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### UTILITY SECTOR OF TOURISM INFRASTRUCTURE IN INDUSTRY 4.0: CHALLENGES AND SOLUTIONS

This article is an original attempt to define the necessity of providing the components of Industry 4.0 of the utility sector of tourism infrastructure. The problem is that the tourism utility sector faces challenges in Industry 4.0, such as the need for infrastructure modernization, digital integration, sustainability, and meeting changing tourist expectations. The study is conducted based on data from four (Croatia, Albania, Portugal, Montenegro) leading countries in terms of international tourism receipts as a percentage of GDP, as well as Romania and Ukraine as countries with great tourism potential. The significant impact of Industry 4.0 technologies on the development of tourism in these countries, is proved in this article. This study seeks to investigate the obstacles encountered by the tourism infrastructure utility sector in Industry 4.0 and suggests solutions to overcome these challenges. The article proposes a conceptual framework for creating a new scenario for the utility sector, which will be used for efficiently increasing operation of tourism infrastructure objects. Using empirical research, two scenarios are suggested: an optimistic one, where smart technologies facilitate the traveler's life, and a pessimistic one, where technologies do not affect the course of the journey. Also, the linear regression method was used to create the forecast in accordance with the offered scenario. Presented scenarios help identify how smart technologies can make the traveler's life easier by providing fast and efficient travel planning through online applications, and also, show the negative consequences, when technologies do not work properly or unforeseen circumstances arise, leading to delays, disrupted plans, and inconveniences during the journey. The authors noted that the scientific novelty of this research lies in its consideration of the impact of smart technologies on decision-making processes in complex travel situations. A forecast of the number of tourists, and travelers to the studied countries until 2024, was made.

Keywords: **Industry 4.0 and smart technologies, risks, forecasting, transport, insurance, a predictive scenario for risk minimization.**

JEL Classification: C53, F20, F29, L83, O33.

**Problem statement.** The tourism industry is an important sector of the global economy, contributing significantly to employment, economic growth, and development. The sector encompasses a wide range of activities, including transportation, accommodation, food and beverage services, attractions, and entertainment. In recent years, the industry has witnessed significant changes and advancements due to the emergence of Industry 4.0 technologies.



**Analysis of recent research.** Industry 4.0, also known as the Fourth Industrial Revolution (Schwab, 2017; Makiela, Stuss & Borowiecki, 2022; Chernenko, Korohodova, Moiseienko & Hlushchenko, 2020), refers to the integration of digital technologies into various aspects of the economy and society. These technologies include artificial intelligence, big data analytics, robotics, Internet of Things (IoT), and cloud computing. The adoption of these technologies has transformed traditional industries and created new opportunities for innovation and efficiency (Kagermann & Winter, 2018; Hermann, Pentek & Otto, 2015; Howaldt, Kopp & Schultze, 2017; Vörös, 2022). In papers by (Gomes Lopes & Ferreira, 2023; Tang, Huang, Zhao & Tang, 2022) promoting the application of computer and sensor technology in smart tourism, consideration of networking tourism innovations, sources of tourism innovation, smart tourism ecosystem, forecasting and innovation research in tourism are proposed. The utility sector of tourism infrastructure plays a crucial role in supporting the operations and services of the tourism industry (Koliopoulos & Katsoni, 2020; Mandic, Zheljko & Kordić, 2018; Seetanah et al., 2011). It includes transportation systems, accommodation facilities, energy supply, water and waste management, telecommunications, and other essential services (Rahmawati, Hendratono, Pradini & Hewan, 2023; Setiawan et al., 2023). The efficient and reliable provision of these utilities is essential for the smooth functioning of the tourism industry and the satisfaction of tourists. In light of the intricate interplay highlighted above, the burgeoning significance of research dedicated to international insurance and risk management in tourism becomes increasingly pronounced (Kyrylov, Hranovska, Boiko, Kwilinski & Boiko, 2020; Biener & Zou, 2024; Yankol-Shlack & Banulescu-Radu, 2023).

Acknowledging the contributions and efforts of researchers in advancing scientific and methodological approaches to the subject matter, it is worth noting that certain aspects remain underexplored in the existing scientific literature, necessitating further research in the field. Additional research is warranted to explore the role of the utility sector of tourism infrastructure in Industry 4.0. This article also extends the previous research efforts of the authors by delving into more intricate methods delineated in their prior papers (Chernenko, Hlushchenko, Korohodova & Moiseienko, 2022; Hlushchenko, Korohodova, Chernenko & Moiseienko, 2023). The study considers the basic principles of the scenario modeling described in (Zgurovsky, Gavrysh, Solntsev, Kukharuk & Skorobogatova, 2020).

**Purpose and objectives.** This study explores Industry 4.0 challenges in the utility sector of tourism infrastructure and proposes solutions. It introduces a novel methodological approach using a comparing optimistic and pessimistic scenarios for tourist experiences. The aim is to analyze the impact of Industry 4.0 technologies on managerial decision-making during complex travel situations, assessing benefits and potential negative consequences.

**Results and discussion.** Three key areas where Industry 4.0 can enhance the utility sector for travelers are transportation systems, accommodation facilities, and energy supply. In transportation, smart systems using IoT and big data analytics optimize traffic flow, suggest routes, and introduce dynamic pricing. Accommodation facilities transform into smart hotels using IoT, data analytics, and AI for personalized experiences. Energy sustainability is addressed through renewable sources, smart grids, and energy storage systems, ensuring stability and reducing costs.

As Statysta's specialists have researched, "when executives in the global travel and hospitality industry were surveyed on the main business priorities of travel and hospitality companies in 2020, roughly half of respondents stated that "new technology to better serve customers and/or suppliers" was a business priority. When those same executives were asked whether their company had an individual or team directly responsible for digital transformation, 84 percent stated that they did have someone responsible for digital transformation in 2020 (Statysta, 2022).

A characteristic feature of the digitalization of tourism is the automation of management and service processes both at the local level and the formation of integrated information systems and platforms, as well as the introduction of digital technologies into the activities of tourism business entities and tourism infrastructure. As noted by Kotler (2019), digital communication takes place in both online and offline forms, using Internet technologies or any other digital media, the Internet network, local networks, digital television, POS terminals, and interactive screens. Integrated information and communication technologies and platforms include universal global travel bookings systems like Skyscanner, Booking.com, Otel.com, Agoda.com, Hotels.com, Airbnb, Trivago, Skyscanner, Kiwi, Onetwotrip, Hotelworld, Home Awayy, DB Navigator and specialized ones, like websites of airlines (Wizzair, Ryanair, Iberia and Vueling, UIA); independent accommodation and

accommodation selection systems (TripAdvisor, TripMyDream, Rome2rio, izi.TRAVEL); search and navigation services (Google.com, Bing, Ask.com, Ukr.net, I.ua, Online.ua, Meta); car rental (Europcar and Hertz, Economy bookings, Uber and Taxify, Ultimate Drives); financial services (Privat24, Oschad24, Monobank); travel blog services (Twitter, Blogger, WordPress.com, Blog.com, LiveJournal, Blogoreader, Meta.ua, Hiblogger.net, VKursi.com); multifunctional global administrators (Glovo, UberEats); system of user-generated content (User-Generated Content) etc. These technologies are widely used in Ukraine.

Mobile devices and mobile applications are recognized as the most effective and dynamic future communication trends in the tourism sphere. Their main purpose is to meet the needs of customers and optimize communication, reduce user costs and increase the income of business entities in the field of tourism. In this area, experts distinguish the following types of mobile applications: translators, maps, hotel reservation services (Hotellook, Booking), ticket purchase and comparative integrated sales services (Aviasales, Skyscanner), guides and directories (TravelMe), search for fellow travelers (BlaBlaCar), rental cars (Sixt), travel visualization applications (TripTrip, Spottly), search engines (Momondo, Kayak, Bilet, Arr In The Air, Hotel Reservation Service, Hotels.com, Expedia.com), insurance and many others. At the same time, the wide range of use of mobile devices requires the creation of specialized software products and sites of business units and corporate online platforms.

In the field of tourism, Big Data and Analytics are technical solutions that transform unsystematized data into personalized tourism information. Blockchain Technology enhances data protection, optimizes transaction accounting, and improves reliability in booking, calculation, and customer feedback processes. Artificial Intelligence (AI) implements software algorithms for decision-making, personalized results, and processing non-verbal information in various tourism applications. Virtual and Augmented Reality facilitates immersive experiences, interactive tours, and promotional activities in the tourism sector (Volgger, Erschbamer & Pechlaner, 2021). Internet of Things (IoT) connects objects and devices for seamless service, self-service, remote service provision, and data exchange for analytics (Schwab, 2017; Hermann, Pentek & Otto, 2015). Biometric Technologies uses digital systems for person authentication, reducing the need for physical documents and simplifying procedures (Kagermann & Winter, 2018).

Industry 4.0 technologies offer innovative and immersive experiences in tourism, enhancing destination attractiveness. Challenges in the Utility Sector (energy, water, and waste management, transportation, and infrastructure) maintenance pose challenges that require innovative solutions (Hlushchenko, Korohodova, Chernenko, Moiseienko, 2023). Smart Energy Management addresses energy consumption and carbon emissions through the implementation of smart energy management systems on the tourism sectors of the mentioned countries, helping to advance the sector's growth while enhancing customers satisfaction and drawing in more visitors. The dynamics of total arrivals in each country for 2006-2020 is presented in fig. 1.

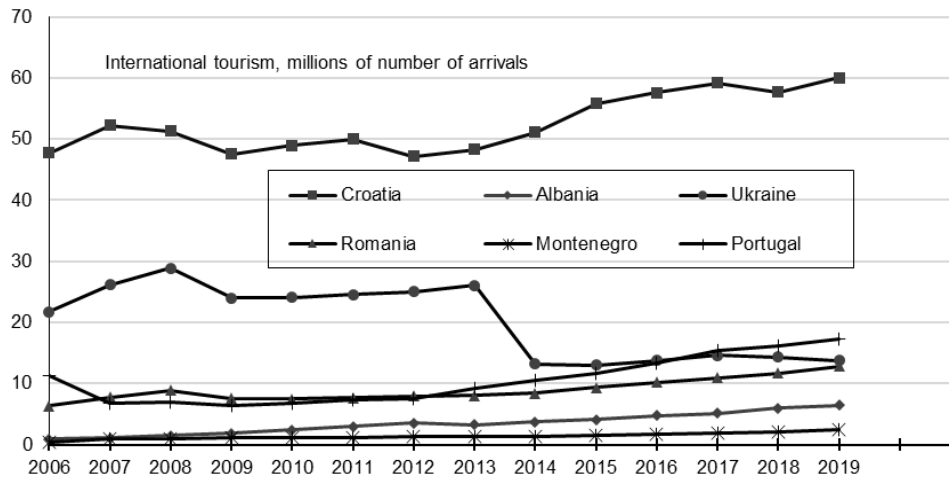
Efficient Water Management implements smart irrigation systems and water-saving technologies to reduce water consumption sustainably. Waste Management ensures proper waste management through IoT-enabled sensors for monitoring, optimizing collection routes, recycling, and disposal processes.

Smart Transportation introduces smart transportation systems, including electric vehicles and intelligent traffic management, to reduce environmental impact and improve efficiency (Rahmawati et al., 2023). Infrastructure Maintenance utilizes IoT-enabled sensors for real-time monitoring and predictive maintenance of tourism infrastructure, ensuring a safe and enjoyable experience. Innovative Solutions and recommendations include smart grids for efficient energy distribution, IoT-enabled waste management, water-saving technologies, electric transportation promotion, and predictive maintenance for a seamless tourist experience. Leveraging Industry 4.0 technologies in the utility sector of tourism infrastructure enhances sustainability, efficiency, and the overall tourism experience, contributing to the industry's long-term development (Gomes, Lopes & Ferreira, 2024).

Drawing from the aforementioned discussion, the authors present their research in the following. The research results may be useful for tourism companies, hotels, agencies, and other participants in the tourism industry who want to understand the impact of Industry 4.0 on the utility sector of tourism infrastructure. The descriptions can help develop strategies and plans to utilize new technologies, ensure service quality, and increase customer satisfaction. Additionally, the

descriptions may be helpful for researchers and academic specialists interested in the development of tourism in the era of Industry 4.0.

The selection of the countries for the study was based on a Global Economy report (The Global Economy, 2020). The study included 4 countries that were chosen as ranking leaders in terms of their already developed and effective tourism potential. Additionally, two promising countries were selected based on the authors' belief in their great potential for future development (World Bank Open Data, 2024; Vörös, 2022). Different Industry 4.0 technologies are applied in the utility sector of tourism infrastructure of: Croatia, Albania, Portugal, Montenegro, Romania and Ukraine, helping to advance the tourism industry and enhance visitor services. These Industry 4.0 technologies have an effect on the tourism sectors of the mentioned countries, helping to advance the sector's growth while enhancing customers satisfaction and drawing in more visitors. The dynamics of total arrivals in each country for 2006-2020 is presented in fig. 1.



**Fig. 1. Dynamics of total arrivals in a given country (2006-2020)**

Source: Author's representation based on the data from UNWTO (2021)

According to the data from the UN agency of the World Tourism Organization (fig. 1), in 2006–2020 Croatia has been the leader in total tourist arrivals. The highest number of arrivals was recorded in 2019, with 60,021 tourists visiting the country. Ukraine and Romania also have significant tourism potential, as evidenced by the increasing trend of total arrivals in both countries since 2010 and 2012, respectively. However, the Covid-19 pandemic caused a significant decrease in tourist arrivals in all the countries in 2020 (UNWTO, 2021).

Croatia is ranked 21st out of 27 EU Member States in the 2022 Digital Economy and Society Index (DESI, 2022). The country faces challenges in the penetration of 100 Mbps services, high-capacity networks, 5G coverage, and broadband pricing. While excelling in open data, Croatia lags in digital public services, with limited user engagement and service delivery. Businesses in Croatia increasingly adopt digital technologies, with notable usage of cloud solutions (35%), e-invoicing (43%), and AI technologies (9%). Despite progress, there is room for improvement in key technologies like big data and AI. The National Development Strategy 2030 outlines measures for Croatia's digital transformation, and the State Agency for the Development of the Digital Society (SADUSD) has developed an Implementation Programme (2021–2024) focusing on societal digitalization and inclusive development. The programme includes initiatives such as cybersecurity skill development, enhanced web accessibility, new e-citizen services, and improved interoperability among public services.

Portugal is ranked 15th among EU member states in the 2022 Digital Economy and Society Index (DESI, 2022), showing a slight improvement from the previous year. The country's Digital Transformation Strategy and Action Plan prioritize digital inclusion, public education, and the

transformation of businesses and public administration. Aligned with Portugal's Recovery and Resilience Plan, the strategy emphasizes digital skills and business/public administration digitalization. The intersectoral plan focuses on three pillars: people, businesses, and public administration, addressing key aspects of the digital transition. Portugal has successfully digitized its public administration, aligning with EU leaders in this domain. A robust legal and regulatory framework ensures administrative simplification, digitalization, data protection, cybersecurity, and public participation. Portugal's strategic investments in digital enablers and political support for reforms contribute to its digital advancement.

Romania is ranked 27th among EU Member States in the 2022 Digital Economy and Society Index (DESI, 2022), highlighting the need for a substantial improvement in the country's digital readiness to meet the Digital Decade targets. While Romania performs well in connectivity, particularly in fixed broadband penetration and coverage, its integration of digital technologies and digital public services lags behind other EU countries. The government's efforts to drive digital transformation include the E-Government Public Policy for 2021-2030, a foundational initiative for e-government services. The Romanian Recovery and Resilience Plan (RRP), with nearly EUR 6 billion in investment, emphasizes digitalization across various DESI dimensions, including digital skills, connectivity, business support, and digital public services.

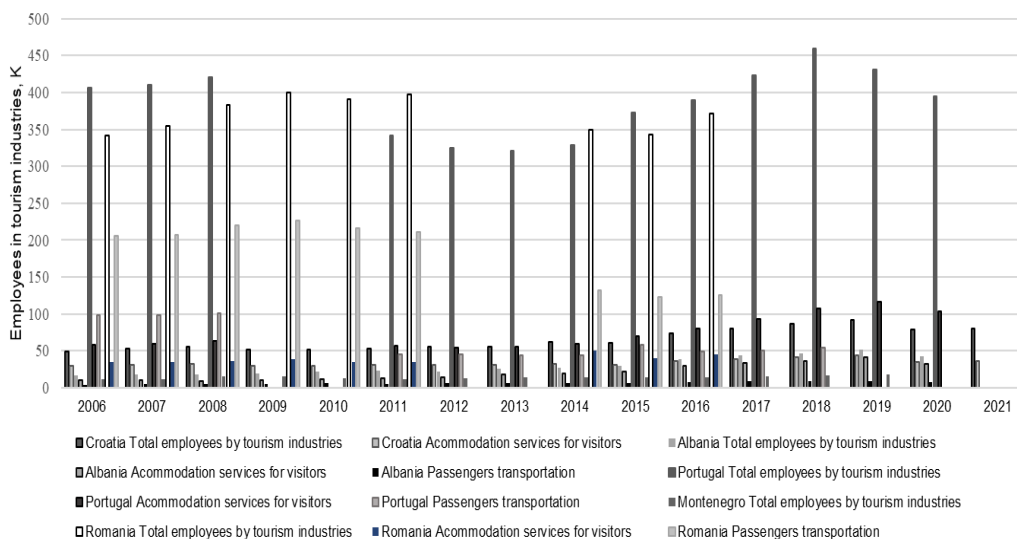
The study on ICT utilization in Albanian tourism (Gjika & Pano, 2020) reveals noteworthy findings. Notably, all employees in surveyed companies possess the required digital skills, with digital archives established at the organizational level. These indicators surpass the average ICT use in the Albanian market, aligning with larger enterprises' standards. Tour operators, outperforming other industries, showcase substantial progress in digitalization.

Online sales are offered by 58.3% of tour operators with websites, emphasizing the role of social media (92.9%) as a crucial marketing tool. Social networks serve as primary communication channels, aiding in product development, service enhancement, and customer data collection. Despite interest in accessing local government digital platforms, limited availability hinders collaboration. Albanian tour operators are yet to fully embrace Tourism 4.0 technologies but express eagerness for future advancements. Government initiatives, improving digital infrastructure and fostering virtual tourism products, are pivotal in accelerating the digitization of Albanian tourism (Gjika & Pano, 2020).

Montenegro relies on tourism for economic growth, with international tourism playing a pivotal role. Despite a burgeoning IT industry, Tomašević, Đurović & Abramović (2019) research focuses on the Montenegrin hotel sector, exploring the integration of new technologies and diverse components into their offerings. Esteemed luxury chains like Hilton and Chedi Hotel-Lustica Bay exemplify best practices, leveraging digital tools for enhanced value. While Montenegro demonstrates proficiency in internet, social network, and mobile phone use, digital technology application in other sectors, particularly among companies, is lacking (Melović et al., 2020). With 74% internet penetration, there's potential for robust digital marketing. Initiatives are underway, including a digital transformation strategy for 2021–2025, to capitalize on these opportunities (Mountains, Sea and IT, 2023).

Ukraine is also making extensive use of Industry 4.0 technologies. In particular, the concept of a smart city has been introduced in the country, which not only makes it possible to improve the living conditions of the local population, but also has a positive impact on the tourism sector. In 2022, it received the "World Smart City Award Special Recognition" – award for the city application "Kyiv Digital" (The official portal of Kyiv City, 2022). In recent years, the authorities of Ukrainian cities have shown increased interest in smart-infrastructure development projects, introducing digital technologies and increasing the level of "intellectualization" of the urban environment. In particular, facial recognition technology is widely used, thanks to which it is possible to make contactless payments in retail networks, as well as travel in public transport. A "smart" lighting system is being implemented, which reacts to traffic and collects information about the state of the environment (temperature, air quality, noise level, etc.). Smart water and gas consumption meters have already been installed in almost all cities, and the use of "smart" garbage containers that signal when they are full is becoming more and more relevant. Our own smart projects are being developed by teams of specialists in Kharkiv, Lviv, Dnipro, Vinnytsia, Poltava, Drohobych, Kyiv, Mukachevo and other cities. Among the main areas and directions of digital transformation in these cities are: e-democracy and city management, education, medicine, ecology, urban mobility and public safety.

With the introduction of new technologies and a change in the approach to urban planning, Ukrainian cities are gradually becoming more convenient for the life and recreation of citizens and tourists. The segment of industry information portals and specialized services in Ukraine enjoys considerable attention from investors and has significant potential for development. Among the presented forms of Internet portals are Internet stores, sites of industry associations, social networks with offers of tours and ratings of enterprises. The availability of these resources contributes to the informatization of the tourism sector, affects the increase in tourist flows and increases investment attractiveness tourism in Ukraine. The comparative analysis of the use of Industry 4.0 technologies carried out shows the unevenness of their use in the countries selected for the study. Portugal, Croatia, Romania and Ukraine have a much higher level of implementation of these technologies in urban infrastructure and in the field of tourism, compared to Montenegro and Albania. Further research can reveal the extent of the relationship between the development of information and communication technologies in the country and the profitability of tourism (fig. 2).



**Fig. 2. Dynamics of employees by tourism industries of research countries for 2006-2021**

Source: Author's representation based on the data from UNWTO (2022)

The United Nations agency of the World Tourism Organization (UNWTO, 2022) conducts research employee engagement by tourism industries in the following spheres: accommodation services for visitors, passengers transportation, travel agencies and other reservation services activities, food and beverage serving activities and other tourism industries. Data analysis (fig. 2) showed that, among the researched countries the most workers in tourism industries are involved in Portugal and Romania. The least of employed workers is observed in Albania and Montenegro. In Croatia and Albania, the most employees are engaged in accommodation services for visitors. It should be noted that in Romania and Portugal the most workers are involved in the transportation of passengers.

Based on the above, it is of interest to explore the impact of Digital Technologies, i.e., possible scenarios for tourists, travelers. At the same time, along with differences in cultures and levels of development of countries, there are common factors that are equally significant for any country and that act as stimulators or obstacles to the effectiveness of tourism processes.

The main parameters of the effectiveness of the tourism process are thus the following: the distance of the destination (D); number of travelers (NT); number of transport units (U); number of types of transport (TT); Duration of transfers (if any) (DT); availability and duration of delays in the submission of transport and its departure (DD); availability of alternative transport and the possibility

of changing the route at each intermediate point to the destination (AT); ability to plan a trip using digital technologies (route designer) (R); convenience and functionality of the website of transport companies and the ability to perform operations of purchase and exchange of travel documents online (W); availability of access to the Internet at each stage of the trip (I); relevance of data and their updates in Google Maps (GM); availability of online support service for guests of host hotels (H); the total cost of the trip (F); the policy of transport companies regarding the compensation of tourist losses caused by the fault of transport companies (P); non-predictable factors (N).

The mentioned factors should be considered simultaneously when realizing tourist trips. Their combination creates the conditions and grounds for making decisions on (a) the potential effectiveness of tourism, (b) the risks of tourism and (c) the feasibility of tourism.

Travel planning toolkits (online applications) can provide tourists with a convenient and easy way to organize their trips. They can quickly find different destinations, check transport availability and book tickets, and plan the optimal route based on duration and distance. This allows tourists to use their time effectively and reduce the stress associated with travel arrangements. The main condition is a stable Internet connection (5G) and a smart phone with an online application.

However, it should be emphasized that the availability and accessibility of digital technologies is not a decisive factor in the implementation of a travel plan, as the course of events is often influenced by unpredictable factors of a non-digital nature:

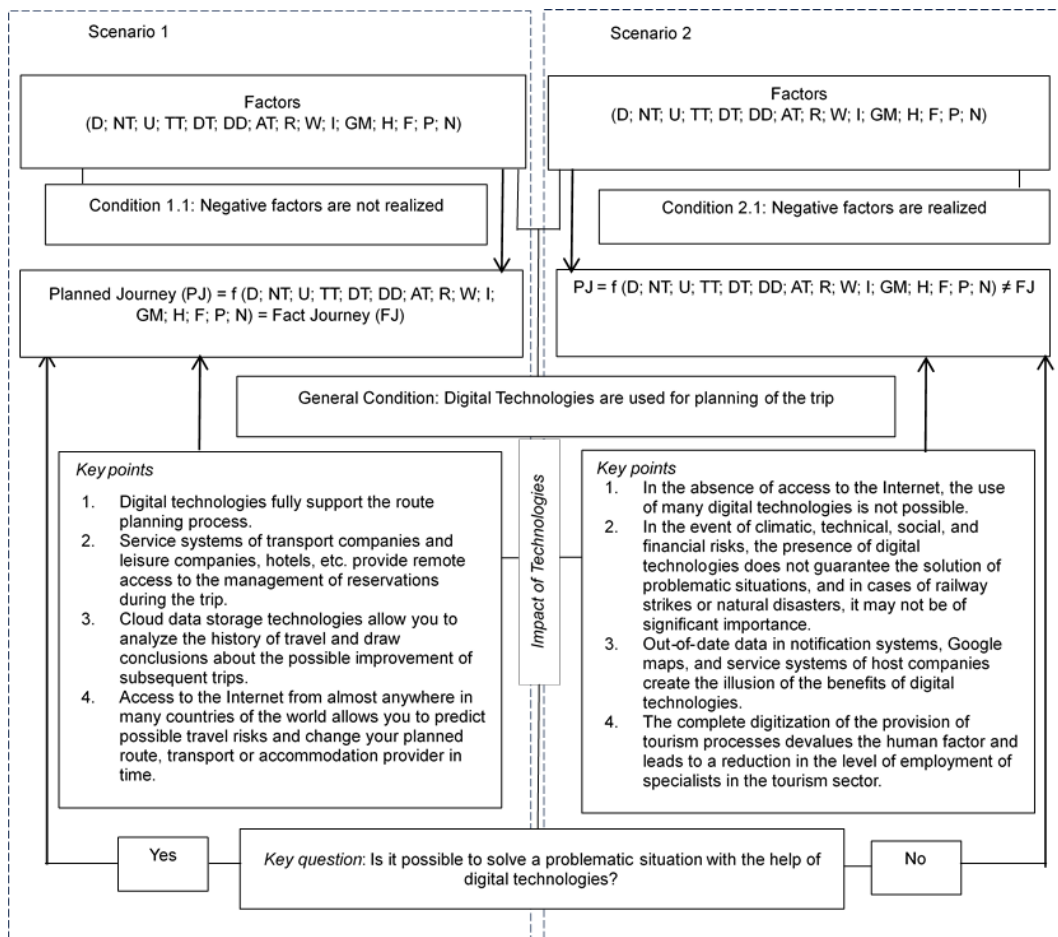
- duration and distance, travel time between destinations may be delayed due to unforeseen circumstances (traffic jams or public transport delays). The distance may be longer than expected due to incorrect route planning or unavailability of optimal vehicles. Considering unpredictable circumstances, such as "departure delays", which introduce an additional negative aspect to the pessimistic one, tourists may encounter disruptions in their departure schedule stemming from various factors, including weather conditions, transportation-related technical issues, or organizational challenges. This can lead to interrupted plans and the stress associated with the uncertainty and inconvenience of travel;

- tourists cannot always be sure of the availability and efficiency of different types of transport: a car may not be available due to insufficient number of cars or technical problems; public transport may not provide comfortable conditions etc.

Considering the factors and possible risks of travel logistics, it is advisable to define general scenarios of the tourism process: optimistic and pessimistic (fig. 3). The first scenario is based on the hypothesis that smart technologies enhance the tourist experience. The other one – pessimistic scenario – by which technologies do not affect the course of the trip and create the illusion of simplicity of planning, refutes this hypothesis.

Using methods of analysis, synthesis, and comparison, a hypothesis testing was conducted to establish the relationship between Industry 4.0 tools and the functioning of municipal infrastructure. One of the tasks in assessing the impact of Industry 4.0 on smart tourism is the study of the dynamics of tourist flow indicators. Therefore, the authors conducted a comparative analysis using methods of comparison, statistical grouping, to form a sample from 6 tourist countries. Employing empirical research, two scenarios were proposed (fig. 3): an optimistic one, where smart technologies enhance the tourist experience, and a pessimistic one, where technologies do not affect the course of the journey. Linear regression method was used for forecasting.

According to (fig. 3) when planning tourist, travelers' trips, it is important to consider multiple factors simultaneously. These factors contribute to the overall conditions and to the basis for making decisions regarding the potential effectiveness, risks, and feasibility of tourism. It is advisable to analyze these factors and the potential risks associated with travel in order to define general scenarios for the tourism process. Two scenarios that can be considered are the optimistic scenario and the pessimistic one, which were offered by the authors. In the optimistic scenario, it is hypothesized that smart technologies enhance the overall tourist experience. This means that the use of advanced technologies can positively impact various aspects of the trip, such as planning, navigation, and access to information. The optimistic scenario assumes that these technologies make the tourist experience more convenient and enjoyable. On the other hand, the pessimistic scenario challenges this hypothesis by suggesting that technologies do not significantly affect the course of the trip. In this scenario, it is believed that despite the illusion of simplicity in planning and using technology, the actual impact on the tourist experience is minimal. This scenario implies that relying too heavily on technology may not necessarily enhance the overall travel experience.



**Fig. 3. the influence of digital technologies and a number of factors**

Source: author's development

By considering these scenarios, stakeholders, tourism companies, hotels, agencies, and other participants in the tourism industry can better understand the potential effects of smart technologies and make informed decisions regarding their implementation. It is important to carefully assess the risks and benefits associated with these technologies before fully embracing them in the tourism sector.

Below (Fig. 4), the authors try to offer a forecast for the number of tourists and travelers in 2024 based on data from the countries selected for the study (World Bank, 2022): Croatia, Albania, Portugal, Montenegro, Romania and Ukraine.

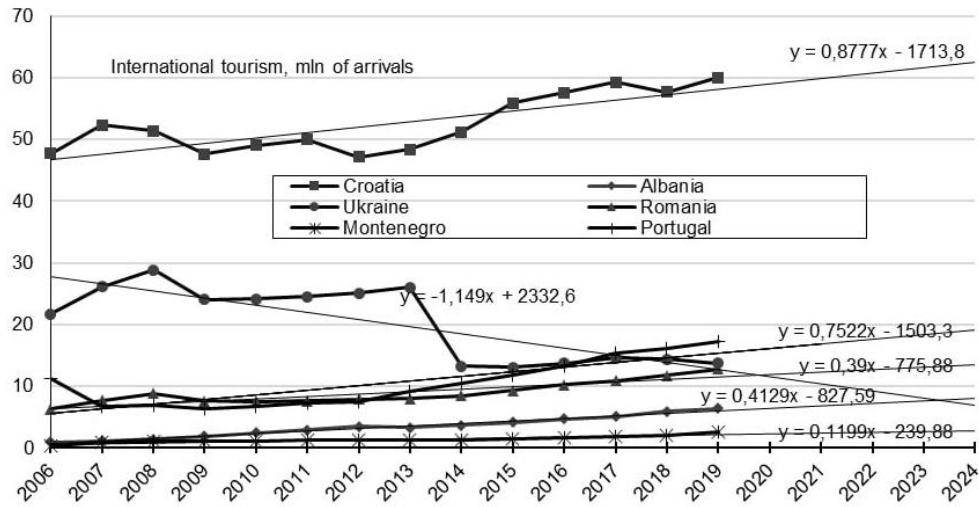
Figure 4 displays the trends in the number of foreign tourists in the countries under study, as determined by the linear regression method. Figure 4 illustrates a clear connection between the level of tourism development and implementation of Industry 4.0 technologies in different countries. The data shows that countries like Croatia and Portugal, with more advanced levels of implementation, have the strongest correlations, supporting the author's hypothesis.

As for Albania, Montenegro, and Romania, lower values should be noted along the trend lines. Regarding Ukraine, according to the built trend line, the country is characterized by a downward trend.

The optimistic scenario (for the studied five counties) suggests that smart technologies can greatly enhance the overall tourist experience by providing convenience and access to information.



This scenario assumes that technology can positively impact various aspects of the trip, making it more enjoyable and efficient. The pessimistic scenario for Ukraine challenges this hypothesis by suggesting that technology may not significantly affect the course of the trip. It implies that relying too heavily on technology may not necessarily enhance the overall travel experience. This scenario emphasizes the importance of considering other factors and not solely relying on technology for a successful tourist trip.



**Fig. 4. Forecasts of the number of tourists, travelers to the study countries through 2024**

Source: Author's representation based on the data from World Bank Open Data (2022)

As for Ukraine's pessimistic scenario for tourist trips in 2024, there could be several reasons contributing to this. One possible reason is the lack of sufficient investment in smart technologies and infrastructure to support tourism. Without proper technological advancements and infrastructure, it becomes challenging to provide a seamless and convenient experience for tourists. Additionally, political instability or conflicts in the region can deter tourists from visiting Ukraine. Safety concerns and negative perceptions can significantly impact the tourism industry, leading to a pessimistic scenario.

Furthermore, limited marketing efforts and promotion of Ukraine as a tourist destination may also contribute to the pessimistic scenario. Without effective marketing strategies and campaigns, Ukraine may struggle to attract tourists and compete with other popular destinations.

Overall, it is crucial for Ukraine to address these factors and invest in smart technologies, infrastructure development, and effective marketing strategies to improve its scenario for tourist trips in 2024. By doing so, Ukraine can enhance the overall tourist experience and attract more visitors to explore its rich cultural heritage, natural beauty, and historical sites.

**Conclusions.** The study showed that Industry 4.0 had a significant impact on the tourism industry, transforming the way tourists plan and experience their trips. Authors present both: challenges and solutions for the development of the utility sector of tourism infrastructure using Industry 4.0 technologies. The study was conducted on the basis of data from four leading countries in terms of international tourism receipts as a percentage of GDP (Croatia, Albania, Portugal, Montenegro), as well as Romania and Ukraine as countries with great tourism potential. The authors proved the significant impact of Industry 4.0 technologies on the development of tourism in these countries. Based on the systematization of the factors influencing the development of tourism in the country, possible scenarios for the development of this industry were proposed and a forecast of the number of tourists, travelers to the studied countries until 2024 was made. The scenarios presented in this article reflect the real decision-making process for planning and implementing a trip, taking

into account the influence of digital technologies and a number of factors in complex management situations.

The research results may be useful for tourism companies, hotels, agencies, and other participants in the tourism industry who want to understand the impact of Industry 4.0 on the utility sector of tourism infrastructure. The descriptions can help develop strategies and plans to utilize new technologies, ensure service quality, and increase customer satisfaction. Additionally, the descriptions may be helpful for researchers and academic specialists interested in the development of tourism in the era of Industry 4.0.

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## КОМУНАЛЬНИЙ СЕКТОР ТУРИСТИЧНОЇ ІНФРАСТРУКТУРИ В ІНДУСТРІЇ 4.0: ВИКЛИКИ ТА РІШЕННЯ

Дана стаття є оригінальною спробою визначити необхідність використання компонентів Індустрії 4.0 у комунальному секторі туристичної інфраструктури. Встановлено проблеми, з якими стикається комунальний сектор туризму щодо застосування Індустрії 4.0, а саме, потреба в модернізації інфраструктури, цифровій інтеграції, забезпечення стійкості і задоволення мінливих очікувань туристів. Дослідження проводилось на базі даних чотирьох країн-лідерів за обсягом надходжень від міжнародного туризму у відсотках до ВВП (Хорватії, Албанії, Португалії, Чорногорії), а також Румунії та України, як країн із значним туристичним потенціалом. В статті доведено суттєвий вплив технологій Індустрії 4.0 на розвиток туризму в даних країнах. Це дослідження має на меті визначити перешкоди, з якими стикається комунальний сектор туристичної інфраструктури в Індустрії 4.0, і запропонувати певні рішення для подолання зазначених проблем. У статті запропоновано концептуальну основу для створення нової моделі роботи комунального сектору, яка може бути використана для ефективного збільшення об'єктів туристичної інфраструктури. Використовуючи емпіричне дослідження, запропоновано два сценарії: оптимістичний, коли розумні технології полегшують життя туриста, і песимістичний, коли технології не впливають на хід подорожі. Для побудови прогнозованої моделі використано метод лінійної регресії. Представлені сценарії допомагають визначити, як розумні технології можуть полегшити життя туриста, забезпечуючи швидке та ефективне планування подорожей через онлайн-додатки, а також показують негативні наслідки, коли технології не працюють належним чином, або виникають непередбачені обставини, що призводять до затримок, зриву планів, та незручності під час подорожі. Автори відзначили, що наукова новизна даного дослідження полягає в розгляді впливу смарт-технологій на процеси прийняття рішень у складних ситуаціях подорожі. У статті спрогнозовано кількість туристів, досліджуваних країн. Результати дослідження можуть бути корисними для туристичних компаній, готелів, агентств та інших учасників індустрії туризму.

Ключові слова: **Індустрія 4.0 та смарт-технології, ризики, прогнозування, транспорт, страхування, прогнозний сценарій для мінімізації ризиків.**

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