

Exploring sustainable tourism innovations through topic modelling

Esplorando le innovazioni del turismo sostenibile attraverso il topic modelling

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Abstract. Innovation and sustainable tourism are closely linked concepts that are critical for the long-term success of the tourism industry. Sustainable tourism involves the responsible use of natural resources, the preservation of cultural heritage, and the promotion of local economies and communities. Innovation, on the other hand, involves the creation and implementation of new ideas, products, and processes that can improve the efficiency, effectiveness, and sustainability of tourism. In this paper, we aim to explore how innovations can combine sustainability and tourism. Many cities and tourist destinations experience the challenges of overtourism and climate change. Governments and the tourism industry need to overcome these challenges in a sustainable and inclusive way. Both governments and organizations have acknowledged the opportunities technology and innovation can offer, but the tourism industry continues to grow in an unsustainable manner. To measure the level of sustainable innovation in the tourism industry, patenting trends have been analyzed. The results of the patent analysis show how patent applications have increased in the past decade and how these are spread on a global scale. Through topic modelling analysis we confirmed that these patents increasingly evolve around different sustainability topics. This paper offers relevant insights to both the academic and practical field.

Abstract. *L'innovazione e il turismo sostenibile sono concetti intrinsecamente legati e fondamentali per il successo a lungo termine dell'industria turistica. Il turismo sostenibile implica l'utilizzo responsabile delle risorse naturali, la tutela del patrimonio culturale e la promozione delle economie e delle comunità locali. Dall'altra parte, l'innovazione comporta la creazione e l'applicazione di nuove idee, prodotti e processi volti a migliorare l'efficienza, l'efficacia e la sostenibilità del settore turistico. In questo articolo, intendiamo esplorare come le innovazioni possono integrare la sostenibilità nel contesto del turismo. Numerose città e destinazioni turistiche devono affrontare le sfide legate all'overtourism e ai cambiamenti climatici. Sia i governi che le imprese devono superare tali sfide in modo sostenibile e inclusivo, riconoscendo le opportunità offerte dalla tecnologia e dall'innovazione. Per valutare il livello di innovazione sostenibile nel settore turistico, sono stati esaminati i trend dei brevetti. I risultati dell'analisi dei brevetti evidenziano un aumento delle richieste nell'ultimo decennio, distribuite su scala globale. Attraverso l'analisi del topic modelling, abbiamo confermato che tali brevetti si concentrano sempre di più su vari argomenti legati alla sostenibilità. Questo documento fornisce approfondimenti significativi sia per il contesto accademico che per quello pratico.*

Keywords: *Topic modeling, Tourism, Patent analysis, Sustainability*

1. Introduction

Tourism is an industry that has experienced significant growth in recent years. With the increase in globalization, the world has become more accessible, and people are more willing and able to travel than ever before. Many factors have contributed to the increase in tourism: 1) improvements in transportation, such as the growth of budget airlines, have made travel more affordable and accessible; 2) the rise of social media. Platforms like Instagram and Facebook have made it easier for people to share their travel experiences and inspire others to visit the same destinations; 3) the spread of technology. From online booking platforms to virtual reality experiences, technology has made travel more accessible, convenient, and immersive.

In detail, in recent years, the tourism and technology sectors have become increasingly intertwined. Technology has transformed the tourism industry by enabling more efficient and personalized travel experiences, improving the marketing and distribution of tourism products and services, and promoting sustainable tourism practices. The rise of online booking platforms has made it easier for people to plan and book their trips and the widespread use of smartphones has led to the development of travel apps that allow travelers to access information, make reservations, and navigate new destinations. Apps like Google Maps, TripAdvisor, and Airbnb have made it easier for people to find their way around and discover new things to do. Virtual reality technology has enabled travelers to experience destinations before they even arrive. Virtual tours, 360-degree videos, and immersive experiences have allowed people to explore new places and make informed decisions about where to travel.

The intersection of tourism with technology has led to what we now commonly refer to as “smart tourism” which refers to the use of innovative technology and data analytics to enhance the tourism experience for visitors while improving the sustainability and efficiency of tourism destinations (Cavalheiro et al., 2021; Lee et al., 2020; Pantano & Styliadis, 2021; Ratten & Braga, 2019). However, while smart tourism holds the promise of increasing sustainability by enhancing efficiency, data-driven decision-making, and responsible travel practices, it also poses challenges related to accessibility, privacy, environmental impact, and social issues. As smart tourism destinations collect more data on visitors, it is essential to ensure that data is collected and stored securely and responsibly. In addition, there may be concerns about the use of AI and automation in the tourism industry, such as the impact on employment and the potential for bias and discrimination. In addition, the increasing amount of temporary visitors decreases the quality of life of the residents by hindering their access to housing and transporta-

tion and causing pollution and other negative environmental effects. This is often described as ‘overtourism’. The COVID-19 pandemic showed the other side of the spectrum when tourism was put on hold, and the economic dependency on it became evident in mostly urban areas (Koens et al., 2018, 2021; Milano & Koens, 2021; Russo, 2021). As a response to overtourism and the environmental issues our world today faces, the tourism industry and governments have both been giving more attention to sustainability. Environmentally friendly consumer behavior is gaining popularity with a rising demand for green products and services, nudging organizations to change their processes and respond to their consumers’ wishes (Han, 2021). From a governmental position, the need for sustainability is clear as new policies and climate agreements are being implemented, and the large tourism industry is part of both the problem and the solution. The European Commission acknowledges the important role of innovation and digital technologies in this transformation towards a sustainable future (European Commission, 2020).

Despite the opportunities for synergy between these two fields, research that specifically focuses on their combination is still limited (Cavalheiro et al., 2021; Pantano & Styliadis, 2021; Ratten & Braga, 2019). One possible explanation for this is that tourism has traditionally been viewed as a relatively static industry, with a focus on preserving heritage and culture rather than innovating and adapting to change. As a result, tourism research has tended to be more focused on issues such as destination management, sustainability, and consumer behavior, rather than innovation. In contrast, innovation research has traditionally focused on high-tech industries such as information technology, biotechnology, and aerospace. As a result, there has been limited attention given to the role that innovation can play in tourism. This is a gap that needs to be filled to fully understand the potential of this combination and to develop effective policies and strategies for promoting innovation in the tourism industry. This paper therefore aims to contribute to both the academic and the practical field with relevant insights and suggestions for future research exploring innovation in the tourism sector using a patent analysis (Gretzel et al., 2015; Ismagilova et al., 2019). More in detail, this contribution attempts to answer the following research question: How do innovations combine sustainability and tourism? Which countries patent the most in sustainability and tourism? How have sustainability innovations in tourism evolved in recent years?

We apply a topic modeling on a large dataset of patents in the tourism industry to identify key themes and topics that are frequently discussed or associated with both fields. This approach allows us to pinpoint prevalent themes and subjects that are commonly linked to both domains. Employing

topic modeling facilitates the monitoring of how themes and trends evolve at the convergence of innovation and tourism. Furthermore, it reveals subtopics and subcategories that might not be immediately apparent.

The organization of the remaining sections is sketched below. In Section 2, we present the theoretical framework. In Section 3, we give the method of how we do this study. Section 4 describes the results. Finally, Section 6 concludes our study through a presentation of the implications, limitations, and suggestions for future research.

2. Theoretical framework

2.1. Sustainability in the Tourism Industry

The World Tourism Organization (UNWTO) defines sustainable tourism as “tourism that takes full account of its current and future economic, social, and environmental impacts, addressing the needs of visitors, the industry, the environment, and host communities.” The UNWTO further elaborates on this definition by stating that sustainable tourism should: 1) make optimal use of environmental resources that constitute a key element in tourism development, maintaining essential ecological processes and helping to conserve natural heritage and biodiversity; 2) respect the socio-cultural authenticity of host communities, conserve their built and living cultural heritage and traditional values, and contribute to inter-cultural understanding and tolerance; 3) ensure viable, long-term economic operations, providing socio-economic benefits to all stakeholders that are fairly distributed, including stable employment and income-earning opportunities and social services to host communities, and contributing to poverty alleviation; 4) provide enjoyable tourism experiences to visitors that are respectful of the host community and their cultural and natural heritage, providing a meaningful connection to the people and places visited (del Vecchio et al., 2018; UNWTO & UNEP, 2005).

Scholars have been studying the environmental, social, and economic impacts of tourism and exploring ways to make the industry more sustainable from a triple-bottom-line perspective. This approach emphasizes the need to balance not only economic prosperity but also social well-being and environmental preservation. In the context of tourism, the triple bottom-line framework encourages researchers and industry stakeholders to assess how tourism activities can generate positive economic outcomes while simultaneously contributing to the social and environmental health of the destinations. In recent years, the need for sustainability in the tourism industry has

become even more pressing due to more extreme environmental issues, such as climate change, pollution, and loss of biodiversity. These issues are threatening the natural and cultural resources that tourism depends on and are also impacting the well-being of local communities and economies (Koens et al., 2021). Even though many tourists are aware of the negative side effects traveling can have on the environment, they continue to do so because of their desires and cultural habits (Buckley, 2012). However, a growing number of tourists are now incorporating Lifestyles of Health and Sustainability (LOHAS) principles into their travel choices, striving for more sustainable and eco-friendly ways of exploring the world (Han, 2021). LOHAS consumers prioritize products and services that are environmentally friendly, socially responsible, and healthy. In terms of the tourism industry, LOHAS consumers are increasingly interested in travel experiences that align with their values and priorities. They seek out eco-friendly and sustainable accommodations, transportation, and activities, and are willing to pay a premium for these options. LOHAS travelers are also interested in cultural immersion, authentic experiences, and engaging with local communities. To cater to the needs and preferences of LOHAS consumers, many tourism businesses have developed sustainable and eco-friendly practices and products. For example, hotels and resorts have implemented energy-efficient lighting and heating systems, water conservation programs, and recycling initiatives. Airlines and transportation companies have also adopted more sustainable practices, such as using biofuels and reducing carbon emissions (Choi et al., 2021).

In this context, it becomes increasingly evident that technology plays a pivotal role in driving sustainable tourism practices, leading to reduced consumption, and minimized waste generation, as indicated by Gore et al. (2021). However, the study conducted by Santos et al. (2021) reveals a notable imbalance in research focus within the tourism industry, with a substantial body of work dedicated to sustainability but relatively limited attention on the crucial relationship between innovation and tourism. This gap represents a missed opportunity, especially considering the evolving dynamics of the tourism landscape. To address this imbalance and capture the nuanced connections between innovation and tourism, the implementation of topic modeling should be considered. By employing this technique, researchers can uncover hidden themes, emerging trends, and cross-disciplinary insights that are essential for guiding strategic decision-making and ensuring the industry's future resilience and adaptability. In the specific context of technology's role in sustainable tourism, topic modeling can elucidate the multifaceted ways in which innovation positively influences the industry. From reducing carbon footprints through electronic ticketing to improving resource management with smart technology and fostering social sus-

tainability through enhanced communication and community engagement, these insights can inform industry stakeholders and policymakers about the pivotal role innovation plays in shaping the future of sustainable tourism.

In this scenario, the concept of smart tourism, which places a strong emphasis on harnessing innovation and technology to improve the overall tourism experience, optimize destination management, and drive sustainable development, has emerged.

Smart Tourism

Smart tourism refers to the use of advanced technology and data analytics to enhance the tourism experience for both tourists and industry stakeholders. Smart tourism aims to improve the efficiency and effectiveness of tourism operations, enhance the tourism experience, and promote sustainable tourism practices (Corbett & Mellouli, 2017). The relationship between tourism and emerging technologies such as Artificial Intelligence (AI), Big Data, and robotics has evolved significantly in recent years, transforming the way the tourism industry operates and improving the overall traveler experience (Buhalis and Law, 2008).

One of the key components of smart tourism is the use of data analytics and artificial intelligence (AI) to analyze large amounts of data on tourist behavior, preferences, and feedback (Hashem et al., 2016). This data can be used to identify trends, patterns, and insights that can be used to optimize tourism operations and improve the tourist experience (Lee et al., 2020). For example, data analytics can be used to develop personalized tourism recommendations for individual travelers based on their preferences and past behavior. Smart tourism also includes the use of technology to enhance the tourism experience. For example, mobile apps can be used to provide tourists with real-time information on local attractions, transportation options, and weather conditions. Augmented reality and virtual reality technologies can be used to provide immersive and interactive experiences for tourists, such as virtual tours of museums or historical sites. Smart tourism can also promote sustainability by improving the management of natural resources and reducing the environmental impact of tourism activities (Sigala, 2018). Moreover, smart tourism can contribute to the economic sustainability of tourism by improving the efficiency of tourism operations and promoting innovation and entrepreneurship. For example, the use of digital platforms and online booking systems can help tourism businesses reach new markets and attract more customers (Buhalis, 2020).

Smart tourism has not yet been rigorously researched as a theme on its own (Gretzel et al., 2015). However, smart tourism is an important aspect of a smart city, the concept from which it has emerged in the past decade

(Križaj et al., 2021). Existing literature has emphasized the essential role of digital technologies in the development of smart and sustainable cities (Angelidou et al., 2018; Corbett & Mellouli, 2017; Hashem et al., 2016; Ismagilova et al., 2019; Woetzel et al., 2018). Smart tourism destinations make use of the 'smartness' originating from smart city research and methodologies (Križaj et al., 2021). Gretzel et al (2015) have split smart tourism into smart destinations, smart experiences, and smart business. They emphasize how digital technologies are crucial in the conceptualization and development of smart tourism initiatives. Even though the term smart tourism is novel, the tourism industry has been using a wide range of technologies for a longer period, also known under the term 'e-tourism' (Buhalis, 2020). Examples of technologies used in e-tourism relate to improving the travelers' experience by offering real-time information, offering the ability to interactively share their experiences, anticipate their needs, and offer personalized recommendations. Smart tourism takes e-tourism to another level, with more advanced technologies like cloud computing, Radio-Frequency-Identification (RFID), and the Internet of Things, to connect the physical and digital world (Gretzel et al., 2015). Tourism has been heavily influenced by technology, it has changed the way tourists travel, purchase tickets, place bookings and find information. Technology has allowed tourism to become more cost-efficient and more widely available (Gore et al., 2021). Because the tourism industry is a knowledge-intensive industry, technological usage through big data and data analytics are particularly useful for (social) innovation and value creation, and therefore an improved competitive advantage (del Vecchio et al., 2018; Polese et al., 2018). Tourists interact with locals through (social) platforms and other integrated services, and share knowledge and decision support, leading to more open innovation. Smart tourism initiatives hereby contribute to satisfying visitors' demands by offering all-inclusive (technology-enhanced) experiences and improving the quality of those experiences (del Vecchio et al., 2018).

The European Capital of Smart Tourism rewards European cities based on their performance in four categories 1) sustainability, 2) accessibility, 3) digitalization, and 4) cultural heritage and creativity. The sustainability category entails the inclusion of residents in reducing seasonality effects on the environment, in addition to managing and protecting a city's natural resources. The accessibility category strives for all visitors regardless of their age, cultural background, or physical impairment, to be able to use (digitally available) multilingual services. The digitalization category looks at a city's usage of digital technologies to improve all facets of the tourism experience, to make it easier for visitors to access services, and to support local businesses to thrive. Finally, the cultural heritage and creativity category aims to

protect and capitalize on cultural legacy and creativity benefiting the tourism destination, industry, and tourists themselves. Through this European Capital of Smart Tourism initiative, the goal is to promote innovation in European cities, and thereby improve visitor experiences, partnerships, and sustainability (European Commission, 2022a). With the increase of traveling citizens and travel coming back to pre-pandemic times, it is even more relevant to focus on the sustainability and digitalization of tourism, this paper will particularly focus on these two categories as they relate to the research questions that were previously introduced.

Next, overtourism, a consequence of modern tourism, is explained. This closely relates to sustainability and innovations could play a role in overcoming this challenge.

2.2. Overtourism

In addition to the positive effects tourism can have on a city or country economically, tourism also knows its downsides. Examples of this are the “overexploitation of resources”, “liberalization of common goods, markets, and services” and “social discontent” (Koens et al., 2018). The concept of the negative impact tourism can have on communities and their environment is known as overtourism (Koens et al., 2018; Lee et al., 2020; Milano & Koens, 2021). Overtourism is a consequence of the growing popularity of tourism, and is still present in many areas, despite the sustainability efforts coming from the tourism industry and governments. It is seen as a complicated issue, requiring scientific solutions from a multidisciplinary approach. Therefore, more academic research is needed to form relevant solutions to sustainability implications and to overcome overtourism (Mihalic, 2020). Tourism has been seen as a tool for sustainable (economic) growth in cities. However, functionalities like public transportation, accommodations, and cities’ infrastructure which were all initially created for the local population, are now often shared by an increasing number of tourists. A popular trend for tourists is to move away from mass tourism and live the authentic lives of locals, merging the local and tourist population even more through new platforms like Airbnb and Uber to create high-quality experiences (Koens et al., 2018; Lee et al., 2020).

Koens et al. (2018) emphasize that “technological or smart solutions alone will not solve overtourism”. Even though it can play a role in the development of a city’s capacity, overtourism is a mainly social issue with many stakeholders. Smart solutions like the rising number of disruptive platforms in the sharing economy have even intensified the overtourism problems. Smart tourism initiatives should therefore take the social factors into account

(Koens et al., 2018, 2021; Milano & Koens, 2021). At the same time, smart cities and their management approaches are seen to respond to the population growth in cities and should therefore be considered to battle overtourism issues. Even though not directly linked to tourism, smart cities integrate multiple elements related to tourism like housing, infrastructure, the environment, and public transport. Additionally, smart technologies can increase competitiveness and the use of information at tourist destinations and therefore play a role in the strategic solutions for overtourism (García-Hernández et al., 2019). Smart tourism solutions can support the creation of spaces in cities where both tourists and residents can enjoy themselves, especially in cities where residents now have a negative perception of incoming visitors. These smart cities have shown to be willing to invest heavily in the necessary resources to create an improved environment for residents and visitors, and to improve their quality of life (Lee et al., 2020). Smart solutions should be developed from a holistic perspective in collaboration with local citizens, organizations, and governments, to be able to make a significant impact. On their own, smart solutions have shown weak results in reverting overcrowded tourist destinations. However, they are unmissable for analyzing the situations (García-Hernández et al., 2019).

3. Methodology

Tourist experiences and tourist satisfaction are both key areas of investment and are expected to continue their growth in the coming years (Lee et al., 2020; Pantano & Stylidis, 2021). Innovation has been a trend in the tourism industry for decades. The emerging service economy and the rise of the Internet and digitalization use have contributed to this (Aldebert et al., 2011; Hjalager, 2010). In the past few years innovation in tourism has gained more attention and is seen as a strategic component to achieving long-term growth and success (Pikkemaat et al., 2019). The patenting trends in the tourism industry have not been thoroughly researched, as many scholars have not yet recognized their relevance (Pantano & Stylidis, 2021). The main field of research into smart tourism has been from a marketing and management perspective, thereby creating a gap for academic research from a technological perspective (Cavalheiro et al., 2021; Križaj et al., 2021). More recently, Pantano & Stylidis (2021) and Cavalheiro et al (2021) have both conducted a patent analysis on technologies in the tourism industry and found this to be a relevant tool to gain a better understanding of the role of innovation in the tourism industry, in a large amount of data available.

Following the nano-technology sector, the tourism industry is increasing the most in the growing number of patents (Pantano & Stylidis, 2021). The quickly growing number of patents has led to an increase in the use of patent analysis in research and organizations with new tools and analysis techniques being developed (Abbas et al., 2014). Patent analysis is relevant for assessing innovations and technological advances in different industries to be able to strategically improve organizations' competitive position (Abraham & Moitra, 2001). Therefore, in this research, the patents are used as a proxy to measure innovation in the tourism industry and to discover the role of innovation in supporting sustainable tourism (Cavalheiro et al., 2021). The patent analysis of companies in the tourism industry will be used to investigate the trends of digital technologies and innovation over the past few years.

To identify innovation related to sustainable tourism, a three-step process (Figure 1) is implemented. First, we drew on patents as a proxy of innovation. From this perspective, even though patents better refer to invention rather than innovation, they are often preliminary to innovation and are traditionally used to explore the innovation performance of firms and regions. Patent data can be collected from different sources. We opted for the Orbit database since it is one of the largest accurate patent databases and contains comprehensive information on global intellectual property (Questel, 2022, O'Leary, 2017). Second, we define the research strategy. None, to our knowledge, has already tried to sample tourism patents specifically sustainable tourism patents. Therefore, defining the research strategy was challenging. After much discussion with colleagues and experts in the field, we opted for the most linear choice, because other strategies would have increased the complexity without significant benefit. This decision pertained to the selection of patents that exhibited both "sustainab*" (e.g., sustainability or sustainable) and "touris*" (e.g., tourism or tourist) keywords in their title, keywords, claims, or abstract. No time-period constraints were included. No further criteria like country of origin or firm size were included. Data was downloaded in a CSV file and then analyzed through R by performing descriptive statistics to gather information on the patent data. In particular, we fitted a topic model using Latent Dirichlet Allocation (FitLdaModel function of textmineR package) to develop a content analysis of sampled patents' abstracts. Topic modeling is part of machine learning and natural language processing (NLP) modeling. It provides a 'probabilistic framework' for the frequency in which terms appear in the text. This way, the text belonging to the claims of each patent is explored to discover word co-occurrence. This is done by a statistical algorithm, to detect semantic structures in the text. The

topic modeling results are then visualized to gain a better understanding of what they entail (Grün & Hornik, 2011).

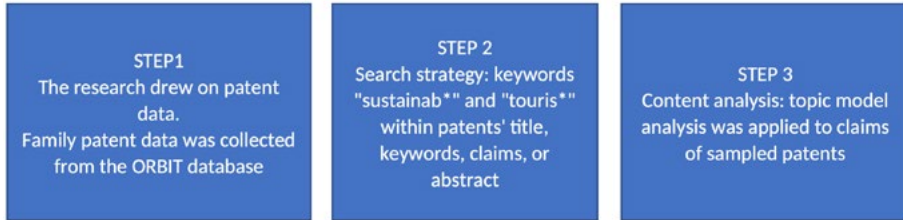


Figure n.1 - Three-step research design

4. Results

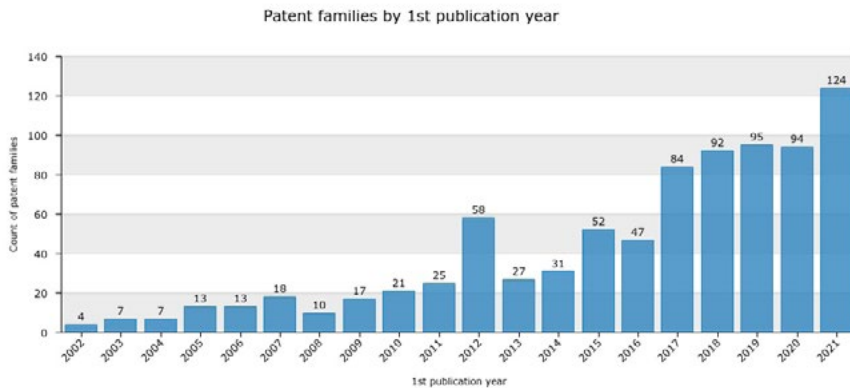
4.1. Descriptive analysis

By analyzing a large dataset of patents in the tourism industry, the current level of innovation and sustainability will be examined. Table 1 provides an overview of the general information of the dataset. A total of 2896 family patents were collected. Using a family patent allows us to avoid double-counting risk when the same patent is protected in several countries and registered at different patent offices. The earliest date of patent publication was 1957. However, most of the patents were published between 2002 and 2022. Most of the patents were applied for by organizations. Less than 25% was applied for by individuals. Only 8% of organizational patents were collaborative. Although sustainable tourism patents resulted to be distributed across different technological classes, more than 40% are concentrated in six classes (IT methods for management, Other special machines, Civil engineering, Environmental technology, Transport, and Computer technology). The most prevalent countries where patents have been published are China and the United States. China has been the leading country in patent filings since 2011, with more than 40 percent of all patent filings coming from China, so it might not be surprising that this also applies to the tourism industry (WIPO, 2021).

Table 1: Descriptive Statistics of the Database

Measurement	Result
Number of family patents	2896
Publication date:	1957-2022 (increasing intensity from 2002)
Assignees	675 patents applied for by individuals and 2,221 patents applied for by organizations, with 178 of the latter involving inter-organizational collaboration.
Main technological classes	IT methods for management (378), Other special machines (256), Civil engineering (205), Environmental technology (184), Transport (135), and Computer technology (100).
Main countries	China and the United States

Figure 2 reveals that the number of patents has increased significantly since 2002. This shows how innovation in the tourism industry has become more popular in recent decades and confirms the results of patent research conducted by Cavalheiro et al. (2021) and Pantano & Stylidis (2021). Patent publications have increased in general and the tourism industry is part of this trend.



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Figure 2: The number of patent families by their first publication year

Figure 3 shows the technology domains in which the patents belong, 'IT methods for management' is the most common domain. This class, in particular, includes IoT and digital technologies to manage touristic issues (e.g.,

information and people flows). The ‘environmental technology’ is also one of the more common domains in the dataset indicating the presence of sustainability in the tourism industry innovations.

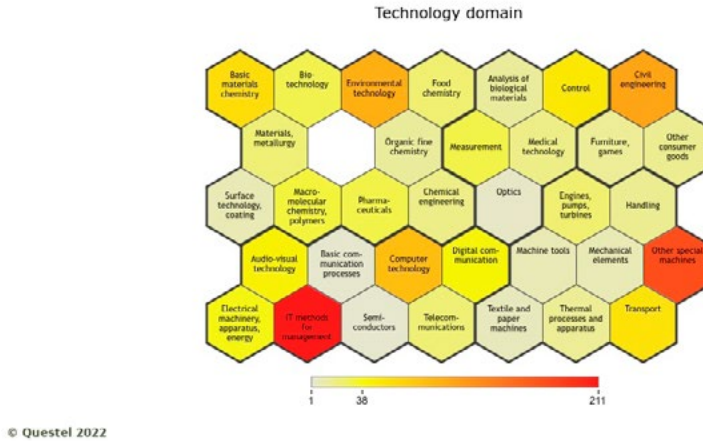


Figure 3: The technology domains of the patents

In addition to the descriptive statistics of the patent dataset, a content analysis has also been conducted. The content analysis is used to further research whether and how much the patents combine innovation and sustainability in tourism, by analyzing the textual data that is present in a large part of the dataset. Firstly, we implemented a topic model referring to single words that occur several times across patents. However, the results did not allow clear topics to be identified. Therefore, we implemented a second topic model based on coupled words. In this case, the software focuses on couples of words that are contiguous in the text and often occur together across patents. This provided a better understanding of the content. Only this second model will be discussed in the following section, and hereafter these results are used to answer the research questions.

4.2. Topic modelling

This research uses patent claims as the main source for analyzing the main topics combining tourism with sustainability. A patent claim usually consists of three parts: a preamble that serves as an introductory section to recite the primary purpose, function, or property; a transitional phrase, such as comprising, having included, consisting of, etc.; and a claim that is not included in the patent claim. Claims, on the one hand, reveal the central inventive matter and main technological scope of a patent; on the other hand, they are written in concise but precise language, making them the best resource for

identifying technological arguments and facilitating the analysis of patent documents (Chen et al. 2015).

Figure 4 shows the coherence and prevalence of the coupled word topics. The latter are two important measures used in topic modeling to assess the quality of the generated topics. Coherence measures the degree of semantic similarity between the words within a topic. It is an important metric for evaluating the interpretability and usefulness of a topic. Higher coherence values indicate that the words within a topic are semantically similar and reflect a coherent theme. Prevalence, on the other hand, measures the extent to which a topic is distributed across the corpus. It is an important metric for evaluating the importance and relevance of a topic. Higher prevalence values indicate that a topic is more widespread and relevant to the corpus. Topic 1 has a high coherence score near 0.75 and topic 8 almost reaches a score of 1. This means that the coupled words in these two topics are associated with each other and have a high semantic similarity. The prevalence scores of topics 1 and 8 however, are both below 10. This means that the probability of being distributed throughout the entire dataset is low. For the coupled word topics, topics 2, 5, and 9 have the highest prevalence scores. However, they are all below 20 so still indicate a low distribution probability of the topics throughout the data.

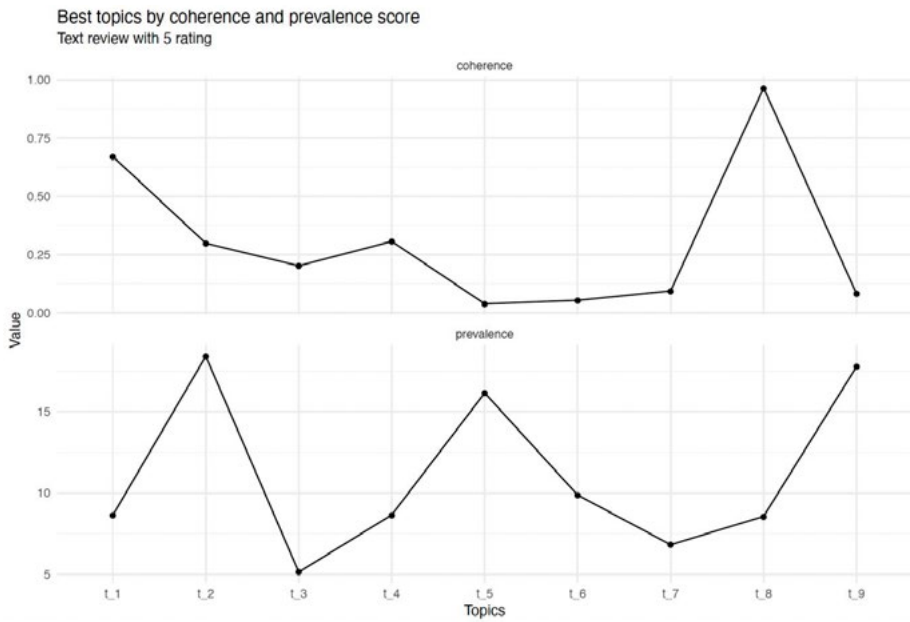


Figure 4: Topic model – coupled word coherence and prevalence.

Topic 1 is mainly related to the themes of urban efficiency; words such as “accessible urban” and “publicly accessible” arise. It thus emerges that innovations that include the terms sustainability and tourism also emphasize the importance of urban sustainability, efficient use of resources, and, above all, accessibility of resources.

Topics 2, 3, 8, and 9 exhibit a strong connection to healthcare, a pivotal facet of sustainability and one of the most critical Sustainable Development Goals. Two key facets intersect with tourism and health. On one hand, health tourism stands out as a significant category within the tourism sector. This encompasses both medical tourism, where individuals travel to access specific healthcare services and medical treatments, and the wellness tourism segment, catering to those seeking services to enhance their physical, psychological, and aesthetic well-being.

On the other hand, the risk of health-related diseases can act as a barrier, as several destinations may require specific vaccinations and might have underdeveloped healthcare infrastructure. For instance, the COVID-19 pandemic significantly curtailed tourism for a period and introduced heightened concerns and bureaucratic measures in the subsequent years. Therefore, fostering medical innovation becomes a pertinent priority in addressing the intricate relationship between tourism and sustainability.

From this perspective, Topic 2 contains paired words related to medicinal components such as “dimethylphenyl”, “diaminopyrimidines” and “microbiocidal heterocycles” which are related to several human diseases. This indicates how the topic may be related to health and access to health care, which could play a role in tourism innovations. Topic 3 refers to vaccine composition and conjugate vaccines which are a form of immunization for bacterial meningitis and cholera, while topic 8 is closely related to ‘cgrp’ (Calcitonin Gene Related Peptide). Similarly, topic 9 contains health-related terms such as ‘coronavirus spike’ and ‘human antibody’, and specifically refers to the plasmodium vaccine which is strictly linked to malaria disease. Malaria annually affects millions of people worldwide, above all, in developing countries, and make these destinations less appealing for health-risk tourists and requires other to vaccinate in advance. Therefore, developing medical innovation can help to support international tourism, above all in high-risk destinations.

Topic 3 also presents coupled words like “industrial process”, “sustainable system” and “cooling industrial”, which refer to innovations in the industrial environment and infrastructure. This topic could be linked with the process of rethinking industrial production processes, products, and services to foster the reduction of carbon emissions and plastic use, and replacement of

plastic with alternative materials, urban regeneration, and sustainable tourism.

Topic 4 is more related to the theme of water management. Water is an essential resource for tourism since it is consumed directly by tourists, e.g., for hygiene purposes, but also by the accommodation sector, e.g., for watering gardens, filling swimming pools feeding wellness and spa centers, cleaning rooms, and washing laundry. It is also a prerequisite for many recreational activities, such as golf and skiing. Words such as “treating water”, “water bodies” and “water floating” emerge in topic 4. These words refer to water management and ecosystems, a part of the environment relevant to sustainability and tourist destinations dealing with, among other things, tourism and climate change. Through this topic, therefore, it emerges that innovations in sustainable tourism are addressing this issue.

Topics 5, 6, and 7 are closely related to technologies for tourism management. In these topics, therefore, it emerges how the development of digital technologies is redefining the approach of many economic and social spheres and in particular that of tourism. Tourism is one of the sectors that register a marked use of technologies and digital platforms that mediate the relationship between operators and travelers. This analysis shows how it is also strongly linked to the issue of sustainability. Tourism is a sector that has recently intensified its investments in technology; apps or websites with booking systems have become particularly widespread in 2020, ensuring direct contact with the structures, but at the same time making it possible to avoid physical encounters. It is no coincidence that in the last period, many tourism companies have decided to develop their website with a booking system to be able to offer a fundamental service to customers. These tools have proved useful, not only for booking a hotel room or a flat but also for securing a sunbed and umbrella in a bathing establishment, entrance to a swimming pool, and days in a spa. The most advanced establishments have also equipped themselves with augmented reality systems to allow potential customers to visit a place in a digital preview. Among other things, in tourism, virtual and augmented reality is proving to be crucial, especially for museums and cultural venues.

In particular, Topic 5 delves into the management of tourism flows, evident through terms such as ‘system method,’ ‘system management,’ ‘sensing device,’ and ‘queue management.’ This aligns with the imperative to develop technologies aimed at enhancing the management of tourism flows in urban destinations. The goal is to mitigate an imbalanced distribution of crowds, steer tourists toward various attractions by promoting diverse tours, and alleviate the negative externalities associated with overtourism.

Topic 6 is rooted in the realm of tourism communication and experiential marketing, featuring terms like ‘device method,’ ‘user interface,’ and ‘graphical user.’ In this context, innovations such as virtual reality and virtual touring interfaces assume significant importance.

Topic 7 focuses on data processing and data analytics, invoking the concept of automation with phrases like “intelligent automated” and “automated assistant”. This underscores the crucial role of data in predicting tourism demand and market trends and reiterates the relevance of machine learning and artificial intelligence as pivotal in shaping applications not only in tourism but also in various other domains.



Figure 5: Topic model – coupled word clouds.

Figure 6 shows the trend of topics over time. Topic number 9 increases the most over the years, followed by topic number 5. Topic number 9 mentions the coronavirus spike, which explains the increasing trend as it has been a topic of recent years. The trend in topic 5 confirms the strong interest in linking the topic of technology with that of sustainable tourism. In contrast, topic 2, which is more related to health tourism, has the opposite trend.

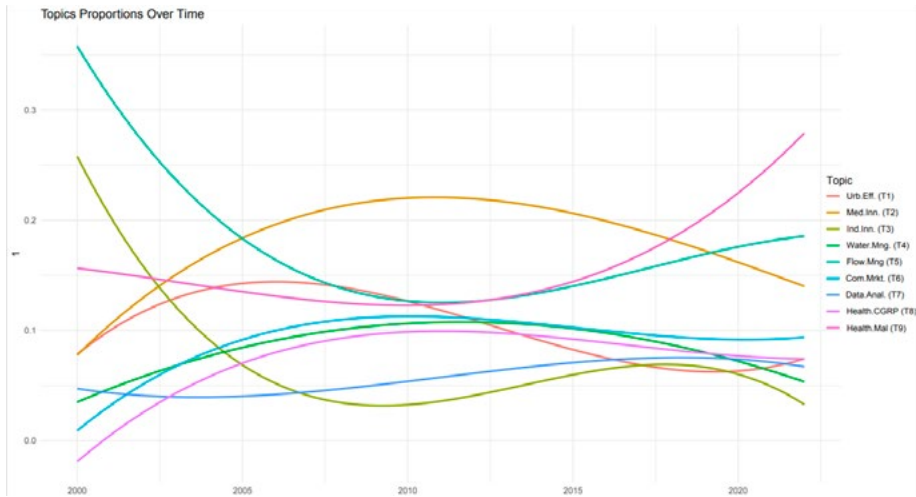


Figure 6: Topic model – coupled word trends.

5. Discussion and conclusions

This research utilizes patent data and employs a topic modeling content analysis to investigate the role of innovation and technological advancement in responding to the increasing focus on sustainable tourism concerns. Its primary objective is to discern the principal domains propelling this advancement.

The analysis of patents in the realm of sustainable tourism underscores its burgeoning significance as an area of innovation. Topic modeling further illuminates the diverse domains in which this innovative landscape is evolving. Notably, this analysis reveals that the inventive processes of sustainable tourism can be categorized into three primary areas.

The first area centers on urban/destination sustainability and grapples with the formidable objectives of enhancing resource efficiency, optimizing the utilization of internal resources, and mitigating the adverse consequences of tourism and overtourism.

The second domain encompasses tourism management. The inventive endeavors in this arena are directed towards identifying groundbreaking solutions, encompassing both hardware and software, to address specific challenges such as managing tourism flows and queues, enhancing communication and experiential marketing, and bolstering the collection and strategic use of data for more effective decision-making in the tourism sector.

These areas are invigorated by technological advancements, the advent of digital transformation, and the growing role of artificial intelligence.

The third sphere draws inspiration from the realms of health and well-being, benefitting from the support of medical innovations. The rise of health tourism and the increasing influence of medical concerns on tourists' behavior and experiences, particularly in less developed destinations like Africa and Asia, stimulate an inventive process geared towards discovering novel medical solutions, spanning medical components, treatments, vaccines, and more. From this perspective, the topic modeling analysis also revealed how the COVID-19 pandemic spurred the advancement of technologies in the domain of sustainable tourism, aimed at providing a swift and proactive response to the pandemic situation.

5.1. Managerial implications

The findings of this study empower managers operating within the tourism industry to forecast their positioning in the sector and make more informed decisions guided by sustainability and technological trends. The global emphasis on sustainability is an undeniable reality that transcends across all industries, with tourism being no exception. There remains substantial work ahead in building a sustainable tourism model that respects its environmental context and the well-being of the local communities. This vision of tourism should be capable of generating profits and benefits while minimizing negative externalities on the environment and society.

Furthermore, this study illuminates the intricate web of connections increasingly linking tourism challenges with innovation. Many solutions to sustainability issues within the tourism framework are contingent upon technological advancements. Artificial intelligence, data collection, and analytics, virtual interfaces, as well as digital communication stand out as prominent trends, underscoring the escalating role that technology plays in bolstering sustainable tourism efforts.

Policymakers and stakeholders must not underestimate this trend; instead, they should foster partnerships and policies to nurture a fresh perspective on and approach to tourism.

5.2. Limitations & Further Research

As is often the case with any empirical study, our research has some limitations. First, in this research, we were not able to overcome the fundamental problem of patent analysis. For example, strategically not all the inventions are patented, nor do they meet the patentability criterion therefore analysing all inventions has been not possible in this study. Future research could

overcome this limitation using a combination of data (primary and secondary data). A second limitation concerns the search strategy driving the sample collection process. This research preliminary explores the thin and invisible link between innovation and tourism from a sustainability perspective. Different keywords may be used to more specifically identify sustainable tourism patents. Finally, patent data covers mainly the technical side of technologies in tourism. One could go for a broader perspective and use LDA for other related data sources such as scientific publications, funding programs, newspapers, and other media coverage.

Despite these shortcomings, we believe that our study is an important step toward understanding the innovations aimed at combining sustainability with tourism. This, in turn, can guide scholars in their efforts to expand the boundaries of knowledge related to the provision of sustainable tourism services in line with the goals of Agenda 2030.

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