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Comparison of European Union Countries in Travel and Tourism Development Using Principal Component Analysis

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Abstract Tourism is undoubtedly one of the most significant factors contributing to the economy and development of countries. Consequently, numerous countries intend to attract more tourists annually by investing in the tourism sector. Countries compete in this domain and seek to enhance their development levels. The Travel and Tourism Development Index (TTDI), featured in the Insight Report by the World Economic Forum (WEF), makes it possible to compare countries in terms of travel and tourism development. This index, which has undergone multiple updates over the years, comprises five dimensions and 17 pillars. This study aims to visualize the travel and tourism development of 27 European Union (EU) countries using principal component analysis (PCA), one of the most well-known dimensionality reduction and unsupervised machine learning methods, by using the 2024 TTDI data of these countries to compare them with each other and identify similar countries. The analysis indicated that three principal components accounted for the majority of variance in the initial dataset, comprising seventeen pillars, and similar countries in terms of travel and tourism development were revealed on the plot constructed accordingly.

Keywords Travel and Tourism Development Index · European Union · Principal Component Analysis · Unsupervised Machine Learning

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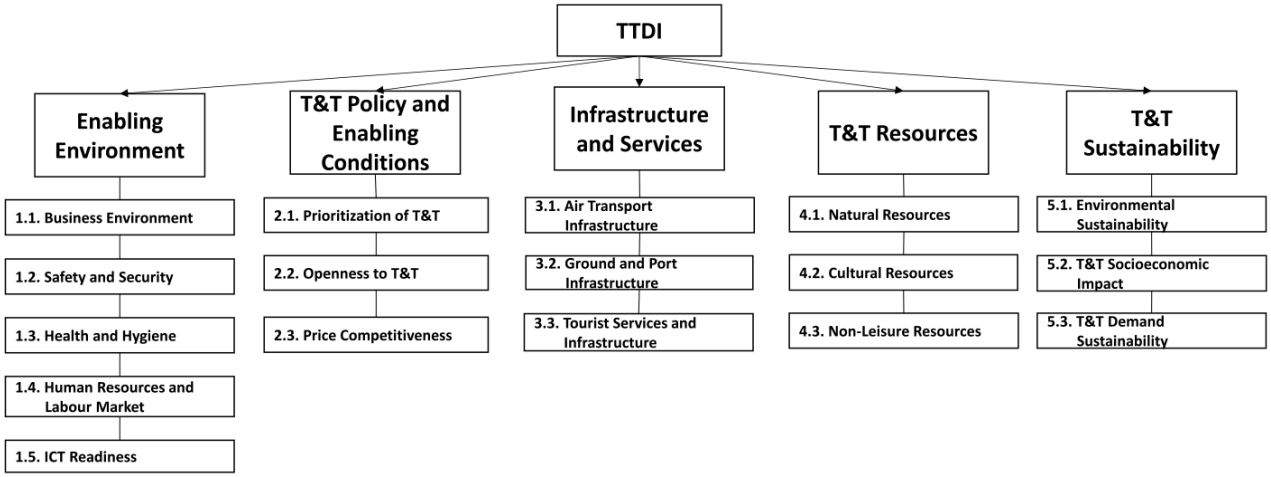
Introduction

Tourism is the act of traveling for personal, family-related, leisure, recreation, or business purposes. This includes traversing various locations, immersing oneself in diverse cultures, and participating in numerous activities (Davidson, 2005). Tourism is important for the economy as it contributes considerably to a destination's economic development by accumulating foreign exchange earnings, providing employment opportunities, and improving infrastructure. In numerous countries, it is widely considered a significant catalyst for enhancing export trade and economic growth (Bunghez, 2016; Li et al., 2017). Tourism significantly enhances local economies by generating sales, profits, employment, tax revenues, and income. The direct effects manifest within the principal tourism sectors, including accommodations, dining establishments, transportation, entertainment, and retail commerce. Tourism nearly influences all economic sectors through secondary effects (Stynes, 1997). Countries compete in the field of tourism to excel in the market compared to their competitors by creating additional value-added products and offering quality, innovative, and attractive services to tourists, gaining significant market share in the local and international tourism market (Aligul, 2024). The WEF's Insight Report, published every two years between 2007 and 2019 under the name of Travel and Tourism Competitiveness Index (TTCI), has been reorganized as the TTDI as of 2022, with an emphasis on sustainability and durability (Gürsakal & Bayram Arlı, 2023). Significant distinctions in frameworks and methodologies between the TTCI and TTDI encompass the incorporation of new pillars (TTDI, 2022). The TTDI serves as a strategic benchmarking instrument for governments, businesses, international organizations, and others to enhance the travel and tourism sector (TTDI, 2024a). It focuses on tourism development from various aspects and provides visibility on the advantages and disadvantages of different aspects in tourism development (Salam, 2024). The TTDI is fundamentally associated with the assessment of tourism development indicators. It supplies the requisite data and analysis to develop sustainable, competitive, and effective tourism policies. This allows for the optimization of tourism's advantages while simultaneously mitigating its negative effects of tourism (Vašaničová, 2024).

The TTDI 2024 edition, covering a total of 119 economies, was created in partnership with the University of Surrey. The university offered significant strategic and technical assistance for the TTDI and related content. This new edition incorporates various enhancements aimed at leveraging newly accessible data, including the World Travel and Tourism Council's newly established indicators regarding the social and environmental impacts of travel and tourism. Consequently, the index is more precise, succinct, and consistent in its country coverage. As illustrated in Figure 1, the TTDI comprises five dimensions and 17 pillars, and there are 102 distinct indicators allocated across the various pillars. The five dimensions are not included in the index calculation and are solely used for categorization and presentation. The overall TTDI score is calculated by sequentially aggregating scores, beginning at the indicator level (the most granular level) and progressing through the pillar levels. The components are amalgamated using the arithmetic mean. The scores for each indicator are initially normalized and evaluated on a scale of 1 to 7, where 1 represents the worst outcome and 7 signifies the best outcome. Finally, countries are ranked according to their overall TTDI scores (TTDI, 2024a).

Figure 1

Five dimensions and 17 pillars of the TTDI



Source: TTDI, 2024a

The five dimensions and 17 pillars of the TTDI are elaborated upon in greater detail below.

The first dimension encompasses the essential conditions required for conducting operations and investments within a country, comprising five pillars: Pillar 1.1 assesses the degree to which a country's policy framework supports corporate operations and investment activities. Pillar 1.2 assesses the degree to which a country subjects its residents, visitors, and enterprises to security threats. Pillar 1.3 assesses healthcare infrastructure, accessibility, and health security. Pillar 1.4 assesses the availability of skilled employees, the dynamism and resilience of the labour market, the equality within it, and the extent of worker protection. Pillar 1.5 assesses the accessibility and use of digital services and information and communication technology infrastructure (TTDI, 2024a).

The second dimension encompasses specific policies or strategic elements that directly influence the travel and tourism sector and comprises three pillars: Pillar 2.1 assesses the extent to which the government actively promotes, monitors, and invests in the sector's advancement. Pillar 2.2 assesses the extent to which a country welcomes visitors and facilitates cross border travel. Pillar 2.3 assesses the expenses associated with travel or operations within a country (TTDI, 2024a).

The third dimension encompasses the quality and availability of tourism services and physical infrastructure, comprising three pillars: Pillar 3.1 evaluates the extent to which a country's infrastructure provides adequate air connectivity and accessibility for both domestic and international travelers. Pillar 3.2 evaluates the efficiency and accessibility of ground and port transportation services and infrastructure. Pillar 3.3. evaluates the investment in, as well as the availability and efficiency of, infrastructure and tourist services (TTDI, 2024a).

The fourth dimension encompasses the primary motivations for traveling to a destination and is structured around three pillars: Pillar 4.1 evaluates the existing natural capital and the advancement of outdoor tourism activities. It is pertaining to landscape features, natural parks, and biodiversity. This pillar emphasizes the enhancement of natural resources instead of the existing natural heritage within a country. Pillar 4.2 assesses the availability of cultural resources, including entertainment facilities and archeological sites. This pillar focuses on promoting and developing cultural resources rather than a country's actual cultural heritage. Pillar 4.3 evaluates the significance and appeal of elements that influence non-leisure travel and

business, encompassing the existence of global cities, prominent universities, and major corporations (TTDI, 2024a).

The fifth dimension encompasses the existing or potential challenges and risks associated with the sector and is structured around three pillars: Pillar 5.1 assesses the energy sustainability of the travel and tourism sector, as well as the overall sustainability of an economy's natural environment and the conservation of natural resources. Pillar 5.2 assesses the social and economic effects of travel and tourism, including induced economic contributions, the generation of high-wage employment opportunities, and the promotion of gender equality in the workforce. Pillar 5.3 evaluates factors indicative of, or risks linked to, overcrowding, demand volatility, and other possibly unsustainable demand trends (TTDI, 2024a).

However, the abovementioned pillars of the TTDI are often intercorrelated. Furthermore, with PCA, a dimensionality reduction and unsupervised machine learning method, the number of these pillars can be reduced. In this study, the data from the 2024 Insight Report on the TTDI for the EU countries were used, and a plot was created by using PCA to visually compare the 27 member countries in terms of their travel and tourism development and to identify similar member countries.

Literature Review

In this section, similar studies on the TTDI and its predecessor, the TTCI, will be discussed.

Kayar and Kozak (2010) analyzed 13 factors affecting destination competitiveness and compared EU and Turkey's levels. This study examines the effectiveness of destination competitiveness determinants. The analysis included secondary data from the TTCI of the WEF. Using this index, the authors grouped 28 countries by competitiveness scores. The findings were analyzed using cluster analysis and multidimensional scaling. The study found that three clusters of selected countries are most competitive due to factors such as health and hygiene, natural and cultural resources, air and ground transport infrastructure. Turkey leads in price competitiveness, but its image as a low-priced country persists in the global tourism market.

Gabor et al. (2012) focused exclusively on European countries, using the 14 pillars outlined in the WEF's Travel & Tourism Competitiveness Report 2011. To examine the grouping of the 14 pillars of the TTCI among the 27 EU and 15 non-EU member countries, PCA with varimax rotation and Kaiser normalization were conducted separately for EU and non-EU countries. Hierarchical cluster analysis and k-means cluster analysis were performed to visualize the clustering of countries based on the resulting principal components.

Leung and Baloglu (2013) used cluster analysis and multidimensional scaling to assess the competitiveness of 16 countries in the Asia-Pacific region using the 2011 TTCI data. A three-dimensional perceptual map was developed to illustrate the competitive positioning of each destination in the tourism industry. Cluster analysis was implemented to facilitate the identification of groupings on perceptual maps. It was used to identify seven destination groups. The competitive advantages and weaknesses of the seven destination groups in this region were examined using perceptual maps. This investigation introduced a novel approach to the interpretation of perceptual maps by integrating multidimensional scaling and cluster analysis. Additionally, it illuminated the methodology's potential to improve or maintain destinations' competitiveness in the constantly evolving tourism market.

Jovanović et al. (2014) explored the homogeneity of Southeast European (SEE) countries in terms of their competitiveness and tourism industry development by employing cluster analysis. The Global Competitiveness Index (GCI) and the TTCI were used to evaluate the competitiveness of these countries. The research

findings reveal that the TTCI and the GCI exhibit a significant correlation and that the SEE countries are not homogeneous in terms of these indices.

Prorok et al. (2017) examined the then 28 EU and 14 non-EU countries using the 2017 TTCI data. To ascertain the number of factors, the authors initially computed the eigenvalues and subsequently employed a scree plot. Upon determining the number of factors and employing the varimax rotation method, these 28 EU and 14 non-EU countries were categorized according to these factors, respectively. Four clusters were required for EU member states, whereas three clusters were required for non-EU countries.

Bednárová et al. (2018) used the TTCI to analyze the tourism competitiveness in EU countries from 2015 to 2017. This study examines factors affecting the competitiveness of countries, focusing on Slovakia. The study encompasses an analysis of the competitiveness of EU countries based on their assessment, employing cluster analysis for tourism expenditures, tourism revenues, and GDP per capita in tourism. The findings indicate that tourism revenues, expenditures, and GDP exert no influence on the TTCI. Slovakia should improve its legal framework, optimize taxation incentives, prioritize the travel and tourism sector, and enhance its branding and marketing strategies to attract visitors.

Ferreira and Castro (2020) performed a factor analysis on the 14 pillars used to calculate the 2019 TTCI to find similar patterns in tourism competitiveness. The analysis of 46 European countries found three factors that explained 76.54% of variation in tourism competitiveness. The cluster analysis grouped European countries into three clusters based on the underlying factors. The results can help stakeholders develop sustainable tourism strategies to boost European tourism competitiveness.

Gabor et al. (2021) used discriminant analysis to explore the dynamic analysis of European tourism destination management and competitiveness. The analysis used the 14 pillars from the Travel & Tourism Competitiveness Report for all European countries and reference years 2011 and 2019. The study added geographical position (East/West/Central), EU membership/non-membership, ex-communist/democratic country, and developed/developing country as new characteristics for the dependent variable in discriminant analysis. This is the first study to dynamically analyze the TTCI pillar(s) that discriminate better based on the characteristics of the countries.

Countries adjacent to the Mediterranean Sea constitute one of the most appealing regions for global tourism, distinguished by varying degrees and types of tourism development. Gargano (2021) conducted a study on tourism competitiveness among Mediterranean countries. The examination is based on the 14 pillars outlined in the Travel & Tourism Competitiveness Report 2019. The study used PCA and hierarchical cluster analysis to examine the grouping of the TTCI's 14 pillars among countries.

Methodology

PCA, an unsupervised machine learning method, is arguably the most prevalent multivariate statistical method used across nearly all scientific disciplines. PCA examines a data table that contains observations characterized by multiple variables, which are typically intercorrelated. The objectives of PCA are as follows:

a) to extract the most significant information from the data table,

b) to reduce the size of the dataset by retaining only this essential information,

c) to simplify the description of the dataset; and

d) to examine the structure of the observations and variables.

PCA calculates new variables known as principal components, derived as linear combinations of the original variables, to attain these objectives. The first principal component must possess the maximum variance, thereby elucidating or extracting the most substantial portion of the variance of the data table. The second component must be orthogonal to the first component while having the maximum variance possible. The remaining components are similarly calculated. PCA also illustrates the similarity patterns among observations and variables by representing them as points on plots (Abdi & Williams, 2010).

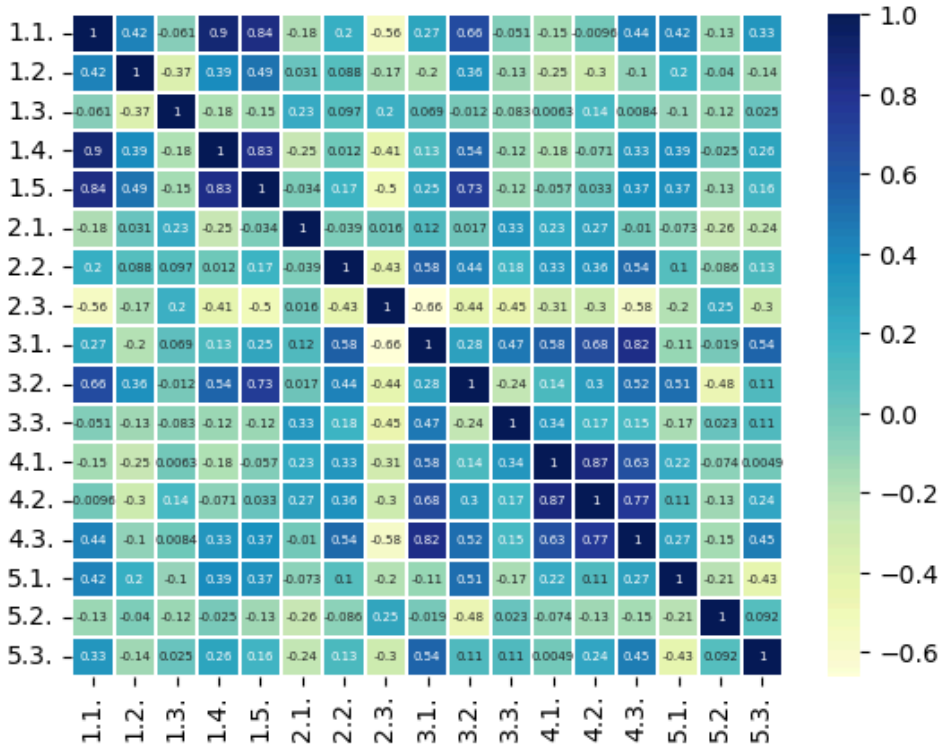
Results

The introduction outlines that the TTDI comprises five distinct dimensions. The total number of pillars under these dimensions is 17. The TTDI is obtained by calculating the average score of the 17 pillars. This study used the 2024 TTDI data from 27 EU countries, condensing 17 pillars into three components through the application of PCA (TTDI, 2024a; TTDI, 2024b). A plot was generated to compare the travel and tourism development of EU countries.

Figure 2 was created to analyze the correlation between the 17 variables. It clearly illustrates a strong correlation coefficient between certain variables, indicating the suitability of PCA. There is a strong positive correlation between Pillars 1.1 and 1.4, as well as between Pillars 1.1 and 1.5. A strong positive correlation can also be observed between Pillars 1.4 and 1.5. A strong positive correlation also exists between Pillars 3.1 and 4.3, as well as between Pillars 4.1 and 4.2.

Figure 2

Correlation matrix between variables



The next step is to determine how many principal components are needed. Therefore, it is essential to compute the proportion of variance explained by each principal component. Table 1 presents explained

variance (eigenvalue) by each principal component along with the corresponding explained variance ratio and cumulative explained variance ratio derived from them.

Table 1

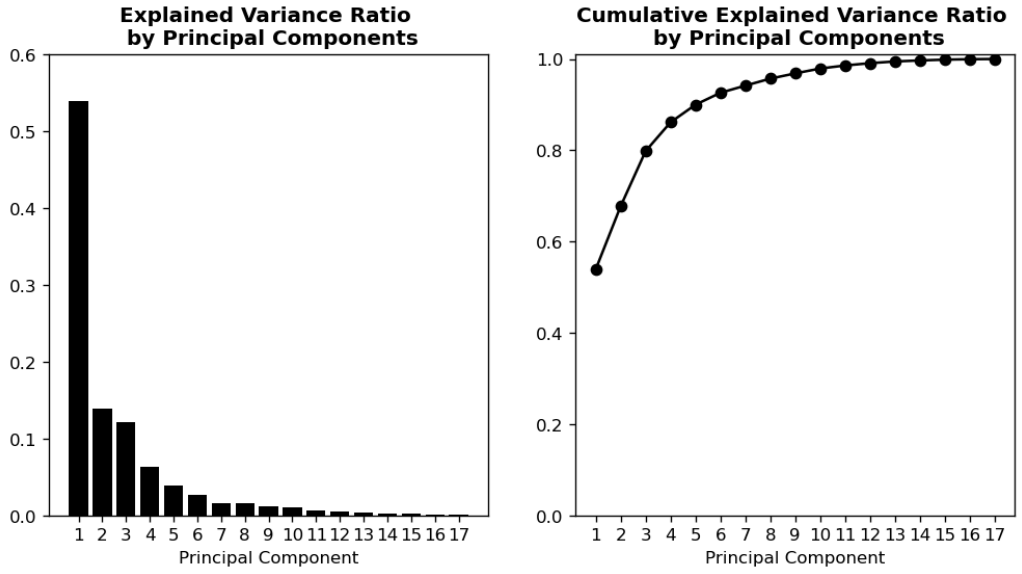
Explained variance, explained variance ratio, and cumulative explained variance ratio by each principal component

	Explained variance	Explained variance ratio	Cumulative explained variance ratio
PC1	5,690866	0,539111	0,539111
PC2	1,460709	0,138377	0,677488
PC3	1,274146	0,120703	0,798191
PC4	0,66646	0,063136	0,861326
PC5	0,406488	0,038508	0,899834
PC6	0,275819	0,026129	0,925963
PC7	0,165818	0,015708	0,941672
PC8	0,161453	0,015295	0,956967
PC9	0,121089	0,011471	0,968438
PC10	0,112631	0,01067	0,979107
PC11	0,070353	0,006665	0,985772
PC12	0,053438	0,005062	0,990835
PC13	0,039613	0,003753	0,994587
PC14	0,023468	0,002223	0,99681
PC15	0,018652	0,001767	0,998577
PC16	0,009895	0,000937	0,999515
PC17	0,005122	0,000485	1

Similarly, Figure 3 illustrates the ratio of explained variance and cumulative explained variance attributed to each principal component.

Figure 3

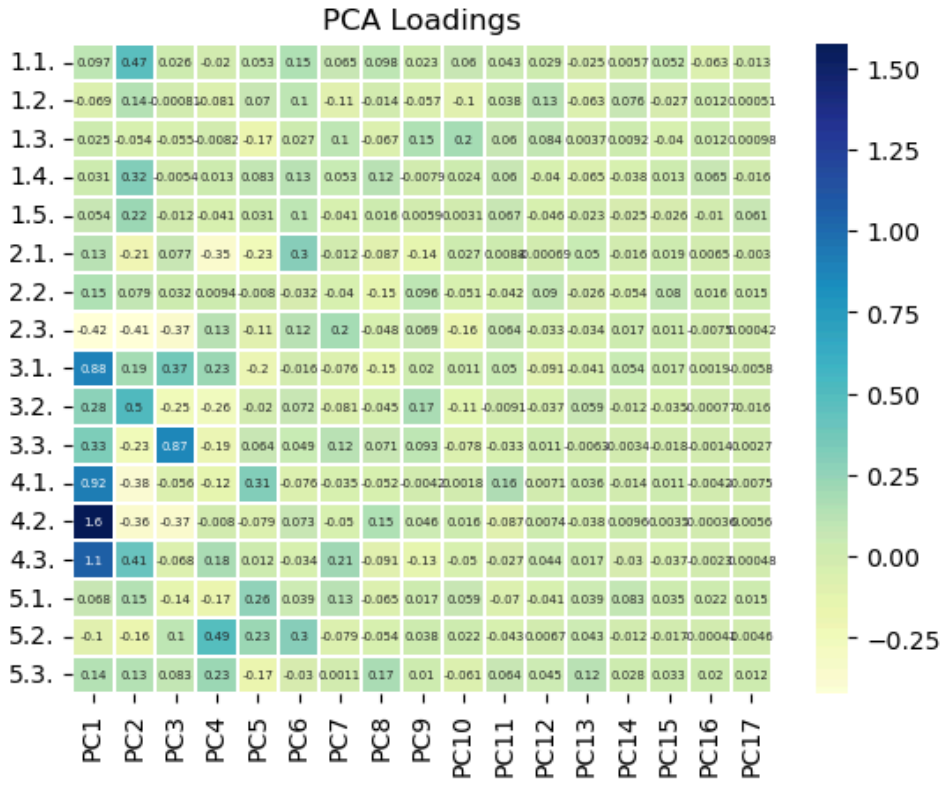
Explained variance ratio and cumulative explained variance ratio by each principal component



The first three principal components account for approximately 79.82% of the total variance, as illustrated in Table 1 and Figure 3. Consequently, the first three principal components were considered adequate, leading to the decision to represent the data in three dimensions, as shown in Figure 5.

Figure 4

PCA loadings



Additionally, Figure 4 shows the PCA loadings, which are a measure of how much a variable contributes to a particular principal component. The loadings on the first three principal components are higher.

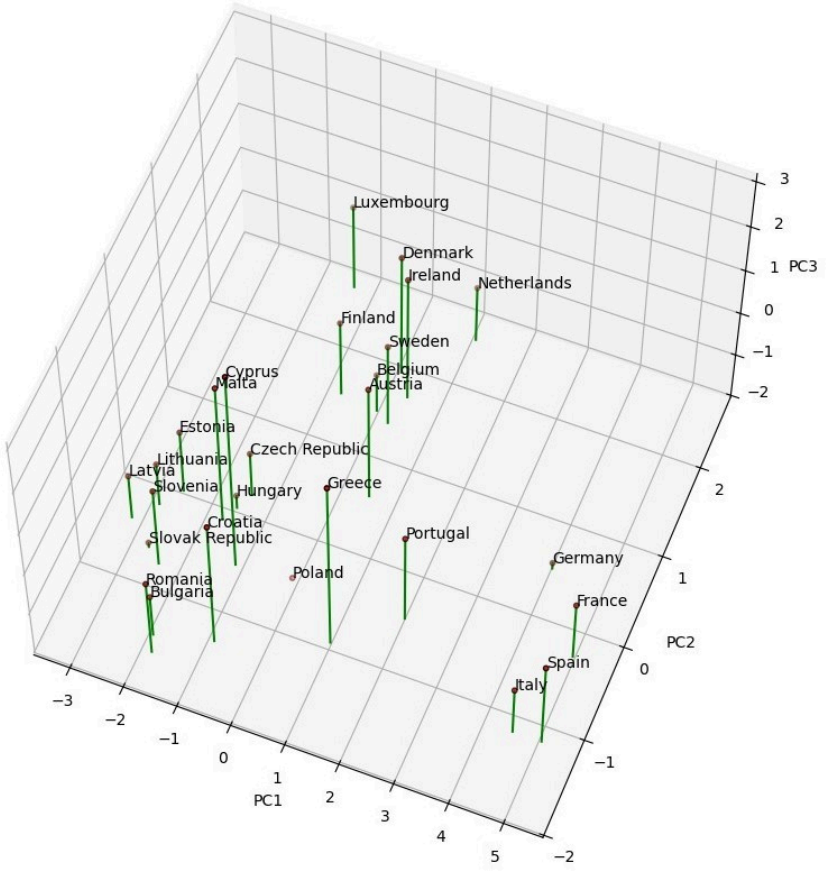
Figure 5 reveals distinct groupings among the 27 countries that are members of the EU. First and foremost, it is immediately apparent that Spain, France, Germany, and Italy are located in close proximity to one another, indicating that they are comparable in terms of tourism and travel development. These four countries have the highest TTDI scores among all EU member states. Upon reevaluating Figure 4, it is apparent that the load on PC1 is high for Pillars 3.1, 4.1, 4.2, and 4.3. Given that these four countries possess high scores on these pillars, they are distinguished from other member countries in Figure 5 along the PC1 axis. Because Estonia, Latvia, Lithuania, Slovenia, and the Slovak Republic have low scores on these pillars, they are positioned furthest from France, Germany, Italy, and Spain along the PC1 axis. As illustrated in Figure 4, the loading of Pillar 3.2 on PC2 is high. Luxembourg and the Netherlands, which exhibit high scores on these pillars, and Bulgaria and Romania, which display low scores, are observed to be separated along the PC2 axis. Pillar 3.3 exhibits a high load on PC3. Cyprus and Greece, which exhibit high scores in this pillar, and Poland and the Slovak Republic, which demonstrate low scores, are separated along the PC3 axis.

Furthermore, Figure 5 shows that the member countries from Eastern Europe are located in close proximity to one another. Additionally, Figure 5 demonstrates that Malta and Cyprus are located in close proximity to one another. According to Figure 5, Denmark, Finland, and Sweden—three countries from the

Scandinavian region—are located in close proximity to one another. However, other member countries, such as the countries that make up the Benelux region, are also comparable in terms of travel and tourism development.

Figure 5

Plot of EU countries' travel and tourism development



Conclusion

Tourism is a substantial contributor to a country's economic development through the generation of foreign exchange earnings, employment opportunities, and infrastructure enhancement. This has led to the widespread recognition of tourism as a crucial economic growth driver in numerous countries. As countries compete in the field of tourism, they make a variety of investments to attract a large number of tourists to visit their territories annually. The Insight Report released by the WEF since 2007 features an index initially termed the TTCI and subsequently the TTDI, which is crucial for countries to compare themselves and develop a strategic roadmap.

The TTDI calculation has undergone significant modification over the course of its existence. The TTDI 2024 edition consists of five dimensions and 17 pillars, encompassing 102 distinct indicators distributed among these pillars. In contrast to the studies discussed in the literature review, the data for this study were obtained from this edition. The study shows that the 17 pillars of the TTDI are intercorrelated. Therefore, in this study, PCA, a dimensionality reduction and an unsupervised machine learning method, was used to analyze the data from 27 EU member countries. The findings of this study indicate that the first three

principal components explain approximately 79.82% of the total variance in the dataset. As mentioned in the literature review section, in a similar study, Gabor et al. (2012) applied PCA for 27 EU countries based on the 14 pillars of 2011 TTCI data and found that four components explained 82.92% of the total variance. In another similar study, Prorok et al. (2017) employed PCA for 28 EU countries using the 14 pillars from the TTCI 2017 report and found that four components explained 79.041% of the total variance.

This approach made it possible to visualize the dataset in three dimensions, which made it easier to identify comparable countries in terms of their travel and tourism development. The study's findings indicated significant disparities and diverse classifications regarding travel and tourism development among EU countries. They are considered important for policymakers.

Future research may compare the findings of this study with those obtained using other methods, such as cluster analysis or multidimensional scaling, and evaluate the consistency of the findings obtained using these two methods with the findings of this study.

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