

CRITICAL SUCCESS FACTORS IN THE ADOPTION OF 5G TECHNOLOGY: EVOLUTION FROM A SYSTEMATIC LITERATURE REVIEW

FATORES CRÍTICOS DE SUCESSO NA ADOÇÃO DA TECNOLOGIA 5G: EVOLUÇÃO A PARTIR DE UMA REVISÃO SISTEMÁTICA DA LITERATURA

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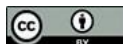
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Abstract

The launch of 5G technology is needed to increase connectivity demand and support the build-out of innovative applications. However, 5G technology comes with many uncertainties, including governance, infrastructure, spectrum, and cost. In addition, there are still many knowledge gaps regarding user adoption and the development of implementation strategies. In light of this context, the study examines the critical success factors in 5G adoption and their evolution from the period 2019 to 2025, creating a reference palette for optimizing practices in 5G adoption for use by both researchers and policymakers looking to create effective deployment. A systematic literature review was conducted following Kitchenham's methodology, which includes planning, development, and reporting phases. The search was conducted using databases including Scopus and Web of Science, and of the 57 relevant

Resumo

O lançamento da tecnologia 5G é necessário para aumentar a demanda por conectividade e apoiar o desenvolvimento de aplicações inovadoras. No entanto, a tecnologia 5G traz consigo muitas incertezas, incluindo governança, infraestrutura, espectro e custo. Além disso, ainda existem muitas lacunas de conhecimento em relação à adoção pelos usuários e ao desenvolvimento de estratégias de implementação. Diante desse contexto, este estudo examina os fatores críticos de sucesso na adoção do 5G e sua evolução no período de 2019 a 2025, criando um conjunto de referências para otimizar as práticas de adoção do 5G, para uso tanto por pesquisadores quanto por formuladores de políticas que buscam criar uma implementação eficaz. Uma revisão sistemática da literatura foi conduzida seguindo a metodologia de Kitchenham, que inclui as fases de planejamento, desenvolvimento e



articles, 59 critical success factors were derived, and reviewed for categorization among healthcare, transportation, entertainment, agriculture, and smart cities. Moreover, theoretical models were found to support these factors, including the Technology Acceptance Model, and approaches adopted by several nations, such as the development of sustainable infrastructure powered by renewable energy, were emphasized as potential avenues for speeding up effective 5G adoption.

Keywords: 5G Technology Adoption. Evolution of Factors. Critical Success Factors. Review.

relato. A busca foi realizada utilizando bases de dados como Scopus e Web of Science, e dos 57 artigos relevantes, 59 fatores críticos de sucesso foram derivados e revisados para categorização em saúde, transporte, entretenimento, agricultura e cidades inteligentes. Além disso, modelos teóricos, incluindo o Modelo de Aceitação da Tecnologia, foram encontrados para corroborar esses fatores, e abordagens adotadas por diversas nações, como o desenvolvimento de infraestrutura sustentável alimentada por energia renovável, foram enfatizadas como possíveis caminhos para acelerar a adoção efetiva do 5G.

Palavras-chave: Adoção da Tecnologia 5G. Evolução dos Fatores. Fatores Críticos de Sucesso. Revisão.

1 INTRODUCTION

Technological advancements aim to enhance the quality of life for millions. In order to achieve this, urban centers should aim to improve their energy utilization, improve transportation systems through autonomy and enhanced mobility, improve health care services, and improve security. In this setting, advanced communication networks, such as fifth-generation (5G) systems, play a central role in enabling a more efficient, secure, and flexible digital infrastructure. This digital infrastructure expands experiential understanding of the environment, informs decisions made within the communities, and ultimately ultimately helps build more resilient and interconnected communities (Gangadhar & Sekhar, 2022). 5G mobile technology illustrates a substantive evolution from its predecessors, offering transmission speeds of 10 gbps to 100 gbps, thus enabling critical applications such as real-time health monitoring and smart-traffic management in urban areas (Singh, 2023). Furthermore, the ability of the systems to sufficiently improve geolocation is particularly exciting, as geolocation is crucial to the performance of smart systems indoors and outdoors (Traboulsi, 2022).

Recent research is beginning to fill this gap by utilizing analytical frameworks to establish the most important factors in the 5G adoption process. Some of the most important factors included trust, performance expectancy, perceived value, and contextual enablers, all of which were strongly associated with the intention to use 5G

networks in developing economies (Dadhich *et al.*, 2023). In addition, the literature suggests that when 5G deployment is planned with considerations for efficient and technology-enabled criteria, operational costs decrease, automation can occur in industry environments, and the use of digital twins support real-time decisions (Williams *et al.*, 2022; Michaelides *et al.*, 2024; Hakiri *et al.*, 2024; Patil *et al.*, 2024). Also, there is evidence that the integration of 5G and artificial intelligence technologies accelerate data analytics in vital industries, such as healthcare and energy (Mourtzis *et al.*, 2021; Moosavi *et al.*, 2024).

In a 5G context, in this way, the enhanced capacity serves to better understand complex environments and make more informed decisions in high stakes decisions based on empirical evidence from industrial trials and pilot deployments (Ansari *et al.*, 2022). Finally, 5G networks may contribute to emissions reductions in smart cities by improving energy efficiency and optimizing traffic management (Mughees *et al.*, 2021; Ferraris *et al.*, 2024).

5G not only brings significantly greater bandwidth and lower latency compared to previous generations but also advanced resource management — for instance, software-defined networking (SDN), network function virtualization (NFV), and network slicing— along with new service level guarantees for mission-critical traffic. Furthermore, it combines accurate positioning and hybrid localization mechanisms that are indispensable for indoor and outdoor intelligent systems (Park *et al.*, 2023; Mogyorósi *et al.*, 2022). Studies further show that the integration of 5G and edge computing also provides seamless support for applications including autonomous vehicles and remote surgery (Musa *et al.*, 2022; Barral *et al.*, 2022). These capabilities define 5G as a fundamental enabler of sustainable urban development and citizen well-being, as noted in successful smart city pilot projects and stringent real-life evaluations (Banerjee *et al.*, 2024). Nevertheless, social acceptance of 5G is contingent upon public views about privacy and health risk assessments. Therefore, meaningful transparent communication plans and strong trust policies are also needed to ensure public acceptance of 5G infra- and resource structure (Di *et al.*, 2022).

Various deployment issues exist with the launch of 5G, depending on the application context. In high-speed rail transportation, for instance, wireless communication must deal with challenges such as propagation losses, Doppler effects,

and penetration of the vehicle. To address these challenges, path loss models have been created and advanced through hybrid modeling and optimization techniques. These new and improved models provide a more accurate representation of real propagation environments. This development not only enhances the reliability of the network in a high mobility environment, but also is critical to planning safe and secure communication infrastructure, which is a key aspect of 5G adoption for safety-critical applications (Lukman *et al.*, 2022).

Outside of mobility scenarios, the acceptance of 5G depends in part on the end-user experience. For highly interactive services such as online gaming, QoE (Quality of Experience) has become the key indicator that is more meaningful than traditional QoS (Quality of Service) technical parameters. Artificial neural networks have been able to make predictive models of user perception based on monitoring the network, with predictive accuracies of almost 80%. This combination of 5G capabilities and artificial intelligence will be critical in establishing 5G in the area of digital entertainment and other developing applications (Tan *et al.*, 2022).

Simultaneously, the rollout of Multiple-Input Multiple-Output (MIMO) antennas and beamforming approaches at scale in dense urban areas has led to public concern about reaching exposure limits to electromagnetic field (EMF) levels. Recently published research employing assessments using ray-tracing simulations showed that exposure would increase with user density, but still remain under the limits set by international organizations, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. To increase public acceptance and regulatory approval, there is a demand for detailed analyses of possible spatially dependent EMF exposure values. This is another important consideration for technology adoption (Salem *et al.*, 2022).

As the promise of the technology continues to be realised, a need for reliable high-speed connectivity is becoming more evident. The density of devices and use case is dictating the need to successfully provide Enhanced Mobile Broadband (eMBB), Ultra-Reliable Low-Latency Communication (URLLC) and Massive Machine-Type Communications (mMTC) while guaranteeing the quality of experience. Measurements of standalone (SA) 5G network performance propose performance uptake and a viable rollout; however, bottlenecks occur under certain workloads (Czajkowski *et al.*, 2024;

Cainelli *et al.*, 2023). Further, operators are undergoing rollout of Open Radio Access Network (O-RAN) architectures leading to a positive and flexible infrastructure deployment (Bonati *et al.*, 2020).

This development has been particularly pronounced in North America and to a limited extent in the Latin America region. A sectoral assessment concurs that the value creation of 5G is not simply based on coverage, but also on business and ecosystem strategies that facilitate the creation of new business models and reconfigurations of value chains (Parcu *et al.*, 2023; Whalley, 2024). Furthermore, markets with SA deployments and extensible vertical use cases are seeing a greater consolidation of performance and adoption (Czajkowski *et al.*, 2024; Cainelli *et al.*, 2023).

That said, Latin America has not overcome structural problems that preclude full-scale 5G adoption. Infrastructure costs, energy use and limited spectrum access will inevitably negatively impact the sustainability of the deployment. Infrastructure sharing policies and pro competition policies arguably provide fundamental enablers to reduce emissions and optimize capital expenditure (CAPEX) and operating expenditure (OPEX) while also improving coverage and service quality (Oughton *et al.*, 2025; Knieps, 2024; Williams *et al.*, 2022). If there was coordinated regulatory reform and coordinated investment effort, the region may fully realize more efficient and resilient deployment of 5G (Czajkowski *et al.*, 2024; Parcu *et al.*, 2023).

Most academic research around 5G primarily focused on technical development, while the social and organizational aspects received less attention than they should have. Evidence is starting to accumulate on the supply-side factors —the role of the operators and vendors, value proposition design, and revenue generation in new markets — while evidence gaps are still present in scaling up sustainable and replicable adoption models (Magnaghi *et al.*, 2025; Whalley, 2024). At the same time, studies on security and privacy concerns highlight the emerging threat levels to user trust and willingness to adopt the technology (Khan *et al.*, 2020; Ramezanzpour *et al.*, 2023; Patil *et al.*, 2025; Zhang *et al.*, 2024).

To understand, not only how 5G works, but also why adoption is limited (as it currently exists) and uneven adoption across regions, requires analyzing not only the technical capabilities (e.g., URLLC, slicing, mobile edge computing) but also the packaged solutions, and validated performance measures. A number of evaluations have

been made in the field, including in ports, manufacturing, and smart cities, where improvements in latency, link stability, and edge-assisted operations have been noted, but bottlenecks still exist under heavy traffic loads (Charpentier *et al.*, 2024; Michaelides *et al.*, 2024; Banerjee *et al.*, 2024; Mertes *et al.*, 2024). These evaluations suggest that the performance needed for mission-critical applications are feasible but requires a fine-grained plan, multi-layer orchestration, and zero-trust security governance (Zhang *et al.*, 2024; Nencioni *et al.*, 2023).

The adoption of 5G technology is influenced by a combination of economic, infrastructural, and user-centric factors that vary according to the national and market context. From an implementation perspective, economic viability and investment efficiency play a fundamental role, as demonstrated by the techno-economic analysis conducted in Brazil, where infrastructure sharing and cost optimization strategies were identified as key factors for the national deployment of 5G technology, especially in rural and underserved areas (Rech *et al.*, 2025). Complementing this macro perspective, consumer-oriented studies emphasize that adoption is strongly driven by perceived relative advantage, ease of use, and confidence in network performance. For example, empirical evidence from Malaysia shows that users are more likely to adopt 5G technology when they perceive clear performance improvements over previous generations and experience low ease of use, highlighting the importance of aligning network deployment with consumer readiness (Lee *et al.*, 2025). Taken together, these findings suggest that successful 5G adoption requires an integrated approach that simultaneously addresses economic feasibility at the infrastructure level and user-level acceptance determinants, rather than relying on purely technical or market-driven strategies.

Critical Success Factors (CSF) in the adoption of 5G technology represent key determinants of successful implementation, encompassing technological, regulatory, and economic dimensions that must be strategically aligned to ensure optimal outcomes. A comprehensive understanding of these factors enables both public authorities and private stakeholders to mitigate implementation challenges while maximizing the benefits associated with large-scale 5G deployment (Frank *et al.*, 2022).

5G technology substantially enhances communication capabilities and system performance, producing transformative effects across sectors such as healthcare,

education, transportation, and agriculture. These impacts have become particularly evident in the context of global disruptions, such as those triggered by the COVID-19 pandemic, where 5G has acted as a catalyst for innovation and generated significant multiplier effects. Despite these advantages, limited insight persists regarding user responses to perceived value and trust associated with 5G technology, highlighting an important gap in the current adoption literature (Rahman *et al.*, 2022; Shah *et al.*, 2023).

According to Israr *et al.* (2021), critical success factors in sectors such as telecommunications and smart cities include the rapidly increasing demand for data traffic and the requirement for dense, energy-efficient network infrastructures. Nevertheless, performance is constrained by challenges such as bandwidth bottlenecks and reliability issues. Dadhich *et al.* (2023) further identify additional determinants, including performance expectancy, social influence, hedonic motivation, perceived trust, and price value, as relevant drivers influencing 5G adoption.

Similarly, Maeng *et al.* (2020) argue that high deployment costs and a perceived lack of necessity constitute major barriers to 5G adoption, suggesting that enhancing perceived usefulness and revising pricing models are essential to increasing user acceptance. Mustafa *et al.* (2022), employing the Unified Theory of Acceptance and Use of Technology (UTAUT) framework, analyze 5G adoption and demonstrate that awareness of health and environmental impacts significantly predicts the acceptance of sustainable technologies. Finally, Ariansyah *et al.* (2019) emphasize that successful 5G adoption in Indonesia depends on the alignment of business models, privacy and security considerations, and enabling technologies such as SDN and NFV with clear regulatory policies and well-defined market opportunities.

While there has been tremendous advances in deploying 5G around the world, there is a research gap regarding how and why adoption outcomes differ across geographic areas, especially in developing and emerging economies. In fact, the literature has been largely dominated by reviews focused on technical aspects such as spectral efficiency, latency, or network architecture, or empirical studies on individual acceptance in developed markets. Few studies have taken more integrative approaches that are informed by both the technological, organizational and contextual factors that influence adoption across different economic sectors. This literature review extends this work by examining the progression of CSF between 2019 and 2025, based on a scoping review of

evidence drawn from the healthcare, transportation, entertainment, agriculture, and smart city sectors.

This study is motivated by the pressing need to interpret 5G adoption not only as a technological innovation, but as an enabler of sustained digital transformation. Evidence exists that barriers such as high infrastructure costs, regulatory fragmentation, and limited frequency availability continue to impede large-scale adoption in emerging economies. Indeed, these barriers reflect a need to build a conceptual framework around the drivers, challenges, and enablers all in one framework or model. The framework demonstrates that drivers such as innovation incentives, institutional readiness, and digital literacy shape the adoption process; challenges such as funding barriers, interoperability, and public trust inhibit the adoption process; enablers such as enabling regulation, infrastructure sharing, and collaboration of ecosystem actors provide opportunities for the potential for sustainable diffusion (GSMA, 2024; Kala & Chaubey, 2024; Goggin & Villanueva-Mansilla, 2023). The interaction of the three dimensions determines the rate and depth of 5G assimilation across each sector.

As a result, this review contributes a new and multi-sectoral synthesis that situates the evolution of the CSF within socio-technical and policy dynamics. By tying together, the technological enablers with the socioeconomic and institutional contexts, this study provides useful contributions for policymakers, researchers and industry participants seeking to enhance 5G adoption in underserved regions. In this way, it makes an important distinction compared to the previous reviews, as it offers a broader representation that sees 5G, at once, as a technological imperative as well as a tactical enabler of sustainable development (Magnaghi *et al.*, 2025; Whalley, 2024; Rossi, 2023).

As telecommunications technologies become increasingly embedded in developing economies, it is imperative to identify and understand the factors that determine the success or failure of 5G adoption. From this perspective, this investigation primarily aims to evaluate the CSF in 5G adoption and how they have evolved from 2019 to 2025. This study aims to respond to the following main question: How have CSF evolved in the adoption of 5G technology? Addressing this research question enables policymakers and service providers to design more effective strategies that are better aligned with the specific realities of these markets. By understanding the changes and emerging trends associated with critical success factors, stakeholders can anticipate

challenges and opportunities, thereby optimizing efforts to overcome technical, economic, and regulatory barriers and promoting a faster and more widespread adoption of 5G technology.

This study examines the critical success factors influencing the adoption of 5G technology in order to identify their evolution over time. Its primary objective is to support stakeholders in optimizing adoption strategies and practices, while also providing researchers with insights into the dynamic behavior of these factors across different stages of technological diffusion.

The main contributions of this article are threefold:

- (A) to provide a comprehensive overview of 5G technology adoption, including its conceptual foundations, evolutionary trajectory, and key analytical perspectives;
- (B) to present a structured inventory of critical success factors associated with 5G adoption; and
- (C) to analyze the temporal evolution of these critical success factors in the context of 5G technology adoption.

This paper is structured into four sections. Section 1 introduces the study by outlining the background, a brief review of the relevant literature, the research motivation, objective, and principal contributions. Section 2 describes the research methodology adopted in this study. Section 3 presents the results and discusses the main findings. Finally, Section 4 concludes the article by summarizing the key conclusions and implications.

2 METHODS

This section employed the methodology proposed by Kitchenham (2004), where a systematic review of the literature is defined as a formal process to identify, assess, and analyze relevant research; research can be about a question, topic or trend, or phenomenon. The studies discussed in this process will be regarded as a primary study, while the systematic review will be treated as a secondary study. More recently, Carrera-Rivera *et al.* (2022) further clarified that the systematic literature review is a rigorous methodology that allows the researcher to adequately gather, identify, and critically analyze the research that has already been published with an aim to enhance the

transparency and reproducibility of the analysis in a technological or scientific study. This literature review methodology is an organized process consisting of three phases:

- **Planning:** research questions are developed, and the search protocol is developed. The search protocol identifies sources, time frames, search strings, and exclusion and inclusion criteria.
- **Conducting:** the search protocol is implemented and relevant articles were selected.
- **Reporting:** statistical analyses of the selected articles are completed, including trends, quality assessment, and distribution.

2.1 Planning

This study addresses three research questions (RQ) concerning the adoption of 5G technology:

RQ1: What factors affect the uptake of 5G technology?

RQ2: What theories or models have been applied to the factors impacting the uptake of 5G technology?

RQ3: What strategies have countries used in the uptake of 5G technology?

The information search was conducted using the Scopus and Web of Science (WoS) databases, covering the period 2019–2025, selected due to the high volume of relevant results within this timeframe.

Articles were filtered using the following search string: ("critical success factor" OR "CSF") AND ("adoption" OR "implementation" OR "deployment") AND ("5G" OR "5G technology"). The string was applied to titles, abstracts, and keywords, subsequently adapted to each search engine.

For the purposes of this study, the inclusion and exclusion criteria applied in the SCOPUS and Web of Science (WoS) databases were clearly defined. The inclusion criteria considered only journal articles and review papers published between 2019 and 2025, written in English or Spanish, and belonging to the fields of Computer Science and Engineering. Additionally, the documents had to explicitly address at least one of the research questions posed in the review and, preferably, be available in Open Access

format. Conversely, the criteria for exclusion eliminated works that studied technologies unrelated to fifth-generation (5G) systems, work without an adoption model or framework, and articles written in languages other than English or Spanish.

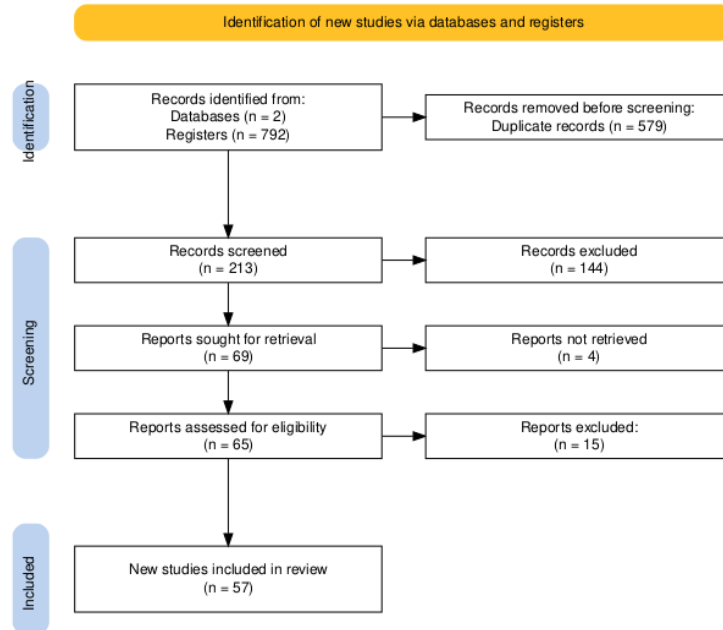
2.2 Conducting

The protocol that was settled on in the planning phase was applied following the process shown in Figure 1. In turn, this was based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which sets forth transparent and reproducible guidance for the identification, selection, and synthesis of relevant studies (Page *et al.*, 2021). Recent research highlights that PRISMA can be adapted to a context that relies on technology and applied science, which advances the traceability and quality of the evidence assembled (Haddaway *et al.*, 2022).

1,964 of the 1,971 articles that the search first turned up were from WoS, while 7 came from Scopus. After removing duplicates and applying the selection criteria, 792 potential articles remained. These were subsequently filtered by title, reducing the number to 213; by abstract, to 69; by introduction and conclusion, to 65; and finally, 57 articles were selected after a full-text review.

Figure 1

Process employed for the systematic literature review following the PRISMA framework



Source: Page *et al.*, 2021

2.3 Reporting

The total number of selected studies represents 2.89% (57) of the 1,971 potential articles. In addition, the identifiers of the selected articles are provided. The search strategy applied to the selected databases yielded a total of 1,971 potentially eligible articles. Specifically, 7 records were initially retrieved from Scopus and met the established inclusion criteria. In the case of Web of Science (WoS), 1,964 documents were identified, from which 50 were finally selected after applying the screening process. Altogether, the systematic review considered 57 articles for in-depth analysis.

The analysis of the literature shows that a total of 57 articles (100%) address the factors influencing 5G adoption (RQ1). Of these, 18 studies (31%) address the theories or models underlying such factors (RQ2) and 32 articles (56%) explore the strategies that diverse countries utilize to adopt 5G (RQ3). This representation gives a clear, organized depiction of the breadth and focus of these studies. Although the first study on the adoption of 5G technology is Qiang (2019), the first research studies addressing CSF specifically for the adoption of 5G technology were 2020, followed by the peak in 2021 (18 articles), likely influenced by the 5G rollout in various countries (Gonzalez, 2019).

Also reveals a decreasing trend in publications; this decline in the number of studies suggests a maturity phase in 5G research and a shift of focus toward emerging technologies such as 6G and quantum communication, which pose new challenges in terms of fairness, accountability, and transparency.

With ten articles, IEEE Access is the most regularly published journal. IEEE Transactions on Network and Service Management and the IEEE Internet of Things Journal follow with four pieces apiece. In addition, 22 journals were grouped under the category “Other journals,” each represented by a single selected article. In total, 38 journals were identified, of which 19 are classified as Q1, 10 as Q2, 2 as Q3, and 7 as Q4. The majority of the publications, 63% (36 articles), correspond to Q1 journals, followed by 19% (11 articles) in Q2. This distribution does not reflect the prestige or impact factor of the journals, but rather their publication frequency, since IEEE Access has an open access model and a faster editorial cycle. It was also verified that the count includes only peer-reviewed articles, excluding conference papers and preprints, which guarantees the quality of the content and, consequently, the reliability of the conclusions that can be drawn from these studies.

3 ANALYSIS AND DISCUSSION

The following section begins addressing the research questions posed during the planning phase of the systematic literature review. These are supported by the corresponding references, according to the findings from the selected studies:

3.1 RQ1: what are the factors influencing the adoption of 5G technology?

A total of 59 CSF for 5G adoption were identified across the 57 selected articles, which are detailed in this section. They need to be categorized for clearer understanding. However, no established taxonomy for these factors was found in the literature. Consequently, taxonomies from 4G adoption studies (the predecessor technology) were reviewed with the aim of extending them to the 5G context. Park *et al.* (2015) proposed a taxonomy oriented toward functional, social, and personal dimensions, while Sabzian *et al.* (2018) classified factors around user-related dimensions such as mobile devices and

operators, biometric systems, perception, and context. Nevertheless, these taxonomies do not include economic sectors that strongly influence governmental decision-making for 5G adoption, nor do they account for strategic factors such as those related to smart cities. For this reason, this study introduces a new taxonomy that integrates these sectors, providing a broader framework for analyzing 5G adoption, which were grouped into the categories of healthcare, transportation, entertainment, agriculture, and smart cities.

3.1.1 Factors in the healthcare sector

Twelve factors were identified in eight studies, as shown in Table 1. The "ID" associated with each factor indicates its identification code, while the "Frequency" column signifies the number of studies in which the factor appeared, indicating its level of importance in the literature. The more relevant factors are based on their conceptual and empirical importance based on frequency of occurrence and contextual relevance, and they are infrastructure readiness, regulatory clarity, institutional support, and technology readiness.

Adoption of 5G technology in healthcare stems from the need for better efficiency, accessibility, and accuracy of medical services. Although there is no strong concentration of factor-specific studies within this category, key aspects highlighted include low latency for remote surgery (F04), automation of medical diagnostics (F06), connectivity for telemedicine (F07), and real-time data management (F10).

The healthcare sector comprises factors related to 5G technology and the implementation of solutions such as telemedicine, remote surgery, real-time patient monitoring, and large-scale medical data management. These applications are enabled by the low latency and high reliability of 5G networks (Intel, n.d.; Zamzami, 2023; Muhammad *et al.*, 2021).

Table 1*5G Technology Adoption Factors in Healthcare*

ID	Factor	Description	Frequency	Reference
F01	Telemedicine in rural areas	Enables remote medical consultations in rural areas with limited healthcare coverage.	1	(Muhammad <i>et al.</i> , 2021).
F02	Rapid interventions in medical emergencies	Allows rapid interventions through telemedicine and connected emergency systems.	1	(Muhammad <i>et al.</i> , 2021).
F03	Connected medical equipment	Efficiently connects medical equipment, enabling continuous and remote patient monitoring.	1	(Muhammad <i>et al.</i> , 2021).
F04	Low latency for remote surgery	Provides low-latency networks to perform real-time remote surgeries with precision and efficiency.	2	(Zreikat & Mathew, 2024; Muhammad <i>et al.</i> , 2021).
F05	Predictive maintenance in healthcare	Predicts maintenance needs of medical equipment, improving operational efficiency and reducing costs.	1	(Muhammad <i>et al.</i> , 2021).
F06	Automation of medical diagnostics	Uses artificial intelligence and 5G to automate medical diagnostics and improve treatment accuracy.	2	(Hu & Zhang, 2020; Zamzami, 2023).
F07	Connectivity for general telemedicine	Enhances telemedicine system connectivity with 5G, enabling remote consultations and broader healthcare access.	2	(Zreikat & Mathew, 2024; Muhammad <i>et al.</i> , 2021).
F08	Improvements in wearable medical devices	Strengthens wearable medical devices through 5G, enabling real-time health data transmission for efficient monitoring.	1	(Hu & Zhang, 2020).
F09	Energy efficiency in hospitals	Improves energy efficiency in hospitals, reducing energy consumption of connected equipment.	1	(Khelifi <i>et al.</i> , 2021).
F10	Real-time medical data management	Manages medical data in real time, enabling healthcare professionals to make faster and more accurate decisions.	2	(Zreikat & Mathew, 2024; Hu & Zhang, 2020).
F11	Medical security in sensitive data	Implementation of advanced security measures in 5G networks to protect sensitive data in the health sector, guaranteeing patient privacy.	1	(Jmila & Blanc, 2020).
F12	Network security and trust	Users' perception of network security, data privacy, and overall reliability of 5G infrastructure, particularly relevant for critical and sensitive applications.	1	(Jurić <i>et al.</i> , 2025).

3.1.2 Transport sector factors

Ten factors were identified across ten studies. The transportation sector faces increasing challenges in efficiency, safety, and sustainability, which has driven the adoption of advanced technologies such as 5G. Table 2 presents the factors influencing 5G adoption in this sector, where the greatest concentration of studies focuses on improvement of logistics transportation (F13) and vehicle-to-infrastructure communication (F14).

The transportation sector takes into account 5G adoption issues related to enhanced mobility and safety, which are made possible by 5G's low latency and fast speed. These include the development of autonomous vehicles, real-time traffic management systems, and intelligent logistics. In addition, efficient communication between vehicles (V2V) and between vehicles and infrastructure (V2I) is highlighted (GSMA, 2023; Lopes *et al.*, 2022; Li *et al.*, 2021).

Table 2

Adoption factors of 5G technology in the transportation sector

ID	Factor	Description	Frequency	Reference
F13	Improvement of logistics transportation	Enhancing logistics transportation management by optimizing routes and delivery times through real-time data analytics.	4	(Lopes <i>et al.</i> , 2022; Fang <i>et al.</i> , 2020; Li, 2021; Bany <i>et al.</i> , 2022).
F14	Vehicle-to-Infrastructure (V2I) communication	Implementation of 5G-based V2I technology that enables seamless communication between vehicles and infrastructure, improving safety and traffic flow.	4	(Alotaibi, 2022; Rotter & Do, 2021; Hussein <i>et al.</i> , 2021; Lopes <i>et al.</i> , 2022).
F15	Fault detection in transportation systems	Real-time monitoring for fault detection in transportation systems using 5G networks, improving safety and predictive maintenance.	2	(Hu & Zhang, 2020; Hussein <i>et al.</i> , 2021).
F16	Route optimization for autonomous vehicles	Optimizing route planning for autonomous vehicles, reducing travel time and improving traffic management efficiency.	3	(Zreikat & Mathew, 2024; Hussein <i>et al.</i> , 2021; Fang <i>et al.</i> , 2020).
F17	Latency reduction in traffic systems	Deployment of low-latency 5G networks to improve traffic system management, responding more efficiently to changes and congestion.	2	(AlQahtani & Alhomiqani, 2020; Rotter & Do, 2021).

F18	Public transport optimization	Optimizing public transport operations and planning, improving efficiency and reducing operating costs.	2	(Zreikat & Mathew, 2024; AlQahtani & Alhomiqani, 2020).
F19	Real-time congestion reduction	Dynamic traffic management that reduces congestion in real time through intelligent monitoring and control systems.	2	(Rotter & Do, 2021; Hussein <i>et al.</i> , 2021).
F20	Safety in large-scale transportation	Large-scale transportation systems, improving safety and monitoring through robust and real-time networks.	3	(Deng <i>et al.</i> , 2022; Hussein <i>et al.</i> , 2021; Bany <i>et al.</i> , 2022).
F21	Connectivity for electric vehicles	Enhancing connectivity for electric vehicles using 5G networks, enabling efficient charging and real-time monitoring.	2	(Lopes <i>et al.</i> , 2022; Fang <i>et al.</i> , 2020).
F22	Support for autonomous vehicles	Supporting connectivity and management of autonomous vehicles, improving their ability to communicate with other vehicles and infrastructure.	3	(Zreikat & Mathew, 2024; Rotter & Do, 2021; Lopes <i>et al.</i> , 2022).

3.1.3 Entertainment sector factors

In twelve research, twelve factors were found. The need for technology infrastructures that can provide more immersive, engaging, and high-quality experiences has increased due to the development of digital entertainment. Table 3 presents the factors influencing 5G adoption in this sector, where the greatest concentration of studies focuses on immersive interaction in virtual reality (F26).

The entertainment industry includes aspects of 5G and its potential to change how people access digital experiences and information. It facilitates the development of cloud-based gaming, continuous high-definition video streaming, and immersive applications like Virtual Reality (VR) and Augmented Reality (AR) (ON5G, 2019; Fu, 2021; Praveen *et al.*, 2020).

Table 3

5G Technology adoption factors in entertainment

ID	Factor	Description	Frequency	Reference
F23	Cloud gaming environments	Offering cloud-based video games by improving latency and remote processing capacity to enable real-time gaming experiences.	3	(Ruiz <i>et al.</i> , 2023; Praveen <i>et al.</i> , 2020; Nguyen <i>et al.</i> , 2023).

F24	Multimedia content distribution	Enhancing multimedia content distribution, enabling faster and more efficient delivery of high-quality video and audio.	3	(Lopes <i>et al.</i> , 2022; Zhang <i>et al.</i> , 2020; Praveen <i>et al.</i> , 2020).
F25	Enhancement of online gaming	Optimizing online gaming performance through 5G networks, providing ultra-low latency and improved multiplayer experiences.	2	(Praveen <i>et al.</i> , 2020; Zhang <i>et al.</i> , 2020).
F26	Immersive interaction in virtual reality	Enabling immersive virtual reality experiences with low latency, improving interactivity and real-time responsiveness.	4	(Cheng, 2022; Praveen <i>et al.</i> , 2020; Behravesht <i>et al.</i> , 2021; Fang <i>et al.</i> , 2020).
F27	Augmented reality in live events	Enhancing live events with augmented reality, connecting users interactively with their surroundings.	3	(Fu, 2021; Praveen <i>et al.</i> , 2020; Rotter & Do, 2021).
F28	Immersive cinema and augmented reality	Developing immersive cinema and event experiences through augmented reality, offering next-generation entertainment.	2	(Fu, 2021; Praveen <i>et al.</i> , 2020).
F29	Real-time video streaming	Improving the quality and smoothness of real-time video streaming through 5G, enabling uninterrupted live broadcasts.	2	(Fu, 2021; Lopes <i>et al.</i> , 2022).
F30	4K streaming services	Supporting 4K-quality streaming services, offering better image quality and reduced transmission delays.	2	(Fu, 2021; Zhang <i>et al.</i> , 2020).
F31	Virtual reality in entertainment	Enhancing virtual reality experiences in the entertainment sector, providing more fluid and realistic interactions.	3	(Zreikat & Mathew, 2024; Praveen <i>et al.</i> , 2020; Behravesht <i>et al.</i> , 2021).
F32	Perceived relative advantage	Extent to which users perceive 5G as offering superior benefits such as higher speed, lower latency, and improved service quality compared to previous generations of mobile technology.	2	(Jurić <i>et al.</i> , 2025; Lee <i>et al.</i> , 2025).
F33	Technological compatibility	Degree to which 5G technology is compatible with existing devices, applications, and services, thereby reducing technical barriers and facilitating transition from legacy technologies.	2	(Jurić <i>et al.</i> , 2025; Lee <i>et al.</i> , 2025).
F34	Ease of use	Degree to which users perceive 5G services as easy to use and not requiring substantial effort, learning, or behavioral change.	2	(Jurić <i>et al.</i> , 2025; Lee <i>et al.</i> , 2025).

3.1.4 Factors in the agricultural sector

Eleven factors were identified across 25 studies. The agricultural industry is encountering mounting challenges regarding sustainability, production efficiency, and

resource sustainability. The factors affecting 5G deployment in this industry are seen in Table 4; again, there was no study placed importance on any specific factor; however, the factors analyzed here are the frequency of real-time crop monitoring (F35), the use of Internet of Things (IoT) sensors in agriculture (F39), automation in cultivation (F42), and advanced crop sensors (F44).

The agriculture sector includes 5G-related elements that affect food security and agricultural productivity. It enables the implementation of precision agriculture technologies, such as the use of drones and automated irrigation management, optimizing production through real-time data analytics (Van & Wolfert, 2022; Khelifi *et al.*, 2021; Jmila & Blanc, 2020).

Table 4

5G Technology adoption factors in agriculture

ID	Factor	Description	Frequency	Reference
F35	Real-time crop monitoring	Continuous monitoring of crops through IoT sensors.	3	(Israr <i>et al.</i> , 2020; Cheng, 2022; Muhammad <i>et al.</i> , 2021).
F36	Increase in agricultural productivity	Use of 5G technologies to optimize agricultural efficiency.	2	(Fu, 2021; Hadi, 2023).
F37	Livestock tracking on farms	Monitoring livestock and animals through IoT and 5G technologies.	2	(Guo <i>et al.</i> , 2020; Fang <i>et al.</i> , 2020).
F38	Smart irrigation optimization	Automated irrigation control based on IoT sensor data.	2	(Putri & Novanana, 2023; Khan <i>et al.</i> , 2022).
F39	Use of IoT sensors in agriculture	Deployment of connected sensors for data collection.	3	(AlQahtani & Alhomiqani, 2020; Deng <i>et al.</i> , 2022; Tang <i>et al.</i> , 2020).
F40	Agricultural soil monitoring	Real-time monitoring of soil conditions through sensors.	2	(Jahng & Park, 2020; Rotter & Do, 2021).
F41	Pest control in agriculture	Use of IoT technologies for pest detection and control.	2	(Atharvan <i>et al.</i> , 2022; Tang <i>et al.</i> , 2020).
F42	Cultivation automation	Use of drones and robotics for automating agricultural tasks.	3	(Hadi, 2023; Segura-Garcia <i>et al.</i> , 2021; Velez <i>et al.</i> , 2023).
F43	Agricultural product traceability	Real-time monitoring and control of the supply chain.	2	(Martiradonna <i>et al.</i> , 2020; Jeong & Kim, 2023).
F44	Advanced crop sensors	Deployment of specialized sensors to optimize crop production.	3	(Hoffmann & Kryszkiewicz, 2021; Pandey <i>et al.</i> , 2023; Yu <i>et al.</i> , 2020).

F45	Support for industrial and IoT applications	Capability of 5G to enable industrial automation, Internet of Things (IoT), smart agriculture, and related applications through massive connectivity and ultra-low latency.	2	(Pan, 2025; Zhang <i>et al.</i> , 2025).
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3.1 5 Smart cities sector factors

Fourteen factors were identified across 32 studies. Urban growth and the need to optimize resource use have driven the implementation of advanced technologies to improve sustainability, efficiency, and safety in urban environments. Table 5 presents the factors influencing the adoption of 5G in this sector, where the highest concentration of studies focuses on the monitoring of critical infrastructures (F55).

The smart cities sector includes the various factors that influence the adoption of 5G as they relate to the interconnectedness of urban infrastructures including lighting in buildings, waste management, and public safety. 5G allows for the collection and analysis of real-time data, enhancing the efficiency and quality of life in an urban context (Attaran, 2021; Segura-Garcia *et al.*, 2021; Yu *et al.*, 2020).

Table 5

5G Technology adoption factors in smart cities

ID	Factor	Description	Frequency	Reference
F46	Energy efficiency in smart buildings	Optimization of energy consumption in buildings through automation and intelligent systems.	2	(Martiradonna <i>et al.</i> , 2020; Massaro & Beltran, 2020).
F47	Waste management and recycling	Automated and effective garbage management, including recycling procedures using Internet of Things sensors.	3	(Jmila & Blanc, 2020; AlQahtani & Alhomiqani, 2020; Pandey <i>et al.</i> , 2023).
F48	Smart grids for electricity distribution	Deployment of advanced electrical networks to distribute energy efficiently.	4	(Tohidi <i>et al.</i> , 2021; Behravesht <i>et al.</i> , 2021; Fang <i>et al.</i> , 2020; Bany <i>et al.</i> , 2022).
F49	Air pollution control	Monitoring and controlling air quality in urban areas through smart sensors.	2	(Putri & Novanana, 2023; Liu <i>et al.</i> , 2021).
F50	Energy management networks	Energy infrastructure that manages consumption and distribution more efficiently.	3	(Rotter & Do, 2021; Pandey <i>et al.</i> , 2023; Shen <i>et al.</i> , 2021).

F51	Public safety systems with smart cameras	Use of smart cameras and video surveillance technology to enhance public safety.	2	(Lopes <i>et al.</i> , 2022; Marvi <i>et al.</i> , 2020).
F52	Intelligent urban traffic management	Optimization of traffic systems using real-time data analytics.	4	(Cheng, 2022; Guo <i>et al.</i> , 2020; Hussein <i>et al.</i> , 2021; Sun, 2021).
F53	Urban planning with big data	Use of big data for efficient urban space planning and management.	3	(Muhammad <i>et al.</i> , 2021; Segura-Garcia <i>et al.</i> , 2021; Tiwari <i>et al.</i> , 2024).
F54	Efficient water network management	Monitoring and intelligent management of water resources to ensure efficient distribution.	2	(Xu, 2023; Priya & Malhotra, 2019).
F55	Monitoring of critical infrastructures	Continuous monitoring of critical infrastructures such as bridges, roads, and public utilities.	5	(Lee <i>et al.</i> , 2021; Kaur <i>et al.</i> , 2022; AlQahtani & Alhomiqani, 2020; Khan <i>et al.</i> , 2022; Nardini & Stea, 2024).
F56	Adequate network infrastructure	Availability of robust 5G infrastructure (e.g., small cells, millimeter-wave spectrum, Massive MIMO) capable of ensuring sufficient coverage, high capacity, and ultra-low latency to support advanced digital applications.	4	(Calvo, 2025; Gordon <i>et al.</i> , 2025; Pan, 2025; Rech <i>et al.</i> , 2025).
F57	Investment and operational costs (CAPEX/OPEX)	Level of initial capital investment and ongoing operational costs associated with the deployment and maintenance of 5G networks, which directly affect economic feasibility and scalability.	2	(Calvo, 2025; Rech <i>et al.</i> , 2025).
F58	Regulatory support and public policies	Existence of supportive regulatory frameworks, spectrum allocation mechanisms, and governmental policies that facilitate and accelerate the deployment and adoption of 5G technology.	2	(Calvo, 2025; Rech <i>et al.</i> , 2025).
F59	Integration with edge computing and IoT platforms	Ability of 5G networks to integrate with edge computing and IoT platforms, enabling real-time data processing and supporting smart urban applications.	1	(Lee <i>et al.</i> , 2025).

3.2 RQ2: what theories or models have been used to support the factors influencing the adoption of 5G technology?

In the adoption of 5G technology, various models and theories have been applied to better understand and explain its acceptance. For example, the Technology Acceptance

Model (TAM) (T04) evaluates adoption based on perceived usefulness and ease of use, while the Diffusion of Innovations Theory (T02) examines how a technology spreads within a population.

A total of 12 models have been identified, which have been used to support 25 factors across 18 studies. Table 6 describes these models and indicates the factors they support. In other words, 34 factors lack solid theoretical justification.

Table 6

Theories or models used to support the factors in the adoption of 5G technology

ID	Theory/Model	Description	Factor	Frequency	Reference
T01	Innovation Adoption Model	Explains how new technologies such as 5G are adopted by different users over time, including early and late adoption stages.	F01, F04, F05	2	(Israr <i>et al.</i> , 2020; Jahng & Park, 2020).
T02	Diffusion of Innovations Theory (DOI)	Describes how technological innovations such as 5G spread in society starting from certain initial groups.	F07, F09, F13, F22, F32, F34,	4	(Khelifi <i>et al.</i> , 2021; Jahng & Park, 2020; Lee <i>et al.</i> , 2021; Lee <i>et al.</i> , 2025).
T03	Technology Utilization Theory (TUT)	Explains how perceived usefulness and perceived ease of use influence the adoption of new technologies, such as telemedicine applications in rural areas.	F01, F03, F35	2	(Zreikat & Mathew, 2024; Alotaibi, 2022).
T04	Technology Acceptance Model (TAM)	Describes the factors influencing the acceptance of new technologies, such as perceived usefulness and ease of use.	F06, F08, F11, F13, F22, F23, F32, F34, F36	3	(Hu & Zhang, 2020; Tohidi <i>et al.</i> , 2021; Lee <i>et al.</i> , 2025).
T05	Theory of Planned Behavior (TPB)	States that the adoption of new technologies such as 5G depends on attitudes, subjective norms, and perceived behavioral control.	F06, F11	2	(Chukhno <i>et al.</i> , 2023; Hoffmann & Kryszkiewicz, 2021).
T06	Technology Diffusion Model (TDM)	Focuses on how advanced technologies such as 5G diffuse in key sectors, including transportation and smart cities.	F16, F38	2	(Cheng, 2022; Martiradonna <i>et al.</i> , 2020).
T07	Acceptance Framework Theory (AFT)	Argues that decisions regarding the adoption of new technologies, such as 5G in healthcare applications, are	F04, F11	2	(Israr <i>et al.</i> , 2020; Kaur <i>et al.</i> , 2022).

		influenced by perceived usefulness and ease of use.			
T08	Disruptive Innovation Model	Emphasizes how emerging technologies such as 5G can transform existing industries, creating new opportunities and optimizing services.	F19, F55	2	(Alotaibi, 2022; Hu & Zhang <i>et al.</i> , 2020).
T09	Rogers' Innovation Model	Explains the adoption curve of new technologies, describing diffusion from innovators to laggards in sectors such as healthcare and entertainment.	F29, F48	3	(Jahng & Park, 2020; Chukhno <i>et al.</i> , 2023; Tohidi <i>et al.</i> , 2021).
T10	Transaction Cost Theory	Applies the idea of minimizing the costs of adopting and using technologies in sectors such as agriculture, enabling real-time crop monitoring with 5G networks.	F35, F41	2	(Xu, 2023; Atharvan <i>et al.</i> , 2022).
T11	Smart Supply Chain Model	Explains the integration of high-tech networks such as 5G for efficient supply chain management, including IoT sensors and product traceability.	F20, F43	2	(Atharvan <i>et al.</i> , 2022; Jmila & Blanc, 2020).
T12	Unified Theory of Acceptance and Use of Technology (UTAUT)	Explains technology adoption by integrating key determinants such as performance expectancy, effort expectancy, and social influence, which shape individuals' intention to use and actual use of new technologies.	F12, F32, F34	1	(Jurić <i>et al.</i> , 2025).

3.3 RQ3: what strategies have been employed by countries in the adoption of 5G technology?

According to the identified studies, a total of 33 strategies have been implemented by 17 countries to facilitate the adoption of 5G technology within their territories. Table 7 presents the description of the strategies applied.

Table 7*Strategies used by some countries to adopt 5G*

Country	Strategy	Description	Reference
Saudi Arabia	HetNet deployment	A network architecture was designed combining macrocells and strategically distributed small cells to cover urban, suburban, and rural environments with spectral efficiency. This densification addressed the high demand for data connectivity in dense environments, ensuring low latency, service stability, and continuity. Interoperability among multiple technologies and network layers was key to scalability.	(Alotaibi, 2022).
	Network slicing with SDN/NFV	A logical slicing architecture with SDN controllers and NFV platforms was designed, allowing the physical network to be divided into multiple virtual networks optimized for specific use cases such as telemedicine, logistics, transportation, or gaming. Each slice included specific guarantees for latency, bandwidth, and security.	(AlQahtani & Alhomiqani, 2019).
	Remote health monitoring with AI	By incorporating deep learning algorithms, a continuous observation system for elderly individuals was developed that interacts with 5G. It registered atypical behavioral patterns and provided an improved autonomy for the user, reduced risk, and optimized medical care response through intelligent notifications.	(Zamzami, 2023).
China	Sustainable infrastructure with renewable energy	An essential component of the infrastructure expansion strategy was the installation of energy-sustainable base stations using wind turbines, solar panel integration, and energy consumption optimization. This approach reduced fossil fuel dependency, minimized the carbon footprint, and improved resilience in off-grid regions, without compromising performance or service quality.	(Israr <i>et al.</i> , 2020).
	Immersive education with 5G and VR/AR	By integrating 5G networks with VR/AR educational platforms, teaching was transformed into an immersive model. Low latency enabled complex simulations, haptic interaction, virtual laboratories, and seamless remote collaboration, significantly enhancing technical and medical learning processes.	(Fu, 2021).
	Distributed cloud for 5G VR	A hierarchical cloud architecture was used to manage VR traffic over 5G networks in a decentralized manner. Separation into access, micro, and core clouds distributed processing load, minimized latency, and supported delay-sensitive applications such as real-time gaming or remote surgery.	(Cheng, 2021).
	Unmanned Aerial Vehicle (UAV) as mobile base stations	Drones equipped with mobile base stations were used to provide temporary or emergency connectivity in underserved regions or natural disaster scenarios. Route planning, coverage,	(Xu, 2023).

		and energy consumption were optimized using deep learning-based algorithms, ensuring resilient connectivity.	
	Slicing with Information-Centric Networks (ICN)	An information-centric strategy was used to build a network slice in which packets were addressed by content rather than IP addresses. It is perfect for video distribution, IoT, and automotive settings due to its decreased latency, increased caching, and greater bandwidth efficiency.	(Liu <i>et al.</i> , 2021).
	UAVs for disaster recovery	In crisis situations, an autonomous system with smart UAVs was created to quickly restore 5G coverage. Coverage and operational endurance were optimized through the use of dynamic positioning, energy planning, and clustering approaches.	(Khan <i>et al.</i> , 2022).
	Social-aware D2D in ultra-dense networks	Nearby devices could share material without going over the core network thanks to a mobility similarity-based video distribution system. In dense networks, this decreased latency, decreased core load, and increased system efficiency.	(Zhang <i>et al.</i> , 2020).
	Virtual power plants with edge computing	In Virtual Power Plants (VPPs), where 5G offered real-time connectivity between dispersed agents, edge computing and artificial intelligence were used to enhance energy dispatch, boosting operational resilience and efficiency.	(Fang <i>et al.</i> , 2020).
	Resource management with federated + reinforcement learning	In order to create models that optimize offloading choices, energy management, and resource allocation in ultra-dense networks without jeopardizing user privacy, federated learning (for data protection) and reinforcement learning (for adaptability) were coupled.	(Yu <i>et al.</i> , 2020).
South Korea	Early public investment and adoption simulation	Forecasting and simulation models have been used to assess adoption scenarios and estimate demand since the start of 5G commercialization. Public-private partnerships were encouraged, appropriate regulatory frameworks were made possible, and public investments were focused on critical infrastructure. The proactive strategy reduced deployment time, increased early coverage, reduced technological obstacles, and fostered industry trust.	(Jahng & Park, 2019).
United States	CBRS (spectrum sharing)	Operators were able to share frequencies with governmental and military incumbents without disturbance because to a dynamic and tiered licensing scheme for the C-band spectrum. Particularly in suburban and industrial areas, this novel approach promoted new local business models, lowered entry costs, and democratized spectrum access.	(Massaro & Beltrán, 2020).

Egypt	V2X communications with D2D	Using power control strategies to minimize interference and extend battery life, a direct communication (D2D) system between cars and between vehicles and infrastructure was developed in vehicular contexts, guaranteeing safe and effective communications.	(Hussein <i>et al.</i> , 2021).
Hungary	Automatic UPF scaling	A queuing model was used to address the scalability of the User Plane Function (UPF) by determining when and how many UPF instances to activate based on traffic demand. This allowed for quick reactions to spikes in traffic, increased core network efficiency, and conserved computing resources.	(Rotter & Do, 2021).
India Indonesia	Industrial IoT in Manufacturing 4.0	Production lines were transformed into intelligent and autonomous environments through the use of IIoT technologies integrated with 5G networks. In factories and complex industrial facilities, support for ultra-reliable low-latency connectivity enabled distributed automation, predictive maintenance, and real-time monitoring.	(Atharvan <i>et al.</i> , 2022).
	Blockchain in 5G network slicing	In order to ensure transparency, traceability, security, and trust without the need for a centralized organization, blockchain technology was included into slice management to give an immutable and distributed record of access policies, QoS, identification, and payments across several operators.	(Praveen <i>et al.</i> , 2020).
	Autonomous network selection for 5G factories	For heterogeneous situations with a variety of accessible technologies, an autonomous industrial network selection solution was created. The best network was identified using multi-criteria algorithms that took availability, service requirements, and environmental factors into account.	(Priya & Malhotra, 2019).
	5G laboratories as a service	The use of simulations academic institutions and laboratories were able to test networks with realistic configurations thanks to 5G environments provided as a service. These platforms helped to build specialized skills in next-generation technologies by supporting applied research, validating novel protocols, and providing technical training for professionals.	(Putri & Novanana, 2023).
	Italy	Digital twins for 5G mobile network optimization	Real-time simulation of configurations, performance, and failures in 5G mobile networks was done using digital twins. This made it possible to test scenarios, modify parameters, and forecast behavior before to actual deployment.
Japan	Dynamic TDD with Deep Reinforcement Learning	In order to improve spectrum usage, deep reinforcement learning was used to dynamically modify the uplink/downlink (TDD) ratio in response to user mobility, channel variations, and service requirements.	(Tang <i>et al.</i> , 2020).

Poland	Energy optimization with reinforcement learning	In order to control the energy consumption of antennas in MIMO networks, reinforcement learning algorithms were used to determine when to activate or deactivate them based on traffic. This clever saving strategy aligned with efficiency and environmental goals by lowering operational energy costs without compromising performance.	(Hoffmann & Kryszkiewicz, 2021).
Portugal	QoE for UHD video in vehicles	In order to enable dynamic optimization of video service quality over vehicular 5G networks, which is essential for smart mobility and in-transit entertainment, a multi-level measurement framework was created to gather both technical metrics (throughput, latency, jitter) and subjective metrics (perceived QoE) in real time.	(Lopes <i>et al.</i> , 2022).
United Kingdom	Reconfigurable Intelligent Surfaces (RIS)	With no active energy usage, the use of RIS allowed for dynamic change of the electromagnetic environment, increasing signal gain, removing dead zones, and expanding coverage.	(Velez <i>et al.</i> , 2023).
	Digital predistortion in 5G optical transport	By compensating for nonlinear channel distortions, digital predistortion algorithms have improved the transmission of 5G signals over optical fiber, allowing for error-free high-rate data transport with reduced receiver hardware needs.	(Hadi, 2023).
European Union	Intelligent multicasting and spectrum optimization	Spectrum use was enhanced by combining several Radio Access Technologies (RAT) with beamforming and adaptive multicast techniques. This boosted the experience in high-resolution video, cloud gaming, and augmented reality apps, decreased network congestion, and improved simultaneous content delivery to thousands of users.	(Chukhno <i>et al.</i> , 2023).
	Multiband optical networks for Beyond 5G (B5G) support	Data-intensive applications like volumetric video, distributed analytics, and industrial scenarios now rely on multiband optical networks as their structural foundation. They supported the digital economy in an energy-efficient way by ensuring high availability, low latency, and scalability toward beyond-5G designs.	(Ruiz <i>et al.</i> , 2024).
	Coordinated regulatory and investment-driven deployment	A regional strategy emphasizing coordinated regulation, spectrum management, and large-scale investment was identified. The approach addressed Europe's deployment lag by aligning institutional frameworks, cross-country policies, and investment conditions to support widespread 5G adoption.	(Calvo, 2025).
Brazil	Techno-economic optimization of 5G rollout	A techno-economic assessment framework was employed to guide 5G deployment decisions by analyzing CAPEX and OPEX trade-offs across urban and rural regions. Strategies such as infrastructure sharing, neutral networks, and adaptation of European cost models were used	(Rech <i>et al.</i> , 2025).

		to improve economic feasibility and promote nationwide coverage while supporting digital inclusion.	
Malaysia	Consumer-driven adoption supported by performance and usability factors	A market-oriented strategy was adopted in which 5G diffusion was driven by consumer acceptance. Adoption was supported through perceived performance improvements, ease of use, compatibility with existing devices, and perceived enjoyment, aligning network deployment with user readiness and demand.	(Lee <i>et al.</i> , 2025).
	Behavioral adoption strategy based on acceptance models	National 5G adoption was indirectly supported through behavioral models (TAM and DOI), emphasizing relative advantage, low complexity, and compatibility as levers to accelerate diffusion among consumers and service users.	(Lee <i>et al.</i> , 2025).
Croatia	Trust- and performance-oriented consumer adoption strategy	A strategy focused on increasing user trust and perceived performance of 5G services was employed, highlighting security, reliability, and performance expectancy as key drivers to stimulate adoption at the national consumer level.	(Jurić <i>et al.</i> , 2025).

This research aims to identify and analyze key drivers in the embrace of 5G technology, particularly the evolution of these factors from 2019 to 2025. However, it's essential to note that even though the time frame of the study starts from 2019, after applying the inclusion filters, only 57 articles were included, none of which were published that year. This suggests that some research activities began in that timeframe, so a noticeable amount of them were published only from 2020 onward. Findings revealed 59 factors that included categories: healthcare, transportation, entertainment, agriculture, and smart cities, where significant changes occurred over time in both occurrence and significance.

The main synthesis indicates that 5G technology has driven diverse transformations across sectors, although all converge on the requirement for advanced infrastructure and improved connectivity. Recent studies, like Antevski *et al.* (2021), have focused on how 5G infrastructure tends to significantly improve responsiveness in critical applications, especially healthcare and transportation, consistent with our own findings on strong connectivity.

This research adds to our understanding of how adoption factors differ across contexts and address their distinct contextual-specific needs. Furthermore, it illustrates how adoption factors have been supported by social science-based theories and models,

which give a conceptual basis for the application of these factors. For example, the use of the Innovation Adoption Model in healthcare (Rogers, 2003) and the use of Diffusion of Innovations Theory in transport (Wang *et al.*, 2023) demonstrates how these theoretical frameworks are able to justify CSF across varied contexts. The Diffusion of Innovations Theory has been particularly useful in examining how new technologies like 5G flow across critical infrastructure sectors to enable the adoption of advance solutions in smart cities and urban transportation.

The findings of this study align with previous research on the consequences of 5G, especially with respect to enhancements to critical sectors like telemedicine and urban traffic management (Devi *et al.*, 2023). However, they do not align with studies that anticipated a clear picture of growth across all sectors, we observe a pattern toward stabilization or declining relevance for some factors in new years. This pattern may be the result of a maturity stage in 5G applications. Banda *et al.* (2022) also addressed patterns of stabilization and noted that disruptive technologies, such as 5G, could typically become less novel in at least some sectors following initial adoption. Limitations of this study include a reliance upon academic sources and omitting other potentially emerging sectors expected to leverage 5G. The absence of more recent data in some topics also precluded a more comprehensive assessment of the state of impacts in 2025. These limitations restrict the generalizability of some findings to future developments in mobile technology. Future research would benefit from inclusion of additional types of sources, including reports from industry and case studies in sectors like environmental resources management that are still lagging and less explored.

In light of the worldwide push for emerging technology, most prominently 5G, both developers and developing countries work diligently to remain relevant under the terms of globalization and modernization. Large technical and methodological differences remain in terms of the adoption models used for 5G, making significant analysis, adaptation, and application more complicated - especially in developing countries. In addition, there is no thorough systematization of existing frameworks preventing greater understanding of the main driver of adoption, use, and effective integration in some applications and social and productive contexts.

Earlier reviews of technology adoption, such as those conducted by Granić (2022) and Díaz-Arancibia *et al.* (2024), primarily examined traditional perspectives on the study

of technology adoption (TAM and UTAUT), targeting individual or organizational levels, and published in journals focusing on developed economies. In contrast, the current review incorporates these perspectives in a multisectoral and socio-technical synthesis to understand 5G adoption in emerging economies. This interpretation enables an expanded analytical horizon by associating traditional adoption determinants with contextual variables such as infrastructure readiness, regulatory fit, and institutional fit. In conclusion, the paper complements the previous reviews on information and communication technology adoption by considering the systemic and policy-related situations surrounding the diffusion of 5G.

Ultimately, expanding the current analysis could involve a thorough examination of a specific sector or research into new applications of 5G technology in areas not yet fully explored, such as education and environmental management (Zhang *et al.*, 2023). This research will enable a deeper and broader practical understanding of the CSF in the evolution and adaptation of 5G. These findings will drive greater adoption of 5G in geographically and socioculturally diverse regions.

4 CONCLUSIONS

The CSF in the adoption of 5G technology has been investigated in this study, and their progression between 2019 and 2025 has been identified. It became clear from the systematic literature analysis how aspects in industries including healthcare, transportation, entertainment, agriculture, and smart cities have changed over time in terms of both frequency and significance. Particularly, industries like smart cities and transportation showed consistent increase in 5G technology adoption and use, underscoring the need of reliable infrastructure and low-latency communication. The quantitative results show substantial scholarly interest in fields that are theoretically supported by innovation adoption models and technology diffusion theories, including telemedicine, automated medical diagnostics, and smart energy network management. Impact-wise, these findings not only confirm that CSF is applicable in crucial industries, but they also imply that incorporating 5G into these settings will continue to be crucial for the growth of technology and society. This study's reliance on scholarly sources released in the last five years is one of its main limitations, which could limit the

geographical and chronological reach of 5G applications and trends. Future studies might focus on understudied fields or creative uses in environmental management and education. Overall, this study's primary contribution is the conceptual framework it provides to comprehend the development of CSF in the adoption of 5G, offering a strong basis for further investigation into the adaption and optimization of this technology in many contexts.

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