Technology in Digital Economy: How Effective Technology Enhance Sectoral Contributions in Indonesia?

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A B S T R A C T

Economic growth is an achievement that is the goal of many sectors, especially the economic sector, as these sectors will contribute to a region's economy. The digital era is an era that highlights innovation and advanced technology that has been widely used in various sectors, generally driving a significant increase in sector performance. However, in its application, technology implementation and innovation creation often need to be improved by various challenges. To find out the various challenges that hinder digital transformation, an in-depth analysis is needed in various sectors, which will be the main objective of this study. This study is qualitative with a literature study approach; the data collected comes from various research articles and review articles published in the last ten years. The data analysis used is deductive reasoning to extract information relevant to the theme raised in this study. The results of this study indicate that one of the sectors with the most significant contribution in Indonesia is the processing industry; as one of the largest sectors, the processing industry is one of the sectors that has implemented the use of technology and automation in its operational activities. On a small scale, many home industries have been able to use technology in marketing activities to reach more consumers. Some others need help understanding the use of technology, so they prefer to continue operating conventionally without using technology, causing an imbalance in sales. However, the contribution of the processing industry sector in general is supported by the implementation of technology, which also affects other sectors that contribute significantly to the economy, such as construction and trade.

1. Introduction

Economic growth is an increase in the capacity of a region or country to produce goods and services sustainably. Economic growth is important in improving people's welfare and regional competitiveness. Economic growth has an important role in improving people's welfare and regional competitiveness; in economic growth, the importance of innovation and accumulation of human capital, such as education and knowledge development, are the main factors driving long-term economic growth [1]. In addition, inter-sector connectivity plays an important role in creating positive effects, such as reducing transportation costs, increasing innovation, and expanding the flow of knowledge [2]. This reflects the importance of economic growth in a region and its influence on various things, including the condition of society related to welfare and general quality of life.

Achieving maximum and equitable economic growth needs various factors influencing economic dynamics in different regions and sectors. Globalization can be a major driver through increasing international trade, foreign direct investment (FDI) flows, and technology transfer. However, a careful approach is needed to mitigate its negative impacts, such as

economic inequality, by strengthening the institutional framework and inclusive trade policies. Total Factor Productivity (TFP) is important as a major driver of sustainable economic growth. Increasing productivity through education, job training, technological innovation, and investment in basic infrastructure such as transportation and energy are essential to create inclusive and efficient growth [3]. Strong institutions and good governance are important for encouraging green investment and facilitating business processes. Investment in human capital through higher education and skills training is key to enhancing global competitiveness and reducing economic inequality. Strong regional trade infrastructure, such as transportation networks and digital technology, can improve the distribution of economic benefits more equitably [4]. Furthermore, environmental sustainability must also be a major concern in economic growth by adopting environmentally friendly policies, such as using renewable energy, to ensure that growth does not come at the expense of natural resources. By integrating these approaches, regions, and sectors can achieve optimal economic growth while ensuring that society shares the benefits equally.

Technology plays a key role in driving economic growth and fundamentally transforming sectors. Technology improves production efficiency and expands access to global markets, allowing countries to leverage their competitive advantages in international trade. Adopting new technologies is seen as enhancing non-price competitiveness through research and development (R&D) and improving the quality of human resources [5]. Technology is a key driver in increasing labor productivity in countries such as China and India. Technological developments have transformed the economic structure from an agricultural sector to a more high-tech industrial and service-based sector. The adoption of new technologies facilitated by government policies has driven the transformation of the manufacturing sector to a more modern and productive one, which has supported remarkable economic growth over the past few decades. Technology has also enabled the shift from low-intensity labor to higher value-added sectors, which have contributed significantly to increasing per capita income [6]. Technology has accelerated the pace of economic growth and created an ecosystem that allows countries to adapt to global changes. Adopting new technologies in the manufacturing and services sectors has become the foundation for ensuring sustainable and internationally competitive economic growth.

Human resources (HR) are fundamental in driving optimal economic growth, with appropriate investment in improving HR quality being the key to success. Human capital development contributes significantly to regional economic growth through spatial spillover effects that strengthen regional interactions [7]. Quality HR drives innovation increases labor productivity, and expands the capacity for technology adoption, creating synergies that enhance overall economic growth and the importance of HR composition in the technology adoption process. Higher education not only supports innovation but also enables groups of workers with secondary education to adopt and utilize these innovations in the production process. An elite and mass education combination is needed to transition from economic stagnation to sustainable growth [8]. Therefore, investment in education and training not only strengthens economic competitiveness at the global level but also accelerates the integration of new technologies, narrows economic disparities, and creates an ecosystem conducive to long-term growth.

Quality human resources (HR) are crucial in integrating technology into various productive sectors, increasing efficiency and innovation. Higher education is critical in building the knowledge base to understand and adopt frontier technologies. They note that increasing education levels not only enhances the capacity of the workforce to utilize new technologies but also fosters domestic technology development, thereby strengthening the economy's global competitiveness [9]. Quality education enables faster and more efficient technology diffusion, increasing economic productivity. Quality governance and strategic investment in education

are needed to address structural challenges. Technology has been shown to increase labor efficiency and create new opportunities in sectors ranging from agriculture to manufacturing, which rely heavily on the capability of human resources to utilize it effectively [10]. The recognition of the importance of education, driven by large investments in education and HR development, has resulted in remarkable economic growth. They highlight that quality education fosters high levels of technological mastery, strengthening innovation and productivity in strategic sectors [11]. With trained and educated HR, technology can be adopted and implemented more quickly, a key driver of long-term economic growth.

Utilizing technology has been empirically proven to be an important factor in supporting economic growth in various regions and sectors. Research by [12] shows that access to digital technology, such as high-speed broadband, contributes significantly to regional economic growth. In Europe, expanding broadband infrastructure drives social integration and increases economic productivity, especially in rural areas that were previously left behind due to the digital divide. This increased access is the foundation for accelerating the development of sectors such as education and health services through digital-based innovation. Meanwhile, research by [13] (Ohki, 2023) highlights the role of disruptive innovation in accelerating economic growth through R&D activities carried out by incumbent companies and newcomers. Continuously evolving technology creates pressure to replace old technologies with newer ones, improving product quality and efficiency of production processes. However, this innovation also presents challenges, such as high initial costs and the risk of failure. However, investment in disruptive technology has been shown to provide positive long-term economic growth results by encouraging competition and innovation in various sectors. Another study by [14] focuses on adopting renewable energy technologies as a key driver of economic growth in the context of the global energy transition. They found that investments in renewable technologies, despite significant upfront costs such as replacing old infrastructure, can reduce dependence on fossil fuels. In addition, these technologies generate positive externalities through increased energy efficiency and reduced carbon emissions, ultimately improving overall societal welfare. The study underscores the importance of policy support, such as carbon taxes and technology subsidies, to accelerate the adoption of clean energy technologies that can support sustainable economic growth.

Based on the reflection obtained through various accumulations of information formed from various concepts and theories, illustrations, and empirical evidence, it has provided a clear picture that economic growth is a process created by the presence of various important factors that can support the process and path to achieving economic growth. In the process, one of the important factors for achieving economic growth through high productivity that can be produced by various supported by the existence of technology is to confirm the importance of technology in supporting productivity and its role in supporting various sectors; an in-depth analysis is needed. This study aims to analyze the role of technology in improving the performance of sectors, especially in Indonesia, where there are three sectors with the largest contribution to Gross Domestic Product (GDP): the processing industry, trade, and agriculture. Thus, to find out how technology can play a role in these sectors, this study was carried out with an analysis that focuses on the effect of technology on economic growth, as reflected in the largest sectors in Indonesia.

2. Methodology

This research is qualitative research with a literature study approach that builds reflection on a specific phenomenon at a location; in choosing the right method, this method is considered in line with the purpose of this research to conduct an in-depth analysis of the existence of

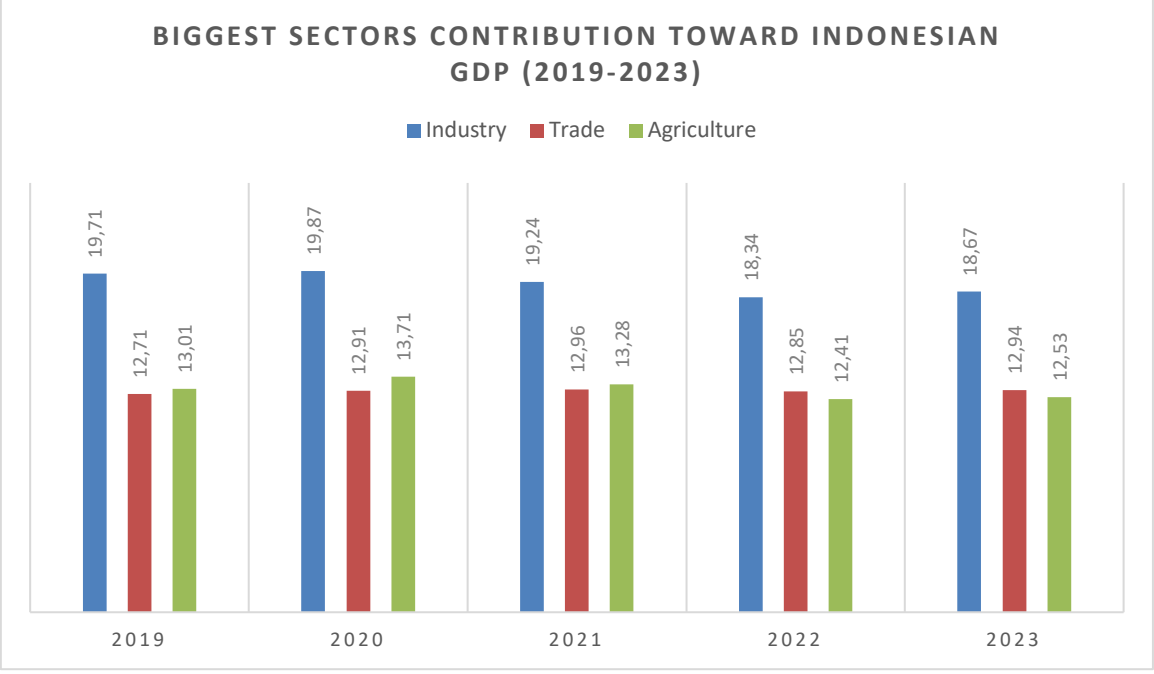
technology in the economy. This research uses empirical data and research as the main data sources that are selected using several criteria that require the articles used to be (1) Articles are research or reviews; (2) Articles published in the last 10 years; (3) Articles through peer-review; and (4) Articles discussing technology and business. By using these criteria in the selection, 30 articles were obtained from a reputable international journal database, namely ScienceDirect, to ensure the alignment of the discussion in this research with the data used; the research results were formulated with the help of Consensus App and Research Rabbit.

The data obtained were then analyzed using deductive reasoning, the most appropriate method for analyzing data originating from various sources and having different and diverse discussions. This method is applied in data analysis to avoid deviations from broad discussions, as this study only focuses on how the existence of technology can support the economy in various sectors. In addition, this analysis method was chosen because of its capability to extract information that is important and relevant to the main discussion and objectives of this study, which facilitates the formulation of research results and potential identification of implications that this study can generate.

3. Results and Discussion

Indonesia is a country that has a wealth of natural resources; with this advantage, Indonesia can import to various countries. To illustrate the condition of the Indonesian economy, three sectors have the largest contribution to gross domestic product. These three sectors can use and maximize the function of technology to improve their performance further. However, there is a debate about whether Indonesia is ready for a comprehensive digital transformation in various sectors. The following graph illustrates GDP contribution data to show the intended economic conditions.

Graph 1. Biggest Sectors Contribution Toward Indonesian GDP (2019-2023)

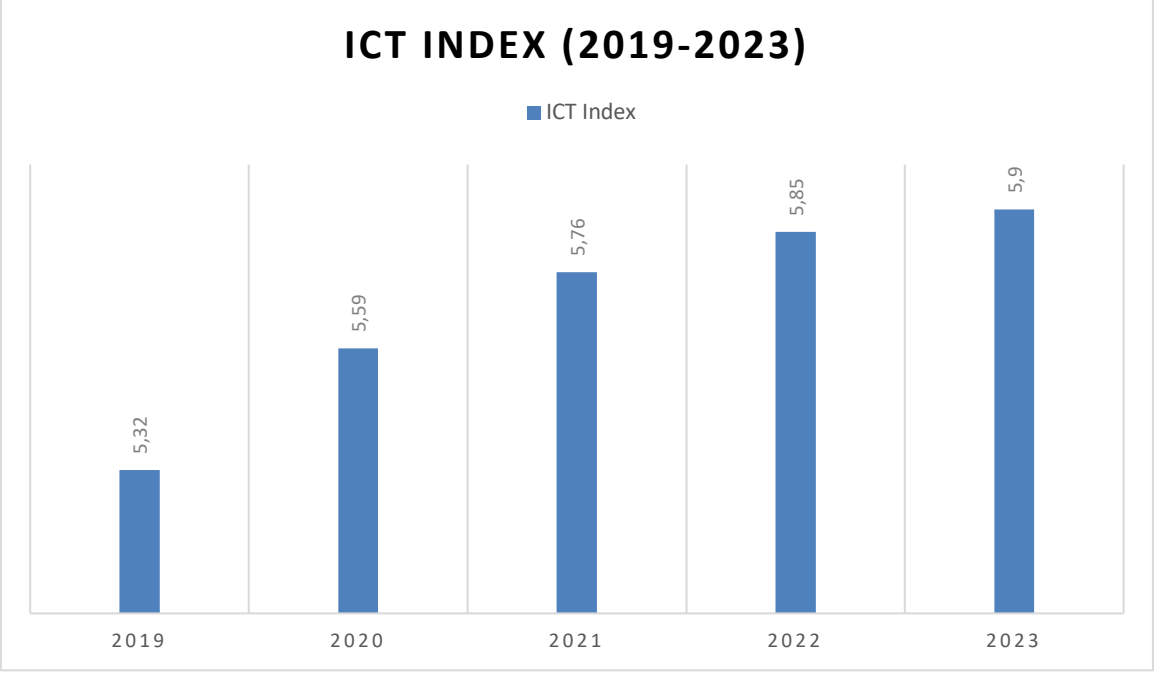


Sources: Indonesia Bureau of Statistics (BPS)

The figure above shows the contribution of three main sectors to Indonesia's Gross Domestic Product (GDP) during the 2019-2023 period, namely Industry, Trade, and Agriculture. Based on this data, the industrial sector consistently contributes to GDP, followed by the trade and agriculture sectors. However, there has been a fluctuating trend in the

contribution of these three sectors over the past five years, with the industrial sector experiencing a gradual decline in contribution from 2020 to 2023. By looking at this illustration, several potential uses of technology have a strategic role in supporting the performance and growth of these sectors. In the industrial sector, adopting industry 4.0 technology, such as automation, artificial intelligence (AI), and the Internet of Things (IoT), can increase productivity, efficiency, and global competitiveness. Digital transformation can also optimize manufacturing processes, logistics, and supply chain management, which contribute to increasing this sector's output and added value. Furthermore, e-commerce technology, big data analysis, and digital platforms in the trade sector can encourage domestic and international market expansion. By utilizing technology, the trade sector can expand consumer access, improve customer experience, and speed up the transaction process, thereby strengthening the contribution to GDP. Finally, in the agricultural sector, using technology such as precision agriculture, drones for land monitoring, and data-based applications for crop management can increase production efficiency. This technology not only helps increase crop yields but also reduces the risk of crop failure, which directly affects the stability and growth of the agricultural sector.

Graph 2. Information and Communication Technology Development Index (2019-2023)



Sources: Indonesia Bureau of Statistics (BPS)

The figure above shows the development of the Information and Communication Technology Development Index in Indonesia during 2019-2023. This index has increased consistently, from 5.32 in 2019 to 5.9 in 2023. This reflects the development of technology and communication infrastructure and the increasing accessibility and quality of ICT services. Although this figure shows a fairly high achievement compared to the overall population, there is still room for further improvement to ensure maximum utilization of technology, especially in supporting the economy. Strengthening the ICT Index is crucial to expanding digitalization in key economic sectors, such as industry, trade, and agriculture. More sophisticated technology can accelerate digital transformation, improve operational efficiency, and expand opportunities for innovation in various sectors. However, continuous investment in ICT infrastructure, increasing digital literacy in the community, and policies that encourage technology adoption are needed to ensure maximum

impact. Thus, a higher ICT Index in the future is expected to encourage inclusive and sustainable economic growth.

3.1 Technological Importance Toward Economic in Digital Era

Technology, especially artificial intelligence (AI), has become a key driver of digital transformation that has had a far-reaching impact on economic growth and structural changes in productive sectors. Several studies have highlighted how AI improves efficiency, drives innovation, and creates competitive advantages in various fields. The following table summarizes the findings of seven studies on the extension of technology in economic activities, covering its impact on entrepreneurial innovation, business resilience, AI-based business models, and its contribution to job creation and economic growth at the global level. Each study provides strategic implications that underscore the urgency of investing in technology and formulating policies that support the adoption and optimization of AI to achieve sustainable and inclusive economic growth.

Table 1. Technology Importance Based on Empirical Research

Researcher	Research Result	Research Implications
Imjai et.al (2024)	AI and design thinking skills enhance entrepreneurial innovation, enabling businesses to adapt and thrive in digital markets.	Education and training in AI competencies are crucial for fostering a digitally adept workforce that drives innovation.
Shore et.al (2024)	Generative AI supports SME resilience during crises, improving decision-making and maintaining competitiveness.	Investments in generative AI tools can buffer businesses against market fluctuations, ensuring stability and growth.
Climent et.al (2024)	AI-enabled business models provide competitive advantages through data network effects and efficient resource use	Firms should prioritize AI investments to achieve long-term economic benefits and customer retention through tailored models.
Haftor et.al (2024)	Predictive AI creates economic value by integrating business models and data-driven insights, improving firm performance.	Effective use of predictive AI requires alignment with business goals and user-centered value creation strategies.
Besiroglu et.al (2024)	AI-augmented R&D accelerates technological change and economic growth by enhancing innovation processes.	Policy frameworks should support AI deployment in R&D to maximize its potential as a growth catalyst.
Saba & Ngepah (2024)	AI positively impacts employment and growth in BRICS economies when supported by governance policies.	Governments must align AI strategies with governance improvements to ensure inclusive and sustainable growth.
Damioli et.al (2024)	AI drives job creation in innovation sectors while offsetting labor-saving effects in automation-heavy industries.	Policymakers should incentivize AI adoption in upstream sectors to balance automation's labor implications.

Sources: Empirical Research (2024)

Technology, especially artificial intelligence (AI), supports innovation and economic growth in the digital era. Research by [15] highlights how design thinking skills and AI competencies can enhance entrepreneurial innovation, enabling businesses to adapt to the challenges of the digital market. This research emphasizes the importance of AI-based education and training in creating a workforce capable of driving innovation. In addition [16] show that Generative AI plays a significant role in supporting business resilience, especially among small and medium enterprises (SMEs), during times of crisis. By automating processes and improving decision-making, AI helps SMEs remain competitive despite market uncertainty. [17] also emphasizes the advantages of AI-based business models, which leverage data network effects to create and sustain economic value, while increasing resource efficiency.

Furthermore [18] research shows that predictive AI can create economic value by integrating data-driven business models, directly improving company performance. This suggests that to leverage AI effectivelybusiness strategies must be aligned with user goals and value creation to leverage AI effectively. In the research and development (R&D) field, [19] show that AI can

accelerate technological change and economic growth by enhancing innovation. However, this study also highlights the need for policies that support the adoption of AI in R&D to maximize the technology's potential as a catalyst for growth. These results emphasize that strategic investment in AI should be a priority for companies and governments to ensure a successful digital transformation.

At the global level, [20] emphasize the importance of collaboration between AI strategy and quality governance to achieve inclusive and sustainable economic growth, especially in BRICS countries. Their study highlights that policies that support technology-friendly governance can amplify the positive impact of AI on employment and growth. Furthermore [21] highlight the positive side of AI in creating jobs in the innovation sector, which can offset the labor-saving effects of automation. These findings underscore the importance of policy incentives to encourage AI adoption in upstream sectors to achieve a balance between technological innovation and its impact on labor. Overall, this series of studies reflects the urgency of technology in economic activities to ensure equitable digital transformation and optimal economic growth amidst global market dynamics.

3.2 Technological Enhancement on Economic Sectors

Technology has become key in increasing productivity and efficiency across economic sectors while driving broader innovation. In the industrial sector, technologies like the Internet of Things (IoT), artificial intelligence (AI), and blockchain have brought significant transformations, enabled process automation and improved operational sustainability. In the trade sector, technology adoption has facilitated compliance management, optimized market strategies, and increased transparency in transactions, contributing to global economic growth. Meanwhile, in agriculture, technologies such as drones, hydroponics, and the digitization of agricultural services have helped increase yields, expand market access for smallholder farmers, and promote sustainability through modern agricultural practices. With technology, each sector cannot increase productivity, address structural challenges, and adapt to increasingly complex business environments. The following studies provide in-depth empirical evidence on technology's contribution to digital transformation and economic growth across sectors.

Table 2. Technological Enhancement Based on Empirical Research

Researcher	Research Result	Research Implication
Industrial Sectors		
Naeem et.al (2024)	Industry 4.0 technologies (IoT, AI, blockchain) enhance manufacturing efficiency and sustainability, particularly in renewable energy.	Support for Industry 4.0 adoption is essential for achieving energy efficiency and global competitiveness.
Strazzullo (2024)	Digital trust in Industry 4.0 technologies boosts productivity and organizational cohesion in manufacturing firms.	Building organizational trust is vital for successful Industry 4.0 implementation.
Liu et.al (2024)	Intelligent manufacturing promotes sustainable development via automation and human-machine collaboration under Industry 5.0.	Firms must align intelligent manufacturing with sustainability goals.
Trade Sectors		
Chaudhry et.al (2024)	Technology empowers transnational entrepreneurs to optimize strategies and operational efficiency.	Incentives for digital adoption can enhance entrepreneurial success.
Bui & Lo (2022)	Multinational Technology Entrances use digital tools for competitive advantages globally.	Early tech adoption is key for emerging market firms.
Charoenwong et.al (2024)	RegTech innovations streamline compliance and trading processes, improving efficiency.	Investments in RegTech reduce compliance costs and enhance transparency.
Agricultural Sectors		

Researcher	Research Result	Research Implication
Choruma et.al (2024)	Digital tools increase productivity and market access for smallholder farmers, though challenges like digital literacy remain.	Improved digital infrastructure is critical for agricultural advancement.
Rakholia et.al (2024)	Technologies like drones and hydroponics boost productivity and sustainability in Indian agriculture.	Initiatives to educate farmers and expand tech access are needed.
Schnack et.al (2024)	Controlled Environment Agriculture (CEA) and genetic editing enhance agricultural output and resilience.	Consumer acceptance is crucial for sustainable food security.

Sources: Empirical Research (2024)

Technology is very important in improving productivity, efficiency, and sustainability in the industrial sector. A study by [22] shows that Industry 4.0 technologies, such as IoT, AI, and blockchain, have improved manufacturing efficiency, especially in supporting renewable energy. This improvement reduces production costs and helps companies contribute to environmental sustainability, [23] further emphasizes the importance of digital trust in technology adoption, which can boost the productivity of manufacturing companies by strengthening internal collaboration. Meanwhile, [24] highlight how smart manufacturing under the Industry 5.0 framework strengthens collaboration between humans and machines, creating a new social and environmental sustainability paradigm.

In the trade sector, technology has also become a significant driver of transformation, [25] reveal how technology helps transnational entrepreneurs optimize market strategies and improve operational efficiency, enabling them to compete in international markets. Research by [26] add that technology-based multinationals from emerging markets can leverage digital innovation to gain a competitive advantage. In addition, [27] highlight the role of RegTech innovation in improving operational efficiency in the trade sector by simplifying compliance and transparency processes. This shows how technology increases productivity and promotes stability and accountability in global trade transactions.

The agricultural sector has also benefited greatly from technological advances, [28] show that digitization in agriculture helps smallholder farmers improve productivity and market access, although challenges such as digital literacy remain. Research by [29] show that new technologies such as drones and hydroponics have increased crop yields while promoting sustainability in agriculture in India. On the other hand, [30] reveal that technologies such as Controlled Environment Agriculture (CEA) and genetic editing are helping to improve agricultural resilience in the Oceania region. These three studies underscore the importance of technology in addressing global challenges in the agricultural sector, from improving food security to environmental sustainability. Overall, the role of technology in various sectors is not only to increase productivity but also to open up new opportunities for innovation and adaptation to global economic dynamics.

The application of technology has great potential to improve the performance and productivity of key sectors in Indonesia and drive more inclusive and sustainable economic growth. In the industrial sector, technologies such as IoT, AI, and blockchain have increased the efficiency of manufacturing processes, supported energy sustainability, and strengthened human-machine collaboration within the Industry 5.0 framework. Digital trust, is also key to ensuring the successful implementation of this technology, which ultimately increases company productivity. This digital transformation optimizes operations and significantly contributes to the global competitiveness of the Indonesian industrial sector. In the trade sector, technology drives efficiency and expands market access domestically and internationally. Technology adoption enables transnational entrepreneurs to manage market strategies better, the importance of early adoption of digital technology by companies from emerging markets to gain competitive advantage. In addition, the role of RegTech innovation in simplifying compliance processes and increasing transparency,

which contributes to the stability and accountability of global trade. This suggests that technology can be a catalyst in addressing the structural challenges facing Indonesia's trade sector.

The agricultural sector has also benefited significantly from technological advances. Digitalization of agriculture helps smallholder farmers increase productivity and market access despite digital literacy barriers. Technologies such as drones and hydroponics have increased crop yields and supported agricultural sustainability in India, providing important lessons for the Indonesian context. Schnack et al. (2024) highlight the role of Controlled Environment Agriculture (CEA) and genetic editing in enhancing agricultural resilience in Oceania. With the adoption of similar technologies, Indonesia's agricultural sector can be better prepared to face challenges such as food security and environmental sustainability. Overall, the application of technology in these three sectors increases productivity and opens up opportunities for innovation that can take the Indonesian economy to the next level.

4. Conclusion

This study shows that technology significantly supports Indonesia's economic growth by increasing productivity and efficiency in key sectors such as industry, trade, and agriculture. Adopting technologies like IoT, AI, and blockchain in the industrial sector has improved manufacturing process efficiency, supported energy sustainability, and strengthened human-machine collaboration within the Industry 5.0 framework. In the trade sector, technology drives market strategy optimization, increased transparency, and operational process efficiency, impacting global stability and competitiveness. Meanwhile, the agricultural sector benefits from digitalization, using technologies such as drones and hydroponics and modern approaches such as Controlled Environment Agriculture (CEA), which increase crop yields, reduce the risk of crop failure, and support environmental sustainability. Overall, the results of this study confirm that inclusive and sustainable digital transformation is needed to achieve optimal economic growth.

5. Recommendation

This research provides important implications for policymakers and industry players. Investment in technology infrastructure, human resource training, and policies that encourage technology adoption should be a priority to ensure equitable digital transformation. In the industrial sector, governments and companies should support the adoption of Industry 4.0 technologies to improve global competitiveness. In trade, technologies such as RegTech should be adopted to improve transparency and efficiency. Meanwhile, improving digital infrastructure and technology education for smallholder farmers in the agricultural sector are key to boosting productivity and sustainability. This research can be expanded with a quantitative approach to measure the specific impact of technology on certain economic indicators such as GDP, labor productivity, and sector contribution to exports. Further research can also explore the challenges of implementing technology at various scales, from small businesses to multinational corporations. In addition, cross-country comparative studies can provide greater insight into how effective technology policies can be implemented to support economic growth globally. Integration between social dimensions, such as digital literacy and societal acceptance of technology, must also be considered in future research.

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