms of the explained variance. The formula for the K-means clustering algorithm is:

$$Minimize \sum_{i=1}^{k} \sum_{x \in s_i} \|x - c_i\|^2$$

where c_i is the centroid of S_i. This ensures that the variance within each of the three clusters is minimized, leading to a more meaningful and interpretable clustering result.

Furthermore, the choice of three clusters aligns with our initial observations of the European countries' data, indicating three distinct patterns in terms of their socio-economic and sustainable development profiles. This clustering approach allows for a clearer differentiation between countries with varying levels of economic development, entrepreneurial activity, and progress towards sustainable development goals. By adopting a three-cluster solution, we aim to provide a more nuanced and in-depth analysis of the European countries, facilitating a better understanding of their unique development trajectories and the interplay between the key variables in our study.

Following this, we employed K-means clustering to further refine the analysis. This partitioning method entails assigning data points to clusters such that the variance within clusters is minimized (MacQueen, 1967). The number of clusters (K) was informed by the outcomes of the hierarchical clustering stage. Through this, we aimed to achieve a robust cluster formation that reflects the socio-economic and sustainable development statuses of the countries in our dataset.

The variables selected for the clustering analysis were:

- SDG Index: Represents the overall progress towards the achievement of all 17 Sustainable Development Goals. Interpreted as a percentage of SDG achievement, with 100 indicating full attainment (Sachs et al., 2023).
- GDP per Capita: An objective measure reflecting the economic health and performance of a country, denominated in current prices (US dollars per capita) for the year 2022 (The World Bank Group, 2023a).
- New Business Density Rate: The number of new company registrations (limited liability corporations) per 1,000 people aged 15-64, for the year 2020 (The World Bank Group, 2023b).
- Countries: The study encompassed 41 European countries, selected based on the availability of all three indicators.

This methodology offers a comprehensive framework for analysing a country's overall development. Gross Domestic Product (GDP) serves as an objective measure reflecting a country's economic health and performance. Typically, a high GDP is

synonymous with prosperity and economic strength, whereas a low GDP may signal economic difficulties (World Bank, 2020). The SDG score indicates a country's commitment and advancement towards achieving the Sustainable Development Goals set by the United Nations, covering aspects of social, environmental, and economic sustainability (Sachs et al., 2023). The new business density rate illuminates the rate of new businesses, specifically those registered as limited liability corporations within a calendar year. This indicator probes into the entrepreneurial vigour and economic activity of a country's working-age population. A higher new business density rate suggests a thriving entrepreneurial ecosystem, characterized by a substantial number of individuals launching new businesses, thereby fostering economic growth, job creation, and innovation (Acs et al., 2015). In contrast, a lower rate could be indicative of entrepreneurial obstacles, such as regulatory impediments or economic adversities (Bosma et al., 2020).

In the realm of clustering, integrating this metric unveils significant insights into the economic diversity amongst countries. It aids in pinpointing countries where entrepreneurship flourishes, potentially influencing GDP and sustainable development, as well as those where entrepreneurial activities may be less pronounced, thus affecting economic progress and the pursuit of sustainable development goals (Acs and Amorós, 2008). Collectively, these indicators present a holistic portrayal of a country's development, encompassing economic growth, sustainability endeavours, and entrepreneurship rates. Moreover, the robust interconnections among these indicators amplify their analytical value for clustering purposes. Countries with robust GDPs might possess the capacity to invest in sustainable initiatives, potentially leading to elevated SDG scores (Griggs et al., 2013). Grasping these interrelationships is pivotal for understanding the nuances of development.

For our computational analysis, we used SPSS software because of its strong statistical computing capabilities and cluster analysis package. Hierarchical clustering was performed using Ward's method followed by K-means clustering.

Our methodology utilises rigorous cluster analysis and relevant socio-economic indicators to comprehensively explore the complex development patterns across European countries. Our methodology adheres to conventional academic structures and employs clear, objective language to ensure comprehension and objectivity. By adopting this approach, we aim to provide nuanced insights into the interplay between economic growth, sustainable development, and entrepreneurship.

3. Results

The clustering method was utilized to group data. Initially, hierarchical clustering was performed, which indicated the requirement to form three clusters in the k-mean clustering process. Drawing a horizontal line at a rescaled distance of approximately 10 on the dendrogram using Ward Linkage, it intersected three vertical lines.

The initial cluster centres are presented in **Table 1**. Cluster 1 is marked by a modest GDP (in USD), low new business density rate (per 1000 people aged 15–64), and high SDG score (percentage of SDG achievement). Cluster 2 demonstrates the lowest GDP, a similar low new business density rate, and a moderate SDG score.

Cluster 3 consists of countries with the highest GDP, a significantly high new business density rate, and a nearly high SDG score.

Table 1. Initial cluster centres.

	Cluster		
	1	**2**	**3**
GDP (USD)	57,428.00	6587.00	126,598.00
New business density rate	3.10	2.86	17.19
SDG score (%)	79.40	73.30	77.60

During the clustering process, the algorithm converged after four iterations, suggesting that the cluster centres reached stability at this juncture. The most significant changes in the cluster centres occurred during the first iteration (**Table 2**).

Table 2. Iteration history.

Iteration	Change in cluster centres (in squared Euclidean distance)[a]		
	1	**2**	**3**
1	6174.835	10,628.321	19,250.002
2	1560.742	648.834	0.000
3	1799.491	627.957	0.000
4	0.000	0.000	0.000

a. Convergence achieved due to no or small change in cluster centres. The maximum absolute coordinate change for any centre is 0.000. The current iteration is 4. The minimum distance between initial centres is 50,841.000, indicating significant initial separation.

Regarding the distribution of cluster members, Cluster 1 includes 10 countries. The largest cluster is Cluster 2, consisting of 27 countries, and Cluster 3 includes the fewest members, encompassing a mere 4 countries, making it the smallest cluster (**Table 3**).

Table 3. Cluster membership.

		Number of cases in cluster	Countries
Cluster	1	10	Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Netherlands, Sweden, United Kingdom
	2	27	Albania, Armenia, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Georgia, Greece, Hungary, Italy, Latvia, Lithuania, Malta, Montenegro, North Macedonia, Poland, Portugal, Romania, Serbia, Slovak Republic, Slovenia, Spain, Russian Federation, Turkey
	3	4	Ireland, Luxembourg, Norway, Switzerland
Valid		41	-
Missing		0	-

The map of countries within particular clusters is presented in **Figure 1**. Countries are grouped into three distinct clusters, each represented by a different colour: green for Cluster 1, yellow for Cluster 2, and blue for Cluster 3. The map has been created with mapchart.net, an online tool for creating custom maps.

Figure 1. Map of formed three clusters.

The final cluster centres (**Table 4**) show significant deviations from the initial centres. In Cluster 1, the GDP has decreased, while new business density rate has increased. In Cluster 2, there has been a substantial increase in GDP from the initial centre, with a slight increase in new business density rate. Notably, the SDG score has increased. In Cluster 3, the GDP has decreased from the initial centre, and the new business density rate has notably decreased. Despite this, there has been a minor increase in the SDG score.

Table 4. Final cluster centres.

	Cluster		
	1	2	3
GDP (USD)	54,613.40	18,492.11	107,348.00
New business density rate	6.83	4.83	9.49
SDG score (%)	82.51	77.06	80.05

Upon analysing the inter-cluster distances (**Table 5**), it is evident that clusters 1 and 2 are the closest in terms of the three variables, as the distance between them is the smallest. In contrast, Cluster 3 is significantly distant from both clusters 1 and 2, especially concerning GDP.

Table 5. Distances between final cluster centres.

Cluster	1	2	3
1	-	36,121.289	52,734.600
2	36,121.289	-	88,855.889
3	52,734.600	88,855.889	-

The ANOVA analysis results (**Table 6**) reveals a significant difference in GDP and SDG scores ($p < 0.001$) between the clusters, indicating that the clusters differ significantly in terms of these two variables. However, there was no significant difference in new business density rate between the clusters ($p = 0.180$), suggesting

that this variable does not distinguish the clusters as effectively as the other two variables.

Table 6. ANOVA results.

	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
GDP	16,051,453,663.418	2	97,836,912.975	38	164.063	<0.001
New business density rate	45.078	2	25.125	38	1.794	0.180
SDG score	112.398	2	10.842	38	10.367	<0.001

The cluster analysis has effectively classified the 41 European countries into three distinct clusters based on their GDP, new business density rate, and SDG score. Cluster 2 signifies countries with lower GDPs and moderate SDG scores, while Cluster 1 countries have moderate GDPs and higher SDG scores. Although comprising only four countries, Cluster 3 includes countries with very high GDPs and relatively high SDG scores.

4. Discussion

The identification of distinct clusters within European countries, based on their performance in entrepreneurship, sustainable development, and economic growth, aligns with the observations made by scholars such as Acs and Szerb (2007), who emphasized the significant role of entrepreneurial activity in economic prosperity. Our findings demonstrate a nuanced interplay between these factors, furthering the understanding of this dynamic relationship.

Moreover, the positive correlation we observed between high levels of entrepreneurial activity and the achievement of Sustainable Development Goals (SDGs) echoes the insights provided by Sachs et al. (2023), highlighting the symbiotic relationship between economic growth and sustainability. This extends the discourse beyond traditional economic measures, emphasizing the importance of integrating sustainable practices into the entrepreneurial ecosystem.

By analysing the clusters' composition, convergence patterns, and significance through statistical tests, we aim to offer a comprehensive understanding of the positioning of these countries concerning their economic prosperity, density rate of new businesses, and sustainable development goals achievement.

- Cluster 1: Western and Northern Europe's Economic and Sustainable Forerunners.

Cluster 1 comprises 10 Western and Northern European countries known for their advanced economies and high living standards. These countries include Austria, Belgium, Denmark, Finland, France, Germany, Iceland, the Netherlands, Sweden, and the United Kingdom. Although each country contributes its distinctive strengths and features to the cluster, they exhibit comparable economic and developmental patterns.

The economic strength of Cluster 1 is evident from its GDP figure of 54,613.40 USD. This indicates a mature and balanced economies. However, it should be noted that compared to other clusters, Cluster 1 may not always rank at the top. This

highlights the dynamic global economic landscape, where even advanced economies encounter tough competition.

When examining the new business density rate, Cluster 1 recorded a rate of 6.83. This figure highlights the strong entrepreneurial drive present in these countries and indicates a favourable atmosphere for new business ventures. However, a refined interpretation is required. This rate indicates a balanced coexistence between emerging and developed businesses, resulting in a diverse business environment that could encourage innovation while utilizing the expertise and stability of established companies.

One noteworthy aspect of Cluster 1 is its exemplary score of 82.51 on the SDG (Sustainable Development Goals) scale in 2023. This impressive score highlights the dedicated efforts of these countries towards meeting sustainable development objectives. It is indicative of effective governance, policies that prioritize holistic development, and a commitment to balancing economic growth with environmental and societal responsibilities.

Taking a closer look at individual countries within this cluster, Germany and France emerge as significant contributors to the European economy. Their emphasis on quality education, infrastructure modernization, and an innovative culture has bolstered their prominence as powerhouses. In contrast, smaller countries like Denmark, Sweden, and the Netherlands are punching above their weight in terms of sustainability. Their proactive measures in sustainable urban planning and adoption of renewable energy serve as global benchmarks. Moreover, most of these countries share an affiliation to the European Union, which influences their similar display of sustainable practices and economic strengths. The EU's directives, standards, and regulations shape the policies and practices of its member states. Despite this, Iceland still aligns with many aspects due to shared regional values and priorities.

In Cluster 1, several strategic imperatives have been identified to guide the development and progress of countries in the region, among which are economic diversification and resilience, innovation and entrepreneurial leadership, sustainability and environmental stewardship, and international collaboration and influence. First, countries in Cluster 1 should continue to diversify their economies, focusing on high-tech and green technologies while investing in education and fostering an innovative startup culture. This diversification will enhance resilience to global economic shocks and promote sustainable growth (Coulson et al., 2020, OECD, 2021).

Maintaining a competitive edge in innovation is key for Cluster 1. Streamlining regulatory frameworks, supporting innovation hubs, and establishing public-private partnerships will bolster the entrepreneurial ecosystem and sustain the region's innovation leadership (Bagheri, 2017; Hassain and Li, 2022; Malibari and Bajaba, 2022).

As frontrunners in sustainable practices, countries in Cluster 1 should lead by example, implementing policies that incentivize sustainable business practices, investing in renewable energy, and actively contributing to international efforts in climate change mitigation and environmental conservation (Turnbull et al., 2021).

Leveraging their economic and innovative strengths, countries in Cluster 1 are well-positioned to lead international collaborations, engage in mutually beneficial

trade agreements, share sustainable practices, and address global economic and environmental challenges through active participation in international forums.

In the context of our results, the patterns observed in Cluster 1 resonate with the findings of Mehmood et al. (2019), who highlighted the significant role of entrepreneurship in economic development. The strong entrepreneurial drive and favorable atmosphere for business ventures in countries like Germany and France align with their emphasis on innovation and infrastructure modernization, as discussed by Carree and Thurik (2010). This cluster's high SDG score is also reflective of the efficient governance and commitment to sustainable development noted by Fernandes et al. (2023), underscoring the pivotal role of policy in fostering holistic development.

- Cluster 2: Diverse Economic Narratives of Central and Southern Europe.

Cluster 2 comprises a diverse group of countries spanning Eastern, Central and Southern Europe, as well as parts of the Caucasus region. The countries that are part of this grouping consist of Albania, Armenia, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Georgia, Greece, Hungary, Italy, Latvia, Lithuania, Malta, North Macedonia, Poland, Portugal, Romania, the Russian Federation, Serbia, the Slovak Republic, Slovenia, Spain, and Turkey. This diverse combination reflects the complex economic and developmental narratives that are intertwined in the region.

One distinctive economic marker for Cluster 2 is its GDP in 2022, which is set at 18,492.11. This suggests that many of these countries are in a developing or transitional economic state. In particular, countries in Eastern and Central Europe have undergone transformative changes in the past few decades, transitioning from socialist or communist economic structures to more market-driven systems. However, this Cluster also includes countries with significant economic strength in history, like Italy and Spain, who have recently faced various economic issues, placing them in this group.

The new business density rate of 4.83 suggests that the entrepreneurial environment may not be as favourable for startup ventures compared to Cluster 1. Possible contributing factors include regulatory constraints, infrastructural challenges, or a more risk-averse business culture present in certain countries.

Regarding sustainability, Cluster 2 attained a moderate SDG score of 77.06. While this figure indicates commendable efforts in sustainability, there remains a distinct gap when compared to the scores of more developed clusters. This does not diminish their accomplishments but rather highlights the potential for even more robust sustainable practices and achievements.

Further exploration into the cluster's composition exposes Italy, Spain, and Greece's involvement resulting from economic pressures and challenges encountered. On the other hand, smaller countries such as Cyprus, Malta, and Slovenia, despite their geographical size, have demonstrated robust economic resilience and growth, making notable contributions to the fabric of the European economy. Newer members of the European Union in this group are gradually aligning their standards and policies with wider EU directives. Their commitment to meeting, and potentially surpassing, sustainable development benchmarks is apparent.

Cluster 2 faces a set of strategic imperatives aimed at addressing its unique economic challenges and disparities, among which are tailored economic strategies,

sustainability and green growth, balanced urban-rural development and sub-regional collaborations for mutual progress.

Recognizing the disparities in GDP and economic challenges, countries in Cluster 2 must design customized economic strategies. This involves identifying unique opportunities for growth, addressing sector-specific hurdles, and implementing policies that stimulate equitable economic development.

A pivotal focus on sustainability is essential. This entails substantial investment in green technologies, revising policy frameworks to prioritize eco-friendly practices, and aligning social and infrastructure reforms with sustainability goals. Such efforts will pave the way for a greener and more resilient economy (Capasso et al., 2019; Xu et al., 2022).

To harmonize development, concerted efforts should be made to foster both urban and rural growth. Strategies might include encouraging rural entrepreneurship, integrating technology in remote areas, and building infrastructure to bridge the urban-rural divide, ensuring that the fruits of growth are equitably shared (Cao et al., 2022; Shao et al., 2021).

Given the vast geographic and economic variances, Cluster 2 countries can significantly benefit from sub-regional collaborations. By pooling resources, sharing best practices, and collectively addressing challenges, these countries can cultivate an ecosystem conducive to sustainable growth and shared prosperity.

The economic narratives of Cluster 2, encompassing countries in various stages of development, mirror the complexities discussed by Zahra et al. (2014) and Schaltegger and Wagner (2011). The varied economic trajectories, from countries undergoing transitions to those facing recent economic challenges like Italy and Spain, align with the dynamic global landscape they described. The moderate SDG score of this cluster and the disparities in sustainable practices highlight the potential for growth and the necessity of tailored strategies for sustainable development, as suggested by Acs and Amorós (2008).

- Cluster 3: The Economic Titans of Europe

Cluster 3 comprises economically influential European countries, including Ireland, Luxembourg, Norway, and Switzerland. They share distinctive economic characteristics that differentiate them from others and render them some of the most prosperous and powerful countries in Europe.

Notably, this group boasts a remarkable GDP figure of 107,348.00 indicative of their economic stability and well-being. Such remarkable economic performance is not simply fortuitous but rather the result of strategic decision-making, distinctive economic models, and specialized sectors propelling their respective economies forward.

Another notable economic feature of Cluster 3 is its high new business density rate of 9.49. This statistic suggests that these countries are prime locations for new company establishment, potentially influenced by their roles as hubs of European commerce and industry. These findings indicate a favourable environment for business development, bolstered by supportive policies, modern infrastructure, and a pro-business culture.

From a sustainability standpoint, the SDG score of 80.05, while impressive, is not the highest among the clusters. This prompts an interesting question, whether rapid

economic growth can coexist with sustainable practices. According to the data, even these European economic powerhouses have room for improvement regarding sustainability.

Examining the individual characteristics of countries within Cluster 3 shows, that Ireland has emerged as a European hub for several global tech conglomerates. This is attributed to its attractive corporate tax policies, which have led to an influx of tech giants and other businesses, resulting in exponential economic growth and propelling Ireland to its present GDP stature (The European Business Review, 2023). Meanwhile, Luxembourg, although diminutive in geography, is monumental in economic influence and stands out as a premier financial epicentre in Europe. Its prominence in banking and as a domicile for investment funds is unparalleled, leading to its economic prosperity. Norway, although not part of the European Union, serves as an example of resource-driven success. It has abundant natural resources, particularly oil, which are the source of its wealth. Its Sovereign Wealth Fund and steadfast dedication to promoting sustainability and social welfare align with its commitment to economic and environmental prosperity. Switzerland represents stability, neutrality, and economic resilience. Its strong banking sector, in combination with a flourishing pharmaceutical and manufacturing industry, solidifies its position as a desirable location for international enterprises and organizations.

Cluster 3 faces a set of strategic imperatives aimed at addressing its unique economic challenges and disparities, which are Economic Diversification, Strengthening Sustainability Commitments, Understanding New Business Dynamics, and Global Collaborative Leadership.

While these countries have robust economies driven by specific sectors, it's crucial to pursue diversification. By expanding their economic base, they can build resilience against global economic fluctuations, ensuring long-term stability and growth (Balland et al., 2022; Freire, 2019).

With commendable SDG performance, these countries are well-positioned to amplify their sustainability commitments and set global benchmarks. This could involve strategic policy shifts, green technology investments, and enhanced public-private partnerships, fostering a model that harmoniously blends prosperity and sustainability (Biermann et al., 2022).

Analysing new business density reveals a complex narrative. The lower density relative to GDP suggests a potential preference for quality over quantity or a leaning towards established firms over startups. Deciphering these trends is vital for fostering an environment conducive to innovation and entrepreneurship (National Research Council, 2007).

Leveraging their strong economic foundations and industry specializations, Cluster 3 countries are primed for leading global initiatives. By championing finance, technology, and sustainability, they can spearhead international partnerships, set new standards, and drive global economic and sustainable development.

Cluster 3's portrayal as economic titans, with countries like Ireland and Switzerland, reflects the insights of Cohen and Winn (2007) on the relationship between entrepreneurship and sustainable development. The high GDP and new business density rates in these countries are indicative of their robust economies and supportive policies for business development. However, the room for improvement in

sustainability, despite their economic prowess, aligns with the findings of Dean and McMullen (2007), suggesting the need for a more harmonious balance between prosperity and sustainability.

5. Conclusion

In the paper, the comprehensive analysis utilized the K-Means clustering algorithm to categorize 41 European countries based on pivotal socio-economic and developmental indicators: GDP figures for 2022, the rate of new business development in 2020, and the Sustainable Development Goals (SDG) score for 2023. Our findings delineate distinct narratives, challenges, and strengths within each cluster, enriching our understanding of Europe's economic and sustainable development landscape. Formed were three clusters:

- Cluster 1: Western and Northern Europe's Economic and Sustainable Forerunners – Countries with robust economies, a vibrant entrepreneurial scene, and high sustainability scores. They are distinguished by their commitment to innovation, diversification, and sustainable practices.
- Cluster 2: Diverse Economic Narratives of Central and Southern Europe – This group comprises transitional economies and historically robust economies facing current challenges. Despite varied economic states, there's a shared effort towards sustainability and economic rejuvenation.
- Cluster 3: The Economic Titans of Europe – Countries with remarkable economic output and favourable conditions for business growth. Their SDG scores are commendable, signalling congruent progress in economic and sustainability domains.

Based on the cluster analysis results, the following conclusions can be drawn in response to the stated hypotheses.

Concerning H1, European countries displayed unique patterns as clustered by their entrepreneurship performance, sustainable development, and new business density. The GDP primarily differentiated the clusters, while the SDG score and new business density provided supplementary nuances.

With regard to H2, the analysis indicates a correlation between a country's higher GDP and a higher SDG score, suggesting a possible link between economic strength and sustainable development achievements. However, the correlation is not entirely linear, as some countries with relatively high GDPs had SDG scores comparable to those of countries with lower GDPs. There is potential synergy between entrepreneurial activity and SDG achievements, but it's not a strict one-to-one correlation.

The clusters present varying dynamics in relation to the H3. Cluster 1 includes countries with moderate GDP, higher SDG scores, and moderate population density. This group represents nations with balanced progress in both entrepreneurship and sustainability. Cluster 2 comprises nations with a lower GDP, moderate SDG score, and a slightly lower rate of new business density. These nations may face challenges in economic growth but still demonstrate a fair commitment to sustainable development. Cluster 3 comprises countries with a high GDP, relatively high SDG score, and an increased new business density, indicating synchronized progress in

entrepreneurship and sustainability. Thus, Clusters 1 and 3 demonstrate synchronized progress, while Cluster 2 exhibits potential discrepancies, suggesting that entrepreneurship growth may not always equate to sustainability advancements (and vice versa).

With regard to H4, diverse country trajectories are evident within Europe. Countries such as Ireland, Luxembourg, Norway, and Switzerland, all within Cluster 3, demonstrate strong performance across all domains, indicating favourable economic, social, and policy contexts that promote both entrepreneurship and sustainable development. Conversely, countries in Cluster 2, such as Albania, Armenia, and Belarus, may encounter distinctive challenges that impede their performance in the three domains. Tailored strategies are necessary for each nation to address economic, political, or societal challenges.

Regarding H5, it can be concluded that policies for countries in Cluster 1 and 3 should prioritize the synergy between entrepreneurship and sustainability, ensuring that economic growth does not hinder sustainable development goals. Moreover, targeted policies are necessary for countries in Cluster 2, to foster entrepreneurial activity while also supporting sustainable development initiatives. This could entail offering incentives to eco-friendly companies, promoting innovation in sustainable industries, or strengthening public-private partnerships for sustainable development.

Key strategic imperatives encompass a range of critical actions for all clusters. Economic diversification is vital to mitigate global economic uncertainties, as supported by research (Balland et al., 2022; Freire, 2019). Sustainability enhancement is a priority across all clusters, with a specific emphasis on Cluster 3. Strengthening commitments to sustainability and integrating sustainable practices with prosperity are crucial for long-term success (Biermann et al., 2022). It is particularly important to encourage an environment conducive to innovation and entrepreneurship, especially for Clusters 1 and 2, as indicated by several studies (Bagheri, 2017; Hassain and Li, 2022; Malibari and Bajaba, 2022). Targeted economic and policy strategies should be employed, taking into account the distinct challenges and strengths of each cluster. Global collaboration and leadership, relevant for Cluster 3, entails leveraging economic and innovative strengths to foster international partnerships and facilitate sustainable global progress (National Research Council, 2007). Policy's focus for Clusters 1 and 3 should include harmonizing economic growth and sustainable development to ensure alignment with sustainability goals. Simultaneously advancing economic growth and sustainability is the goal of Cluster 2 policies, which aim to promote entrepreneurship while also encouraging sustainable development. This can be accomplished through green business incentives and fostering public-private partnerships.

Our study contributes to the body of knowledge by providing a detailed examination of the interplay between entrepreneurship, sustainable development, and economic growth across European countries. It aligns with and extends the research of scholars like Wennekers and Thurik (1999), offering new insights into how different regions within Europe are navigating the complexities of this triadic relationship. By identifying specific clusters and examining their unique characteristics and development paths, our research offers a nuanced understanding that can inform policy-making and strategy development for sustainable national development. The

strategic imperatives identified for each cluster provide a roadmap for addressing the specific challenges and opportunities within these regions, contributing to a more targeted and effective approach to fostering sustainable entrepreneurship and economic growth.

While our study provides valuable insights into the socio-economic and sustainable development landscape of Europe, it is important to acknowledge its limitations. Firstly, the choice of variables—GDP for 2022, new business development rate for 2020, and the SDG score for 2023—while comprehensive, does not encompass all aspects of a country's economic and sustainable development. Factors such as political stability, educational attainment, and technological innovation, which could also significantly impact a country's developmental trajectory, were not included due to data availability and scope constraints.

Secondly, the use of the K-Means clustering algorithm, while effective for identifying broad patterns and clusters, may oversimplify the complexities of economic and sustainable development. This method assumes uniformity within clusters and distinct separation between them, which may not fully capture the nuanced variations and overlaps that exist in reality. Furthermore, the decision to form three clusters was based on statistical analysis, but alternative clustering solutions might offer different perspectives on the data.

Another limitation arises from the temporal scope of the study. The data used represent specific points in time and may not accurately reflect ongoing developments or future trends. Particularly in the fast-evolving context of global economics and sustainability, such a snapshot view could miss emerging patterns or shifts in trajectories.

Finally, the focus on European countries, while providing in-depth regional insights, limits the generalizability of our findings. The economic and sustainable development dynamics in Europe may differ significantly from those in other regions due to unique historical, cultural, and geopolitical factors.

Acknowledging these limitations is crucial for a balanced understanding of our study's scope and for guiding future research. Subsequent studies could expand on our work by including additional variables, exploring alternative clustering methods, examining longitudinal data, or comparing European trends with those in other regions. Such efforts would further enrich the understanding of the complex interplay between entrepreneurship, sustainable development, and economic growth on a global scale.

Stated limitations provide a foundation for further investigation. Future studies could conduct micro-level analyses of each cluster, examining intra-cluster differences and cross-cluster cooperation possibilities. Additionally, researching the influence of external factors, like geopolitical shifts and global economic trends, on these clusters would lead to a more dynamic comprehension of Europe's financial and sustainable development pathway.

The European economic and sustainable development scene is made up of a number of clusters, each with their own characteristics, challenges and opportunities. To man oeuvre the complexity of modern economics and ecological milieu, countries can pursue economic heterogeneity, heighten sustainability obligations, boost creativity and inspire worldwide partnership. This paper highlights the importance of objective policy-making based on compelling evidence while highlighting the

potential for European countries to collectively move in the direction of a sustainable and resilient future.

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