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Current status analysis of 5G mobile communication services industry using business model canvas in South Korea

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ABSTRACT

Recently, faced with stagnating subscriber growth, operators of mobile communication services worldwide are actively seeking to revitalize the convergence industry through partnerships with other sectors. South Korea—which launched the world's first 5G service in 2019—had 32 million 5G subscribers by 2023. However, due to issues such as poor service quality, the lack of compelling services, and inadequate network infrastructure relative to initial projections, subscriber growth has been slower than expected. In this paper, we analyze the deployment of 5G and its business models in vital fields like smart factories and digital healthcare, which are expected to play crucial roles in propelling the industry forward. The business model canvas (BMC) framework is employed to identify essential factors for industry revitalization, major challenges, and future strategies. The analysis reveals that the provision of ultra-broadband and low-latency services has been hindered by delays in deploying services at 28 GHz, crucial for advancing the convergence industry. Enhancing the use of the 28 GHz wireless network would enable critical services for smart factories and digital healthcare, such as mobile edge computing, machine vision, telemedicine, and AI-driven medical applications. Furthermore, it is determined that strategies for revitalization at the government level need urgent implementation, contrasting with the current, less effective sandbox-level strategies. The empirical findings of this study allow for an assessment of why 5G subscriber growth lags behind that of 4G, and assist in the formulation of effective policies. Additionally, this data can serve as a foundation for planning strategies to stimulate the convergence industry using future B5G and 6G networks.

1. Introduction

The mobile communication services industry, a cornerstone of the national economy, is structured around a linear cycle involving service, network (or equipment), and terminal manufacturing sectors: development of new technologies → network establishment → launch of new terminals and services → service activation → development of subsequent technologies (GSMA, 2022; Lee, 2021; Savunen et al., 2023; Yeo et al., 2022). This beneficial cycle has fostered growth across these sectors. Recently, however, the rise of the digital economy has led mobile communication networks to gradually shift away from traditional revenue streams due to a plateau in subscriber growth and increasing complexity within the industrial ecosystem (Bhat & AlQahtani, 2021; MSIT, 2022a; Viswanathan & Mogensen, 2015). Consequently, mobile communication network operators (MNOs) are exploring opportunities in innovative, convergent industries by leveraging their existing wireless networks (Alsaeedy & Chong, 2020; Hartman et al., 2023; Jang & Baek, 2022; MSIT, 2022b; Park & Kim, 2022).

Starting with analog service in 1984, South Korea (henceforth referred to as Korea) completed frequency auctions in 2018, and in April 2019, launched the world's first 5G service (KT, 2018; MSIT, 2020; Yeo et al., 2022). The allocated frequencies for 5G total 2680 MHz, comprising 280 MHz at the 3.5 GHz band for business-to-customer (B2C) purposes and 2400 MHz at the 28 GHz band for business-to-business (B2B) applications. As of December 2023, Korea boasts 32 million 5G subscribers, accounting for 39% of all mobile subscribers (MSIT, 2021; MSIT, 2024; Opensignal, 2022).

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However, in contrast to the adoption of 4G LTE, achieving over 20 million 5G subscribers took an additional 1.6 years, and the proliferation of 5G subscriptions has been slower than anticipated. In 2019, Korea Telecom (KT) projected that 5G would function as a general-purpose technology, catalyzing convergence industries and predicted to generate socio-economic impacts totaling 30.3 trillion Korean Won (KRW, approximately $23.3 billion) in 2025, and 47.8 trillion KRW ($36.8 billion) in 2030 (KT, 2018). At that time, Korea introduced 5G services to explore new vertical industries through integration with smart factories, digital healthcare, immersive content, autonomous vehicles, smart cities, and urban air mobility (ITU-R M.2083, 2015; Kim & Kim, 2023; MSIT, 2021). Nonetheless, contrary to initial projections, the development of these vertical industries lagged due to poor service quality, the lack of pivotal services, and limited investment in facilities to invigorate the B2B sector (Ghildiyal et al., 2023; MSIT, 2022a; Yeo et al., 2022). Thus, five years after the introduction of 5G, there is an imperative need for research to analyze the current state of implementation relative to the original plan and to address any emerging challenges.

In this paper, we focus on the two principal convergence industries: smart factories and digital healthcare. We employ the Business Model Canvas (BMC) framework, which has gained widespread adoption (Afuah & Tucci, 2001; Osterwalder & Pigneur, 2010; Savastano et al., 2023; Song & Jang, 2019; Zott & Amit, 2007), to assess the business model (BM) and current progress. Accordingly, we begin by analyzing the influx of new 5G users and reviewing the implementation status of wireless networks by MNOs.

The rest of this paper is organized as follows: Section 2 examines the conceptual definitions of BM and BMC and reviews prior research on BMs for 5G mobile communication services. Section 3 describes the research methodology and diagnostic framework used to investigate the 5G vertical industries. This section also highlights the research's context and main contributions. Section 4 discusses the value chain of the mobile communication services industry and summarizes the technical features involved in delivering 5G services, and it evaluates the current 5G situation in Korea. Section 5 analyzes the main deactivation factors and presents the BMC for the smart factory and digital healthcare industries, explaining its application in assessing the current status of 5G relative to the original plans. This section also discusses key considerations for advancing to B5G and 6G services. Finally, Section 6 offers conclusions and future research directions, including the limitations of this study.

2. Literature review

First, all the literature and data referenced in this study are summarized. Next, to assess the current state of 5G service provision, the concept of BM is clarified. Recent research trends on BMs in the 5G and 6G contexts are also discussed. Additionally, the BMC is utilized as an effective tool for analyzing the vertical industries supported by the 5G wireless network.

2.1. References and data

Table 1 provides a synthesis of the studies referenced in this investigation. Moreover, data from the Internet, newspapers, and relevant companies and institutions were analyzed to assess the current status of vertical industries.

2.2. Business model

The term 'business model' emerged in the late 1990s when American Internet companies began to patent their business concepts (Afuah & Tucci, 2001; Timmers, 1998). Table 2 presents various definitions of the BM to date. Timmers (1998) describes the electronic commerce BM as an architecture integrating the flow of products, services, and information, and outlines the roles of various stakeholders involved. Johnson et al. (2008) characterize the BM as a narrative describing how firms create and deliver value to customers and how they generate revenue, specifying four critical components: customer value proposition, profit formula, key resources, and key activities. Subsequently, attribute analysis for BM has been applied across diverse industries (Alsaeedy & Chong, 2020; Christopher & Manuela, 2018; Lee, 2023; Lee & Kim, 2023; Oughton et al., 2018; Truong & Nguyen, 2024). Osterwalder and Pigneur (2010) delineate the business through nine building blocks and visualize these blocks on a single canvas to facilitate stakeholder discussions and provide a comprehensive understanding of BMs.

Fig. 1 illustrates the relationship between the nine building blocks proposed by Osterwalder and Pigneur (2010) and BM (Chen, 2022; Moradi et al., 2021; Moreno-Cardenas et al., 2024). The six principles (why, who, what, how, where, when) establish the BM, each translating into a building block of BMC. For instance, "who" aligns with customer segments, and "where" denotes the channels. The "why" describes a narrative on how a company generates profits and how it creates and delivers value to its target customers, as defined in the BM by Johnson et al. (2008). A detailed description of the nine building blocks follows.

2.3. Business model canvas

With the rise of Internet companies, the concept of BM has gained prominence. It is now utilized across various industries, with a consensus that innovation in BMs significantly impacts corporate performance, as evidenced by diverse studies. The BMC, developed by 470 experts globally through collaborative efforts from the initial plan, is a tool used for analyzing BMs efficiently. It organizes all business analysis results in one comprehensive canvas and applies accumulated expertise to real-world practices. Fig. 2 presents the BMC framework, which consists of nine blocks. The value proposition is central; key activities, key resources, and key partnerships on the left; customer segments, customer relationships, and channels on the right; and the cost structure and revenue streams at the bottom.

The nine components of BMC are described as follows.

(1) Customer segments (CS) focus on specific groups by identifying which customers generate value, thereby defining which key customer groups to concentrate on and which to exclude from business considerations.
(2) Customer relationships (CR) define the type of relationships to foster with each customer segment, influencing customer acquisition, retention, and sales initiatives.
(3) Channels (CH) outline the methods for providing communication and delivering goods or services, showing how to convey value to customers.
(4) Value proposition (VP) articulates a mix of goods or services tailored to meet the needs of a specific customer segment. It categorizes the attributes of value into quantitative (price, speed, etc.) and qualitative (design, customer experience, *etc.*).
(5) Key activities (KA) are categorized into production, problem-solving, platforms, and networks, representing essential project tasks required to manage a business effectively.
(6) Key resources (KR) are the most vital assets required for smooth business operation and encompass material, intellectual, human, and financial resources.

Table 1
Summary of references.

References		Main contents
Business model	Afuah and Tucci (2001), Johnson et al. (2008), Lee (2023) Lee and Kim (2023), Magretta (2002), Rappa (2004) Timmers (1998), Truong and Nguyen (2024), Zott and Amit (2007)	BM's definition and application of BM in the mobile communications and various industries
Business Model Canvas	Chen (2022), Lee and Rim (2013), Moradi et al. (2021) Moreno-Cardenas et al. (2024), Osterwalder and Pigneur (2010) Savastano et al. (2023), Song and Jang (2019)	The definition and application of BMC in various industries
5G, B5G, and 6G Technology	3GPP (2023), Agarwal et al. (2021), Giordani et al. (2020) ITU-R M.2083 (2015), ITU-R M.2370 (2015)	Technologies for implementing 5G, B5G, and 6G
5G, B5G, and 6G Services & Industries	Ahokangas and Aagaard (2024), Alsaeedy and Chong (2020) Arisar et al. (2024), Bhat and AlQahtani (2021) Christopher and Manuela (2018), Ghildiyal et al. (2023) GSMA (2022), Huawei (2021), Jang and Baek (2021, 2022) Jang et al. (2001), KT (2018), Lee (2021), Makinen (2023), MSIT (2020, 2021, 2024), Opensignal (2022) Oughton and Lehr (2022), Oughton et al. (2018) Samsung Research (2020), Savunen et al. (2023) Shin et al. (2024), Whalley and Curwen (2024), Yeo et al. (2022)	Service provision and industrial trends of 5G, B5G, and 6G
Smart factory	Fatoba et al. (2024), Hartman et al. (2023), MSIT (2022a) Park and Kim (2022)	Service delivery and industrial trends for the smart factory
Digital healthcare	Kim and Kim (2023), MSIT (2022b) Viswanathan and Mogensen (2015), Wu et al. (2024)	Service delivery and industrial trends for digital healthcare

Table 2
Definition of the business model.

Researcher	Definition
Timmers (1998)	The BM delineates the flow of products, services, and information, explaining the various business participants, their roles, and the potential benefits and sources of revenue for these participants. It precisely defines the relationship between the elements of the value chain and the participants.
Afuah and Tucci (2001)	The BM articulates the value an entity provides to customers, the market segmentation used to deliver this value, the range of products and services, the revenue sources, pricing strategies, all relevant activities, and the capabilities for business performance and execution, *etc.* It clearly outlines the perspectives on revenue generation and system operations.
Magretta (2002)	The BM is characterized as being validated through a narrative test to assess if the story is coherent and a numerical test to determine if the business is sustainable and capable of generating revenue. It emphasizes accountability and numerically tested methods for business sustainability and revenue generation.
Rappa (2004)	The BM describes a method for a company to generate revenue and operate sustainably. It focuses on revenue generation, cost management, and the style of the business.
Zott and Amit (2007)	The BM elucidates the content, structure, and governance of transactions aimed at creating business value. It is perceived from a value-creation standpoint.
Johnson et al. (2008)	The BM narrates how companies create and deliver value to customers and generate profits. The four crucial components of the BM are identified as customer value proposition, profit formula, key resources, and key activities. It also clarifies the main components and attributes of the BM.
Osterwalder and Pigneur (2010)	Nine BM building blocks are delineated, and one canvas is sufficient to explain them. This facilitates discussion and fosters an integrated understanding of the BM.

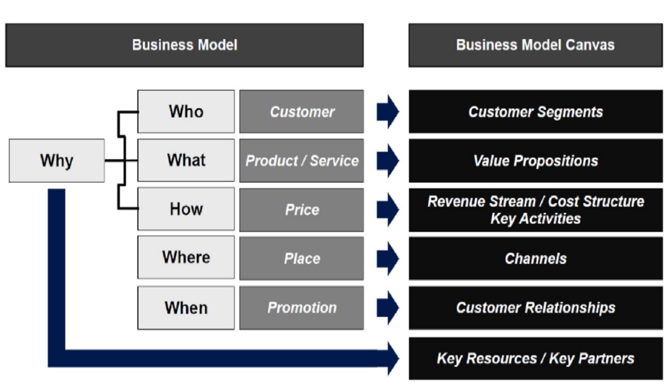


Fig. 1. Relationship between BM and BMC (Chen, 2022; Lee & Rim, 2013; Moradi et al., 2021).

(7) Key partners (KP) pertain to networking arrangements between providers and partners to optimize BMs, reduce risks and uncertainties, secure resources, and facilitate key activities.
(8) Revenue streams (R$) denote the net income a business generates from each customer segment, representing the total revenue after deducting expenses.
(9) Cost structure (C$) details all expenses involved in operating a BM, necessitating an initial assessment of available key resources and the cost of conducting various activities.

2.4. Business model of mobile communication service industry

In the service industry utilizing mobile communication networks, data service provision has become prevalent following 3G,

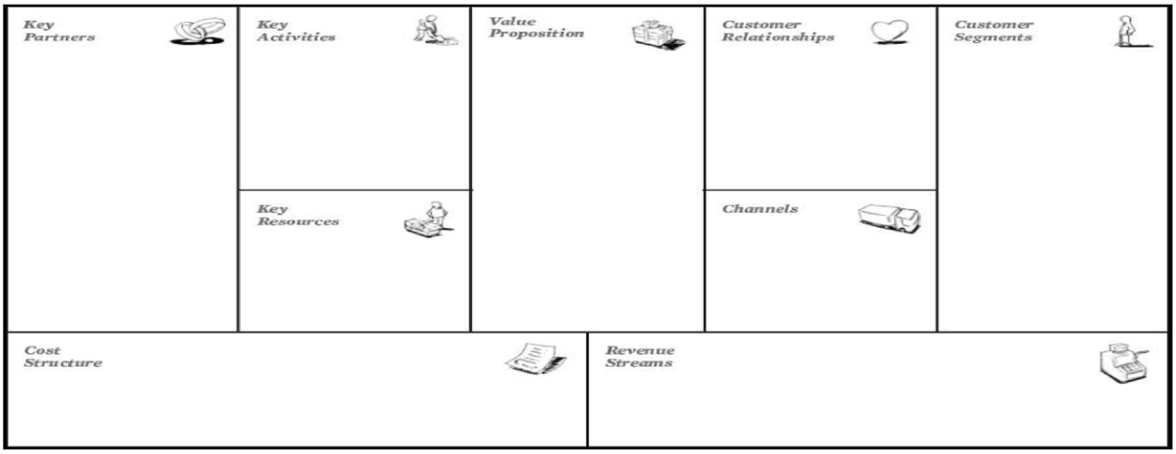


Fig. 2. Business model canvas framework (Osterwalder & Pigneur, 2010; Song & Jang, 2019).

initially starting with voice services (Ahokangas & Aagaard, 2024; Arisar et al., 2024; Jang & Baek, 2021; Oughton et al., 2018). Since the introduction of 5G, mobile communication networks have served as infrastructure for offering convergence (or vertical) services alongside other industries (KT, 2018; Makinen, 2023, pp. 1–47; Shin et al., 2024; Whalley & Curwen, 2024). KT (2018) identified the primary vertical services using 5G networks in Table 3.

Conversely, Shin et al. (2024) and Giordani et al. (2020) identified the principal services of 6G based on scenario-based analyses, which include telemedicine, remote office/school environments, immersive entertainment, intelligent manufacturing, smart grid, smart mobility, and smart healthcare. The primary focus of this research is to diagnose and analyze the foremost 5G vertical services of the smart factory (or intelligent manufacturing) and digital healthcare (or smart healthcare) sectors currently being developed in Korea. The BMs for these core vertical services will be elaborated in Section 5.

3. Research methodology

Fig. 3 illustrates the methodology of this study. It begins by defining the BM and BMC for the 5G mobile communication service industry, selecting two converging industries—smart factory and digital healthcare—as the focal points for analysis. The rationale for their selection is based on the strategic plans to advance 5G, B5G, and 6G as key sectors within Korea.

Initially, the inactivation factors for the two primary vertical industries are analyzed upon establishing the BMC concept for 5G services. To assess the current state of service provision in alignment with the initial plan, three common and four B2B factors are proposed, with a total of seven elements evaluated. The status of service provision is assessed by examining industry-related technologies, policies, and the actual delivery of services. Government

Table 3
5G convergence services.

Service	Key Features	Service	Key Features
Realistic Contents	• Virtual reality (VR), augmented reality (AR), and hologram-based services that enhance immersion and realism. • Pioneering the initial 5G market in the B2C sector, encompassing media and entertainment.	Smart City	• Advancements in traffic control systems. • Utilization of drones and robots for delivery services. • Development of innovative services in transportation and logistics. • Disaster and safety platform services. • High-definition video, precise positioning, rapid accident detection, and real-time on-site response systems.
Smart Factory	• Current construction of wired facilities is being replaced by the low latency and high speed of 5G wireless technology • Enhanced flexibility in manufacturing production lines • Small and medium-sized factories are implementing dynamic manufacturing processes such as multi-species and small-batch production • Enhancing manufacturing with the integration of cooperative robots, cloud computing, and AI connections	Digital healthcare	• Real-time response capabilities for emergency medical care • Enhanced quality of healthcare services • Active continuous monitoring of health conditions • Real-time healthcare delivery through mobile services • Widespread adoption of telemedicine by physicians • Enhanced medical welfare services due to an aging population
Self-driving car	• Utilization of low latency communications including vehicle-to-vehicle and vehicle-to-infrastructure interactions • Sharing of emergency information • Developing infotainment-based self-driving services	Urban air mobility	• Remote control and autonomous flight for drones • Military and hobby drones, intelligent mobile robotic services • Human care, cooperative robotics, disaster relief, and remote surgery • Providing level 4 autonomous driving services

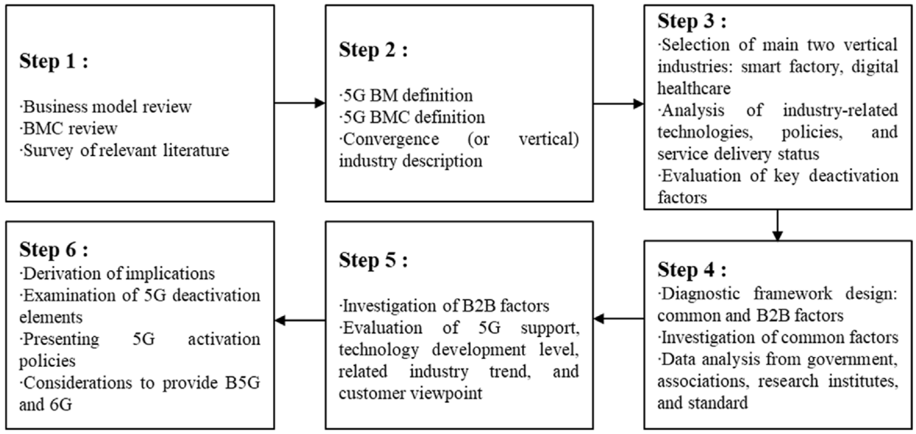


Fig. 3. Research methodology.

agencies, related associations, research institutes, and standardized data are thoroughly reviewed. Subsequently, implications are drawn from these diagnostic and analytical outcomes. After evaluating the 5G inactivation factors, a strategy to energize the 5G, B5G, and 6G industries is proposed. An explanation of the seven diagnostic factors follows in the subsequent section.

3.1. Diagnostic framework

The diagnostic and analytical framework for the smart factory and digital healthcare industries is depicted in Fig. 4. Typically, MNOs deliver communication services by constructing base stations and network infrastructure. To illustrate the commercial relationships between customers (B2C) and related industries (B2B), detailed descriptions are included in the representative services box of Fig. 4. For instance, software companies obtain development fees from smart factories or healthcare institutions by enabling software and service functionalities.

Initially, to diagnose the current state, three common factors are analyzed as follows.

(1) Frequency allocation and network establishment: Conforming to the 5G service standards registered in ITU-R M.2083 (2015), Korea has allocated a total of 2680 MHz, including 280 MHz in the 3.5 GHz band for B2C services and 2400 MHz in the 28 GHz band for B2B purposes. The status of the wireless network's construction using the allocated frequencies is examined.
(2) 5G core technology: The 5G targets high-speed data services, extensive IoT connectivity, ultra-high reliability, and low-

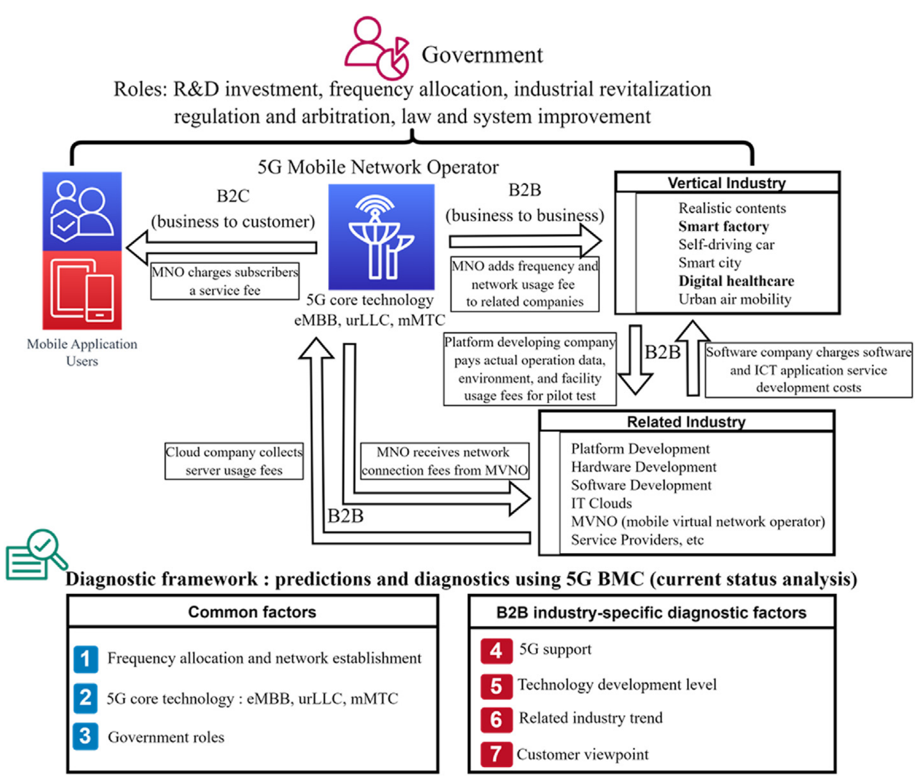


Fig. 4. 5G business model diagnostic framework.

latency communication (ITU-R M.2083, 2015; ITU-R M.2370, 2015). The implementation status of key technologies required to deliver 5G services is assessed.

(3) Government roles: As illustrated in Fig. 4, the government plays a pivotal role in the mobile communication service industry. The government's efforts to stimulate the 5G industry are evaluated, including frequency allocation and enhancements to laws and regulations.

Additionally, as detailed below, four factors related to the B2B industry, where services are delivered through a wireless network constructed by the MNOs, are diagnosed.

(4) 5G support: This factor evaluates the requisite 5G support for providing convergence services. For smart factories, it examines support for data-based optimization operations, flexibility in network establishment, and the provision of ultra-low latency communication. In digital healthcare, it reviews the status of real-time medical monitoring, telemedicine, and data-driven connections.
(5) Technology development level: Generally, smart factory and digital healthcare services utilize local or privately based non-public networks (NPNs). Within the NPN, critical 5G technologies such as network slicing and mobile edge computing (MEC) are employed. This factor also assesses the technology development necessary for vertical services, including the enhancement of machine and mobile robots, and augmented reality in smart factories, as well as the support for big data, artificial intelligence, and blockchain technology in digital healthcare.
(6) Related industry trend: This factor explores the current state of smart factory developments and evaluates the results of standardization and demonstration projects in related sectors. Additionally, it assesses the advancement of healthcare technology and analyzes the industrial trends supporting telemedicine and medical monitoring services.
(7) Customer viewpoint: From a consumer's perspective, this factor examines aspects such as productivity enhancement, sales growth, product defect rates, and cost reduction. It also investigates the advantages of preventive and medical services in the digital healthcare sector.

3.2. Focal research context and its importance

Since Korea was the first to commercialize 5G services globally, the expected level of activation has been slower, potentially impacting the virtuous cycle of the mobile communication industry. The mobile communication sector is crucial to the ICT industry both in Korea and globally. Particularly, the use of 5G in various vertical industries means that delays in activation could significantly affect these sectors. Hence, this study identifies the reasons behind the slow activation of the 5G service industry. The smart factory and digital healthcare sectors, pioneers in integrating 5G for convergence services in Korea, are the focus of this analysis.

To analyze the inactivation factors, the well-known BMC model is utilized, defining three common factors and four industry-specific factors. Various references and empirical data support the theoretical foundation of the BMC and analyze the current status of service provisioning. The significance of this study's findings in terms of theoretical and practical implications is outlined as follows. Employing the theoretical BMC framework and empirical data analysis results from this study, it is feasible to consider prior considerations and implications for B5G and 6G services in the future, along with the preparation of 5G service activation policies.

3.3. Main contributions of research

Contrary to initial expectations, the global number of 5G users is not increasing. Notably, the integration of network slicing and MEC technology within the 5G network is advancing slowly. This study aims to identify a path for service provision in B5G and 6G by diagnosing the reasons for 5G service deactivation and proposing future improvements. Given the extensive use of 5G mobile communication across various industries, delays in activation significantly impact all sectors. Moreover, the deactivation of 5G services may also negatively influence the leadership in B5G and 6G technology development. The primary contributions of this investigation are summarized as follows.

(1) Through empirical analysis, the factors leading to the deactivation of 5G services are evaluated. By thoroughly examining the low service quality, the absence of “killer” services, and the constraints on network facility investments, this study pinpoints areas needing urgent enhancement.
(2) The BMC tool, recently popular for analyzing business models, is applied to assess performance relative to initial plans in the smart factory and digital healthcare industries. Utilizing these results, it is possible to prioritize policies that should receive initial support at both the MNO and governmental levels. Notably, this study pioneers the use of BMC as a business model diagnostic methodology in the field of mobile communication services.
(3) By examining the network establishment and investment status of MNOs in the sector of wireless network facilities and analyzing the current levels of eMBB, URLLC, and mMTC, which are pivotal technologies in 5G, this study identifies crucial improvements needed for the future.
(4) In the smart factory and digital healthcare sectors, technology development trends in the related industries are scrutinized, and enhancements for industrial revitalization are suggested by comparing outcomes to the initial plans. Additionally, this study assesses industry performance from a consumer perspective and highlights the key issues that need addressing.
(5) Finally, the study provides the essential information required to formulate key policies at the government level for the stagnant 5G and the forthcoming B5G and 6G mobile communication service industries.

In summary, the significance of this research is underscored by its theoretical underpinnings and practical implications. Firstly, the BMC theoretical model was applied to identify the primary reasons for the failure in activating the 5G service market, contrary to initial expectations. Secondly, by collecting and analyzing data on the current status of the smart factory and digital healthcare industries, which are developed as key vertical services, deactivating factors are categorized into common and industry-specific factors. Finally, essential implications and government policies required to prevent the recurrence of such errors in the delivery of B5G and 6G services are outlined. These results enable the discovery and support of effective policies, providing new business opportunities for MNOs worldwide, whose markets are experiencing stagnation. This is deemed a critically important research outcome, as the growth of the mobile communication industry significantly impacts other sectors.

4. Mobile communication services industry

In this section, we describe the value chain of the mobile communication services industry and present the technical characteristics of 5G and its current developmental status.

4.1. Value chain of mobile communication services industry

The mobile communication services industry can generally be segmented into three categories: service, network (or equipment), and terminal (Lee, 2021; Lee & Kim, 2023; Oughton et al., 2018). Mobile communication services involve users carrying, moving, or stopping user equipment (UE), and transmitting and receiving voice, data, and videos between a UE and a fixed point or between UEs (Jang & Baek, 2022; Johnson et al., 2008; KT, 2018; Lee, 2021). Historically, services primarily focused on voice and text messaging. Recently, there has been a shift toward data-centric services incorporating video contents. Additionally, there is a growing trend of expanding communication not only between individuals, but also among interconnected devices, commonly known as the Internet of Things (IoTs) (ITU-R M.2370, 2015; Jang et al., 2001; Viswanathan & Mogensen, 2015).

Fig. 5 depicts the value chain of the mobile communication services industry (Christopher & Manuela, 2018; Lee, 2021; Yeo et al., 2022). The network industry focuses on hardware and includes the development, sale, operation, and maintenance of essential equipment like base stations (BSs), systems, and routers needed to set up mobile communication networks. Companies categorized within this network segment include Ericsson, Huawei, Nokia, and Samsung, among others. Although the domestic equipment industry has historically struggled with international competitiveness, making it tough to contend with giants like Ericsson and Huawei, it has shown growth in the overall network manufacturing sector, especially in BS facilities, due to its technological leadership in 5G mobile communication. However, the relay sector, predominantly consisting of small and medium-sized enterprises, faces challenges due to changes in the network structure post the 4G era (Huawei, 2021; Viswanathan & Mogensen, 2015).

Leading terminal manufacturers and sellers of UE (smartphones, tablet PCs, IoT devices, etc.) such as Samsung and Apple provide communication services. In Korea, three MNOs—SKT, KT, and LGU+—have established networks to offer a variety of convergence services, including voice and data. As shown in Fig. 5, the backend industries encompass wired communication networks and cloud services. With the advent of 5G, the cloud industry's role is anticipated to grow significantly. Frontend industries involve platforms (SNS, OTT, etc.) and media channels (drama, music, etc.) that create and distribute digital content.

4.2. Key vertical services of 5G

Smart factories and digital healthcare are identified as the hallmark convergence services in 5G. Fig. 6 illustrates the typical service model in digital healthcare and the crucial technical components necessary for implementing a smart factory.

The following is a summary of the three principal technologies for delivering convergence services.

(1) Mobile edge computing (MEC): MEC is a technology that enables users to experience reduced latency and facilitates real-time services. It enhances data collection, processing, and storage by positioning a server near the user. This approach shortens communication paths and streamlines data handling, consequently reducing communication delays.
(2) Network slicing: 5G services aim to provide all services with diverse characteristics through a single integrated network. Network slicing is a technology that segments the network based on individual service requirements and transforms it into several virtual networks. This technology allows each

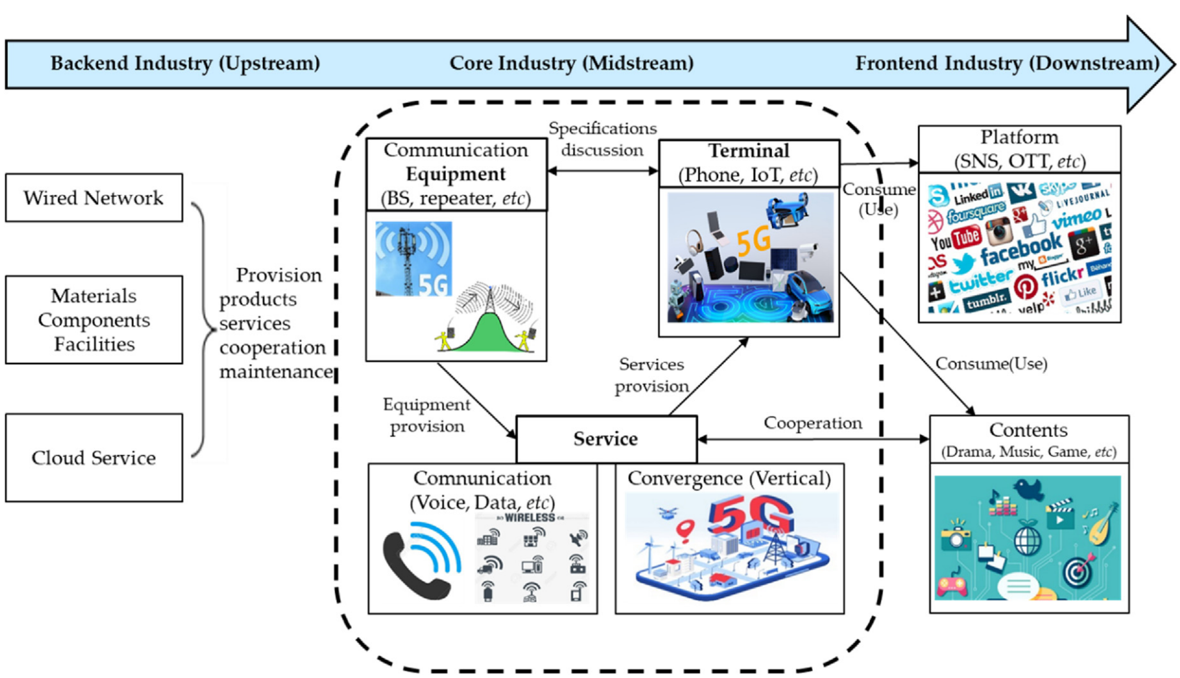
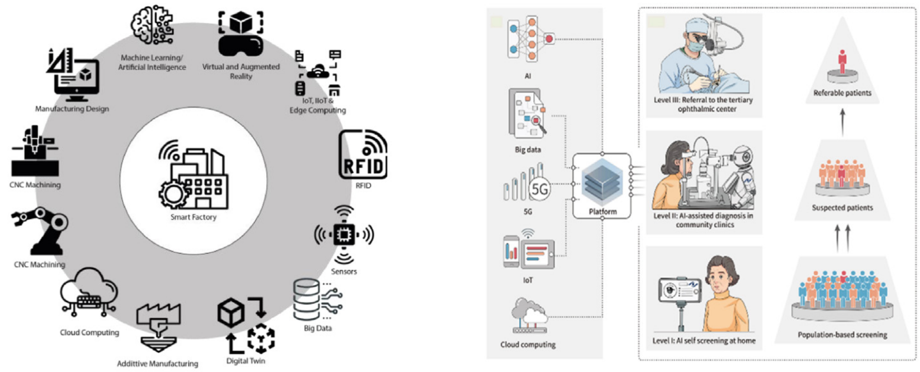


Fig. 5. Value chain of the mobile communication services industry (Lee, 2021; Yeo et al., 2022).



(a) Components of a smart factory (b) Digital healthcare services

Fig. 6. Components of smart factories and digital healthcare services (Fatoba et al., 2024; Wu et al., 2024).

data service to allocate independent network resources and guarantees a minimum quality, unaffected by other services.

(3) Use of millimeter wave band: In the mobile communication industry, the millimeter wave band refers to frequencies of 24 GHz or higher. This band is critical for meeting the high performance and quality demands of 5G services, as it offers a very large spectrum bandwidth suitable for high traffic volumes.

4.3. Current status of 5G

Korea began offering analog services in 1984 and has sustained a robust communication tradition since. Korea was the first country to launch a 5G network and currently offers 5G commercialization services. The official name for what is commonly known as 5G is IMT-2020, designated by ITU and 3GPP (3GPP, 2023; ITU-R M.2083, 2015). The global standard for 5G was established in 3GPP's Release 15 in June 2018. Release 16, in July 2020, focused on the initial commercialization of smart factories and autonomous vehicles, enhancing 5G system performance, and was registered as an official standard by ITU-R. Subsequently, Release 17—announced in March 2022—included convergence services technology advancing beyond 5G commercialization. Release 18 aims to complete the 5G-Advanced standardization by the end of 2023 (3GPP, 2023; ITU-R M.2370, 2015).

The primary specifications to provide 5G services can be summarized as follows.

(1) Enhanced mobile broadband (eMBB): Mobile users should be provided with data rates of up to 20 Gbps on the downlink.
(2) Ultra-reliable and low latency communications (URLLC): Communications are facilitated with 99.999% reliability and a latency of 1 ms (*ms*).
(3) Massive machine-type communications (mMTC): Up to one million devices, including IoTs, can be connected per km^2.

Fig. 7 illustrates the number of mobile subscribers for each generation in Korea (GSMA, 2022; MSIT, 2022b; MSIT, 2024; Opensignal, 2022). The left coordinate indicates the number of users, while the right axis shows the proportion of users by generation for each year. The figure highlights the steady increase in the number of 5G users since its commercialization in 2019. According to a GSMA survey, 8% of global mobile subscribers were using 5G in 2021, and this number is expected to rise to 25% by 2025. In Korea, there were 32.8 million 5G subscribers at the end of December 2023, comprising 39.1% of all mobile users in the country. Since the launch of 5G services, the number of users has grown annually by an average of 70.3%. When comparing the growth rates of 4G and 5G, however, 5G falls significantly short of 4G's growth rate. Specifically, 4G reached 50 million users within four years from 2013, whereas 5G had only 30 million subscribers four years after its introduction in 2019. Notably, the number of 4G users increased in 2023 compared to 2022, a surge that significantly underperformed expectations for 5G growth.

As of December 2023, total 5G traffic reached 874,453 Terabytes (TB), representing 84.2% of the total mobile UEs traffic, and has shown annual increases. The average traffic per 5G user has also risen to approximately 28 GB, which is more than four times the traffic per 4G user of 6.8 GB. Despite the growth in both subscribers and traffic, the rate of increase in the number of 5G users has recently decelerated globally, including in Korea. The primary reasons for this trend will be explored in the subsequent sections.

5. BMC analysis

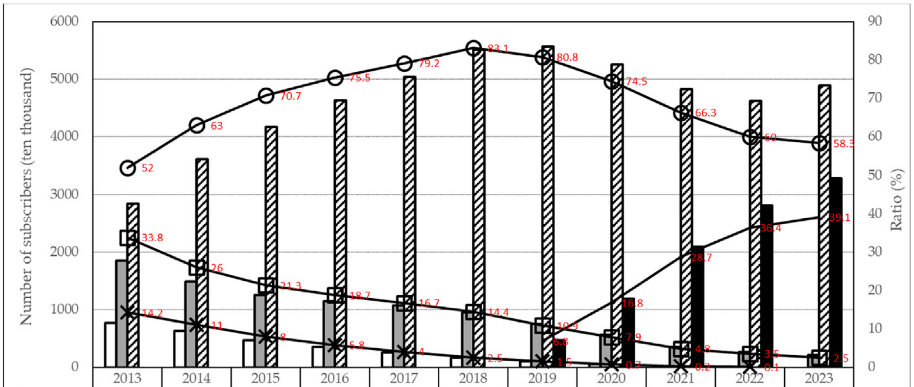
This section discusses the diagnostic results for major issues. It also describes the BMC for 5G core convergence industries, such as the smart factory and digital healthcare, and assesses their current progress.

5.1. Key deactivation factors

The main factors hindering the activation of 5G services include low service quality, the absence of “killer” services, and limited facility investment relative to initial plans, as detailed in the following.

5.1.1. Low service quality

We evaluate service quality by considering the data speed rate, LTE conversion rate, and access time to 5G wireless networks. The theoretical maximum transmission speed for 5G downloads is 20 Gbps. However, Opensignal, a British market research institute, reported a global average download speed of 184.2 Mbps in their 2022 5G Global Awards report. Four years after the commercial launch of 5G in April 2019, Korea has yet to achieve the targeted speed levels. According to findings from the Korea Ministry of Science and ICT (MSIT) (MSIT, 2022b), in October 2021, the average download speed was 801.48 Mbps, while the upload speed averaged 83.01 Mbps. Conversely, the LTE conversion rate, an index that measures the frequency of switching to LTE during data transfer in 5G zones, showed an average conversion rate of 1.88% for downloads. Notably, a lower LTE conversion rate indicates better network performance. Access time, another quality metric, records the



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2G	774	633	471	355	256	167	102	50	17	5	
3G	1849	1487	1254	1144	1066	955	752	560	348	266	213
4G	2845	3609	4169	4631	5044	5513	5569	5256	4829	4622	4895
5G							467	1185	2092	2806	3281
2G(%)	14.2	11	8	5.8	4	2.5	1.5	0.7	0.2	0.1	
3G(%)	33.8	26	21.3	18.7	16.7	14.4	10.9	7.9	4.8	3.5	2.5
4G(%)	52	63	70.7	75.5	79.2	83.1	80.8	74.5	66.3	60	58.3
5G(%)							6.8	16.8	28.7	36.4	39.1

Fig. 7. Number of mobile subscribers and ratio for each generation.

duration for a successful connection by a UE to a 5G network. The average access times were 35.33 ms for downloads and 34.49 ms for uploads.

Survey results (MSIT, 2021; MSIT, 2022b) reveal low user satisfaction with 5G services, with only 23% satisfaction, marking a decrease from previous surveys of 4G and 5G users. Data speed and stability are the principal issues cited for dissatisfaction, as 5G speeds are comparable to LTE speeds, highlighting users' sensitivity to transmission speeds. Among current LTE users, 32% expressed willingness to upgrade to 5G services, a drop from the previously reported 38%. Primarily, high fees are cited as the chief deterrent to adopting 5G. Therefore, data speeds and costs are identified as the main barriers to the expansion of 5G services.

5.1.2. Absence of “killer” services

To date, the primary business models of MNOs have centered on selling subscriptions to UEs based on user traffic usage. Historically, subscriber numbers increased during the 2G, 3G, and 4G eras, particularly during the 2G era with the shift from analog to digital signals. In the 3G era, core services evolved from voice to data, leading to the widespread adoption of smartphones in the 4G era. However, due to the saturation of UE markets and the prevalence of unlimited data plans, MNOs are now seeking new revenue streams through 5G. Although fixed wireless access services have been introduced via a specialized 5G network, they have not proven to be a consistently profitable business model for mobile carriers. Consequently, a definitive “killer” profit model for 5G has not yet emerged, resulting in cautious investment by mobile carriers.

5.1.3. Sluggish facility investment

BSs need to be constructed nationwide to enhance 5G coverage. However, MNOs are hesitant to invest adequately in 5G due to uncertainties, such as users' questionable willingness to pay and a lack of initial demand. As of October 2021, the average 5G coverage in 85 Korean cities was 19,044.04 km^2, administered by three MNOs. A disparity exists in 5G coverage between urban and rural areas, with BSs predominantly constructed in metropolitan areas. Furthermore, each MNO was assigned a target of 100,000 network construction units in the 28 GHz band in 2018, with a forecast to achieve 15,000 units by 2021. However, by April 2022, only about 11% of this target appeared to have been met. Continuing at this rate, it is doubtful that the mandatory number of BS installations will be achieved by 2023. Additionally, 28 GHz, belonging to the millimeter-wave band, requires the installation of more BSs due to its limited reach, thereby increasing construction costs. Until BSs are fully operational, UEs that support 28 GHz are unlikely to be marketed. The lack of adequate facility investment ultimately forces users to experience dissatisfaction with speed and coverage.

Table 4 indicates the predicted and current status of key factors influencing 5G investment. As of December 2021, the deployment of BSs in the 3.5 GHz band for B2C surpassed the target by over 300%, yet the infrastructure for B2B in the 28 GHz band remains drastically insufficient, with only 11% of the plan fulfilled. Furthermore, 5G coverage still stands at 20% of LTE services, indicating that future 5G implementations should prioritize densely populated areas, followed by a nationwide BS construction strategy.

Summarizing the analysis results, the stagnation of 5G services can be attributed primarily to the lack of a “killer” service. It is notable that mobile communication subscribers utilize 5G services for their enhanced data speeds compared to 4G LTE. Specifically, among the eMBB, URLLC, and mMTC standards initially proposed by ITU-R, only eMBB is highly treasured. Contrary to initial expectations, representative and positive business cases for convergence services utilizing 5G have yet to emerge.

5.2. Vertical industrial diagnostics results

The diagnostic results for the smart factory and digital healthcare industry are summarized, highlighting their support as the next generation core convergence industries in Korea.

5.2.1. Smart factory

A smart factory is an intelligent, high-tech factory that is human-centered and leverages ICT technology throughout its manufacturing processes to deliver customized products to each consumer efficiently and economically (Hartman et al., 2023; KT,

Table 4
Diagnostic results for facility investment and government roles.

Main Factors		Predictions and current status
Frequency allocation and network establishment	Predictions	• Total 2680 MHz: 280 MHz (3.5 GHz) + 2400 MHz (28 GHz) • Total frequency usage fee (3.276 trillion KRW): 2.6544 trillion KRW for 3.5 GHz (10 years) and 621.6 billion KRW for 28 GHz (5 years) • Number of BSs (3.5 GHz for B2C): 67,500 units (22,500 × 3 MNOs) • Number of BSs (28 GHz for B2B): 45,000 units (15,000 × 3 MNOs) • Investment exceeds 7.5 trillion KRW for BS construction • Nationwide BS formation targeted by 2030, starting with major cities
	Current status	• Frequency charges total 3.6183 trillion KRW • 11.2% of target for BS construction achieved (May 2022) • 85 cities and 19,044.04 km^2 coverage (20% of LTE coverage as of December 2021)
5G core technology	Prediction	• eMBB: up to 20 Gbps (user experience exceeding 100 Mbps) • URLLC: Less than 1 ms delay in wireless environments • mMTC: A connectivity density of 10^6 per km^2
	Current status	• 801.5 Mbps average download speed, 83.01 Mbps average upload speed • 0.2–5 Gbps for augmented and virtual reality services • 18.61 ms average delay (1 ms in radio, but tens of *ms* including network end-to-end)
Government roles	Prediction	• Deregulation and supportive measures to revitalize the 5G industry • Frequency allocation and R&D investment
	Current status	• Frequency allocation for 28 GHz canceled • Support and promotion of beyond 5G frequencies

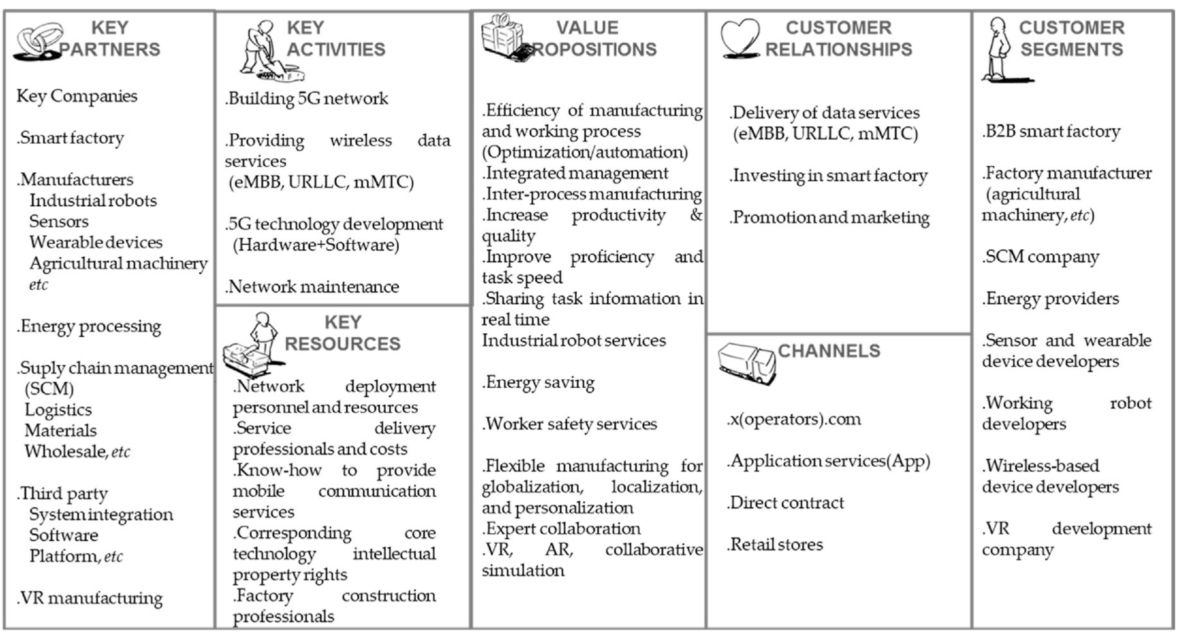


Fig. 8. BMC for smart factory.

2018; Park & Kim, 2022). Recently, many advanced countries have established and operated smart factories that utilize cutting-edge ICT technologies such as big data, IoT, AI, and cloud computing, fostering innovation in the manufacturing sector. These factories demonstrate various benefits through empirical evidence, including integrated facility management, enhanced productivity, and energy conservation. Fig. 8 illustrates the BMC for the smart factory. This study defines seven blocks for the BMC, excluding the cost structure (C$) and revenue streams (R$).

Wire-based facilities that are already established can be converted to wireless facilities leveraging 5G's ultra-high speed and low latency, enhancing the operation of flexible manufacturing and production lines. Particularly for small and medium-sized factories, manufacturing innovation is feasible with the integration of collaborative robots, cloud computing, and AI services, accommodating frequently changing processes and constraints such as mass production of varied varieties.

Table 5 presents the diagnostic outcomes concerning the current state and future predictions based on the BMC shown in Fig. 8. The KT projected that the numbers of smart factories would reach 20,000 by 2025 and 29,375 by 2030 (KT, 2018). Since 2020, the proliferation of smart factories has been notable in Korea, with a total of 13,503 operating as of October 2022, comprising 13,129 small and 374 medium-sized enterprises. In industry sectors, automotive and trailer manufacturing lead with 1666 facilities, followed by machinery and equipment with 1,289, metal processing products with 596, rubber and plastic products with 442, and electrical equipment with 424. With support from the smart manufacturing unit and center (MSIT, 2022a), Korea is advancing projects such as constructing digital twins and smart base block modular facilities, establishing demonstration plants with cutting-edge technologies like M2M, and focusing on standardization,

Table 5
Diagnostic results for smart factory.

Key Factors	Prediction and current status	
5G support	Prediction	• Expansion of data utilization, including optimization based on data. • Growth of real-time connectivity capacity, encompassing network deployment flexibility and ultra-low latency communication.
	Current status	• Lack of support for core technology caused by delays in developing 28 GHz-based technology. • Delays in providing ultra-low latency communication, such as MEC services.
Technology development level	Prediction	• MEC technology development and service delivery. • Develop network slicing technology and services. • Develop machine vision, mobile robots, and AR technologies.
	Current status	• MEC-based systems for some companies (food factories, *etc.*) • Delays in the provision of network slicing-related technologies. • Delays in the development of indoor equipment such as MEC, machine vision, and mobile robots.
Related industry trend	Prediction	• Optimization, flexibility, and collaboration in manufacturing processes. • Flexible production systems interconnect manufacturing processes across factories.
	Current status	• 13,503 smart factories constructed since SKT's inauguration. • Technology development, standardization, and demonstration projects are centered around the smart manufacturing group, highlighting collaboration limitations. • Demonstration plant operations utilize digital twin, block modular, and M2M technologies.
Customer viewpoint	Prediction	• Increased productivity (sales), reduced defect rates, and cost savings are major benefits. • 5G-based wireless connectivity and VR (AR) services facilitate collaboration.
	Current status	• Primarily at the level of demonstration projects with minimal ripple effects. • Wired-based connections and limited use cases for wearables.

demonstration, performance evaluation, and workforce training. Regarding the deployment status, the number of smart factories is anticipated to reach the levels forecasted by 2025. Nonetheless, Table 5 indicates that critical technologies including MEC, network slicing, machine vision, mobile robots, and AR, required for factory development, are still at the demonstration and performance evaluation stage. Consequently, it can be concluded that the evaluation in aspects such as automation, productivity enhancement, and cost reduction in smart factories is considerably below initial expectations.

5.2.2. Digital healthcare

Digital, or smart, healthcare refers to the sector involving the management of personal health and medical information, healthcare systems, devices, and platforms, integrating medical IT with health-related services (Kim & Kim, 2023; Viswanathan & Mogensen, 2015). It also encompasses a human care ecosystem that provides personalized healthcare services and analyzes health examination data, lifestyle, medical utilization, and genetic information gathered from wearable and portable devices or cloud-based hospital systems. As depicted in Fig. 9, digital healthcare can connect a greater number of smart devices through hyper-connected services enabled by 5G technology, allowing individuals to obtain precise diagnoses and prescriptions anytime and anywhere.

Moreover, reliable telemedicine services are planned to be provided through a system stabilized by 5G network slicing technology. Recently, the convergence of ICT technology and industry around big data has blurred the boundaries between the ICT and healthcare sectors. In Korea, it is projected that the proportion of the population aged 65 years or older will surpass 20% by 2025, leading to a super-aged society (MSIT, 2020). Globally, the aging population, rising healthcare costs, and a shortage of healthcare professionals have emerged as significant social issues. Consequently, to address these challenges, some countries are relaxing healthcare regulations and promoting industries, thereby aiming to foster and enhance the healthcare sector.

Starting with a healthcare development strategy based on the

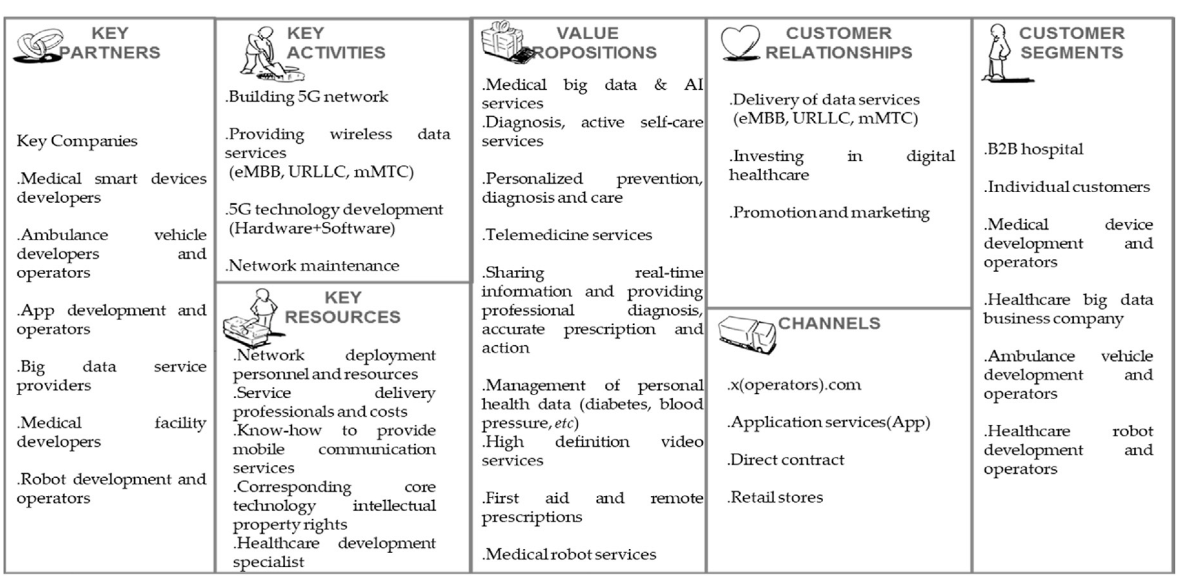


Fig. 9. BMC for digital healthcare.

Table 6
Diagnostic results for digital healthcare.

Factors	Prediction and current status	
5G support	Prediction	• Increased data usage including real-time monitoring and tracking • Increased real-time connectivity capacity, encompassing remote connections and operations • Expanded data utilization such as optimization based on big data
	Current status	• 5G-based flexible medical platform technology expected to be developed by 2026 • Demonstration of a 5G-based AI emergency medical system to ensure timely care in all emergency environments
Technology development level	Prediction	• Advances in healthcare, including cancer diagnosis, exercise prescription, and telemedicine services, utilizing AI, big data, and blockchain • 3rd party benefits from cost savings in pharmaceutical companies' R&D
	Current status	• Focusing on the development of new drugs or treatments • Some investments of big-tech companies in new businesses such as healthcare, AI platforms for cancer diagnosis, and intact care, *etc* • Limitations of direct-to-customer (D2C) business growth due to regulations
Related industry trend	Prediction	• Delivery of preventive healthcare technology, telemedicine, and monitoring services • Reduced R&D costs including tri-phase experiments and insurance costs
	Current status	• Intelligent healthcare services report the largest sales of 752.6 billion KRW, with most industries remaining small • Average business duration for companies is 5.9 years • Since 2016, 218 companies have entered the market, demonstrating high growth potential • Securing business rights through strategic investments by traditional pharmaceutical companies • Development of AI medical solutions and eco-services by Naver and Kakao
Customer Viewpoint	Prediction	• Benefits from preventive public healthcare and the enhancement of patient response services • Reduced life insurance costs due to new drugs and treatments
	Current Status	• Challenges remain unresolved in public sector support, including issues related to disaster, safety, welfare, and environment • Operation of a public healthcare center since 2019 • Lack of indicators such as mobile app service at public health centers, and a 75-point scale for service satisfaction evaluation • Limitations in revising medical laws and provisions for MyData services

fourth industrial revolution in 2017, Korea announced 10 major tasks in the healthcare industry in 2022 and is advancing governance and system enhancements to strengthen medical and ICT convergence industries (MSIT, 2022a; MSIT, 2024). The diagnostic results for digital healthcare are summarized in Table 6.

According to the MSIT, the domestic digital healthcare industry was valued at 1.9 trillion KRW (approximately $1.7 billion) in 2018. The market is segmented by mobile healthcare at 18.8%, health analysis at 17.4%, telemedicine at 14.9%, and digital systems at 13.7%. Since KT only predicted strategic and operational benefits in the public healthcare sector during the initial project estimation, a higher growth rate was anticipated for these four areas. The investigation results (MSIT, 2022b) indicate that the domestic market's growth rate is assessed at 15.3% over five years, and Korea accounts for less than 1% of the global market (with an 18.8% growth), hence a market-based strategy in the global market is urgently needed above all.

Recent trends indicate that the global market is undergoing reorganization around major corporations such as Apple, Amazon, Google, Microsoft, Alibaba, Fitbit, and Cerner. However, in Korea, the market primarily focuses on securing stakes and business rights in healthcare companies through strategic investments by some pharmaceutical firms, with a greater emphasis on the core business of developing new drugs or therapeutic agents rather than on active investments in the digital healthcare sector. Conversely, major technology companies have recently begun investing in the healthcare industry by providing AI medical solutions and establishing medical service ecosystems. Notable examples include Naver and Kakao, which have broadened their operations by launching internal startups (referred to as company-in-company, or CIC) in areas such as AI-based senior healthcare, exercise prescription solutions, cancer diagnosis treatment, and electronic medical record services. Through CICs, they are also expanding investments into new fields like dementia prevention, medical data and software platforms, non-invasive treatments, and prescription drug delivery services.

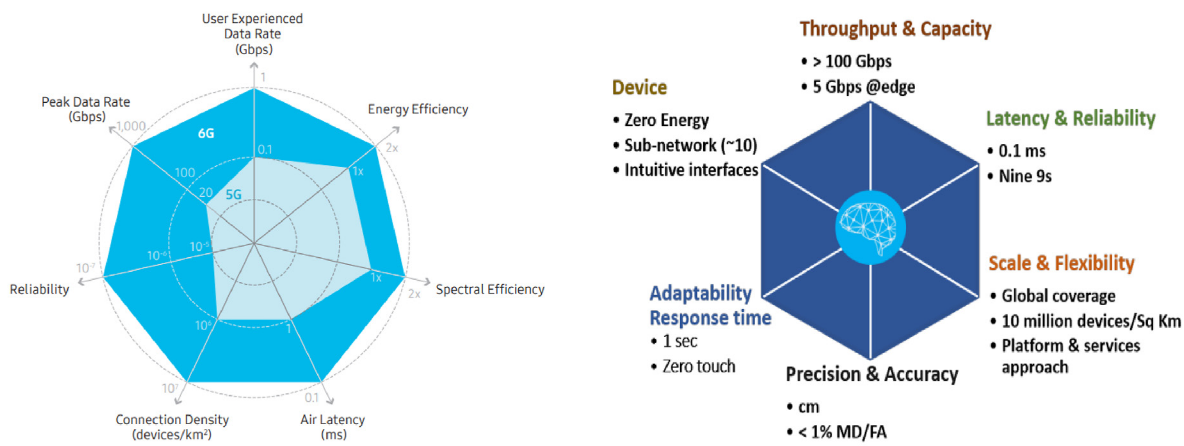
To rejuvenate the digital healthcare industry, it is imperative that laws and regulations be amended. For instance, in the sphere of D2C, which is thriving overseas, the growth of such businesses in Korea is hindered by regulations on telemedicine, prescription drug delivery, and personal medical information management. As a result, it is challenging to provide direct medical services, hence services such as health supplement sales, hospital referrals, or treatment reservation applications are implemented indirectly. Moreover, there are limitations to leveraging fully operational telemedicine platforms. Socio-economic impact analysis results (KT, 2018) suggest that the domestic market achieved sales of 1.35 trillion KRW in 2020, but 53.4% of firms with sales under 500 million KRW and 72% with fewer than 30 employees are still categorized as small businesses. Surveys conducted by the government (MSIT, 2022a; MSIT, 2022b) reveal that companies engaged in healthcare operations encounter numerous challenges, including a constrained market environment, stringent regulations, difficulties integrating innovative services within health insurance frameworks, and a shortage of skilled professionals.

5.3. Considerations to develop B5G and 6G and technical performance requirements

Table 7 presents urgent tasks within the smart factory and digital healthcare sectors. In the smart factory, advanced technologies and services such as MEC, machine vision, mobile robots, digital twins, and AR are necessary for industrial hubs. Additionally, it is crucial to develop technologies to enhance AI and big data-driven collaboration, optimization, and flexible production systems. Tasks such as enhancing safety facilities in the workplace and supporting eco-friendly manufacturing processes are also essential. In the digital healthcare industry, the development of original technologies is needed to progress 5G-based AI and big data-focused medical services. Importantly, healthcare services that address safety, welfare, natural environment, and security concerns in the public sector are critical. Technologies need to be established in public healthcare that include managing the golden time for emergency patients and expanding medical services to remote areas. Most importantly, the government must make timely and significant investments and revise laws and regulations in

Table 7
Key tasks in the smart factory and digital healthcare domains.

5G Services	Major Tasks
Smart Factory	• MEC, machine vision, mobile robot, digital twin, AR technology, and service development • Development and support of 5G-based factory infrastructure, solutions, and platforms • Cost savings through collaborative manufacturing processes, real-time demand responsiveness, flow, and optimal production systems • Provision of AI and big data-driven services • Development of wearable devices, AR and VR equipment, system monitoring, and control facilities
Digital healthcare	• Advanced 5G-based AI and big data-driven medical services • Fostering small businesses and investing in big tech companies • Advancing healthcare in the public sector while addressing safety, welfare, environmental, and security issues • Revision of medical laws to ensure universal medical services and the use of MyData • Securing the golden time for emergency patients and providing remote medical support services • Government investment in and improvement of relevant laws and regulations



(a) 5G·6G technical requirements (b) 6G key requirements

MD: missed detection, FA: false alarm

Fig. 10. Technical requirements for 5G-6G service delivery (Agarwal et al., 2021).

scenarios where MNOs face challenges making new investments due to the absence of “killer” services.

Fig. 10 displays a comparison of the key 5G technical requirements with the anticipated performance indices for 6G (Agarwal et al., 2021; ITU-R M.2083, 2015).

The main features of 6G can be summarized as enhanced compared to 5G.

(1) For 6G, the expected maximum peak data rate is 1 Tbps, at least 20 times that of 5G, and a user-experienced rate of 1 Gbps which is 10 times that of 5G. Such transmission speeds would facilitate immersive multimedia services including extended reality and holograms.
(2) Improving latency relative to 5G is essential for telemedicine and autonomous vehicles. 6G aims to significantly reduce latency to one-tenth that of 5G, achieving a transmission delay of only 100 µs (μs).
(3) Unlike 5G, which solely evaluates the delay time of the wireless component, 6G considers the end-to-end delay. For the first time, a delay jitter of 10^{-3} *ms* and a packet error rate of 10^{-7} have been determined.
(4) In terms of device connectivity, while 5G accommodates one million devices per km^2, 6G aims to connect 10 million devices per km^2.
(5) While 5G supports a UE moving speed of 500 km/h, 6G will accommodate up to 1000 km/h, doubling the speed.

6G is anticipated to launch commercial services between 2028 and 2030. Developing new technology to deliver 6G's core services, distinct from those of 5G, is crucial. Specifically, the creation of compelling “killer” services that consumers recognize and supporting business models are necessary. Moreover, to facilitate the integration of B5G and 6G networks, it is vital to clearly develop representative business cases and introduce “killer” applications beforehand. Without addressing these issues, similar challenges are likely to recur in both B5G and 6G networks in the future.

6. Conclusions

6.1. Summary of results

This study evaluated the successes and challenges of South Korea, the first nation to provide 5G services globally, and offered key insights to effectively deliver beyond 5G and 6G services. By December 2023, the number of 5G subscribers had increased by an average of 70.3% annually, accounting for 39.1% of all mobile users. However, this growth rate is slower compared to that of 4G LTE. Three main factors were identified as causes: inadequate service quality, a lack of core services, and slow network development. Notably, the deployment of 5G base stations (BSs) in the 3.5 GHz range surpassed 300% of the planned number, yet 28 GHz BSs, essential for supporting convergence services across industries, only reached 11% of their target. Consequently, the allocation for the 28 GHz frequency was discontinued, necessitating the immediate preparation of strategic alternatives to provide eMBB, URLLC, and mMTC services, which are fundamental to 5G.

Currently, the Korean government is exploring various options to rejuvenate the convergence-related industry. It is also formulating an investment strategy, prioritizing sectors such as smart factories, digital healthcare, realistic content, autonomous vehicles, smart cities, and urban air mobility for future growth with 5G•6G. For smart factories and digital healthcare, Business Model Canvas (BMC) frameworks were proposed, and their implementation status was compared to initial projections. The findings indicate that critical ultra-low delay communications, vital for smart factories, have not been implemented due to developmental delays in 28 GHz and mobile edge computing technologies. The present count of 13,000 smart factories falls short of original expectations in terms of optimization, efficiency, and operational flexibility. Additionally, the healthcare sector is currently limited to pilot projects for mobile medical platforms and AI systems designed for emergency response, adhering only to sandbox-level regulations. Most crucially, the immediate need is to revise medical laws and regulations and to implement telemedicine services using MyData.

Based on the findings of this study, it is feasible to pinpoint key issues for consideration in advancing beyond 5G and 6G technologies and in delivering future “killer” services. In the current global stagnation of user growth, it has been confirmed that previously established tasks and solutions can be leveraged when developing convergence industries utilizing mobile communication networks. It is also deduced that pivotal tasks needed to reinvigorate the industry can be pinpointed to preemptively provide 6G services. Future research will introduce a plan to launch 6G services, augmented by BMC studies for 6G.

6.2. Research limitations and future study

Utilizing the empirical analysis results, it is possible to identify factors leading to the deactivation of 5G services and to formulate major policies for activating B5G and 6G services in the future. Specifically, a detailed industrial diagnosis using BMC for the first time in the mobile communication industry indicates that a more comprehensive analysis is achievable. At this juncture, with the global increase in mobile communication subscribers stagnating, further research into the 6G business model for providing convergence services through advanced mobile networks is necessary.

In this study, “killer” services were not identified as the primary factor for 5G deactivation, highlighting the need for preliminary research to define the research limitations and prepare industrial revitalization policies for areas such as the smart factory and digital healthcare sectors. Specifically, “killer” applications for convergence services need to be identified, and both the utility of services and business economics must be evaluated. Moreover, research should be undertaken to establish the comparative advantage of utilizing B5G and 6G networks over existing WiFi and FTTx networks. If B5G and 6G convergence services face technical challenges or delays in commercialization, alternatives using WiFi and FTTx should be considered viable. In essence, even with the future launch of B5G and 6G services, limitations will persist in business use of mobile communication networks unless “killer” applications for convergence services and adequate business cases are developed.

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