



**OVERCOMING OBSTACLES: HIGHER EDUCATION INSTITUTIONS  
AND THE SDGS IN THE EU – A CLUSTER ANALYSIS**

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**ABSTRACT**

The aim of this study is to classify Higher Education Institutions (HEIs) in the European Union (EU) based on the financial and knowledge barriers they face in implementing sustainable practices. The data was collected from European universities through the European Deans Council for Sustainable Development (DECODE) sustainability project. Hierarchical cluster analysis was used to group countries based on their sustainability barriers, and each cluster was analyzed based on the socio-economic structure of the countries and the management organization of the universities. The findings suggest that countries with low scores on both the knowledge and financial side exhibit similarities and those facing higher financial barriers also tend to experience lower levels of knowledge barriers. The study provides valuable insights into the challenges and needs of HEIs in each country regarding Sustainable Development Goals (SDGs). This research can guide policymakers and universities in developing effective strategies to overcome financial and knowledge barriers and promote sustainability practices in HEIs.

**Keywords:** *Higher Education Institutions, Cluster Analysis, European Union, Sustainable Development Goals*

**1 INTRODUCTION**

Sustainable development has emerged as a pressing global concern for individuals, organizations, and governments. To address this challenge, the United Nations (UN) established the 2030 Agenda for Sustainable Development, which includes 17 Sustainable Development Goals (SDGs) and 169 objectives. Sustainable development principles are closely linked with SDGs, requiring a fundamental restructuring of higher education institutions (HEIs). The higher education sector is well positioned to address

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the environmental challenges facing the planet and support the SDGs' objectives, the green transition, and the European Union's Green Deal initiative. Specifically, three SDGs - quality education (SDG 4), decent work and economic growth (SDG 8), and reducing inequalities (SDG 10) - are crucial for sustainable economic development in HEIs (Gupta and Vegelin, 2016; De Paula, 2017; Annan-Diab and Molinari, 2017; Cottafava et al., 2019).

However, each nation possesses unique characteristics and requirements, resulting in distinct challenges when attempting to implement sustainable practices (Jabbari et al., 2020). Sarvajayakesavalu (2015) supports this argument, stating that each country faces specific challenges when striving to achieve the SDGs. Therefore, identifying the most significant obstacles to sustainable goals in the setting of large European universities, outlining countries that have implemented best or worst practices, and understanding if there is a recognizable pattern can help improve and enhance targeted development plans.

The primary objective of this research is to enhance the understanding of the obstacles that HEIs throughout the European Union (EU) encounter while implementing sustainable practices. Using hierarchical cluster analysis methodology, this paper classifies countries based on their sustainability barriers and detects socioeconomic tendencies. The aim is to distinguish common and unique features between countries, pinpoint the primary challenges, and present a framework to address these problems efficiently by prioritizing actions. To accomplish this, an alternative index of sustainable practices at an academic level was developed by utilizing an original dataset obtained from European universities that participated in the European Deans Council for Sustainable Development (DECODE) Sustainability project. The study concentrates on two primary obstacles that deans confront while implementing sustainable practices: financial and knowledge challenges, as suggested by prior literature.

The main contribution of this study is to provide insights into the progress and socio-economic and organizational structures of higher education institutions in the European Union. This analysis offers a more in-depth understanding of the progress made by countries toward achieving SDGs by grouping them based on their similarities and identifying the gaps between them. Accordingly, the differences in structures and priorities among countries enable a better understanding of the challenges and opportunities each one faces in advancing toward more sustainable academia. This study provides valuable insights that can inform targeted and effective interventions to address gaps and accelerate progress toward achieving the SDGs in HEIs.

To the best of our knowledge, no previous research has classified countries according to their barriers to implementing sustainable practices at the higher education level. Most previous studies are limited to the study of sustainable indicators for selected countries, neglecting the role of barriers faced at the academic level (e.g., Caglar and Gurler, 2021; Drastichová and Filzmoser, 2019; Allievi et al., 2011). Nonetheless, research on sustainable strategies among EU countries using cluster analysis and focusing on HEIs is a relatively new study area.



The study is essential for policymakers as promoting sustainable practices in higher education can positively impact the broader economy with significant spillover effects for society. Sustainable practices can encourage the development of new technologies, industries, and companies that support sustainability, leading to job creation and economic growth. In addition, sustainable practices in higher education can contribute to broader social and environmental benefits, such as reducing greenhouse gas emissions, protecting natural resources, and improving public health.

The remainder of the paper is structured as follows. Section 2 presents the theoretical foundations of the study and related literature. Section 3 outlines the research design, scope of the study, data, and the method used in this study. Section 4 summarizes and discusses the conclusions and implications of the research outcomes.

## **2 BACKGROUND**

### **2.1 *Obstacles to Sustainability in HEIs***

Higher education institutions are recognized for their crucial role in promoting sustainability, and there is a growing expectation among stakeholders for them to become sustainable organizations. Nonetheless, accomplishing this goal can be a complex task that requires overcoming significant barriers and challenges (Aleixo et al., 2018). The available literature on this topic shows that many universities aim for sustainable development. However, they point to significant obstacles hampering their progress.

The first issue relates to environmental knowledge. Sustainability is often viewed as a complicated and ambiguous concept that can pose challenges for individuals and organizations wishing to incorporate sustainability principles into their practices. According to Leal Filho (2011), Shriberg and Harris (2012), and Wright and Horst (2013), sustainability is often perceived as an abstract and multifaceted issue that encompasses a range of economic, social, and environmental considerations. This complexity can make it difficult for individuals and organizations to develop a clear understanding of sustainability and identify concrete actions consistent with sustainable development goals. As a result, there is a need for more clarity and coherence in how sustainability is defined and operationalized and more significant efforts to promote sustainability literacy and awareness among individuals and organizations across sectors.

A second challenge that can hinder the integration of sustainability practices in universities is the lack of financial resources and funding. As reported by Figueredo and Tsarenko (2013), Shriberg and Harris (2012), and Waas et al. (2012), sustainable development initiatives often require significant financial investments, which can be an obstacle for universities with limited budgets. In addition, as Velazquez et al. (2005) reported, sustainability may not always be a top priority for universities, which can further limit the availability of financial resources for sustainability-related projects and initiatives. This lack of financial support



can hamper universities' ability to implement sustainable practices, resulting in missed opportunities to make meaningful changes toward a more sustainable future. Therefore, it is essential to identify and implement innovative funding mechanisms and funding models to support sustainability efforts at universities and raise awareness of the importance of sustainable development among university stakeholders, including funders and decision-makers.

This article analyzes the obstacles that HEIs in EU countries face in their sustainability efforts. To achieve this, the article develops two indices that reflect the main barriers faced by academic leaders: knowledge barriers and financial barriers. These indexes comprehensively overview universities' critical challenges in pursuing sustainable development. By clustering these indexes, the article attempts to identify common sustainable barriers across EU countries and provide policy recommendations to overcome them. The results of this study can inform the development of effective strategies and policies that support higher education institutions on their journey to sustainability and ultimately contribute to a more sustainable future for all.

### **2.2** *Cluster analysis in the EU countries for SDGs goal*

This paper employs a cluster analysis to group data based on geographical location and identify socio-economic patterns. The data is obtained from interviews conducted as part of the DECODE project following Alexio et al. (2016). They performed a cluster analysis focusing on sustainability issues in HEIs with interviews involving 20 individuals. Higher Education Institutions (HEIs) are frequently regarded as privileged stakeholders or significant observers in studies concerning sustainable strategies (Hancock and Nuttman, 2014). This qualitative and exploratory analysis based on interviews with a cluster approach aligns with previous attempts in the literature.

Although the limited number of countries is common in qualitative studies based on this type of survey (Akenji, 2016), it is important to note that cluster analysis is highly sensitive to the choice of algorithm, particularly in small sample sizes (Jain, 2010). However, in this study, the indicators are aggregated from hundreds of observations at the university level, which helps to ensure within-variability. Furthermore, both analysis techniques and literature suggestions were used to enhance the robustness of the findings. Cluster analysis is a widely used technique among scholars to explore the relationship between SDG targets and European trends across countries. For instance, Jabbari et al. (2020) employed cluster analysis by combining development and environmental indices. Allievi et al. (2011) applied cluster analysis to classify EU-27 countries into 5-6 clusters depending on the indicator. Similarly, Drastichová and Filzmoser (2019) studied SDGs in EU countries using a similar number of clusters. Petrov et al. (2018) focused on Southeast European countries to cluster Sustainable Development Goals, while Ç ağlar and Gürler (2021) investigated the same relationship and found that the optimal choice is five clusters.

Overall, the study of sustainable strategies among EU countries using cluster analysis with a focus on HEIs is still a nascent research area. However, recent results have been highly innovative and offer valuable policy recommendations that are consistent with both the methodology and theoretical frameworks of the research.



### 3 RESEARCH METHODOLOGY

To investigate the features of Higher Education Institutions (HEI) in the European Union, a cluster analysis was utilized to classify countries into similar groups. Cluster analysis is a broad term encompassing various techniques that aim to identify distinct clusters within a dataset and subsequently classify them accordingly (Everitt, 1993). As an effective statistical tool for identifying objects with similar characteristics in a dataset, cluster analysis is widely acknowledged (Chinese and Meneghetti, 2004). This method considers each object as a point in a multi-dimensional space defined by its attributes, and calculates the distance between two objects to determine their similarity in terms of each attribute (Banfield and Raftery, 1993). Hierarchical clustering, which includes agglomerative and divisive methods (Andre, 1996), is commonly used in research. This paper employs the agglomerative hierarchical method.

This study comprised several research steps. The initial phase involves collecting university data from an original dataset of European universities sourced from the Sustainability Projects of the European Deans Council for Sustainable Development (DECODE). In the subsequent stage, we determine essential variables representing the fundamental barriers of the higher education institution (HEI) sector, which can be evaluated for data collection. After selecting variables, we aggregate them across countries and define normalized barriers indexes. In the third phase, cluster analysis is implemented to categorize the 26 countries into distinct groups. Subsequently, the clusters are characterized and interpreted based on the selected indicators. More in detail, after obtaining the clusters, each cluster was examined by the member countries' governance, skills, and availability of funds, using descriptive statistics and correlation analysis. Lastly, dissimilarities between clusters are defined, and the policy implications are analyzed.

#### 3.1 Variables

This study aims to assess the barriers that universities face in achieving academic sustainability, focusing on two critical indicators, namely knowledge and financial barriers. Knowledge-related barriers to sustainable practice within academia refer to the challenges universities face in the dissemination, production, and application of knowledge related to sustainability issues. These challenges can include limited access to information and resources, lack of awareness and understanding of sustainability issues, inadequate opportunities for collaboration and networking, and inadequate training and capacity-building programs. Financial obstacles in sustainable practice within academia refer to the challenges that universities face in securing adequate funding and resources to support their sustainability initiatives. These obstacles may include limited financial resources, inadequate funding mechanisms, and competing priorities within the institution. Indicators used in this study for financial and knowledge-related obstacles to sustainable activities in academia in the different countries are:

- **Financial obstacles:** the interviewees, members who work in academic



institutions, consider lack of funds a key obstacle in implementing sustainable practices.

Dimension	Question	Scale	N° of answers
Environmental Knowledge Index	Knowledge obstacles in academic staff to undertake sustainability initiatives	5	509
Financial Index	Financial obstacles in academic staff to undertake sustainability initiatives	5	509
Timing	Timing in sustainability activities in the unit	4	431
Gender	Gender of respondent	2	462
Size	Students per unit	7	509
R&D	Percentage of public expenditure in R&D	-	-

Table 1: Note: Scale for the knowledge and financial index: Strongly disagree = -2; Disagree = -1; Neutral= 0; Agree = 1; Strongly agree = 2; Scale for timing variable Not yet addressed - don't know= 0; Only recently= 1, For a longer period= 2, Before 17 SDGs= 3. Scale for gender; Male = 1; Female = 0. Scale for size, based on the number of students < 50 = 1; 50-99 = 2; 100-499 = 3; 500-999 = 4; 1000-2499 = 5; 2500-5000 = 6; > 5000 = 7.

• **Knowledge obstacles:** the interviewees, members who work in academic institutions, consider a lack of environmental knowledge a key obstacle in implementing sustainable practices.

After identifying the clusters, this study analyzes the socio-economic and politico-cultural structures of the UE countries by utilizing a set of indicators that act as proxies for various aspects of the countries' structures, including their economic development, political institutions, and cultural values. Specifically, the following indicators are used in the study:

• Gender: The questionnaire is divided according to the gender of the academic institution members who are being interviewed - male or female.

• Timing: This refers to the adoption of sustainable solutions, and the answers are categorized into the following range: only recently up to 3 years, for a longer period of 3-5 years, or before SDGs goals.

• Dimension: Universities are categorized based on the number of students they have.

• Research and Development Expenditure: The percentage of public expenditures in research and development in a specific country.

Table 1 summarizes the variable properties used in this study.

### 3.2 Data

The data used in this study were collected from the "DECODE" Sustainability. This dataset can be disaggregated by different hierarchical levels, improving the quality of the results. Secondly, we try to understand whether economic barriers in this policy are



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prohibitive. This survey is predicated on the idea that achieving a sustainable EU is a "prerequisite" for higher education and its three core goals of education, research, and involvement (EC 2019). The information is gathered through interviews with deans, vice-deans, directors of academic departments, and representatives of the academic community. The primary topic of discussion throughout the interviews was the academic units' sustainability initiatives. The study investigates the achievement of the SDGs goals, focusing on policy implementation. It particularly emphasizes the challenges, financial and knowledge-related, that, according to the interviewee's perceptions, impede the realization of sustainable practices.

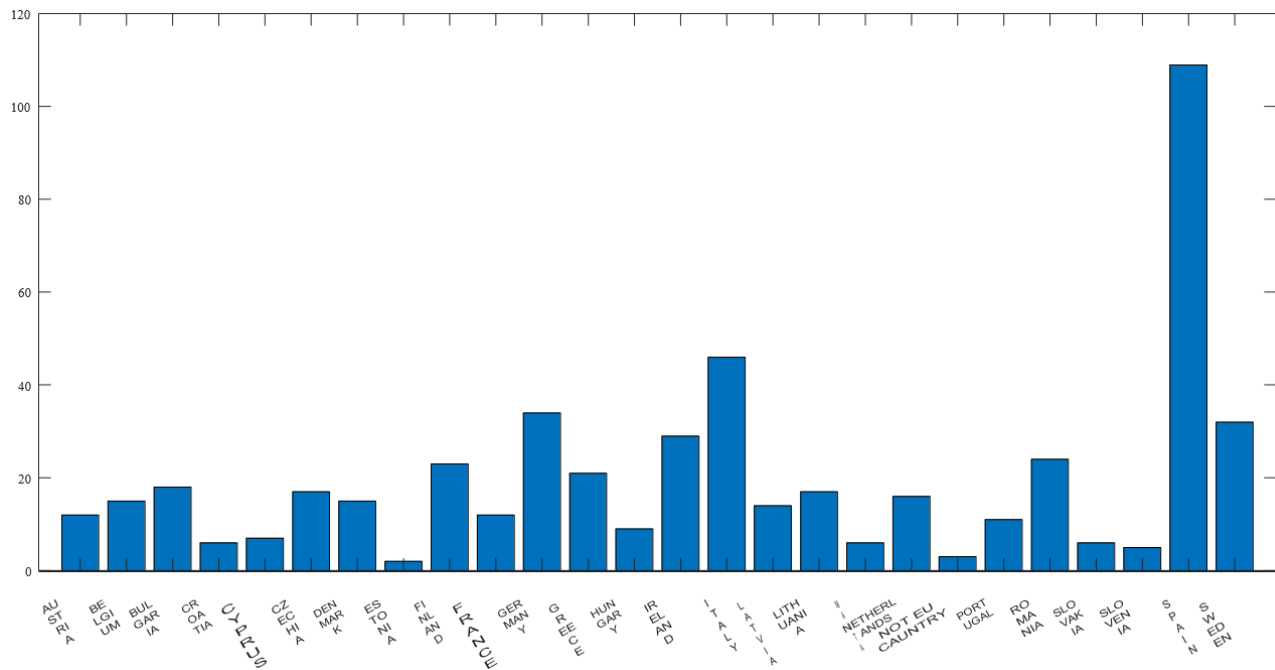


Figure 1: Higher education institutions distribution across countries in this study

The report pertains to universities in 25 European countries plus a group of no EU countries. Countries follow this distribution: 50% of the respondents come from Northern European countries, 27% of them from Southern Europe, and the remaining 23% from Eastern Europe (see Figure 1). All three dimensions (economic, social, and environmental) of sustainable development affected by SDGs as described by UNs are involved. The target group of the study is units of academic managers, in particular Deans, Directors/Heads of Academic Units (82%), and a smaller share of Vice-Deans or similar responsibilities (16% together). As a result, the analysis seeks to pinpoint the potential and obstacles that academic unit heads or their representatives have when integrated and putting sustainability efforts into their work on social engagement, research, and education. To pursue these goals, the obstacles that stand in the way of achieving the SDGs goals can be divided into two categories: financial and knowledge. We have identified the question focused on these topics and we proceeded to the codification of answers. Finally, we have summarized and standardized the values. The



same steps have been followed to construct structural evaluation indicators of each cluster (timing, gender, dimension, R&D expenditure). After coding, the weighted average has been calculated. The following steps are to proceed into the standardization to compare the level of financial and knowledge obstacles. The chosen method is to the min-max normalization [-2,2]:

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)} \tag{1}$$

This method allows for a rescaling of data in a range that make comparable classification among countries. The method also respects the variability within the observation.

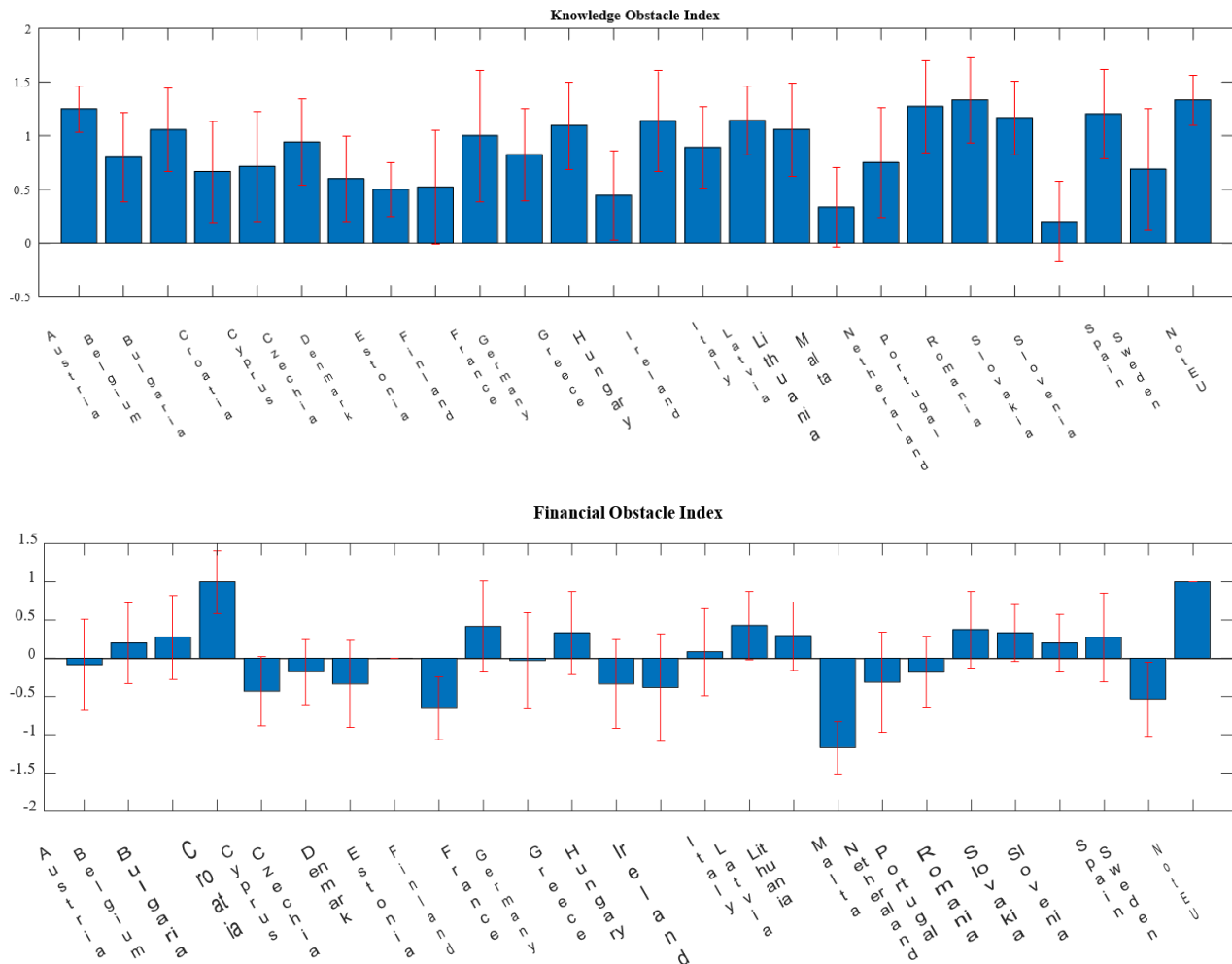


Figure 2: Knowledge and Financial Obstacles Indexes for HEIs



### 3.3 Sustainable Obstacles Index for HEIs

Before clustering countries, country-specific features are examined. Table 2 show descriptive statistics. Figure 2 displays financial and knowledge indexes for the EU countries and relative variability within the country. The most evident difference is that all countries-target complain about the presence of knowledge obstacles. The level of this kind of obstacle is higher in non-EU countries that respect EU ones. Romania shows the highest value against Slovenia (the lowest). The level of variability inside each country reflects the number of respondents but is quite similar for this category of obstacle. Focusing on financial obstacles, not all countries complain lack of financial support. Malta has the lowest value (-1.17), on the contrary, Croatia has the highest one (1.00). In this kind of obstacle, the variability inside each country is much higher than the previous one. It reflects reasonable structural characteristics of the countries.

The awareness (in terms of knowledge barriers) of EU countries is generally higher, which can be seen as the result of European awareness policies. Greater awareness also implies greater awareness of the gaps in achieving the goals. This can be considered one of the reasons for the fact that all nations show positive values in the perception of knowledge obstacles. In contrast, perceptions of financial obstacles are reasonably related to available funds and comparisons with other universities and nations. This is reflected in greater internal variability and negative values.

The correlation matrix in Table 3 shows the correlations between different obstacles and indices related to sustainable development in universities. Correlations with absolute values greater than 0.3 are considered moderate to strong, while those with absolute values less than

0.3 are considered weak. The results suggest that financial barriers correlate moderately with knowledge barriers (0.511) and weakly with temporal barriers (0.138) and the dimension index (0.095). This indicates that financial constraints can impede the development of sustainable practices, which require expertise and knowledge but are not necessarily dependent on the timing or the size and scope of the institution's sustainability efforts.

Table 2: Descriptive Statistics

	<b>Max</b>	<b>Min</b>	<b>Mean</b>	<b>Dev. St</b>
Time obstacles index	1.50	-0.45	0.34	0.38
Knowledge obstacles index	1.33	0.20	0.88	0.32
Financial obstacles index	1.00	-1.17	0.02	0.48
Timing index	2.15	0.67	1.50	0.32
Gender index	0.67	0.08	0.35	0.15
Dimension index	6.00	2.67	4.52	0.69



Table 3: Correlation matrix

	Time obstacles	Knowledge obstacles	Financial obstacles	Timing Index	Gender Index	Dimension Index
<b>Times obstacles</b>	1.000					
<b>Knowledge obstacles</b>	-0.228	1.000				
<b>Financial obstacles</b>	0.138	0.511**	1.000			
<b>Timing Index</b>	-0.319	0.003	-0.356	1.000		
<b>Gender Index</b>	-0.202	0.179	-0.018	-0.006	1.000	
<b>Dimension Index</b>	0.294	0.049**	0.095	-0.106	0.024	1.000

The Timing Index is moderately correlated with barriers to knowledge (-0.319), suggesting that a lack of awareness and understanding of SDGs can contribute to delays in implementing sustainable practices. The Gender Index is weakly correlated with all other variables, suggesting that gender factors may not play a significant role in the barriers and opportunities related to sustainable development in higher education institutions. The Dimension Index correlates weakly with financial barriers (0.095) and moderately with knowledge barriers (0.049), suggesting that the size and scope of the institution’s sustainability efforts can be influenced by the organization’s knowledge and expertise related to sustainable development. Overall, these results provide insights into\* \* the complex interrelationships between various barriers and indicators related to sustainable development in higher education institutions and can serve as a basis for the development of effective strategies and policies to support sustainable development efforts in the sector.

#### 4 RESULTS

The hierarchical clustering technique, the "agglomerative method," was employed to generate clusters from the normalized data. The squared Euclidean distance was calculated between each pair of countries during the agglomeration process. This method allows for obtaining a set of hierarchically ordered distributions. An exploratory analysis of the dendrograms is carried out to obtain the clusters. The best cut is decided based on the literature and the exploratory analysis.

Dendrograms were used to identify increasing clusters for each category of obstacles, considering the appropriate distances and similarities. It is worth noting that a trade-off exists between the number of clusters and the level of information efficiency (as illustrated in Figure 3). Selecting a more significant number of clusters may allow for more specific identification of subgroups within each category of obstacles, but this may also reduce the clarity of the resulting clusters.

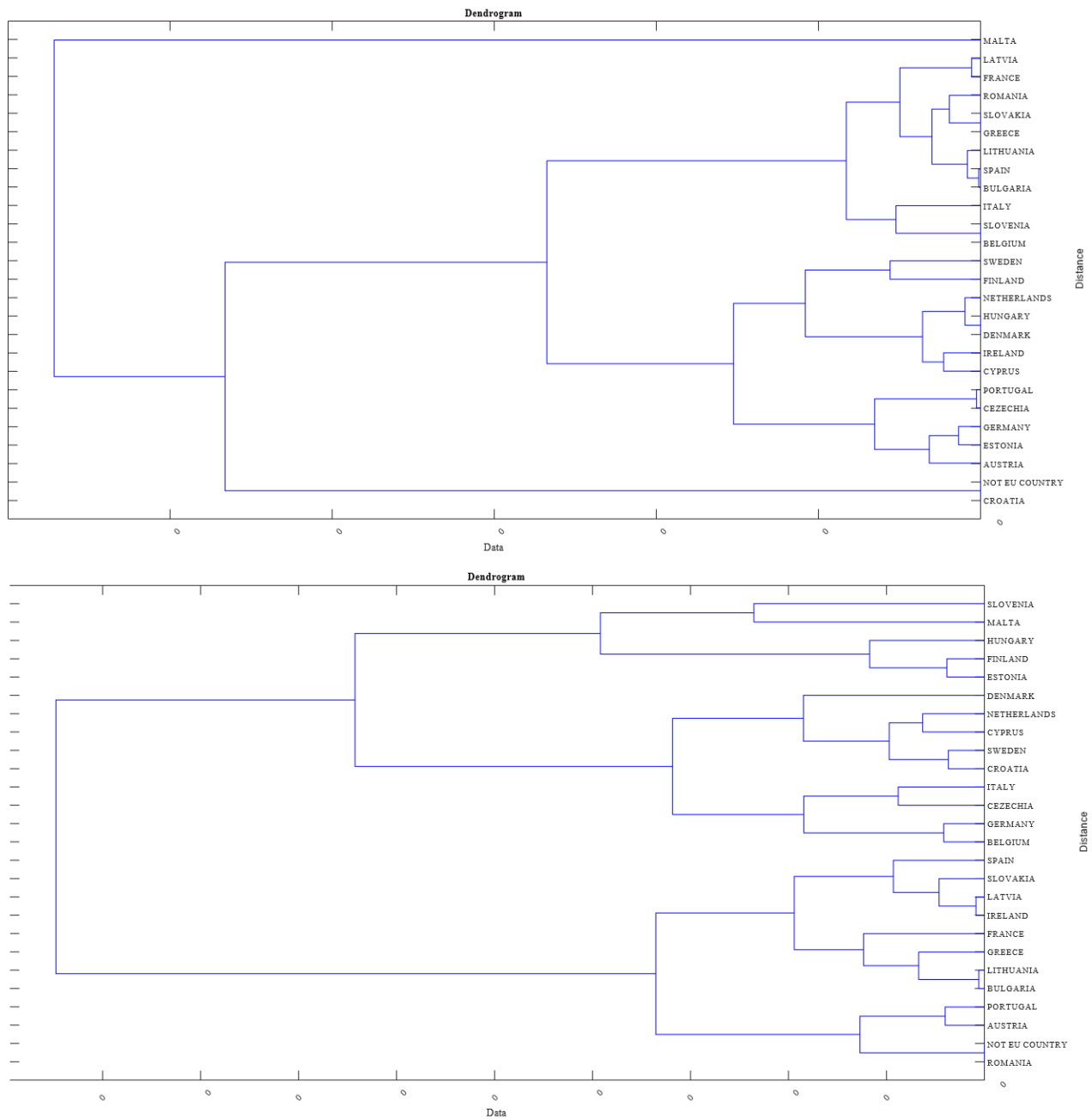


Figure 3: Dendrograms: Top Panel: Financial Obstacles Index; Bottom Panel: Knowledge Obstacles Index

On the other hand, choosing fewer clusters may result in more general categories that may not capture the intricacies of the data. Therefore, the optimal number of clusters must be determined based on the specific needs and objectives of the analysis.



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Moreover, prior literature on this subject focuses on the EU countries and has suggested that utilizing a cluster solution with 5 clusters allows for better control over the underlying dimensions while yielding compelling insights into the geographical distribution of the identified clusters. The use of 5 clusters has been found to strike a balance between specificity and comprehensiveness, allowing for identifying nuanced subgroups within each category of obstacles while maintaining an appropriate level of information efficiency. Additionally, this cluster solution has been shown to provide valuable information on the distribution and characteristics of the identified clusters across different geographical regions. To strengthen this result, we also perform the elbow method. The elbow method is used to determine the optimal number of clusters for a given dataset in a clustering analysis.

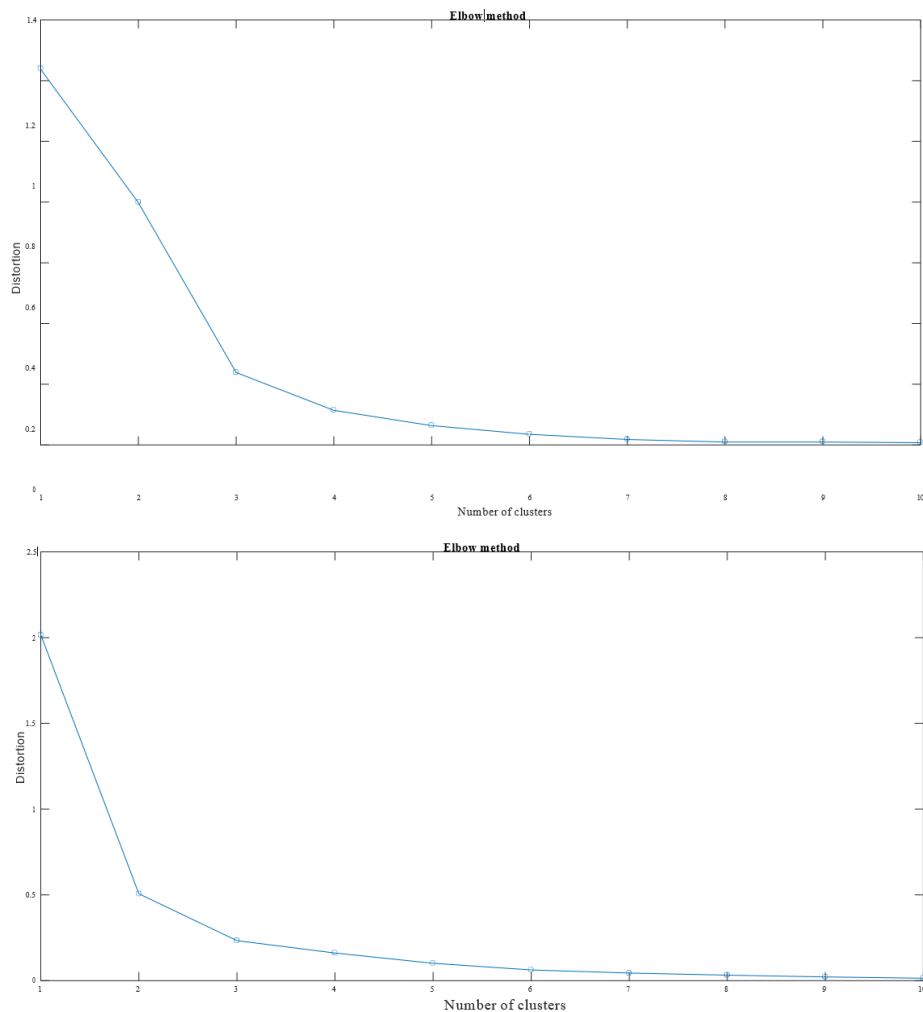


Figure 4: Elbow method - Top Panel: Financial Obstacles Index; Bottom Panel: Knowledge Index

The method involves calculating the sum of squared distances (SSE) between each data point and its corresponding cluster centroid for varying numbers of clusters. The optimal number of clusters is typically determined when the SSE value stops decreasing



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significantly, corresponding to the elbow point in the plot. As shown in Figure 4, the number of clusters corresponding to the change in the slope of the curve shows evidence in favor of 5.

The resulting geographical distribution shows some preliminary evidence (Figure 5 and Tables 4 and 5). The first pattern can be identified by focusing on cluster size. In both cases (knowledge and financial obstacles), the size of the clusters is non-homogeneous: the hierarchical technique identifies two larger clusters, two smaller ones, and one cluster that could be considered residual. The larger clusters drive the overall EU average, while the smaller ones describe groups of countries far from the average value (in a positive or negative direction). The differences among these countries are statistically significant <sup>1</sup>.

Knowledge barriers and financial barriers are positively related to the lowest value: countries with fewer financial barriers also have fewer knowledge barriers (northern Europe is always in the highest part of the distribution). More complex is the relation for the countries that exhibit a higher level of financial obstacles; In some cases, those who exhibit or complain about higher financial barriers exhibit a similar result for knowledge barriers (Mediterranean and southern Europe).

On the other hand, there are interesting exceptions located in Central and Southern Europe (i.e., Italy and Germany) where the level of financial barriers is relatively high, but that of knowledge barriers is nevertheless low.

The largest group of countries with an average knowledge obstacle index of around 0.67 (medium-high) emerges. These are mostly Mediterranean European countries and some Eastern European countries. Two other interesting clusters are to be found in that grouping of Central European countries (plus Portugal), which has an average obstacles-index of 0.49\* (medium), and in that of Northern Europe of 0.34\* (medium-low). Regarding the obstacle presented by financial constraints, it is noteworthy that the two most prominent clusters exhibit distinct levels of knowledge barriers.

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<sup>1</sup>The statistically significant is computed by performing a non-parametric average difference test at 10% level.



*Clusters*

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>
Austria	Bulgaria	Belgium	Estonia	Malta
No-EU	France	Croatia	Finland	Slovenia
Portugal	Greece	Cyprus	Hungary	
Romania	Ireland	Czechia		
	Latvia	Denmark		
	Lithuania	Germany		
	Slovakia	Italy		
	Spain	Netherland		
		Sweden		

Table 4: Clusters-Knowledge Obstacles

*Clusters*

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>
Belgium	Austria	Cyprus	Croatia	Malta
Bulgaria	Czechia	Denmark	No-EU	
France	Estonia	Finland		
Italy	Germany	Hungary		
Greece	Portugal	Ireland		
Latvia		Netherland		
Lithuania		Sweden		
Slovakia				
Slovenia				
Spain				
Romania				

Table 5: Clusters-Financial Index

One of these clusters, comprising nations from Western and Eastern Europe, primarily Mediterranean countries such as Spain, France, Greece, and Bulgaria, demonstrates a medium-high value of 0.81\*. The other cluster, encompassing Northern, Central, and Southern European countries, including Norway, Germany, and Italy, exhibits a medium value of 0.50\* and is geographically transversal.

The results presented in this study provide insightful evidence about the relationship between financial and knowledge barriers in Europe. The non-homogeneous cluster sizes and significant differences among countries with varying levels of barriers indicate that there is a need for targeted policies that address the specific obstacles faced by each group. The identification of clusters with varying levels of obstacles can provide a useful starting point for policymakers to design effective policies that cater to the specific needs of each group.

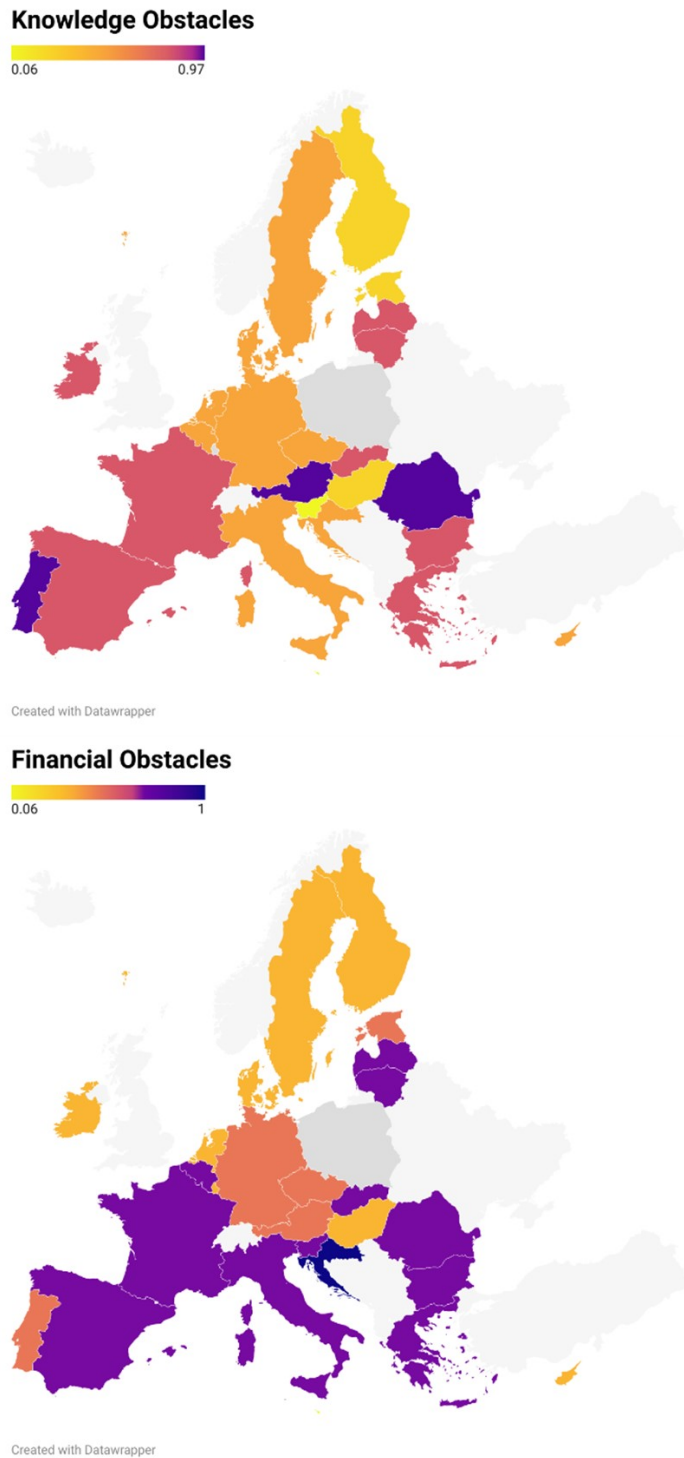


Figure 5: Geographical Distribution: Top Panel: Knowledge Obstacles Index; BottomPanel:Financial Obstacles Index



### 4.1 Socioeconomic Characterization

The non-homogeneous cluster sizes and significant differences among countries with varying levels of barriers suggest that there may be other factors at play that contribute to the observed patterns. For this purpose, this section provides a socio-economic characterization based on the main drivers of management organization: skills (timing), governance (gender and size) availability of funds (R&D expenditure).

### 4.2 Financial obstacles

This section conducts a socio-economic analysis by examining the primary drivers of management organization as they relate to the financial obstacle index. Figure 6 presents a box plot visualizing the distribution of the financial index. Focusing on the three largest clusters (A, B, and C). Cluster A 0.67 (medium-high) represents Mediterranean European countries and some Eastern European countries, cluster B Central European countries (plus Portugal), which has an average obstacles-index of 0.49\* (medium), and in that Northern Europe of 0.34\* (medium-low). The two minor clusters outliers D (1.00 high) represent Croatia and E (0.00 low) Cyprus. Regarding timing, countries included in the Cluster C that exhibits a medium-low level of financial obstacles have the highest timing value.

Consistently clusters with a high level of financial obstacles have the lowest R&D expenditure (about 24%) and vice versa for the other clusters. It is interesting to note that cluster A, which represents Mediterranean and Eastern European countries with a medium-high level of obstacles, exhibits the lowest R&D expenditure, indicating the need for policies that promote innovation and investment in these regions. Interestingly, higher levels of financial obstacles (0.67) correspond to lower levels of the gender index (0.43), and clusters that have a gender index higher than 0.5 show financial obstacles lower than 0.5. In any case, the variability of gender is very high to obtain reliable results. The dimension index does not show a clear evident pattern. It is more difficult to interpret the border clusters representing the highest level of financial barriers (Croatia) and the lowest (Cyprus) because they are outside the described pattern and can be regarded as outliers. In general, these clusters follow the well-documented pattern of socioeconomic inequalities in Europe.

In general, these clusters follow the well-documented pattern of socioeconomic inequalities in Europe. Mediterranean countries and Eastern countries suffer worse economic conditions. Consequently, the Universities receive fewer funds compared to other European countries. The relation between gender and financial obstacles is quite understandable: The less is importance given to research, the less is sensibility towards social themes (e.g., sustainability) like gender inequalities. The same scheme can justify the values of timing.

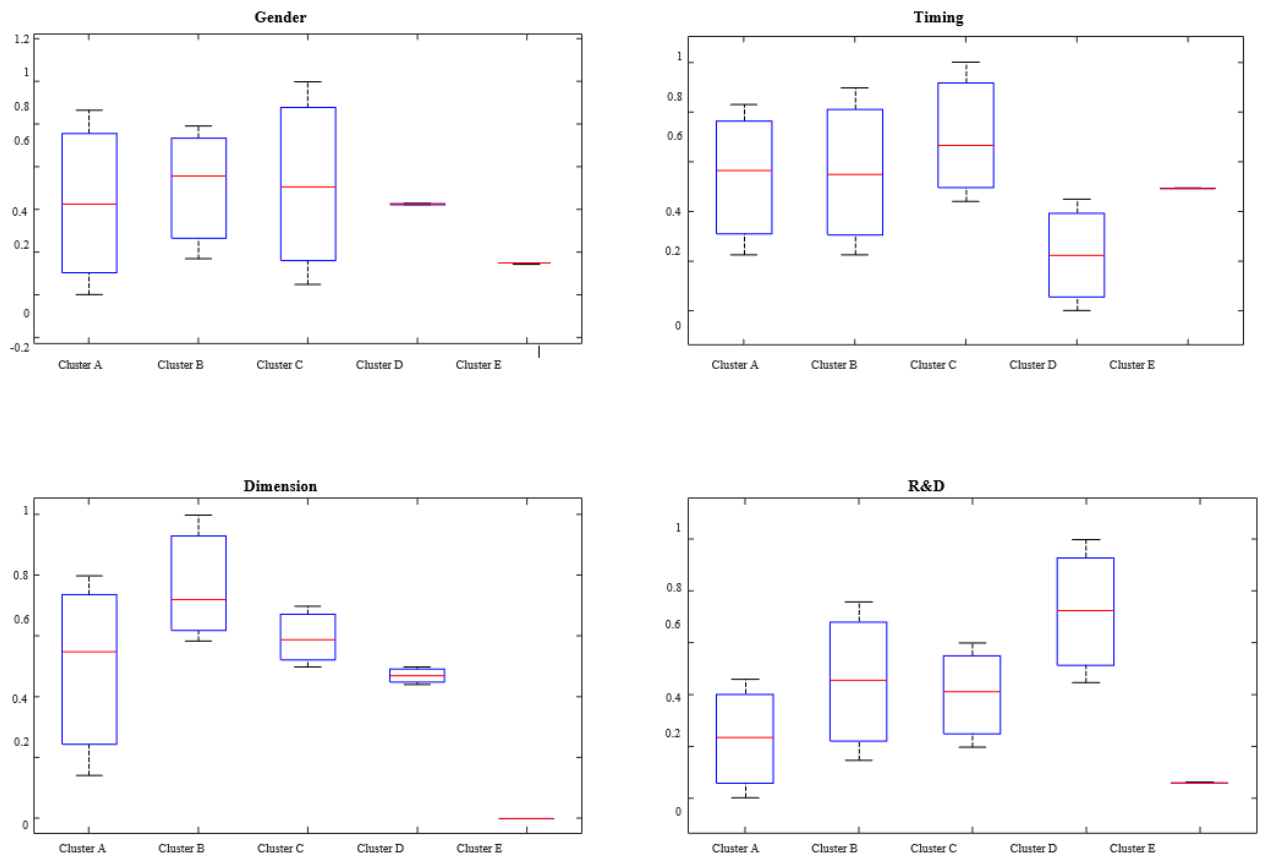


Figure 6: Box Plot Financial Index

### 4.3 Knowledge obstacles

In this section, a socio-economic analysis is performed to investigate the primary determinants of management organization with respect to the knowledge obstacle index. To visually represent the distribution of the knowledge index, a box plot is depicted in Figure 6. The clustering of knowledge barriers shows interesting changes compared to the financial ones. The two largest clusters have quite different values of knowledge barriers. Cluster B has a value of

0.81 (medium-high) and groups countries from Western Europe (Spain, France) and Eastern Europe (Greece, Bulgaria), but mainly Mediterranean countries; cluster C has a value of 0.50 (medium) and is a transversal geographical cluster grouping Northern, Central and Southern Europe (e.g., Norway, Germany, Italy). Cluster A with the highest level of knowledge barriers groups Poland, Portugal, and Austria (0.97), while cluster D has medium-low levels in Finland, Estonia, and Hungary (0.25). Cluster E which includes Slovenia has the lowest value (0.06). Also, in this case, D and E can be considered outliers. The study revealed that cluster C had the highest values in the timing index, with a knowledge

obstacle value of 0.5, although no clear pattern was observed overall. Additionally, in terms of public expenditure on R&D, cluster C showed the highest R&D value (47%) compared to cluster B, which had a high level of knowledge obstacles but only about 23% of R&D expenditure. The level of the gender index was similar in both clusters, hovering around 50%. Interestingly, the clusters showed a similarity in size, despite their differences in knowledge barriers.

To further elaborate on the study findings, it is worth noting that the higher R&D expenditure in cluster C could be a contributing factor to their higher value in the timing index. This may suggest that increased investment in RD could lead to more timely progress toward achieving the SDGs. On the other hand, the higher level of knowledge obstacles in cluster B, despite its smaller size, highlights the potential role of education and capacity building in overcoming such barriers.

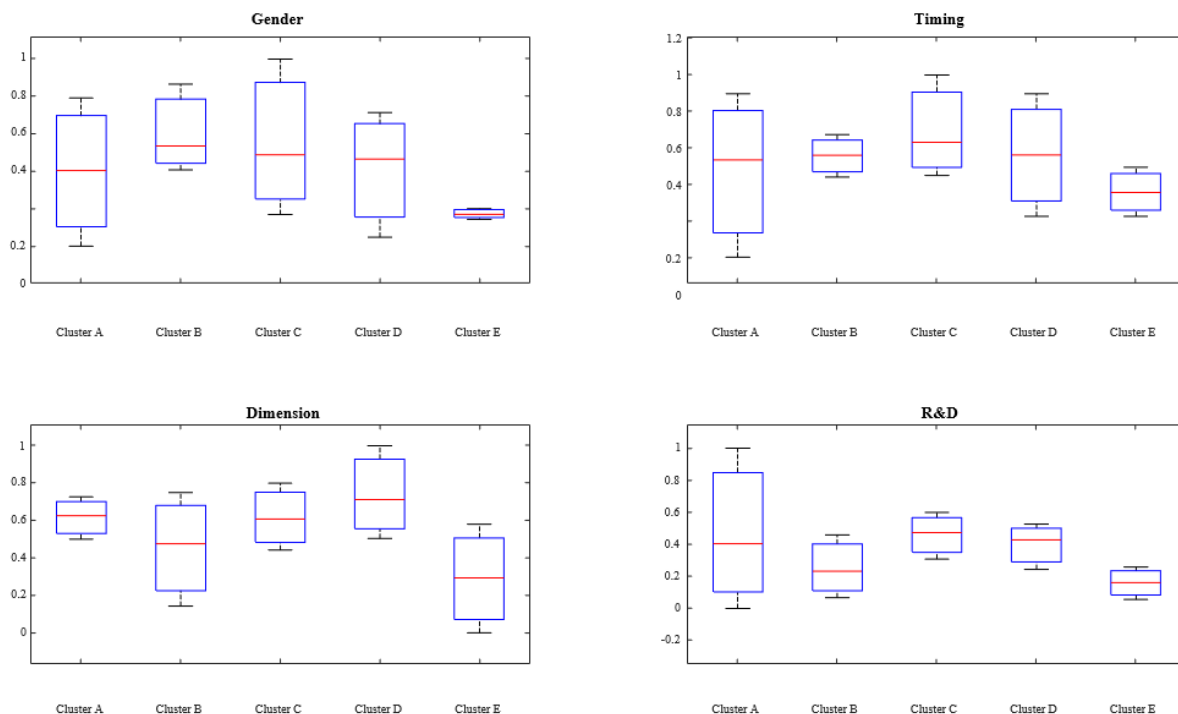


Figure 7: Box Plot Knowledge Index

The similarity in gender index between the two clusters is also an interesting observation, as it suggests that gender inequality may not necessarily be a significant factor affecting progress towards the SDGs. However, it is important to note that the study did not explore the specific factors contributing to the gender index values, and further research maybe needed to fully understand the relationship between gender equality and SDG progress. Finally, the similarity in size between the two clusters, despite their differences in knowledge barriers, suggests that countries of different sizes face similar challenges in achieving the SDGs. Knowledge barriers do not follow the well-known socio-economic patterns within the European Union.



Furthermore, the breakdown of the knowledge barriers does not lead to a similar pattern with regard to the distribution of the gender index.

## **5 CONCLUSIONS**

Empirical evidence suggests that financial barriers follow easily identifiable patterns. They generally reflect socio-economic inequalities between European countries. In general, lower financial barriers are associated with better timing, higher R&D expenditure, and a better gender index. More cross-national is the distribution of knowledge indexes. Several factors may intervene on these to increase the bias: greater awareness implies greater awareness of the obstacles, on the other hand, the level of knowledge and effort on the subject is more anchored in ethical or moral motives.

However, it is possible to find a perception of high knowledge barriers in countries exhibiting high R&D expenditure and a good gender index or, on the contrary, perceived low barriers in countries with several opposite characteristics. More cross-national is the distribution of knowledge indexes. Several factors may intervene on these to increase the bias: greater awareness implies greater awareness of the obstacles, on the other hand, the level of knowledge and effort on the subject is more anchored in ethical or moral motives.

In general, however, we can identify a certain recurrence because countries with low values on both the knowledge and financial side are similar; on the contrary, nations complaining of higher financial obstacles may also complain of lower levels of knowledge obstacles. It is difficult to establish whether the lower level of knowledge barriers exhibited is due to greater effort on the part of countries or to an overestimation of their knowledge (Dunning Kruger effect).

The overview of the above considerations makes it difficult to establish a bi-directional (causal) relationship between the two obstacles. On the contrary, it prompts one to consider them differently: implementing and increasing awareness plans and policies is always useful. This is not always true of funds, for if they are not supported by adequate knowledge, they could easily be inefficient. This may have implications for policymakers and international organizations in terms of targeting their efforts toward countries with specific needs and challenges, regardless of their size.

## **REFERENCES**

- [1] Aleixo, A. M., Leal, S., & Azeiteiro, U. M. (2018). Conceptualization of sustainable higher education institutions, roles, barriers, and challenges for sustainability: An exploratory study in Portugal. *Journal of cleaner production*, 172, 1664-1673.
- [2] Allievi, F., Luukkanen, J., Panula-Ontto, J., & Vehmas, J. (2011). Grouping and ranking the EU-27 countries by their sustainability performance measured by the Eurostat sustainability indicators. *Trends and future of sustainable development*, 9.



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- [3] Annan-Diab, F., & Molinari, C. (2017). Interdisciplinarity: Practical approach to advancing education for sustainability and for the Sustainable Development Goals. *The International Journal of Management Education*, 15(2), 73-83.
- [4] Banfield, J. D., & Raftery, A. E. (1993). Model-based Gaussian and non-Gaussian clustering. *Biometrics*, 803-821.
- [5] Akenji, L., Bengtsson, M., Bleischwitz, R., Tukker, A., & Schandl, H. (2016). Ossified materialism: introduction to the special volume on absolute reductions in materials throughput and emissions. *Journal of Cleaner Production*, 132, 1-12.
- [6] Çağlar, M., & Gürler, C. (2022). Sustainable Development Goals: A cluster analysis of worldwide countries. *Environment, Development and Sustainability*, 24(6), 8593-8624.
- [7] Chinese, D., Meneghetti, A., & Nardin, G. (2004). Diffused introduction of Organic Rankine Cycle for biomass-based power generation in an industrial district: a systems analysis. *International Journal of Energy Research*, 28(11), 1003-1021.
- [8] Cottafava, D., Cavaglià, G., & Corazza, L. (2019). Education of sustainable development goals through students' active engagement: A transformative learning experience. *Sustainability Accounting, Management and Policy Journal*, 10(3), 521-544.
- [9] de Paula Arruda Filho, N. (2017). The agenda 2030 for responsible management education: An applied methodology. *The International Journal of Management Education*, 15(2), 183-191.
- [10] Drastichová, M., & Filzmoser, P. (2019). Assessment of sustainable development using cluster analysis and principal component analysis. *Problemy Ekorozwoju*, 14(2).
- [11] Everitt, B. S. (1993). *Cluster analysis*. John Wiley & Sons, New York, NY.
- [12] Figueredo, F. R., & Tsarenko, Y. (2013). Is "being green" a determinant of participation in university sustainability initiatives?. *International Journal of Sustainability in Higher Education*, 14(3), 242-253.
- [13] Gupta, J., & Vegelin, C. (2016). Sustainable development goals and inclusive development. *International environmental agreements: Politics, law and economics*, 16, 433-448.
- [14] Hancock, L., & Nuttman, S. (2014). Engaging higher education institutions in the challenge of sustainability: sustainable transport as a catalyst for action. *Journal of cleaner production*, 62, 62-71.
- [15] Jabbari, M., Shafiepour Motlagh, M., Ashrafi, K., & Abdoli, G. (2020).



- Differentiating countries based on the sustainable development proximities using the SDG indicators. *Environment, Development and Sustainability*, 22, 6405-6423.
- [16] Jain, A. K. (2010). Data clustering: 50 years beyond K-means. *Pattern recognition letters*, 31(8), 651-666.
- [17] Filho, W. L. (2011). About the role of universities and their contribution to sustainable development. *Higher Education Policy*, 24, 427-438.
- [18] Petrov, V., Trivić, N., & Ćelić, . (2018). Assessing sustainability of the Southeast Euro- pean economies. , 65(2), 519-529.
- [19] Sarvajayakesavalu, S. (2015). Addressing challenges of developing countries in imple- menting five priorities for sustainable development goals. *Ecosystem Health and Sustain-ability*, 1(7), 1-4.
- [20] Shriberg, M., & Harris, K. (2012). Building sustainability change management and lead- ership skills in students: lessons learned from “Sustainability and the Campus” at the University of Michigan. *Journal of Environmental Studies and Sciences*, 2, 154-164.
- [21] Velazquez, L., Munguia, N., & Sanchez, M. (2005). Deterring sustainability in higher education institutions: An appraisal of the factors which influence sustainability in higher education institutions. *International Journal of Sustainability in Higher Education*, 6(4), 383-391.
- [22] Waas, T., Hugé, J., Block, T., Wright, T., Benitez-Capistros, F., & Verbruggen, A. (2014). Sustainability assessment and indicators: Tools in a decision-making strategy for sustainable development. *Sustainability*, 6(9), 5512-5534.
- [23] Wright, T., & Horst, N. (2013). Exploring the Ambiguity: What Faculty Leaders Really think of Sustainability in Higher Education. *International Journal of Sustainability in Higher Education*, 14(2), 209-227.

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