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ECONOMIC IMPACTS OF INTELLIGENT TRANSPORTATION SYSTEMS (ITS) IN SMART CITIES (SC): A Study of International Scientific Production

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ABSTRACT

Intelligent Transportation Systems (ITS) are essential for the development of smart cities, enhancing urban mobility and promoting sustainability. With the growth of cities and the need to reduce environmental impacts, understanding the economic effects of ITS is crucial for informing public policies and guiding strategic investments. This study analyzed the international scientific production on the subject, using bibliometric and sociometric methods to map the main trends and knowledge gaps in the field. Data were collected from the Web of Science and analyzed using VOSviewer software, considering publication patterns, international collaborations, prevalent research topics, and connections among references. The results show that, despite the increasing interest in the subject, there is not yet a consolidated theoretical core. The most frequent keywords include "smart cities," "sustainability," "COVID-19," "urban planning," and "economic assessment." Additionally, reference co-citation and bibliographic coupling identified two main research clusters: one focused on the relationship between smart cities and sustainability, and the other on urban planning and mobility. These findings underscore the need for greater integration among studies and provide directions for future research.

Keywords: Smart Cities, Intelligent Transportation Systems, Economic Impacts, Bibliometric Analysis, Sociometric Analysis, Urban Mobility.

1 INTRODUCTION

Cities play a central role in economic and social development, especially with the increasing migration of populations from rural to urban areas. This growth drives the economy, culture, and social life, but also generates challenges in urban mobility and infrastructure maintenance (Alam et al., 2024). In Brazil, where 85% of the population lives in urban areas, transportation directly influences productivity and quality of life (Lopes & Leite, 2021).

To address these challenges, some cities have adopted solutions based on the concept of “smart cities,” combining infrastructure, technology, and services with urban planning. In São Paulo, for example, these strategies connect people more efficiently to urban spaces, facilitating access to essential services, promoting the use of clean energy, water reuse, waste treatment, and improved mobility, in addition to ensuring high-quality public services (PUCRS, online, 2024). In this context, Intelligent Transportation Systems (ITS) play a fundamental role, employing technology to improve traffic flow, reduce congestion, and minimize environmental and economic impacts (Sefako et al., 2024).

The idea of smart cities places citizens at the center of urban management, leveraging technologies to enhance planning, public administration, and sustainability. The goal is to develop more efficient, innovative, and competitive cities that attract investments and ensure sustainable growth over time (Weiss, 2019). However, there is still no single model that defines a smart city. According to Pérez et al. (2020), the construction of such cities is based on six key pillars: environment, mobility, governance, economy, people, and quality of life. One of the major challenges is to integrate technology and innovation in an accessible manner, ensuring that different sectors can share information in real-time.

Given the complexity of the topic and the need for innovative solutions, it becomes essential to map the scientific production on the economic impacts of ITS in smart cities. In a scenario of a growing volume of academic publications, with thousands of articles published daily, such mapping helps to guide research efforts more efficiently, preventing duplication of studies and highlighting areas that still require further exploration (De la Torre-López et al., 2024; Zaidi et al., 2023). To this end, this study adopts a state-of-the-art approach, which organizes existing knowledge and identifies future trends (Jorge, Buzato & Luquetti, 2023). Furthermore, it employs bibliometrics to analyze the impact of publications and sociometrics to map collaborations among researchers and institutions (Freeman, 2004; Newman, 2001).

This study seeks to answer the following research question: What is the state of the art of the international scientific production on the economic impacts of ITS in smart cities? The general objective is to analyze the scientific production on this topic through bibliometric and sociometric analyses. The specific objectives include:

(a) Analyzing the international scientific production on the economic impacts of ITS in smart cities based on bibliometric indicators.
(b) Analyzing the international scientific production on the economic impacts of ITS in smart cities in the context of sociometrics.
(c) Analyzing the most aligned articles in the context of the economic impacts of ITS in smart cities.

The study adopts an exploratory-descriptive quantitative approach, using bibliometrics as the primary method. Data were collected from the Web of Science to ensure broad and updated coverage of the topic.

This paper is structured into five sections: (1) Introduction, presenting the topic, objectives, and relevance of the research; (2) Literature Review, exploring concepts of smart cities, urban mobility, and ITS; (3) Methodology, detailing the criteria and techniques for bibliometric and sociometric analysis; (4) Analysis and Discussion of Results, presenting the state of the art of the scientific production; and (5) Conclusion, summarizing the main findings and suggesting directions for future research.

This study aims to broaden the understanding of the economic effects of Intelligent Transportation Systems (ITS) in smart cities, analyzing publication trends and academic collaboration networks. Its purpose is to organize the available knowledge and guide future research, while offering insights for researchers and decision-makers seeking innovative solutions in urban mobility and sustainable planning.

2 LITERATURE REVIEW

The concept of smart cities emerged in the late 1990s, linked to the Smart Growth movement, which sought to address problems caused by unregulated urban expansion. Initially, this movement focused on making land use more efficient, protecting the environment, and improving urban planning. With the advancement of Information and Communication Technologies (ICTs) – including computers, networks, and mobile devices – large corporations began using the term smart city to describe the application of technology in urban management. Starting in 2005, companies like IBM, Cisco, and Siemens promoted this idea, investing in solutions for transportation, energy, water supply, and public safety (Harrison & Donnelly, 2010).

Contemporary smart cities are built upon three core principles. The first seeks to improve the quality of life for residents by providing greater connectivity and easier access to essential services such as healthcare, education, and transportation. The second focuses on the efficiency of urban services, using technology – such as sensors and applications – to improve traffic flow and make public transportation more agile, helping to reduce congestion and pollution. The third principle is aimed at sustainable economic growth, driven by the digitalization of urban services, which increases efficiency, reduces costs, and attracts investment in technology, opening space for new startups and creating new employment opportunities (Herbst, 2024).

The evolution of this concept shows that smart cities go beyond the simple application of technology. As highlighted by Biloria (2021) and Lopes & Leite (2021), it is essential to also consider social, economic, and institutional factors to ensure balanced and sustainable development. For these authors, smart cities represent a model of urban planning that places inclusion, efficiency, and innovation at the core of decision-making. This comprehensive vision is particularly relevant in the face of the challenges of accelerated urbanization, which include social and economic inequalities, lack of essential services, pollution, difficulties in accessing cultural and educational resources, traffic congestion, and crime (Francisco Júnior et al., 2021).

The literature on smart cities presents a diversity of definitions and characteristics, depending on the perspectives of different authors. For Komninos (2002), these cities connect the physical and digital worlds through high-speed networks, sensors, and smart devices, creating more efficient management and promoting knowledge sharing. Giffinger et al. (2007) highlight that smart cities excel in six main areas: economy, people, governance, mobility, environment, and quality of life, and are characterized by autonomous, conscious, and strategic citizens. Dirks and Keeling (2009) add that these cities interconnect different urban systems, such as transportation, energy, and governance, with technology serving as the basis for resource optimization and improved quality of life. Furthermore, Kanter and Litow (2009) and Harrison and Donnelly (2010) state that these cities foster cross-sector collaboration, aiming for integrated and efficient management.

These concepts emphasize how the construction of smart cities involves interconnected aspects, particularly regarding the relationship between technology, governance, and social issues. Nam and Pardo (2011) describe such cities as organic and connected systems, where collaborative governance, creativity, and social inclusion are essential. Neirotti et al. (2014) expand this perspective, suggesting that technology should be aimed at improving urban services such as transportation, energy, and health, while Bouskela (2016) and Bibri (2018) stress the importance of sustainability and citizen participation in creating innovative and resilient solutions. Finally, Lopes and Leite (2021) propose that smart cities are composed of two domains: the "hard" domain, related to technological and physical infrastructure, and the "soft" domain, which addresses social and human aspects such as governance and inclusion.

In this context, urban mobility emerges as a fundamental aspect, as its efficiency directly impacts the quality of life and economic development of smart cities. Giffinger et al. (2007) define smart mobility as the ease of movement within and between cities, including the use of technologies such as transportation applications and traffic monitoring systems. Avella Netto and Ramos (2017) broaden this view, arguing that urban mobility transcends mere physical movement, involving a complex process that encompasses social, economic, and environmental factors essential for the equitable distribution of urban opportunities.

Ensuring efficient urban mobility involves overcoming diverse and interconnected challenges. The increasing use of private vehicles causes constant congestion and increases air pollution, while unregulated urban sprawl hinders equitable access to opportunities (Banister, 2002). In light of this scenario, new planning approaches have gained prominence, prioritizing the connection between different modes of transport, improving public transportation, and encouraging walking and cycling. Madapur et al. (2020) particularly emphasize the importance of micromobility – including bicycles and e-scooters – to solve the "first and last mile" problem, improving the connection between origins/destinations and the main public transportation system.

However, urban mobility is not static. It is influenced by factors such as demographic changes, technological advancements, and new forms of work (Banister, 2002). Emerging technologies, such as sensors, cloud computing, and the Internet of Things (IoT), enable the optimization of traffic and public transportation, making travel more efficient and sustainable (Komninos; Schaffers; Pallot, 2011). Furthermore, sustainable transportation policies, such as investments in public transport and cycling infrastructure, reduce dependence on fossil fuels and strengthen cities' ability to address challenges such as climate change and energy crises (Newman; Beatley; Boyer, 2009). Modern planning, based on continuous monitoring and simulations, allows for more efficient adjustments to transport infrastructure. In this process, Intelligent Transportation Systems (ITS) play a key role, using automation and data analysis to improve traffic and public transport, making urban travel more efficient and sustainable (Hall; Tewdwr-Jones, 2011).

ITS represent the main technological innovation applied to contemporary urban mobility. Their historical development dates back to the 1960s, when early experiments with dynamic vehicle routing used real-time data to indicate more efficient routes (Vanajakshi; Ramadurai; Anand, 2010). Shaheen and Finson (2013) define these systems as technological sets that connect vehicles, people, and infrastructure through communication systems, data processing, and automation, aiming to improve the safety, efficiency, and convenience of transportation.

Current ITS solutions are diverse and impact multiple aspects of urban mobility. In traffic management, notable examples include adaptive traffic signal control systems that automatically adjust signal timing to reduce congestion, and incident management platforms that monitor traffic in real time using sensors and cameras (Shaheen; Finson, 2013). In the realm of shared mobility, ITS enable the development of innovative services such as carsharing and bikesharing, which reduce the need for individual vehicle ownership. Elhoseny and Hassanien (2020) complement this perspective by highlighting emerging technologies such as Cooperative Adaptive Cruise Control (CACC), which automatically adjusts vehicle speed, and Digital Twins, which create virtual replicas of urban systems for simulation and planning purposes.

The economic benefits of ITS can be observed from different perspectives. At the operational level, technologies such as electronic toll collection (ETC) generate significant fuel savings – such as the 1.2 million gallons saved annually on the New Jersey Turnpike, one of the largest highways in the United States – in addition to reducing emissions of pollutants such as VOCs and NOx (Shaheen and Finson, 2013). In terms of urban productivity, intelligent traffic management systems can reduce average travel time by up to 15%, as observed in cities like Singapore (Vanajakshi, Ramadurai, and Anand, 2010). Moreover, dynamic eco-driving, which guides drivers on more efficient driving patterns, can reduce fuel consumption by 10% to 20% without increasing travel duration (Shaheen; Finson, 2013).

Automatic vehicle identification and weigh-in-motion are additional examples of technologies that save time and fuel, allowing trucks to be registered while remaining in motion, without the need to stop. A study by Iowa State University showed that each truck that can bypass a weigh station saves up to 0.4 gallons of fuel (Shaheen; Finson, 2013).
In addition to these direct benefits, ITS encourage the emergence of new markets and business models. Shared mobility services have demonstrated the potential to replace between 9 and 13 private vehicles for each shared car, significantly reducing total vehicle miles traveled (Shaheen and Finson, 2013). From a macroeconomic perspective, the implementation of ITS has proven to be a factor in attracting investment and creating jobs, as demonstrated by the case of Greece, where projects in this area have created more than 5,000 direct jobs (Stamopoulos et al., 2023).

Despite these advances, the implementation of ITS faces significant challenges that limit its transformative potential. Ghosh and Lee (2010) highlight that even in technologically advanced cities, congestion persists as a chronic problem, with average travel speeds in some cases comparable to those of a century ago. This shows that, no matter how sophisticated the technological solutions may be, they do not replace the need for integrated urban planning and comprehensive public policies. As argued by Grant-Muller and Usher (2014), ITS should be understood not as ends in themselves, but as tools to promote sustainable economic development, requiring an approach that combines technological innovation, efficient governance, and social participation.

3 METHODOLOGY

This research adopts an exploratory-descriptive approach with a quantitative focus, using bibliometrics and social network analysis as the primary research methods. The exploratory approach is necessary because the topic is still under development, with few consolidated studies. This allows for a broader understanding of the subject and the identification of new perspectives for analysis, as highlighted by Bortoloti (2015). At the same time, the descriptive nature is reflected in the organization and presentation of the characteristics of scientific output in the area, such as the temporal evolution of publications, the most influential authors, and the main research lines.

The quantitative focus is determined by the use of bibliometric metrics and social network analysis to quantify and map the evolution of studies in the area. Bibliometrics, according to Araújo (2006), allows for the evaluation of how knowledge is produced and disseminated by using statistical methods to analyze scientific data. Additionally, social network analysis was employed to examine the connections between researchers, institutions, and countries, helping to understand how these interactions influence knowledge circulation (Freeman, 2004).

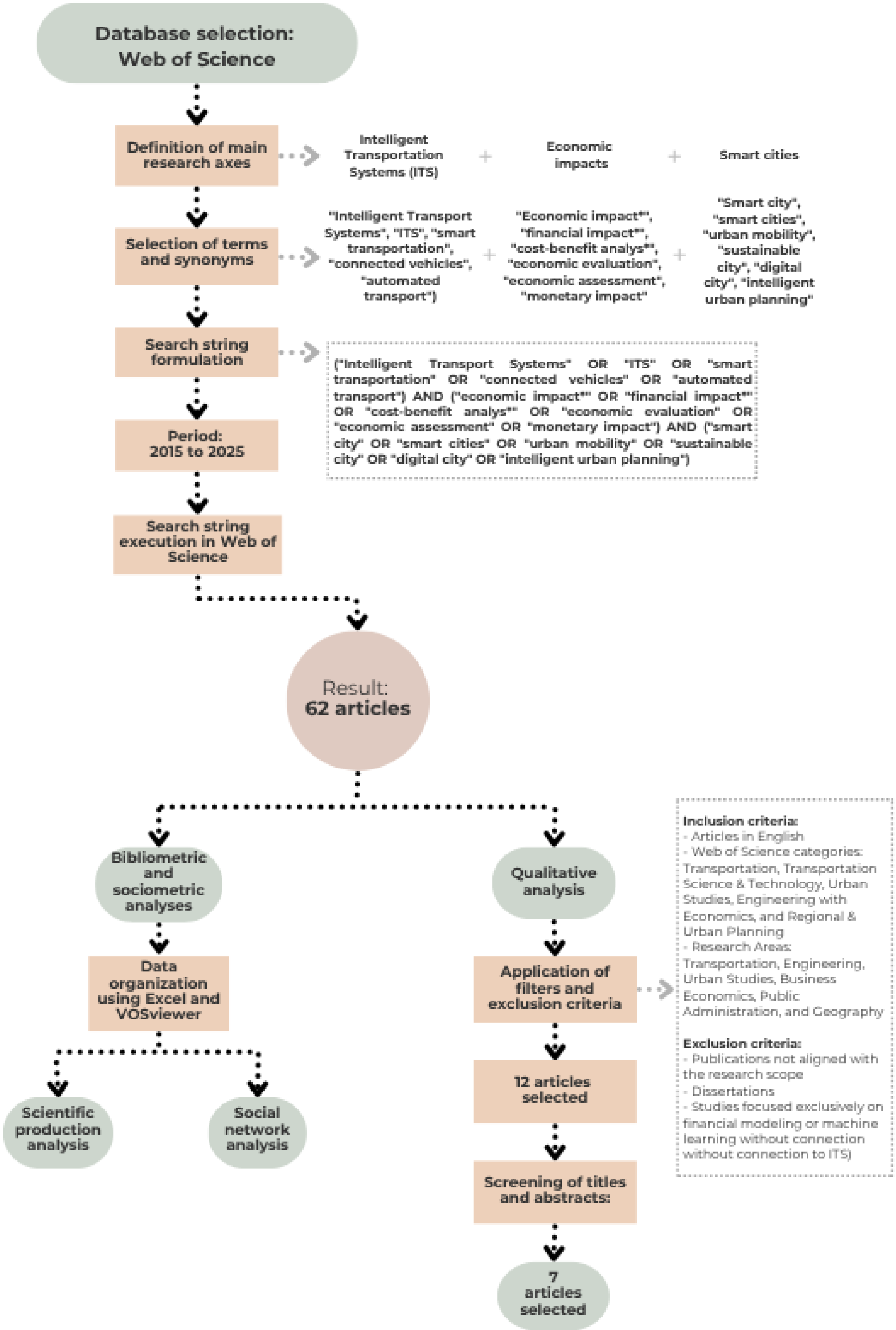
The research followed principles from three fundamental bibliometric laws: Lotka's Law (1926), which describes the unequal distribution of scientific productivity, indicating that a few authors publish most of the works; Bradford's Law (1934), which shows how scientific articles are concentrated in a small group of specialized journals; and Zipf's Law (1949), which analyzes the frequency of words in academic texts, highlighting that shorter and simpler terms tend to recur more frequently.

In network analysis, different connections between scientific works were examined. Co-authorship (Newman, 2001) helped identify collaborations between researchers. Co-citation (Small, 1973) indicated articles frequently cited together, revealing key studies in the field. Bibliographic coupling (Kessler, 1963) measured the similarity between studies based on shared references, and word co-occurrence (Rijsbergen, 1979) was used to map relationships between concepts and identify research trends.

Data collection was conducted using the Web of Science database, chosen for its importance and comprehensiveness in indexing high-impact scientific articles, being considered the ‘gold standard’ for citation analysis due to its rigorous and historical coverage (Leydesdorff; Opthof, 2010). The search strategy combined terms related to three main axes: Intelligent Transportation Systems (ITS), economic impacts, and smart cities, using Boolean operators to optimize results and enable the selection of relevant studies.

Initially, 62 articles published between 2015 and 2025 were identified. These articles underwent a screening process to eliminate duplicates and works outside the thematic scope. As a result, 12 studies were selected for a more detailed analysis through the reading of titles and abstracts. Among these, 7 articles that directly addressed the economic impacts of ITS in smart cities were considered the most relevant for the qualitative analysis. Figure 1 illustrates, through a flowchart, the stages of the methodological process adopted in this research.

Figure 1 – Article Selection Framework



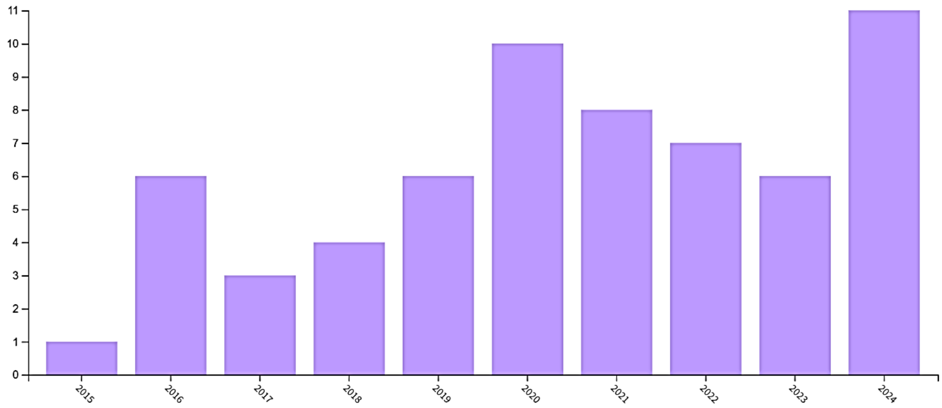
Source: Prepared by the authors, 2025.

To organize and interpret the data, the software Excel and VOSviewer were used. Excel allowed for the organization of quantitative information, such as the evolution of publications over the years and the geographic distribution of the studies. VOSviewer was employed to visualize scientific collaboration networks, facilitating the identification of connections between authors, co-citation patterns, and thematic relationships based on keyword co-occurrence.
The results were structured in three stages: (1) general bibliometric analysis, which provided an overview of the scientific production; (2) network analysis, which examined the connections between researchers and institutions; and (3) qualitative analysis, focused on the most relevant articles regarding the economic impacts of ITS in smart cities. This combined approach enabled not only the quantification of academic output but also the identification of trends and gaps that may guide future research.

4 ANALYSIS AND DISCUSSION OF RESULTS

Initially, for the bibliometric and sociometric analyses, the 62 documents found were considered, using the software VOSviewer and Excel, as well as the Analyze Results tool available in the Web of Science, which provides data on the articles, such as the number of publications per year, assisting in the creation of the presented illustrations. Based on this information, it was possible to analyze the evolution of publications over time. Chart 1 highlights an increase starting from 2016, with peaks in 2020 (10 publications, 16.13%) and 2024 (11 publications, 17.74%). In 2015, only one article was published (1.61%), indicating a low initial interest. Between 2021 and 2023, there was a decline compared to 2020, but in 2024 the number rose again. Since 2025 has no records yet in the analyzed database, the data presented goes up to 2024. This publication pattern suggests that the topic has, to some extent, attracted increasing attention from the academic community over the years.

Chart 1 – Number of articles published per year, 2015 to 2024



Source: Extracted from the Analyze Results tool of Web of Science, accessed in 2025.

Regarding researcher productivity, 217 authors were identified, with the majority (211) having published only one paper on the topic. Table 1 presents the eight most productive researchers, each with two articles. Since no author has a significantly higher number of publications, this indicates that research on the economic impacts of ITS in smart cities has been developed by various authors, without a dominant group concentrating most of the studies.

Table 1 – Authors with at Least Two Publications

Author	Number of publications
Allam, Z.	2
Ferreira, J.P.	2

Isidoro, C.	2
Kaewunruen,S.	2
Khavarian-garmsir, A.R.	2
Kim, S.	2
Lee S.	2
Sharifi, A.	2

Source: Prepared by the authors using data from Web of Science and Excel (2025).

Table 2 presents the main sources that have published on the topic, with five journals having more than one publication. Sustainability leads with four articles, followed by Cities, Energies, IEEE Access, and Sustainable Cities and Society, each with two publications. The impact factors of these journals range from 3.0 to 10.5, reflecting different levels of relevance in the field. According to Garfield (2006), the impact factor measures the importance of journals based on the average number of citations received in the two preceding years. Although widely used to rank journals, assist researchers in choosing where to publish, and guide libraries in subscription selection, Garfield highlights some limitations, such as differences between fields, language influence, and possible editorial biases. Nevertheless, this metric remains one of the most relevant in science.

Table 2 – The five sources with the highest number of publications

Source	Number of publications	Impact Factor
SUSTAINABILITY	4	3.3
CITIES	2	6.0
ENERGIES	2	3.0
IEEE ACCESS	2	3.4
SUSTAINABLE CITIES AND SOCIETY	2	10.5

Source: Prepared by the authors using data from Web of Science and Excel (2025).

The top 10 countries with the highest number of publications on the topic are listed in Table 3. The United States leads with 11 publications, followed by China with 8. The United Kingdom, South Korea, and Spain each have 6 publications. Australia, India, and Italy recorded 4 publications each, while France and Portugal have 3. These figures reveal that research on the subject is conducted worldwide, with the U.S. having the largest share.

Table 3 – Number of publications by country

Country	Number of publications
United States	11
China	8
United Kingdom	6
South Korea	6
Spain	6
Australia	4
India	4
Italy	4
France	3
Portugal	3

Source: Prepared by the authors using data from Web of Science and Excel (2025).

The research areas with the highest number of publications on the topic are highlighted in Table 4, indicating the fields of knowledge that most explore this issue. Engineering leads with 20 publications, demonstrating its relevance in scientific production. Next, "Science and Technology - Other Topics" appears with 15 publications, while "Computer Science" and "Environmental Science and Ecology" each have 11 publications. The field of "Transportation" also stands out with 10 publications, reinforcing its importance in the discussion. Other areas such as "Energy and Fuels" (9), "Urban Studies" (8), and "Telecommunications" (6) show how the topic involves diverse fields. Finally, "Business Economics" (5) and "Construction and Building Technology" (4) have fewer publications but still contribute to the debate.

Table 4 – Distribution of Publications by Research Area

Research Areas	Number of publications
Engineering	20
Science and Technology – Other Topics	15
Computer Science	11
Environmental Science and Ecology	11
Transportation	10
Energy and Fuels	9
Urban Studies	8
Telecommunications	6
Business Economics	5
Construction and Building Technology	4

Source: Prepared by the authors using data from Web of Science and Excel (2025).

Among the 133 institutions identified in the Web of Science, only 14 had two or more publications on the topic, as shown in Table 5. Among them, the Indian Institute of Technology System, the State University System of Florida, the University of Aveiro, and the University of Florida were the most prolific, each with three articles. Other notable institutions such as the Massachusetts Institute of Technology (MIT), the University of Oxford, and the University of California System recorded two publications each. The geographic diversity of these institutions indicates a global interest in the topic, encompassing universities from Asia, Europe, North America, and Oceania.

Table 5 – Institutions with the highest number of publications on the topic

Institution	Country	Number of publications
Indian Institute of Technology System - IIT System	India	3
State University System of Florida	USA	3
Universidade de Aveiro	Portugal	3
University of Florida	USA	3
Deakin University	Australia	2
Hiroshima University	Japan	2
Massachusetts Institute of Technology - MIT	USA	2
National Technical University of Athens	Greece	2
Shenzhen University	China	2
Univ. Paris 1 Panthéon-Sorbonne	France	2

University of Birmingham	United Kingdom	2
University of California System	USA	2
University of Isfahan	Iran	2
University of Oxford	United Kingdom	2

Source: Prepared by the authors using data from Web of Science and Excel (2025).

In summary, the bibliometric analysis showed growth in publications on the economic impacts of Intelligent Transportation Systems (ITS) in smart cities, especially from 2020 onwards. However, the total number of studies remains relatively low, indicating that the topic is still developing and could be further explored. Additionally, publications are dispersed across different journals and authors, suggesting the absence of a consolidated research core. This opens space for more in-depth studies and collaborations that expand knowledge in the field.

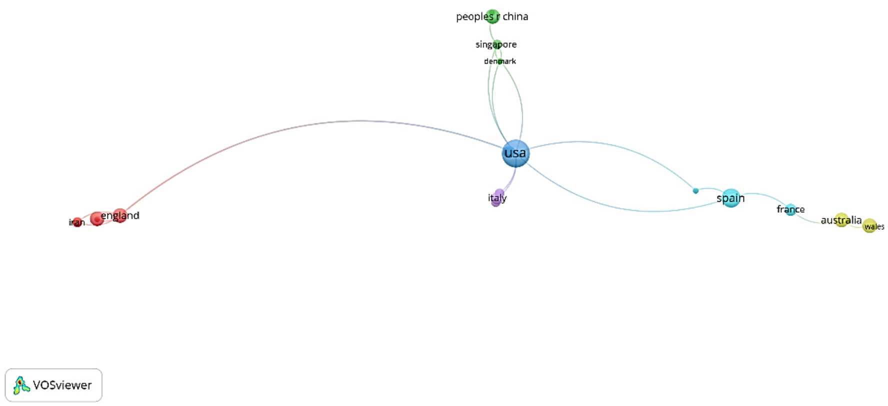
Complementing the bibliometric analysis, a network analysis was conducted using the VOSviewer software, which enables visualization of connections among academic studies. The tool identifies collaborations between authors, keyword frequency, and studies with shared references (Van Eck & Waltman, 2010). These analyses helped map patterns in academic production, highlighting the main authors, institutions, and themes structuring the field of study on the economic impacts of ITS in smart cities.

The co-authorship network analysis identified 33 countries in the analyzed publications, but only 24 showed connections among themselves in the generated map (Figure 1), forming a collaboration network. The other 9 countries had more isolated participation, without strong enough links to be included in the main graph. The 24 connected countries were organized into six groups (clusters), representing partnership patterns among different regions and institutions.

Cluster 1 (red) includes the Czech Republic, England, Iran, Japan, and South Korea. Cluster 2 (green) comprises Denmark, Germany, Israel, China, and Singapore, highlighting collaborations between Europe and Asia. Cluster 3 (dark blue) connects Poland, Portugal, Switzerland, and the United States, suggesting interaction between European and North American countries.

Cluster 4 (yellow) groups Australia, India, Indonesia, and Wales, indicating partnerships in the Asia-Pacific region. Cluster 5 (purple) includes Finland, Italy, and Turkey, while Cluster 6 (light blue) encompasses France, the Netherlands, and Spain, evidencing strong cooperation among European countries.

Figure 1 – Country Co-authorship Network

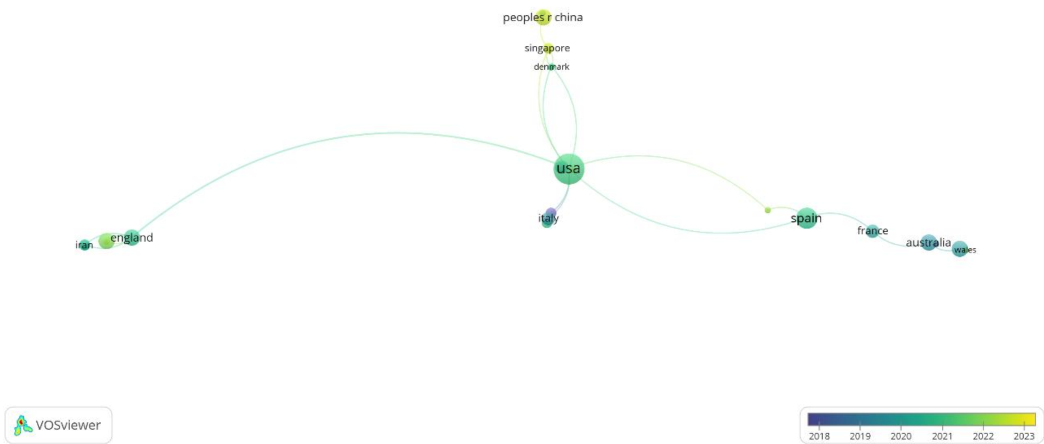


Source: Prepared by the authors using VOSviewer software (2025).

The difference between the 33 identified countries and the 24 countries that are actually connected shows that not every published study involves significant international collaborations. The fact that the countries are divided into groups indicates that some regions have more consolidated scientific networks, while others have more limited collaborations.

Figure 2 shows the years in which the studies were published, using colors to indicate the period between 2015 and 2025. Bluish tones represent older publications, while yellow tones indicate more recent ones. The collaboration network structure remains the same, but now it is possible to see when each country published more. For example, China and Singapore appear in yellow, showing that they had more recent publications, while Poland and Turkey appear in purple, indicating that their scientific collaborations mostly occurred earlier in the analyzed period. This visualization helps to understand how collaboration among countries has evolved over time.

Figure 2 – Co-authorship between countries by year, 2015 to 2025



Source: Prepared by the authors using VOSviewer software (2025).

In the keyword co-occurrence analysis, 248 terms were initially identified. To highlight the most relevant ones, a minimum occurrence threshold of 2 was set, reducing the number to 21. Subsequently, the application of a thesaurus file standardized the terms, resulting in 19 keywords. A thesaurus file is a set of rules used in tools like VOSviewer to standardize words, helping to correct spelling variations, abbreviations, or synonyms, ensuring that similar terms are treated as a single concept (Van Eck & Waltman, 2010).

At the time of generating the map (Figure 3), VOSviewer indicated that 17 keywords were connected, organized into 5 clusters. Cluster 1 (red) groups terms related to economic evaluation and sustainability; Cluster 2 (green) concerns urban planning and mobility; Cluster 3 (blue) includes terms such as COVID-19, electric vehicles, resilience, and smart city, reflecting different aspects of smart cities; Cluster 4 (yellow) addresses technologies like the Internet of Things and smart parking; and Cluster 5 (purple) clusters the themes of accessibility and simulation.

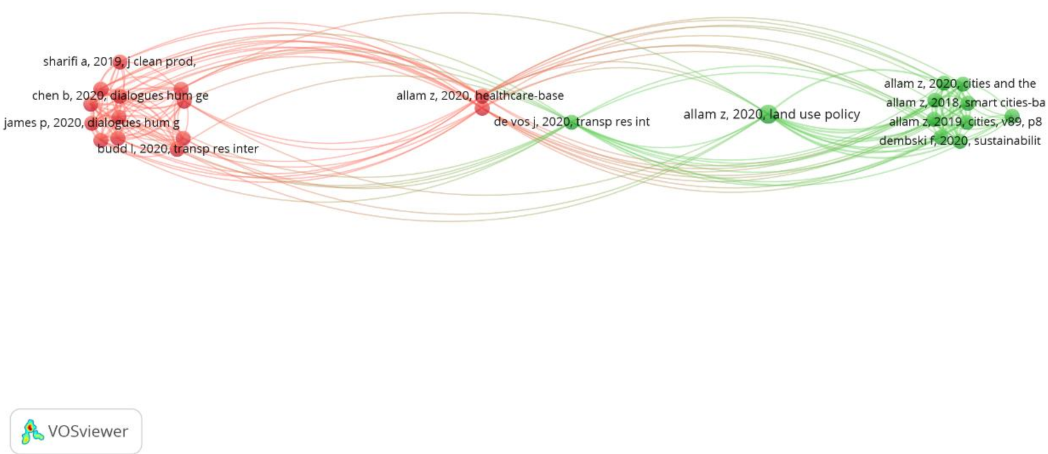
Figure 3 – Keyword Co-occurrence

Source: Prepared by the authors using VOSviewer software (2025).

Among the identified keywords, *smart city* was the most frequent, appearing 22 times and standing out as the central concept of the research. Other relevant terms included *sustainability* and *COVID-19* (5 occurrences each), as well as *urban planning* and *economic evaluation* (4 occurrences each).

The following analysis is of reference co-citation, a bibliometric method that identifies connections between studies based on the frequency with which two references are cited together in other works. When this occurs frequently, it indicates that the studies address similar topics and belong to the same research field (Small, 1973). The database contained a total of 2,510 references; however, by applying the criterion of including only those cited at least twice, this number was reduced to 56. To standardize author names and avoid duplications, a thesaurus file was used. This enabled the generation of a map (Figure 4) with 25 connected references, organized into two groups, highlighting the main relationships between studies in the area.

Figure 4 – Most cited documents in the analyzed articles



Source: Prepared by the authors using VOSviewer software (2025).

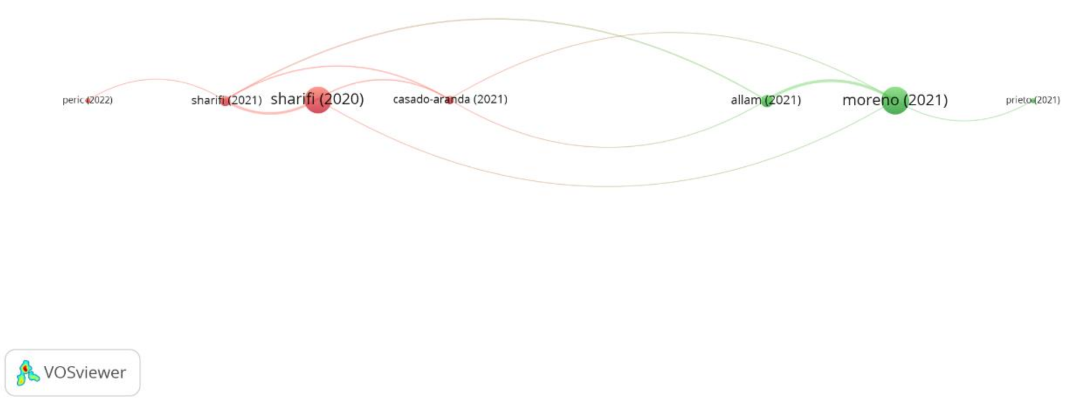
The co-citation analysis showed that the references were divided into two main groups. The first group, consisting of 14 studies, includes authors such as Sharifi (2019), Chen (2020), and James

(2020), who investigate sustainability and human impact on smart cities. The second group, with 11 references, comprises studies by Allam (2018, 2019, 2020), De Vos (2020), and Dembski (2020), which address urban planning, mobility, and technology in cities. Considering the themes of each group, there appears to be a relationship between ideas on sustainable development and technological advances in cities. However, 31 references from the initial network were not connected, meaning they were not frequently cited together enough to form links in the map. This may be due to many of the analyzed articles citing different references without a clear pattern of co-citation. As a result, some references remained isolated in the analysis, without direct connections to the formed groups.

Besides co-citation, another way to analyze the connections between studies is through bibliographic coupling. This method examines the relationship between the articles themselves, based on the references they share. According to Kessler (1963), two articles are bibliographically coupled when they cite the same sources, indicating they belong to the same research field or use a similar theoretical basis. This type of analysis allows for the identification of groups of studies addressing similar topics and helps understand which subjects are more discussed in the area.

In the conducted bibliographic coupling analysis, 50 articles were considered, and different thresholds were tested (minimum of 0, 1, 2, and 3 occurrences). Regardless of the chosen threshold, only 7 articles showed connections among themselves and were included in the map (Figure 5). Cluster 1, with 4 studies, includes the works of Casado-Aranda (2021), Peric (2022), Sharifi (2020), and Sharifi (2021), which share similar references. Cluster 2, with 3 studies, contains the works of Allam (2021), Moreno (2021), and Prieto (2021), which also have connections among themselves

Figure 5 – Bibliographic coupling



Source: Prepared by the authors using VOSviewer software (2025).

The presence of only seven connected articles shows that the analyzed studies cite many different references, without a clear pattern of sharing. This indicates that research within this topic is fragmented and not necessarily based on the same foundational studies. This result highlights the need for greater collaboration among researchers in the field to develop a more well-defined theoretical framework.

Following the bibliographic coupling analysis, the most cited articles within the theme of this research were identified. Table 1 presents the five studies with the highest number of citations, highlighting their authors, research areas, and academic impact.

Summary Table 1 - The 5 most cited works in the research

Nº	Author	Article	Research Areas	Citations
1	Moreno (2021)	*Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities*	Engineering; Urban Studies	640
2	Sharifi (2020)	*The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management*	Environmental Sciences and Ecology	603
3	Allam (2021)	*Future (post-COVID) digital, smart and sustainable cities in the wake of 6G: Digital twins, immersive realities and new urban economies*	Environmental Sciences and Ecology	132
4	Sharifi (2021)	*Contributions of Smart City Solutions and Technologies to Resilience against the COVID-19 Pandemic: A Literature Review*	Science and Technology – Other Topics; Environmental Sciences and Ecology	89
5	Jamei (2017)	*Investigating the Role of Virtual Reality in Planning for Sustainable Smart Cities*	Science and Technology – Other Topics; Environmental Sciences and Ecology	86

Source: Prepared by the authors using VOSviewer software, Web of Science, and Excel (2025).

The five most cited articles illustrate how the pandemic impacted cities and how new technologies can make them better prepared for crises. Moreno (2021) introduced the concept of the "15-Minute City," where everything people need, such as work, leisure, and basic services, is within a 15-minute reach from home. This idea can reduce traffic and make cities more inclusive and sustainable.

Sharifi (2020) analyzed how COVID-19 changed cities, affecting the environment, economy, and transportation. The pandemic exposed vulnerabilities but also accelerated changes. In another study, Sharifi (2021) showed how smart technologies helped control public health and mobility during the crisis, while also warning about issues such as privacy and unequal access to technology.

Allam (2021) studied advanced technologies like 6G, augmented reality, and "Digital Twins" (digital replicas of cities), which have the potential to greatly improve urban planning. Jamei (2017) demonstrated that virtual reality helps test city projects before construction, avoiding mistakes.

Other studies also contribute to the debate, addressing shared mobility (Nahmias-Biran, 2021), sustainability indicators (Macedo, 2017), and the economic impacts of the smart cities industry (Kim, 2016; Stamopoulos, 2024). Research on logistical challenges (Heddebaut, 2018; Sahu, 2022) and the effects of high-speed rail lines on real estate appreciation (Rungskunroch, 2020) further highlights the diverse approaches within this topic, demonstrating its relevance across multiple fields.

The analysis of total link strength indicated that certain articles are more strongly connected within the field, revealing stronger relationships between these works. These data are shown in Table 6. Moreno (2021), Allam (2021), Sharifi (2021), and Kim (2016) had the highest scores, with 12 connections, meaning they share many references with other studies. Stamopoulos (2024) scored slightly lower, with 11, but still stood out. This suggests that these articles serve as foundational works for other research on smart cities, urban mobility, and sustainability, highlighting their influence in the field

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Table 6 – The five strongest links in bibliographic coupling

Article	Total Link Strength
Moreno (2021)	12
Allam (2021)	12
Sharifi (2021)	12
Kim (2016)	12
Stamopoulos (2024)	11

Source: Prepared by the authors using VOSviewer software, Web of Science, and Excel (2025).

The analysis conducted with VOSviewer helped visualize how researchers around the world collaborate and which topics appear most frequently in studies on the economic impacts of Intelligent Transportation Systems (ITS) in smart cities. The results show that not all countries collaborate intensively and that some regions have stronger scientific networks than others. It was also possible to observe that the keyword analysis revealed the main topics discussed in the field, highlighting "smart city," "sustainability," "COVID-19," "urban planning," and "economic evaluation." Finally, the co-citation of references indicated two major groups of studies, one focused on sustainability and the other on urban planning and mobility. This information helps better understand the scientific production on the subject and can guide future research.

For a more detailed qualitative analysis of studies aligned with the theme of this research, from the 62 articles found in the database, 7 were selected after applying filters, inclusion and exclusion criteria, and reading titles and abstracts, as described in the methodology. These studies approach, from different perspectives, the economic impacts of intelligent technologies applied to transportation in urban contexts, using various methodologies such as modeling and simulation, case studies, and empirical analyses.

The work by Bas et al. (2022) analyzes the economic impacts of adopting cooperative adaptive control (a technology that automatically adjusts vehicle speed based on traffic conditions, signals, and roads), using simulations to predict its effects on the electric and combustion vehicle markets. Ferreira et al. (2020) propose a method to evaluate the economic value of bicycle use, considering environmental, energy, and health benefits.

Sahu, Pani, and Santos (2022) analyze studies on urban logistics in India and review policies focusing on the efficiency of freight transportation, which implies economic impacts related to logistics operation and planning. Meanwhile, Nahmias-Biran et al. (2021) use an activity-based accessibility model to examine how on-demand automated mobility might influence the urban transport system, emphasizing the economic consequences of this transformation.

Heddebaut and Di Ciommo (2018) study the effects of creating a transport hub in the city of Lille, highlighting its potential impact on mobility and urban growth, with related economic implications. The study by Stamopoulos et al. (2023) calculates the economic effects of the smart cities industry, discussing both the sector's growth potential and the environmental challenges involved. Schreurs, Scheerlinck, and Gheysen (2023) analyze the impact of waterborne transportation in New York, assessing how increased access can generate economic and social changes in neighboring communities.

The selected studies present different ways to analyze the economic impacts of Intelligent Transportation Systems (ITS) in smart cities. Heddebaut & Di Ciommo (2017), although not directly investigating economic effects, emphasize that the creation of urban hubs can strengthen specific regions, improve mobility, and promote more sustainable transportation modes, which indirectly contribute to local economic development.

Ferreira et al. (2020) associate bicycle use with reduced transportation and public health expenses, also highlighting environmental and productivity gains. Nahmias-Biran et al. (2021) discuss how on-demand automated mobility can increase access for low-income populations to opportunities in the city, potentially leading to a more balanced distribution of economic benefits.

Bas et al. (2022) demonstrate that technologies like ecological adaptive control (Eco-CACC) help save fuel, especially in gasoline vehicles. For electric vehicles, the impact is smaller due to the lower cost of electricity. Sahu et al. (2022) point out that freight transportation logistics problems in India increase operational costs, but that the use of technologies and infrastructure improvements can reduce expenses related to congestion and pollution.

Schreurs et al. (2023) analyze the ferry system in New York and conclude that it helped increase property values near terminals and boosted the economy in some city areas, although this also brought risks of gentrification. Finally, Stamopoulos et al. (2023) highlight that the Smart Cities Industry has generated economic growth and more jobs in Greece but also raises concerns about increased emissions and their environmental effects.

The analyzed articles were published in relevant academic journals in the fields of transportation and smart cities. Notably, *Transportation Research Part A - Policy and Practice* (impact factor 6.3) and *Cities* (impact factor 6.0) present the highest indices among the sample's journals, according to Journal Citation Reports (JCR) data for the year 2023 (CLARIVATE ANALYTICS, 2023). This reinforces the quality and importance of the selected studies for this research.

5 CONCLUSION

This study analyzed how the international scientific literature has addressed the economic impacts of Intelligent Transportation Systems (ITS) in smart cities, using bibliometric and sociometric methods. This approach allowed for the identification of trends, gaps, and relevant collaborations, providing a structured and up-to-date overview of the topic.

The results showed that, despite the growth in the number of publications between 2015 and 2025, there are still few studies directly focused on the subject. There is no dominant group of authors; eight researchers published two articles each. The journals with the highest number of publications were *Sustainability*, *Cities*, *Energies*, *IEEE Access*, and *Sustainable Cities and Society*. The countries with the greatest scientific output were the United States, China, the United Kingdom, South Korea, and Spain. The main disciplines involved are Engineering, Computer Science, Environmental Sciences, and Transportation. Among the most productive institutions, the Indian Institute of Technology System, the State University System of Florida, the University of Aveiro, and the University of Florida stood out.

Regarding scientific collaboration, the co-authorship analysis showed that, among the 33 countries identified, only 24 formed active networks organized into six clusters, with a higher concentration in Europe, North America, and Asia. The keyword co-occurrence analysis revealed a focus on 'smart city,' 'sustainability,' 'COVID-19,' 'urban planning,' and 'economic evaluation.' The co-citation analysis highlighted two major research groups: one focused on sustainability and the environment, and the other on urban planning and technology. However, the presence of 31 isolated references demonstrates the fragmentation of the field. Additionally, the bibliographic coupling analysis revealed little connection between articles, with only seven presenting direct links.

Seven articles specifically analyzed the economic impacts of ITS through modeling, simulation, and case studies. These studies indicated that ITS contribute to reducing operational costs, improving vehicle flow, decreasing time and fuel waste, increasing urban productivity, and attracting investments. They also drive sectors related to innovation and mobility and generate employment. However, challenges include the need for greater integration among systems and public policies. Technologies such as real-time traffic control and shared mobility stood out, and the journals *Transportation Research Part A - Policy and Practice* and *Cities* published the most relevant studies.

Among the limitations of the study, the exclusive use of the Web of Science database is highlighted, which may have restricted the diversity of the sample, in addition to including data for the year 2025, which is not yet fully recorded. The scarcity of studies directly focused on the economic impacts also limited the sample.

It is recommended that future research explore the long-term effects of ITS on urban economies, comparing different regions and development levels, integrating different transportation systems, and assessing the role of public policies and social inclusion. This study reinforces the importance of deepening the debate on ITS as instruments for more efficient, sustainable, and economically balanced cities.

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