The Strategic Impact of 5G/6G on Business Transformation: Opportunities, Challenges, and the Future of Connectivity

ISBN: 978-1-943295-24-1

Huzaib Shafi Shah
Rajendra Gupta
Rabindranath Tagore University
(huzaibshafishah+aims@gmail.com)
(rajendra.gupta@aisectuniversity.ac.in)

5G has enabled advancements in automation, IoT, and real-time communication, and 6G is poised to enhance connectivity with AI integration, terabit speeds, and ultra-low latency. In this paper, we examine the transformative effects of 5G and 6G technologies on the business landscape, highlighting their roles in driving innovation across manufacturing, healthcare, and logistics industries. We further explore the economic impact, new business models, and challenges related to infrastructure costs and cybersecurity to offer insights into how these technologies will shape the future of global business and digital transformation.

Keywords: 5G, 6G, Business Impact, Industry 4.0, Smart Cities, Economic Impact

1. Introduction

1.1 Background and Context

5G transformed mobile network capabilities, bringing unprecedented speed, reliability, and low latency, enabling applications across various sectors. 5G networks are reshaping manufacturing, healthcare, and transportation industries by facilitating automation, IoT, and smart city applications. In the meantime, the early visions for 6G are even more ambitious, targeting integrated AI-driven network management, ultra-high data rates, and sustainability goals aligned with global objectives such as the United Nations Sustainable Development Goals (Ojutkangas et al., 2022). This evolution will change the business operation, creating new opportunities, challenges, and market dynamics.

1.2 Importance of 5G/6G in Business

5G is transforming industries by enabling higher data capacities supporting innovative services such as virtual and augmented reality (VR/AR), autonomous vehicles, and real-time cloud computing (Petri Ahokangas et al., 2024). These technologies pave the way for Industry 4.0, emphasizing the digitization and interconnection of production systems. As companies begin leveraging 5G, the subsequent rollout of 6G will drive even more impactful shifts. 6G's vision, among others, includes real-time digital twins, ubiquitous connectivity, and intelligent decision-making through advanced AI integration (Akbar et al., 2022). These features will be crucial for maintaining global competitiveness and sustaining long-term growth.

1.3 Research Aims and Objectives

In this research, we primarily aim to explore and evaluate the impact of 5G and 6G on the business world, focusing on technological, economic, and operational changes. The objectives of this paper are:

- To explore the role of 5G/6G in business transformation across healthcare, manufacturing, and smart cities, with a focus on operational efficiency, automation, and business models.
- To explore the economic impact of 5G/6G on market growth, labor market, operational efficiency, productivity, and strategic business model shifts.
- To identify the challenges, risks, and regulatory implications businesses (might) face while adopting these technologies, including cybersecurity, ethical concerns, and geopolitical factors.

1.4 Scope

Technical advancements have always impacted business processes, leading to adapting business models and productivity enrichments. This paper analyzes how 5G & 6G influence business models, productivity, and the competitive landscape across manufacturing, healthcare, and smart cities.

1.5 Literature Review

1.5.1 Publication Selection Process

Variants and combinations of the keywords 6G, 5G, Open RAN, business models, security, smart cities, industry 4.0, manufacturing, financial, economic, healthcare, regulations, market, automation, business impact, sustainability, productivity, and ethics were used to search for publications on Google Scholar, IEEEXplore, ResearchGate, Semantic Scholar, and Elicit.

The results were sorted by year of publications and reference counts, filtered for multiple keywords in the text, and reviewed further to select the ones documenting anything related to the objectives of this paper.

While only a few, with a focus on any of the sectors/domains/features aimed to look into by this study, were selected for comprehensive review and comparison, many were used to document relevant information about use cases, technologies, and other references in this study.

1.5.2 Review of Prior Publications

(Asghar et al., 2022) review the evolution of wireless communication towards 6G, examining its potential to outdo 5G limitations and drive a paradigm shift in connectivity. The authors discuss key enabling technologies like terahertz and molecular communication. Challenges such as data security, privacy, and ethical considerations are also explored. The paper emphasizes the role of AI, ML, and deep learning as crucial enablers of 6G. (Ahokangas et al., 2023) emphasize the need for a holistic framework to guide the development of 6G. They argue that current research primarily focuses on techno-economic aspects, overlooking crucial considerations such as business models, regulatory aspects, sustainability, and human centricity. The authors propose a multi-perspective, multi-level, and multi-stakeholder approach to envisioning a future-proof 6G. (Alsharif et al., 2024) focus on the potential of 6G wireless networks in revolutionizing Smart Energy Grid Management (SEGM). It examines the vision, enabling techniques, and potential applications of 6G in SEGM, highlighting its ability to enhance scalability, security, real-time monitoring, and dynamic spectrum access. The authors also explore the integration of 6G with blockchain and digital twin technologies for improved grid resilience and reliability. (Asif Raihan, 2023) provides an overview of the implications of AI in 6G wireless communication and discusses recent advances, use cases, and open challenges related to 6G. The author focuses on aspects like robust connectivity, communication latency, edge computing, UAV applications, and security issues. The authors (Jahid et al., 2021) explore the convergence of blockchain, IoT, and 6G technologies, highlighting the potential of blockchain to address challenges related to security, privacy, spectrum resource scarcity, and interoperability in 6G and IoT ecosystems. They discuss the benefits, challenges, and future research directions and emphasize its potential in Industrial IoT and Industry 4.0 applications. The authors (Qadir et al., 2023) provide a comprehensive overview of the 6G Internet of Things, outlining recent advances, use cases, and open challenges. They discuss the evolution of communication networks from 1G to 6G. They highlight the shortcomings of previous architectures and the need for 6G to address the ever-growing demands of wireless communication. They also explore the key enabling technologies like THz communication, VLC, and molecular and quantum communication. (Sharma et al., 2024) examine the role of 6G technologies in advancing smart cities. The authors provide a comprehensive review of potential 6G technologies like THz communication, AI, blockchain, and quantum communication and their potential applications in smart grids, smart healthcare, and smart waste management. The authors also discuss challenges and future research directions for realizing the full potential of 6G in smart cities. Skrzypek in (Skrzypek, 2021) discusses the impact of digitalization on organizational management, focusing on the role of 5G and 6G networks. The author emphasizes the importance of these technologies for businesses to join global networks and highlights the opportunities they create for economic and social development. The paper also acknowledges concerns related to digitalization and stresses the need for increased public awareness. (Sridharan & Govindarajan, 2024) focus on the future of wireless technologies beyond 5G, particularly highlighting the potential of 6G. They discuss the limitations of 5G in handling the increasing data demands of emerging applications and outline the key drivers, enabling technologies, and research challenges associated with 6G. (Yrjölä et al., 2020) examine the role of sustainability as both a challenge and a driver for 6G business strategies. They use an anticipatory action learning approach to develop future scenarios for sustainable 6G, analyzing them from an ecosystemic business model perspective. The research identifies key trends, uncertainties, and their implications for strategic options and business models in the context of 6G and sustainability.

Table 1 compares the publications against the major topics covered. Entries are marked ‘Yes’ if the given publication discusses the topic in detail or touches on it to show a direction of where to know more. From among the publications that discuss Industry 4.0 or Industry 5.0, Table 2 lists the industries touched upon or discussed in detail by those publications. Our study explores all these sectors and industries.

1.6 Market Statistics

Table 1 *Matrix of Addressed Sectors by each Publication*

	About Technology	Business Models / Impact	Industry 4.0 / 5.0	Economic Impact	Policies & Regulations	Future Trends
(Ahokangas et al., 2023)	Yes	Yes	Yes	Yes	Yes	Yes
(Alsharif et al., 2024)	Yes	No	Yes	No	No	Yes
(Asghar et al., 2022)	Yes	No	Yes	Yes	No	Yes
(Asif Raihan, 2023)	Yes	No	Yes	No	No	Yes
(Jahid et al., 2021)	Yes	Yes	Yes	Yes	Yes	Yes
(Qadir et al., 2023)	Yes	No	Yes	No	No	Yes
(Sharma et al., 2024)	Yes	No	Yes	No	No	Yes
(Skrzypek, 2021)	Yes	No	Yes	Yes	No	Yes
(2024)	Yes	No	No	No	No	Yes
(Yrjölä et al., 2020)	Yes	Yes	No	Yes	Yes	Yes

As of the writing of this paper, Custom Market Insights reports the 5G market size to be USD 113.99 Billion in 2023 and projected to be USD 11,948.72 Billion by 2032 with a compound annual growth rate (CAGR) of 65.4%. The forecast period of this report is 2024-2033, with 2023 as the base year, Europe as the largest market, and Asia-Pacific as the fastest-growing market (Katelin Kharrati, 2024). Even though 6G is still in its nascent stages of development, the market for it alone is expected to grow with a CAGR of 35.2% (Katelin Kharrati, 2023). This shows the overall potential that 5G & 6G collectively have and are anticipated to have in the business world over the next few years.

Table 2 *Industries addressed by publications discussing Industry 4.0 / 5.0*

	Smart Cities	Manufacturing	Supply Chain	Healthcare	Automotive	Retail / E-Commerce	Media & Entertainment
(Ahokangas et al., 2023)	Yes	No	No	No	No	Yes	Yes
(Alsharif et al., 2024)	Yes	No	No	Yes	No	No	No
(Asghar et al., 2022)	Yes	Yes	No	No	Yes	No	No
(Asif Raihan, 2023)	Yes	Yes	No	No	Yes	No	No
(Jahid et al., 2021)	Yes	Yes	No	No	No	No	Yes
(Qadir et al., 2023)	Yes	Yes	No	Yes	Yes	No	No
(Sharma et al., 2024)	Yes	Yes	No	Yes	Yes	No	No
(Skrzypek, 2021)	No	Yes	Yes	No	No	No	No

2. Evolution of Mobile Networks: From 5G to 6G

2.1 Overview of 5G Technology

The fifth-generation mobile network, 5G, has revolutionized telecommunications by enhancing speed, reducing latency, and improving connectivity. It operates in three distinct frequency ranges, viz: low-band, mid-band, and high-band (millimeter waves), making data speeds from 100 Mbps to 20 Gbps possible, with low latency (Taofeek Olayinka Agboola et al., 2024). These data rates enable real-time communication, making 5G a critical enabler for Industry 4.0 applications like IoT, smart cities, autonomous vehicles, cloud computing, etc. The capability of 5G networks to accommodate connected devices, is about one million devices per square kilometer, making it ideal for dense urban environments (Sharma et al., 2024).

2.2 6G Vision and Emerging Technologies

The sixth-generation mobile network (6G) is predicted to emerge better than 5G in terms of speed, latency, and connectivity, among other features. 6G is expected to enable AI-powered, real-time decision-making across many devices and businesses (Musa, 2023). 6G will provide peak data speeds of up to 1 terabit per second while maintaining extremely low latency (Akbar et al., 2022). These advancements will improve capabilities for real-time immersive experiences and ultra-reliable low-latency communication (URLLC), which are necessary in areas such as healthcare, education, and entertainment. 6G is projected to include quantum communication technology, which will improve security and data integrity in communications (Sharma et al., 2024).

Sustainability is a requirement in modern networks. The 6G strategy prioritizes sustainability and energy efficiency to meet the growing demand for green communication systems. With intelligent energy management, 6G is expected to reduce the carbon footprint of telecommunications infrastructure by utilizing renewable energy sources and energy-efficient network designs (R. Kumar et al., 2023).

2.3 Comparison Between 5G and 6G

5G was, in itself, a big leap from 4G in terms of speed, latency, and device connectivity. The jump to 6G is expected to further enhance these metrics. Table 3 summarizes the main differences between 5G & 6G.

Table3 *Comparison between 5G & 6G*

Feature	5G	6G
Data Rate	Up to 20 Gbps	Upto 1 Tbps
Latency	Millisecond (ms)	<1 ms
Frequency	Sub-6 GHz, mmWave	Sub-THz, THz
Energy Efficiency	1000x compared to 4G	10x compared to 5G
Mobility	350 km/h	>1000 km/h
Traffic density	10Tb / s / sqkm	>100Tb / s / sqkm
Spectrum efficiency	3-5x compared to 4G	>3x compared to 5G

As 5G brought a transformative shift from 4G, 6G is expected to introduce revolutionary capabilities such as AI integration, enabling fully autonomous systems and devices. 5G primarily introuced support for enhanced mobile broadband (eMBB), massive machine-type communication (mMTC), and URLLC. 6G is expected to take it to the next level by facilitating services like intelligent networked systems and machine learning models integrated into the communication

frameworks (Ahammed et al., 2023). These new features will enable more accurate predictions, real-time analytics, and autonomous network management, thus enhancing overall operational efficiency across industries.

Sustainability is a requirement in modern networks. 5G brought some improvements in energy efficiency, but 6G will focus on eco-friendly solutions and integrate energy-harvesting technologies & renewable energy sources into network operations(Chauhan et al., 2024) (Alsharif et al., 2024). This will help mitigate the increasing environmental impact of large-scale telecom deployments.

3. Business Transformation through 5G/6G

3.1 Digital Transformation Across Industries

In the context of Industry 4.0, 5G provides the backbone for real-time automation, robotics, and machine learning applications that rely on massive machine-type communications (mMTC) and ultra-reliable low-latency communication (URLLC). 6G, with its promise of ubiquitous AI integration and even greater data transmission capacities, is expected to revolutionize these transformations by enabling AI-driven decision-making in real time (Aagaard, 2024).

The impact of 5G and 6G extends to digital transformation strategies, particularly in terms of cloud computing and the Internet of Things (IoT). 5G networks allow for seamless interconnectivity between devices, supporting more advanced cloud services and IoT solutions that drive efficiency and innovation in industrial processes (R. & Chavhan, 2022). 6G's anticipated ability to process terabits of data per second, along with its real-time digital twin capabilities (Lin et al., 2023), will further enhance automation, optimization, and predictive analytics across industries, pushing digital transformation to new heights.

3.2 5G/6G in the Context of Industry 4.0

Industry 4.0, characterized by smart factories, IoT, and the fusion of digital and physical worlds, has found its technological enabler in 5G. 5G's support for automation, advanced manufacturing, and predictive maintenance has already begun reshaping production processes. Example: 5G's low-latency communication allows for precise control of robotic systems in real-time, furthering the development of intelligent production systems (Beshley et al., 2023).

Intelligent production systems are expected to bring a revolution to industries. 6G is anticipated to build on this foundation by incorporating AI and machine learning capabilities right into network infrastructure. 6G, like 5G, will have computing capacity available closer to the edge. Intelligent systems can analyze data, make decisions, and fine-tune production parameters in real-time and can be deployed across the network. These intelligent systems will enable autonomous factories to function with marginal human participation. Other features that 6G brings to the table include the support for holographic communication, enabling remote & immersive control of production processes & systems. Enabling the systems to benefit from those, 6G is expected to facilitate deeper integration between humans & machines in Industry 4.0 environments (Gera et al., 2023).

3.3 5G/6G and Smart Cities

Telecommunications have a strong impact on the development of smart cities. 5G, along with other technologies, has enabled the deployment of sensors and IoT devices across urban environments, facilitating the efficient management of resources such as energy, transportation, and public services. These grids enhance the ability to monitor, manage, and optimize city infrastructure in real-time, contributing to the development of more sustainable, resilient, and connected cities (Chauhan et al., 2023).

Monitoring a simulated network and replaying events to recreate scenarios makes monitoring, investigation, and problem-fixation faster and easier. Digital twins have been popularized in various fields. 6G networks are set to further transform smart cities by enabling innovative features like the real-time digital twin concept, where cities will have digital models of physical infrastructure that are constantly updated and monitored(Lin et al., 2023). This capability will allow city planners and operators to simulate and optimize urban operations, from traffic management to energy distribution. Following on the capabilities brought in by previous generations, 6G's enhanced AI-driven systems will also enable more autonomous city services. It'll include automated transportation systems and intelligent waste management, furthering the vision for smart cities (Gera et al., 2023).

3.4 Innovation in Business Models

Business models are the basis of the economy for any company. 5G and 6G are not only transforming operations within industries but are also catalyzing innovation in business models. The flexibility and scalability provided by network slicing in 5G allow businesses to offer new, customized services to different market segments, especially in industries like telecommunications, healthcare, and entertainment. Network slicing enables multiple virtual networks to run on the same physical infrastructure, supporting various services with distinct requirements, such as high bandwidth for streaming and low latency for critical applications (Huang et al., 2023).

AI, blockchain, and IoT have been trending in their own spaces. 6G's integration of advanced AI and blockchain technologies promises even more disruptive business models. A network leveraging all three can work wonders. AI will be embedded into networks, enabling predictive maintenance, optimizing supply chains, and providing enhanced customer experiences through data-driven insights. Blockchain, combined with AI and IoT, will facilitate secure, decentralized transactions, paving the way for digital market platforms where businesses can offer highly tailored services based on real-

time data analytics (Gera et al., 2023). These innovations will force the organizations to reconsider their business strategies and offer better value propositions in a digital-first economy.

4. Key Industry Use Cases of 5G/6G

4.1 Manufacturing and Supply Chain

Technology, in general, has always had a major impact on the manufacturing and supply chain sectors. Telecommunications have played a critical role in bringing about drastic changes in these sectors. 5G in conjunction with other technologies has already shown transformative potential in the manufacturing and supply chain sectors by enabling the creation of smart factories that rely on automation, IoT, and real-time data analytics. With 5G's URLLC & mMTC in place, industries are capable of leveraging autonomous robotics, predictive maintenance, and highly efficient inventory management systems (Beshley et al., 2023). As we move towards 6G, this transformation is expected to deepen with the integration of AI and real-time digital twins. These technologies will allow manufacturers to monitor entire production lines remotely and adjust processes on the fly, ensuring seamless and uninterrupted operations.

Similar to the disruptive changes in manufacturing, supply chains will also benefit from 6G's enhanced connectivity. Blockchain technology integrated with 6G networks could enable real-time tracking of goods and verification of authenticity, improving transparency and reducing the risk of fraud or counterfeiting in global trade networks (Rojek et al., 2024). The increased automation and coverage facilitated by 6G will result in streamlined, highly efficient logistics and supply chain operations.

4.2 Healthcare

We have already seen a disruptive trend in healthcare. Proof-of-concept remote surgeries have already been demonstrated. Complex surgeries often require highly experienced and accomplished surgeons who cannot travel everywhere, given the demand for their skills at their place of employment. 5G has enabled those technological advancements relying on high-speed, low-latency communications using which these remote surgeries are possible and can be made available to far-off remote areas without the necessity of having the patient travel thousands of miles to meet the right surgeon. 6G will take these capabilities further by providing higher data rates and ultra-low latency to operate such systems. Furthermore, with the support for holographic communication and real-time 3D models for remote surgeries, facilitating more complex procedures, and improving the precision of medical interventions is better possible (Alsamh et al., 2024).

Self-diagnosis using smart devices has already shown benefits in the real world. 6G networks will further enable AI-driven diagnostic tools that analyze patient data in real-time, providing personalized treatment plans and early diagnosis capabilities. Additionally, 6G's low latency and high bandwidth will ensure that large amounts of data, such as genomic information or real-time MRI scans, can be processed instantly, enabling more efficient medical research and development. (A. Kumar, 2023)

4.3 Automotive and Transportation

Autonomous vehicles, self-driving capabilities, and smart transportation systems have already made it to the use of the general public. The automotive industry is undergoing a revolution with the adoption of 5G, which is facilitating the development of autonomous vehicles and smart transportation systems. 5G networks enable vehicle-to-everything (V2X) communication, where vehicles interact with infrastructure, other vehicles, and pedestrians, enhancing road safety and traffic efficiency (R & A, 2023). Yet again, 6G will enhance these capabilities by integrating AI to create intelligent transportation systems that can dynamically adjust traffic flows, optimize routes, and reduce congestion in real-time.

Moreover, 6G's ultra-low-latency data transfer could allow remote driving capabilities, where operators can control vehicles from miles away in real time (Kakkavas et al., 2024). The enhanced connectivity and data processing capabilities of 6G will play a pivotal role in fully autonomous and connected transportation networks, transforming both public and private transport systems.

4.4 Retail and E-Commerce

Innovations in the e-commerce sector have always been at the forefront of every generation of mobile communications. The retail and e-commerce sectors are benefiting from 5G-enabled innovations such as augmented reality (AR) and virtual reality (VR) shopping experiences, allowing consumers to try on products virtually and interact with 3D models before making a purchase (Thomas, 2024). 6G will enhance these experiences by introducing real-time holographic displays and immersive shopping environments.

Extending the features from other sectors, 6G will also revolutionize supply chains within e-commerce by enabling faster, more efficient logistics and inventory management. Logistics systems will be impacted by AI-powered systems that will optimize shipping routes, predict consumer demand, and enable dynamic pricing based on real-time data. This real-time adaptability will make e-commerce more responsive and customer-centric (Rojek et al., 2024).

4.5 Media and Entertainment

The media and entertainment industries are rapidly transforming with the adoption of 5G, which allows for faster streaming, enhanced gaming experiences, and the rise of cloud-based platforms. 5G networks enable the seamless delivery of high-definition content, VR, and AR experiences, which are increasingly becoming mainstream (Pappala, 2024).

As 6G emerges, these experiences will become more immersive, with the potential for real-time holographic communication, ultra-high-definition streaming, and interactive virtual environments. 6G's low latency and high-speed capabilities will enable new forms of content consumption. That'll include virtual concerts, 3D live sports broadcasts, and deeply interactive media experiences (Bekaroo & Dawarka, 2023). This shift will redefine how media is produced, distributed, and consumed.

5. Economic Impact of 5G/6G on Business

5.1 Productivity Gains and Operational Efficiency

5G has already demonstrated its potential to boost productivity and operational efficiency across industries by enabling automation, real-time data exchange, and improved connectivity. With faster data transmission rates and lower latency, businesses can enhance processes like predictive maintenance, remote monitoring, and automation in manufacturing (Eric Yeatman et al., 2023). For example, in logistics, 5G with IoT supports the optimization of supply chains by offering real-time tracking of goods, reducing downtime, and minimizing operational inefficiencies.

6G, as discussed in previous sections, is expected to build on these gains by offering even greater bandwidth and ultra-low latency. It'll thus enable real-time digital twins, where businesses can create digital replicas of their operations for enhanced control and predictive analysis. This will allow companies to detect inefficiencies, reduce downtime, and optimize processes in real time, leading to significant productivity improvements. Furthermore, integrating AI in 6G networks will streamline decision-making processes and reduce manual interventions, thereby enhancing overall operational efficiency.

5.2 Job Market and Skills

While 5G and 6G technologies offer opportunities for increased efficiency, they will also disrupt the job market. The automation enabled by these technologies could lead to job displacement in sectors reliant on manual labor, such as manufacturing and logistics. However, these same industries will also witness the creation of new roles, particularly in areas related to digital technologies, data science, AI, and cybersecurity (Sulaimon A Melemuku, 2023).

The shift to 5G and eventually 6G will require significant upskilling and reskilling of the workforce to meet the demand for expertise in IoT, machine learning, and advanced data analytics. Governments and educational institutions must play an active role in facilitating this transition, ensuring that the workforce is prepared for the new technological landscape (Aluvala, 2024). Moreover, 6G's AI-driven operations will require new job roles in the oversight and management of autonomous systems.

5.3 Market Growth and Investment Opportunities

Telecommunications have always enabled better economy and investment opportunities. New technological companies have always found the base with telecommunication services and rely on the Internet. The economic potential of 5G and 6G is vast, with market analysts forecasting significant growth in sectors such as telecommunications, manufacturing, healthcare, and smart cities. 5G is expected to contribute trillions of dollars to the global economy over the next decade by enabling new services and industries (Forge & Vu, 2020). The continued evolution to 6G will only enhance these opportunities by enabling advanced applications such as holographic communication, AI-powered automation, and real-time data processing.

While investments are attracted by sectors with better connectivity, it is important to take a note about realizing the potential of 5G & 6G networks. Investment in infrastructure is critical to the realization of 5G and 6G's economic benefits. Telecom operators, governments, and private companies are expected to invest heavily in building the necessary infrastructure for these networks (Forge & Vu, 2020). Additionally, 6G will open new markets for products and services that leverage ultra-fast connectivity and AI, from real-time healthcare diagnostics to advanced manufacturing solutions.

5.4 Challenges and Risks for Businesses

As discussed in previous sections, the benefits of 5G and 6G are substantial. However, there are challenges and risks for businesses as well. One of the primary risks is the high cost of infrastructure deployment and the potential for unequal access, particularly in rural or less economically developed areas. Additionally, the rapid pace of technological advancements may lead to increased obsolescence of current systems, requiring businesses to upgrade their networks and equipment to remain competitive constantly (Chauhan et al., 2024).

Security has always been a concern with technology as it increases the potential for attacks. Pertinently, cybersecurity is another significant concern as 5G/6G networks increase the number of connected devices and data points, thereby expanding the attack surface for cyber threats. Businesses will need to invest in robust cybersecurity measures to protect sensitive data and prevent potential breaches (Petri Ahokangas et al., 2024). Moreover, navigating the regulatory landscape, particularly around data privacy and international standards, will be critical for businesses operating in multiple regions.

6. Policy, Regulation, and Ethical Considerations

6.1 Government Policies and Regulations

Telecommunications are the backbone of any country, necessitating the need for better policies and regulations. The rollout of 5G and the anticipated dawn of 6G has placed telecommunications policy at the forefront of national and international agendas. Governments worldwide are defining policies that aim to amplify the technological potential of 5G & 6G while

upholding national interests. The regulatory frameworks focus on spectrum allocation, infrastructure investments, and ensuring network security. For instance, many countries are pushing for the development of Open Radio Access Networks (ORAN) to avoid vendor lock-in and enhance security through diversified infrastructure, and the same is already extensively witnessed in 5G (John Lee et al., 2022).

6G's networks will support a vast array of critical industries such as healthcare, transportation, and smart cities. Due to that, its impact on global communications will require international cooperation on spectrum management, data privacy, and cybersecurity. Policymakers will need to balance innovation with security concerns, particularly as 6G integrates AI and quantum computing technologies, which may raise new challenges for data governance (Mischa Dohler & Dimitra Simeonidou, 2021).

6.2 Ethical Implications of 5G/6G

Like every other technology and the previous mobile network generation, ethical considerations are always to be accounted for. And the ethical considerations of 5G/6G networks are multifaceted, touching on issues such as data privacy, cybersecurity, and the social implications of AI-driven automation. With 6G networks predicted to integrate vast amounts of personal data, the ethical management of this information becomes crucial. While policies like the European Union's General Data Protection Regulation (GDPR) regulation exist, governments and businesses must address how personal and sensitive data is collected, stored, and shared, ensuring users retain control over their digital footprints (Ahokangas & Aagaard, 2024).

Furthermore, the automation enabled by AI in 6G may lead to societal disruptions, including job displacement in sectors dependent on human labor. Ethical frameworks must consider the implications of automation on the workforce, advocating for responsible technology use and workforce reskilling initiatives (Kaan Sahin & Tyson Barker, 2021). Furthermore, ethical debates around AI bias, decision-making autonomy, and surveillance in smart cities will become more prominent as 6G enables ubiquitous connectivity. It is worth noting that there have already been concerns about such surveillance raised in many scenarios.

6.3 Global Competition and Geopolitical Implications

The deployment of 5G and the development of 6G have escalated geopolitical tensions, particularly between leading technological powers such as the United States, China, and the European Union. The development of 6G is seen as a strategic priority that could determine future global leadership in digital economies. National security concerns have led to increased scrutiny of supply chains, with many governments excluding specific vendors from their 5G infrastructure due to fears of espionage and cyber threats (John Lee et al., 2022).

These dynamics will intensify as nations race to secure technological leadership and establish global standards for the next generation of networks. Countries like China and the US are already heavily investing in 6G research and development. They perceive the technology to be pivotal for future economic and military superiority (John Lee et al., 2022). This competition may lead to a fragmented global landscape where differing technological standards and regulatory frameworks could hinder global collaboration.

7. Future Outlook and Emerging Trends

7.1 Next-Generation Use Cases

As noted above, the future of 5G and 6G networks promises a transformative impact on various sectors through next-generation use cases that will significantly enhance connectivity and introduce new functionalities. 6G networks, expected to integrate ultra-low latency, higher frequencies, and enhanced AI capabilities, will introduce new paradigms in immersive experiences like holographic communication, extended reality (XR), and real-time digital twins. These use cases will redefine telecommunications and revolutionize the healthcare, education, and manufacturing industries (Vaigandla et al., 2021). Using holographic communication will facilitate real-time collaboration across borders, enabling immersive remote surgeries and virtual meetings in the business world (Sharma et al., 2024).

The Internet of Everything (IoE) is another emerging trend driven by 6G technology. This concept will extend beyond the traditional Internet of Things (IoT) by embedding AI into everyday devices, leading to AI-IoE, and allowing them to self-diagnose and predict future issues. In smart cities, 6G will enable more efficient resource management, autonomous transportation, and enhanced public safety through advanced data analytics (A. Kumar, 2023).

7.2 Predictions for Business Evolution

Businesses are expected to undergo a profound evolution with 6G, marked by greater reliance on AI-driven processes, real-time data analytics, and machine learning. This will have a serious impact on all industries. Industries such as telecommunications, retail, and manufacturing will embrace AI-enabled automation, reducing operational costs and improving decision-making. With the increased network capacity of 6G, businesses will adopt digital twins to simulate and optimize their operations, leading to reducing inefficiencies and improving sustainability (Lin et al., 2023).

Business processes will be impacted, and the swing towards 6G will also necessitate new business models. Network slicing allows the creation of multiple virtual networks tailored to specific business needs. It has already introduced transformative changes in the business processes with the launch of 5G. This capability will enable industries like telecommunications and media to offer differentiated services to their customers. It'll thus drive new revenue streams and enhance customer experience (Huang et al., 2023).

7.3 Research and Development Challenges

With potential benefits, significant challenges need to be navigated for all the new technologies for adoption. While the potential benefits of 6G are vast, there are significant challenges in its development. One of the primary challenges is spectrum scarcity. 6G networks will operate at frequencies above 100 GHz. It'll need new techniques for spectrum management to avoid interference and ensure efficient data transmission (Chowdhury et al., 2020). The deployment of 6G networks will require enormous infrastructure investments. It'll include advanced base stations, fiber optic networks, and low-orbit satellites to ensure ubiquitous coverage.

Security and privacy are also critical concerns in any telecommunications development. The spread of AI-enabled devices and data-intensive applications will expand the attack surface for cyber threats. Addressing these vulnerabilities will necessitate robust encryption methods, AI-based security solutions, and collaborative international efforts to establish global standards for 6G security (Nguyen et al., 2021).

8. Discussion and Contributions

In this paper, we focus on industries such as manufacturing, healthcare, and smart cities and examine the strategic impact of 5G and 6G on business transformation. 5G is already enabling automation, IoT, and data-driven decision-making in many sectors by facilitating advanced connectivity, ultra-reliable low latency, and substantial increases in data capacity. In the meantime, 6G is being developed to extend these capabilities through AI integration, real-time digital twins, and potential advancements in quantum communication, holding the promise of even greater industry shifts. While this study offers valuable insights into both 5G's established impact and 6G's potential, it is also speculative regarding the latter. The implications of 6G's high-speed connectivity and AI integration are explored in various contexts, such as remote surgeries in healthcare and autonomous systems in smart cities. We suggest significant operational gains and efficiency improvements. This study also explores challenges, such as cybersecurity vulnerabilities and infrastructure costs, highlighting potential barriers to adoption.

This paper contributes to the literature on giving a holistic view of business transformation by synthesizing the strategic implications of 5G and 6G across several key industries. It identifies the anticipated advancements in connectivity, operational efficiency, and new business models. By examining the benefits and challenges across multiple sectors, the paper offers a comprehensive overview that could guide researchers, policymakers, and business leaders in strategizing for future network deployments and studies.

9. Limitations and Future Research Opportunities

While 5G has seen widespread adoption by countries across the globe, 6G is still in its nascent stages of development. This positions limitations on the study as the predictions regarding 6G's prospective applications are speculative and based on emerging research (Uusitalo et al., 2021). There are constraints associated with the rapidly evolving nature of these technologies, and the regulatory frameworks governing their use may differ across regions, therefore impacting this study's generalizability. We primarily rely on current projections and theoretical advancements in 6G, as the technology is still in development. Consequently, findings related to 6G are speculative and should be interpreted as hypothetical scenarios rather than confirmed outcomes. Additionally, the scope spans several industries, leading to broad rather than deep insights across each. Another limitation is the lack of empirical data and case studies, which restricts the paper's capacity to provide validated insights. Moreover, since technological advancements and regulatory frameworks differ by region, the generalizability of the findings is somewhat limited.

Further research could focus on case studies of organizations that have adopted 5G to evaluate real-world impacts, challenges, and return on investment. As 6G technology matures, longitudinal studies will be essential to test the proposed benefits and evaluate the extent of its adoption across different sectors. Future studies should analyze the technical challenges of implementing 6G, such as spectrum management and AI integration, alongside regulatory implications, particularly in areas like data privacy and cybersecurity. Given 6G's capacity for pervasive connectivity, exploring ethical considerations related to data privacy, AI-driven decision-making, and potential job displacement would be highly relevant.

10. Conclusion

In this paper, we underscore the transformative potential of 5G and 6G in shaping the future of business. 5G is already enabling significant advancements across industries by facilitating automation, real-time analytics, and seamless IoT integration. Looking forward, 6G technology promises to enhance these capabilities with ultra-fast connectivity, real-time digital twins, and AI-driven autonomous systems, driving a new era of digital transformation. However, the path to realizing 6G's potential is fraught with challenges, from high infrastructure costs to cybersecurity concerns. The paper highlights that, while 5G adoption has already begun reshaping industries, 6G's impact remains speculative yet promising. Future research, case studies, and pilot projects will be essential to validate these findings, guiding both academia and industry in harnessing the full potential of next-generation connectivity.

11. References

1. Aagaard, A. (Ed.). (2024). Business Model Innovation: Game Changers and Contemporary Issues. Springer International Publishing. https://doi.org/10.1007/978-3-031-57511-2

2. Ahammed, T. B., Patgiri, R., & Nayak, S. (2023). A vision on the artificial intelligence for 6G communication. ICT Express, 9(2), 197–210. https://doi.org/10.1016/j.icte.2022.05.005
3. Ahokangas, P., & Aagaard, A. (Eds.). (2024). The Changing World of Mobile Communications: 5G, 6G and the Future of Digital Services. Springer International Publishing. https://doi.org/10.1007/978-3-031-33191-6
4. Ahokangas, P., Matinmikko-Blue, M., & Yrjola, S. (2023). Envisioning a Future-Proof Global 6G from Business, Regulation, and Technology Perspectives. IEEE Communications Magazine, 61(2), 72–78. https://doi.org/10.1109/MCOM.001.2200310
5. Akbar, M. S., Hussain, Z., Ikram, M., Sheng, Q. Z., & Mukhopadhyay, S. (2022). 6G Survey on Challenges, Requirements, Applications, Key Enabling Technologies, Use Cases, AI integration issues and Security aspects (Version 2). arXiv. https://doi.org/10.48550/ARXIV.2206.00868
6. Alsamh, M. H., Hawbani, A., Kumar, S., & Hamood Alsamhi, S. (2024). Multisensory Metaverse-6G: A New Paradigm of Commerce and Education. IEEE Access, 12, 75657–75677. https://doi.org/10.1109/ACCESS.2024.3392838
7. Alsharif, M. H., Jahid, A., Kannadasan, R., & Kim, M.-K. (2024). Unleashing the potential of sixth generation (6G) wireless networks in smart energy grid management: A comprehensive review. Energy Reports, 11, 1376–1398. https://doi.org/10.1016/j.egyr.2024.01.011
8. Aluvala, Prof. R. (2024). Monumental Transition From 5G To 6G: Skill Development Needs And Workforce Evolution Imperative. Educational Administration: Theory and Practice, 13699–13706. https://doi.org/10.53555/kuey.v30i5.5986
9. Asghar, M. Z., Memon, S. A., & Hämäläinen, J. (2022). Evolution of Wireless Communication to 6G: Potential Applications and Research Directions. Sustainability, 14(10), 6356. https://doi.org/10.3390/su14106356
10. Asif Raihan. (2023). An Overview of the Implications of Artificial Intelligence (AI) in Sixth Generation (6G) Communication Network. Research Briefs on Information and Communication Technology Evolution, 9, 120–146. https://doi.org/10.56801/rebicte.v9i.164
11. Bekaroo, G., & Dawarka, V. (2023). AI-Assisted Extended Reality Toward the 6G Era. In D. A. Milovanovic, Z. S. Bojkovic, & T. P. Fowdur, Driving 5G Mobile Communications with Artificial Intelligence towards 6G (1st ed., pp. 403–423). CRC Press. https://doi.org/10.1201/9781003205494-14
12. Beshley, M., Klymash, M., Scherm, I., Beshley, H., & Shkoropad, Y. (2023). Emerging Network Technologies for Digital Transformation: 5G/6G, IoT, SDN/IBN, Cloud Computing, and Blockchain. In M. Klymash, A. Luntovskyy, M. Beshley, I. Melnyk, & A. Schill (Eds.), Emerging Networking in the Digital Transformation Age (Vol. 965, pp. 1–20). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-24963-1_1
13. Chauhan, D., Mewada, H., Gondalia, V., Almalki, F. A., Patel, S., Modi, H., Kavaiya, S., Trivedi, Y., & Mujlid, H. M. (2024). Balancing Technological Innovation and Environmental Sustainability: A Lifecycle Analysis of 6G Wireless Communication Technology. Sustainability, 16(15), 6533. https://doi.org/10.3390/su16156533
14. Chauhan, D., Sharma, S., & Singh, V. (2023). Roadmap from 4G to 6G in Smart Cities Impact and Challenges. International Journal of Wireless and Microwave Technologies, 13(6), 39–50. https://doi.org/10.5815/ijwmt.2023.06.05
15. Chowdhury, M. Z., Shahjalal, Md., Ahmed, S., & Jang, Y. M. (2020). 6G Wireless Communication Systems: Applications, Requirements, Technologies, Challenges, and Research Directions. IEEE Open Journal of the Communications Society, 1, 957–975. https://doi.org/10.1109/OJCOMS.2020.3010270
16. Eric Yeatman, Chris Tucci, & Marika Iivari. (2023). Sectoral Systems of Innovation and the UK's Competitiveness: The UK Telecommunications Sector. Imperial College London. https://www.imperial.ac.uk/media/imperial-college/research-and-innovation/the-forum/public/Sectoral-Systems-of-Innovation_Telecommunications_June-2023.pdf
17. Forge, S., & Vu, K. (2020). Forming a 5G strategy for developing countries: A note for policy makers. Telecommunications Policy, 44(7), 101975. https://doi.org/10.1016/j.telpol.2020.101975
18. Gera, B., Raghuvanshi, Y. S., Rawlley, O., Gupta, S., Dua, A., & Sharma, P. (2023). Leveraging AI-enabled 6G-driven IoT for sustainable smart cities. International Journal of Communication Systems, 36(16), e5588. https://doi.org/10.1002/dac.5588
19. Huang, S.-Y., Chen, C.-Y., Chen, J.-Y., & Chao, H.-C. (2023). A Survey on Resource Management for Cloud Native Mobile Computing: Opportunities and Challenges. Symmetry, 15(2), 538. https://doi.org/10.3390/sym15020538
20. Jahid, A., Alsharif, M. H., & Hall, T. J. (2021). The Convergence of Blockchain, IoT and 6G: Potential, Opportunities, Challenges and Research Roadmap (arXiv:2109.03184). arXiv. http://arxiv.org/abs/2109.03184
21. John Lee, Meia Nouwens, & Kai Lin Tay. (2022). Strategic Settings for 6G: Pathways for China and the US. https://www.iiss.org/globalassets/media-library---content--migration/files/research-papers/2022/08/strategic-settings-for-6g-pathways-for-china-and-the-us.pdf
22. Kaan Sahin & Tyson Barker. (2021). Europe's Capacity to Act in the Global Tech Race (Report No. 6, 44 pp.; DGAP). https://dgap.org/en/research/publications/europes-capacity-act-global-tech-race
23. Kakkavas, G., Diamanti, M., Karyotis, V., Nyarko, K. N., Gabriel, M., Zafeiropoulos, A., Papavassiliou, S., & Moessner, K. (2024). 5G Perspective Of Connected Autonomous Vehicles: Current Landscape and Challenges Toward 6G. IEEE Wireless Communications, 31(4), 299–306. https://doi.org/10.1109/MWC.014.2300277
24. Katelin Kharrati. (2023). Global 6G Market Size Likely to Grow at a CAGR of 35.2% By 2033 [Press Release]. https://www.custommarketinsights.com/press-releases/6g-market-size/
25. Katelin Kharrati. (2024). Global 5G Technology Market Size Likely to Reach at a CAGR of 65.4% By 2033 [Press Release]. https://www.custommarketinsights.com/press-releases/5g-technology-market-size/

26. Kumar, A. (with Jain, R., Gupta, M., & Islam, S. M. N.). (2023). 6G-Enabled IoT and AI for Smart Healthcare: Challenges, Impact, and Analysis (1st ed). Taylor & Francis Group.
27. Kumar, R., Gupta, S. K., Wang, H.-C., Kumari, C. S., & Korlam, S. S. V. P. (2023). From Efficiency to Sustainability: Exploring the Potential of 6G for a Greener Future. Sustainability, 15(23), 16387. https://doi.org/10.3390/su152316387
28. Lin, X., Kundu, L., Dick, C., Obiodu, E., Mostak, T., & Flaxman, M. (2023). 6G Digital Twin Networks: From Theory to Practice. IEEE Communications Magazine, 61(11), 72–78. https://doi.org/10.1109/MCOM.001.2200830
29. Mischa Dohler & Dimitra Simeonidou. (2021). FROM 5G TO 6G GOVERNANCE [Policy Paper]. University of Bristol. https://www.bristol.ac.uk/media-library/sites/engineering/research/smart-internet-lab/From%205G%20to%206G%20Governance%20Paper.pdf
30. Musa, A. (2023). History of security and privacy in wireless communication systems: Open research issues and future directions. In A. L. Imoize, C. Meshram, D.-T. Do, S. Kadry, & L. Muthukaruppan (Eds.), Security and Privacy Schemes for Dense 6G Wireless Communication Networks (pp. 31–60). Institution of Engineering and Technology. https://doi.org/10.1049/PBSE021E_ch2
31. Nguyen, V.-L., Lin, P.-C., Cheng, B.-C., Hwang, R.-H., & Lin, Y.-D. (2021). Security and Privacy for 6G: A Survey on Prospective Technologies and Challenges. IEEE Communications Surveys & Tutorials, 23(4), 2384–2428. https://doi.org/10.1109/COMST.2021.3108618
32. Ojutkangas, K., Rossi, E., & Matinmikko-Blue, M. (2022). A deep dive into the birth process of linking 6G and the UN SDGs. Telecommunications Policy, 46(1), 102283. https://doi.org/10.1016/j.telpol.2021.102283
33. Pappala, S. (2024). The Transformative Impact of 5G Technology on Industrial Automation, Gaming and Entertainment, Healthcare, and Autonomous Vehicles. 13(7). https://doi.org/10.15680/IJIRSET.2024.1307062
34. Petri Ahokangas, Annabeth Aagaard, Irina Atkova, Seppo Yrjölä, & Marja Matinmikko-Blue. (2024). Business models in 5G/6G mobile communications. In 5G, 6G and the Future of Digital Services. Springer Nature.
35. Qadir, Z., Le, K. N., Saeed, N., & Munawar, H. S. (2023). Towards 6G Internet of Things: Recent advances, use cases, and open challenges. ICT Express, 9(3), 296–312. https://doi.org/10.1016/j.icte.2022.06.006
36. R, D. K., & A, R. (2023). Revolutionizing Intelligent Transportation Systems with Cellular Vehicle-to-Everything (C-V2X) technology: Current trends, use cases, emerging technologies, standardization bodies, industry analytics and future directions. Vehicular Communications, 43, 100638. https://doi.org/10.1016/j.vehcom.2023.100638
37. R., D. K., & Chavhan, S. (2022). Shift to 6G: Exploration on trends, vision, requirements, technologies, research, and standardization efforts. Sustainable Energy Technologies and Assessments, 54, 102666. https://doi.org/10.1016/j.seta.2022.102666
38. Rojek, I., Jasiulewicz-Kaczmarek, M., Piszcz, A., Galas, K., & Mikołajewski, D. (2024). Review of the 6G-Based Supply Chain Management within Industry 4.0/5.0 Paradigm. Electronics, 13(13), 2624. https://doi.org/10.3390/electronics13132624
39. Sharma, S., Popli, R., Singh, S., Chhabra, G., Saini, G. S., Singh, M., Sandhu, A., Sharma, A., & Kumar, R. (2024). The Role of 6G Technologies in Advancing Smart City Applications: Opportunities and Challenges. Sustainability, 16(16), 7039. https://doi.org/10.3390/su16167039
40. Skrzypek, E. (2021). Digitalization along with 5G and 6G Networks – Determinants and Consequences. Annales Universitatis Mariae Curie-Skłodowska, Sectio H – Oeconomia, 55(1), 51. https://doi.org/10.17951/h.2021.55.1.51-66
41. Sridharan, H., & Govindarajan, S. (2024). The Future of Wireless Technologies: Beyond 5G and the Path to 6G. International Journal of Science and Research (IJSR), 13(7), 1606–1619. https://doi.org/10.21275/SR24913031614
42. Sulaimon A Melemuku. (2023). Artificial Intelligence and the Associated Threats on the Human Workforce. https://doi.org/10.13140/RG.2.2.35991.14248
43. Taofeek Olayinka Agboola, Job Adegede, Taiwo Gabriel Omomule, Oyekunle Claudius Oyeniran, & Lemuel Omotayo Aina. (2024). A REVIEW OF MOBILE NETWORKS: EVOLUTION FROM 5G TO 6G. Computer Engineering and Intelligent Systems. https://doi.org/10.7176/CEIS/15-1-06
44. Thomas, A. (2024). The emerging role of e-commerce in today's business: A conceptual study. Asian Journal of Management and Commerce, 5(1), 428–439. https://doi.org/10.22271/27084515.2024.v5.i1f.289
45. Uusitalo, M. A., Rugeland, P., Boldi, M. R., Strinati, E. C., Demestichas, P., Ericson, M., Fettweis, G. P., Filippou, M. C., Gati, A., Hamon, M.-H., Hoffmann, M., Latva-Aho, M., Parssinen, A., Richerzhagen, B., Schotten, H., Svensson, T., Wikstrom, G., Wymeersch, H., Ziegler, V., & Zou, Y. (2021). 6G Vision, Value, Use Cases and Technologies From European 6G Flagship Project Hexa-X. IEEE Access, 9, 160004–160020. https://doi.org/10.1109/ACCESS.2021.3130030
46. Vaigandla, K. K., Bolla, S., & Karne, R. (2021). A Survey on Future Generation Wireless Communications-6G: Requirements, Technologies, Challenges and Applications. International Journal of Advanced Trends in Computer Science and Engineering, 10(5), 3067–3076. https://doi.org/10.30534/ijatcse/2021/211052021
47. Yrjölä, S., Ahokangas, P., & Matinmikko-Blue, M. (2020). Sustainability as a Challenge and Driver for Novel Ecosystemic 6G Business Scenarios. Sustainability, 12(21), 8951. https://doi.org/10.3390/su12218951