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Research Article

Digital Transformation in Tourism: A Factor Analysis Approach

*Suyunova Fotima

PhD student, University of world economy and diplomacy

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Abstract

The rapid digitalization of the tourism sector has significantly reshaped industry dynamics, consumer behavior, and service delivery. This study applies factor analysis to assess the impact of digital transformation on tourism performance, identifying key technological, operational, and market-driven factors influencing growth and competitiveness. The findings provide insights into how digital tools, platforms, and innovations contribute to improved efficiency, customer engagement, and sustainable development within the tourism industry. These results can guide policymakers and industry stakeholders in implementing targeted strategies for digital integration and innovation.

Keywords: *PCA, factor loading analysis, cluster approach.*

INTRODUCTION

The tourism industry is one of the most dynamic sectors of the global economy, contributing significantly to employment, income generation, and cultural exchange. In recent years, the sector has undergone a profound transformation due to rapid digitalization. Digital technologies - including online booking platforms, mobile applications, social media marketing, and data analytics - have reshaped the way tourists plan, experience, and share their travels.

Digital transformation not only enhances operational efficiency for tourism businesses but also influences consumer behavior and expectations. For instance, travelers increasingly rely on digital information, reviews, and virtual experiences to make informed decisions. Consequently, tourism enterprises must adopt and integrate innovative technologies to remain competitive in an evolving market landscape.

Despite the growing recognition of digitalization's importance, there remains a need for systematic analysis to identify the specific factors through which digital technologies impact the tourism sector. Factor analysis offers a robust quantitative approach to uncover the underlying dimensions that drive performance, customer engagement, and growth in tourism.

This study aims to evaluate the effects of digital transformation on the tourism industry using factor analysis, highlighting the key technological, operational, and market-related factors that shape its development. The findings can inform both policymakers and industry stakeholders on effective strategies for fostering digital innovation and enhancing the overall competitiveness of the tourism sector.

Although digitalization in tourism has gained attention in recent years, existing studies often focus on individual technologies, such as online booking platforms or social media, rather than examining the broader, systemic effects of digital transformation across the entire tourism sector. Moreover, much of the current research relies on qualitative assessments or case studies, lacking quantitative analysis to identify the key factors driving tourism performance in the digital era.

Additionally, most studies are limited to specific countries or regions, which restricts the generalizability of their findings. There is a need for a comprehensive, data-driven approach that can uncover the main dimensions of digital transformation and their relative impact on tourism outcomes. This study addresses this gap by applying factor analysis to evaluate how technological, operational, and market-related factors influence the growth and competitiveness of the tourism industry.

LITERATURE REVIEW

The term "digital economy" was one of the first coined by Canadian scientist Don Tapscott (D. Tapscott) (1996). His most famous book, "The Digital Economy: Promise and Danger in the Age of Networked Intelligence [1]," serves as the foundation for the theory of the digital economy. He was the first to hypothesize that in 30 years information technology would become an integral part of the economy and business. In turn, back in 1995, the American computer scientist Nicholas Negroponte in his study "Being Digital" defines the formation of the digital economy as the merging of the digital and interactive entertainment world into a single digital network. He believes that the emergence of the digital economy will lead to the digitalization of human life and economic activity. [2]

Michael L. Katz, M.L., Professor Emeritus at the University of California, argues that the digital economy relies on platforms that gain more and more value as more and more users join them. This self-reinforcing mechanism can lead to rapid growth.[3]

According to American economist Paul Romer, digital technologies allow for faster dissemination and exchange of knowledge, which can stimulate innovation and economic growth.[4]

Researchers Erik Brynjolfsson and Luca Hitt (Brynjolfsson E. and Hitt L.) studied the relationship between digitalization and productivity improvement. They claim that digital technologies will increase productivity by automating routine tasks, making decisions based on data, and optimizing operations.[5]

According to Dianne Dredge– director of Tourism CoLab, an Australian online tourism education agency, and Dr. Giang T. Phi, digitalization of tourism: [6]

- leads to creativity and innovation in tourism;
- contributes to a greater individualization of visitors' impressions;
- increases customer satisfaction;
- Inspires new business models, new value chains, new business ecosystems;
- opens up new opportunities for consumers and manufacturers;
- Offers new opportunities to target marketing organizations to support small and medium-sized businesses.

A study conducted by Swedish academic Stefan Gössling S. [7] provides insight into the evolution of virtual and augmented reality in tourism. The article explores elements such as smartphones, augmented reality, virtual reality, big data, and AI/ML. These elements have fundamentally changed tourism. Digital technologies give tourists the opportunity to get an unforgettable experience. The use of mobile devices, virtual reality, augmented reality, and artificial intelligence social media platforms has transformed various aspects of the travel experience.

Foreign researchers S. Verma, L. Warrior, B. Bolia and S. Mehta [8] have shown in their work the social, psychological, economic and environmental consequences of the introduction of technological innovations and ICT in the tourism industry. In the context of tourism, the impact of technology on social networks, identity formation, mental functions, learning and consumer choice is considered. Numerous technological opportunities contribute to the development of digital tourism. Spanish economist Jose Ramon Saura (J.R. Saura) [9] pays special attention to key digital marketing strategies and developments in the digital tourism industry. His work covers issues such as search engine optimization, search engine marketing, app store optimization, sentiment analysis, social media usage, remarketing, programmatic advertising, and marketing. Based on the definitions and concepts put forward by the above-mentioned authors, the following author's definition can be given:

"Digital tourism is the introduction of innovative and digital technologies (online payments, e–tickets) into the tourism industry, which stimulate its competitiveness on the world stage. You can also call it a computer information system based on tourist information." The advantage of this definition is that it combines the concepts of smart tourism and e-tourism.

Analyzing the digitalization of the tourism industry, it is worth noting the current growth of the role of artificial intelligence in the tourism industry. Tourism digitalization and artificial intelligence (AI) are interconnected and complement each other, creating more efficient and personalized solutions for the tourism industry. In their collective article, foreign researchers Lei Tong, Wei Yan, and Otilia Manta [10] analyze how artificial intelligence (AI) contributes to smart automation in the tourism industry. They focus on the role of the Internet of Things (IoT) in creating more efficient management systems that enhance customer service. In addition, the article examines the impact of investments in environmental, social and corporate practices (ESG) on the implementation of AI and IoT in the tourism business. The authors claim that the synergy of these technologies not only optimizes operational processes, but also contributes to the sustainable development of the industry. The study also highlights the importance of integrating AI and IoT into investment strategies to achieve sustainable tourism development.

The aim of the research by the Greek scientist Konstantinos Solakis [11] is to identify the key factors and technologies that influence the process of creating values using artificial intelligence. The results of the study show that technologies such as service robots, self-service kiosks with artificial intelligence, chatbots, and virtual reality play an important role in creating a value chain in the tourism and hospitality industry.

METHODS

In order to evaluate level of digitalization of tourism and hospitality industry, there were constructed digital tourism index. For creating digital tourism index there were used data from 22 countries and 13 indicators. For determining the weight of factors there were used Principal Component Analysis and Exploratory Factor Analysis. Then used cluster approach for identifying best practices among countries. The indicator system was selected based on research by Xinna Zhao [12] and Rui Tang. [13]

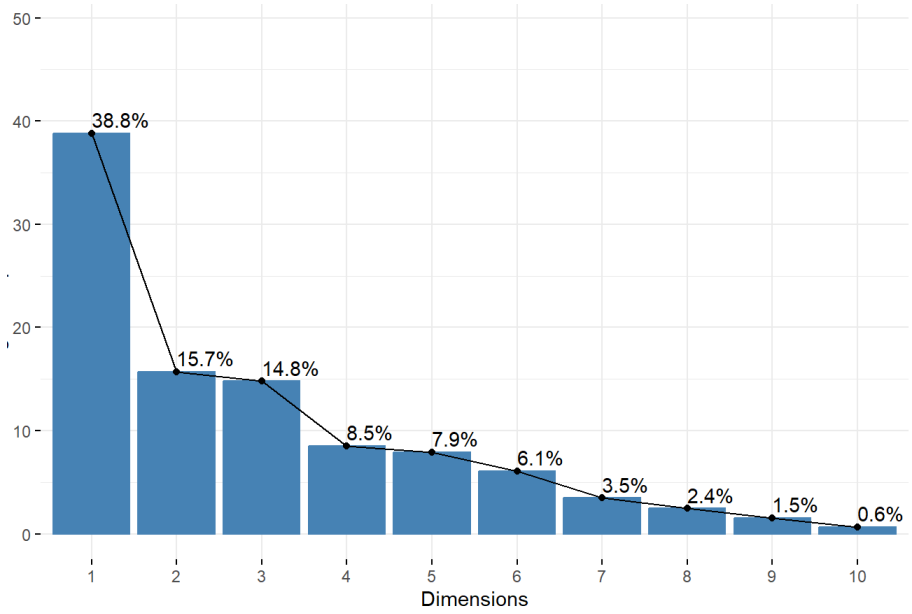
The system of indicators for the development of digital tourism

Mobile cellular subscription (for 100 people)
Fixed broadband subscribers (per 100 people)
Internet users (% of the population)
Education expenditures as a percentage of GDP (%)
Research and development expenditures (% of GDP)
Communications, computers, etc. as a percentage of exports of commercial services
Exports of high-tech goods as a percentage of exports of industrial products
Exports of ICT products as a percentage of total exports
Total number of hotels and similar establishments per 1000 sq.km
Total number of hotel rooms and similar per 100 people
Number of employees in the field of accommodation and catering in % of the population
International tourism, number of arrivals, million)
Domestic tourism (Domestic trips, in % of the population)

Results and Analysis

The purpose of applying the principal component method is to simplify complex data by preserving as much information as possible. Also, the use of the principal component method makes it possible to remove multicollinearity, reduce dimensionality and compress information without large losses.

The results Principal Component Analysis is shown in the Picture 1. The results underline, that first three dimensions explain 73% of variance.



Picture 1. Percentage of explained variance

Source: Author own computation

According to the Picture 1 first component explain 38,8% of variance. It means that first component contains the basic information of the data. The second and third components are less informative, but still have contribution in constructing digital tourism index.

The next table provides information about eigenvalues, variance and cumulation of components.

Table 1. Results of Principal Component Analysis

Component	Eigenvalue	Variance	Cumulative
Dim1	5.047	38.8%	38.8%
Dim2	2.038	15,7%	54,5%
Dim3	1.922	14,8%	69,3%

Source: Author own computation

The results of the analysis provide that, eigenvalues of all three dimensions are higher than 1, which means they are appropriate for the chosen index. The cumulative of three dimensions is 69,3%. In other words, it explains 69,3% of variance.

Table 2. Contribution of variables to components (Dim.1, Dim.2 Dim3)

Dim.1 (38.8%) — «Digitalization»

Indicators	Ctr	Interpretation
Research and development expenses (% of GDP)	17	Strong influence
Fixed broadband subscribers (per 100 people)	15,5	Strong influence
Communications, computers, etc. as a percentage of exports of commercial services	11,3	Moderate impact
Internet users (% of the population)	8,6	Moderate impact

Dim.2 (15.7%) — «Tourism infrastructure»

Indicators	Ctr	Interpretation
Total number of hotels and similar establishments per 1000 sq.km	25,6	Strong influence
Total number of hotel rooms and similar per 100 people	9,5	Moderate impact

Dim.3 (15.7%) — «Digital skills»

Indicators	Ctr	Interpretation
Education expenditures as a percentage of GDP (%)	15,1	Strong influence

Source: Author own computation

The results highlight that; there are 3 sub-indexes of final index. The overall index constructed by the arithmetic mean of the three subindexes.

The next stage is applying Explanatory factor analysis. The aim of applying this method identify latent (hidden factors).

Table 3. Factor Loadings

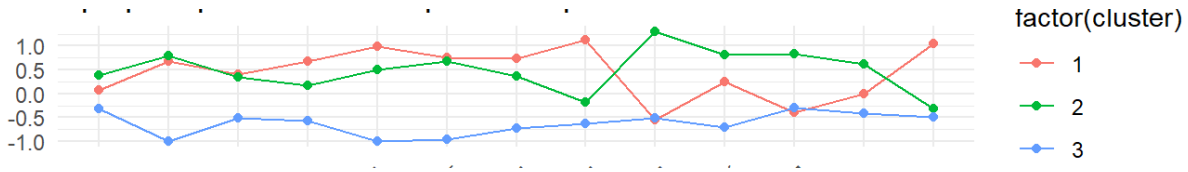
№	Indicators	Digitalization	Tourism infrastructure	Digital skills
1	Exports of ICT products as a percentage of total exports	0.8		
2	Research and development expenses (% of GDP)	0.8		
3	Exports of high-tech goods as a percentage of exports of industrial products	0.7		
4	Fixed broadband subscribers (per 100 people)	0.6		
5	Internet users (% of the population)	0.5		
6	Education expenditures as a percentage of GDP (%)			0.6
7	International tourism, number of arrivals, million)		0.4	
8	Total number of hotel rooms and similar per 100 people		0.8	
9	Number of employees in the field of accommodation and catering in % of the population		0.7	

Source: Author own computation

The factor loadings reveal a clear three-dimensional structure: the Digitalization component is shaped primarily by innovation intensity and technological capacity, as indicated by strong loadings for ICT exports, R&D expenditures, high-tech exports, and broadband penetration, with internet usage contributing moderately. The Tourism infrastructure component reflects the structural availability of tourism services, strongly driven by the number of hotel rooms and employment in accommodation and catering, while international arrivals provide additional support. Finally, the Digital skills component is defined by investment in education, indicating the role of human capital development in strengthening countries' ability to participate in the digital economy.

The final index was constructed by the results of PCA and EFA. Digitalization subindex include: Exports of ICT products as a percentage of total exports, Research and development expenses (% of GDP), Exports of high-tech goods as a percentage of exports of industrial products, Fixed broadband subscribers (per 100 people), Internet users (% of the population). The Tourism infrastructure subindex include Total number of hotels and similar establishments per 1000 sq.k., Total number of hotel rooms and similar per 100 people, Number of employees in the field of accommodation and catering in % of the population. The digital skills subindex includes education expenditures as a percentage of GDP (%).

The next stage is applying cluster analysisıo. Cluster analysis is used to identify homogeneous groups of objects based on a set of features. Its goal is to identify the structures hidden inside the data by grouping observations so that objects within each cluster are as similar to each other as possible, and differ significantly between clusters. This method allows us to classify countries by the level of development, digitalization or tourism infrastructure, identify typological differences and use the obtained groups for further comparative analysis.



Picture 1. Profiling clusters by variables
Source: Author own computation

The cluster profiling results demonstrate distinct patterns of countries' development across digitalization, ICT structure, and tourism-related variables. Cluster 1 (red) shows consistently higher-than-average standardized values across most indicators, indicating countries with strong digital infrastructure, high research and education investment, well-developed ICT export capacity, and comparatively advanced tourism infrastructure. Cluster 2 (green) reflects a more balanced pattern: values fluctuate around the average, suggesting medium-level performance across digital, economic, and tourism dimensions. This cluster likely includes countries with moderately developed ICT sectors and tourism services but without extreme strengths or weaknesses. Cluster 3 (blue) is characterized by predominantly negative standardized values, revealing systematically lower performance. Countries in this cluster lag behind in broadband access, ICT exports, R&D spending, hotel capacity, and tourism activity. Overall, the three clusters represent (1) highly developed digital-tourism systems, (2) moderately developed and transitional systems, and (3) low-performing countries with limited digital and tourism capacities.

Cluster profiles:
Cluster 1: These are countries with high digitalization, strong ICT infrastructure, innovation, developed exports of digital products and less developed physical infrastructure. Examples: USA, Great Britain, Korea.
Cluster 2: Countries with a focus on traditional tourism and physical infrastructure, moderately digitalized, are less active in exporting ICT. Examples: Spain, France, Italy, Turkey.
Cluster 3: ** These are countries with low digitalization, poorly developed exports and tourism. Perhaps they are at the initial stage of digital transformation. Examples: Uzbekistan, Tajikistan, Pakistan, Indonesia.

DISCUSSION

The findings of this study provide valuable insights into the multifaceted impact of digital transformation on the tourism sector. Through factor analysis, it was possible to identify distinct underlying dimensions that shape the adoption and effectiveness of digital technologies in tourism. The results suggest that digital transformation is not a singular phenomenon but rather a combination of infrastructure readiness, digital skills, and the integration of technology into tourism services. This confirms the notion that successful digitalization in tourism requires both technological capacity and human capital development.

The first factor, representing digital infrastructure, highlights the importance of high-quality broadband access, mobile connectivity, and the availability of ICT services. Regions or tourism enterprises with better infrastructure were more likely to adopt innovative digital solutions, such as online booking platforms, virtual tours, and smart tourism

applications. This aligns with previous studies emphasizing that infrastructure forms the backbone of digital transformation and determines its reach and scalability.

The second factor, related to digital skills and technological literacy, underscores that merely having access to digital tools is insufficient without the capability to utilize them effectively. Tourism operators with higher digital competency can enhance customer engagement, personalize experiences, and implement data-driven marketing strategies. This finding reinforces the argument that human capital investment should accompany technological upgrades in order to maximize the benefits of digitalization.

Finally, the third factor points to the integration of digital technologies into tourism service offerings. Adoption of digital platforms, e-commerce, and smart technologies enables service innovation and operational efficiency, creating a competitive advantage for tourism providers. The interaction among these factors suggests that digital transformation in tourism is a complex, interdependent process where infrastructure, skills, and service integration mutually reinforce each other.

The practical implications of these findings are significant. Policymakers and tourism authorities should prioritize investments not only in technological infrastructure but also in training programs to develop digital skills across the workforce. Similarly, tourism enterprises should adopt a holistic approach, ensuring that technology adoption is aligned with strategic goals and customer needs. From a research perspective, this study contributes to the understanding of digital transformation as a multi-dimensional phenomenon in the tourism sector, offering a framework for future studies to examine its effects on performance, competitiveness, and sustainability.

CONCLUSION

This study highlights the critical role of digital transformation in shaping the modern tourism sector. By applying factor analysis, we identified three key dimensions—digital infrastructure, digital skills, and technology integration—that collectively determine the effectiveness of digitalization in tourism. The results underscore that successful digital transformation is not merely about adopting new technologies but requires a coordinated approach that combines robust infrastructure, skilled human capital, and the strategic integration of digital tools into tourism services. The findings have practical implications for policymakers, tourism authorities, and industry practitioners. Investments in high-quality digital infrastructure, comprehensive training programs, and innovative service design are essential to enhance competitiveness, improve customer experiences, and drive sustainable growth in the tourism industry. Overall, this study contributes to a deeper understanding of the multi-dimensional nature of digital transformation in tourism. By recognizing and addressing these interrelated factors, destinations and enterprises can effectively leverage digital technologies to remain resilient, innovative, and competitive in an increasingly digitalized global tourism landscape.

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