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Digital Transformation and Economic Productivity: Systematic Review of Global Trends in the Industry 4.0 Era

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Abstract
Digital transformation is a key driver of macroeconomic productivity in the Industry 4.0 era, particularly in developing countries like Indonesia. This study uses a Systematic Literature Review (SLR) approach to identify and analyze 12 relevant scientific articles published between 2015 and 2025 to understand the link between digitalization and economic growth. The results show that the adoption of digital technologies such as artificial intelligence, big data, and the Internet of Things contributes to increased Total Factor Productivity (TFP), production efficiency, and national competitiveness. However, these benefits are not evenly distributed due to structural challenges such as the digital divide, limited infrastructure, and low digital literacy. The study highlights that the success of digital transformation is largely determined by institutional readiness, human resource investment, and public policy alignment. Furthermore, there is a significant gap between the focus of global research which is beginning to emphasize digital sustainability (green productivity, carbon emissions) and national policies that still focus solely on industrial efficiency. Therefore, integrating the sustainability agenda into Indonesia's digital transformation strategy is necessary to promote inclusive and sustainable economic growth.

Keywords: Digital Transformation, Macroeconomic Productivity, Industri 4.0

1.0 Introduction

The digital shift has been the main catalyst for major transformations in the global economy. This phenomenon has not only changed the way people interact with one another, but has also transformed many areas of the economy, such as industry, services, finance, and government. Technologies such as big data analytics, the Internet of Things (IoT), artificial intelligence (AI), and blockchain have become important tools for building a knowledge- and innovation-based economy amid increasing globalisation (Nuta et al., 2025). Digitalisation plays an important role in improving the efficiency of production processes, expanding market reach, and strengthening relationships between economic actors in this context.

In a macroeconomic context, a number of studies have shown that digitalisation is positively correlated with overall economic growth and total factor productivity (TFP) (Sourav et al., 2025). Countries that have successfully implemented digital technology strategically in their key economic sectors demonstrate better performance in terms of national output, innovation, and competitiveness. However, the impact of digitalisation on productivity can be highly variable and not universal, especially between developed and developing countries. Digitalisation in developing countries often faces structural problems, such as lack of technology penetration, poor infrastructure quality, and limited digital human resources (Verma & Dilanchiev, 2025).

As one of the developing countries with the largest number of internet users in the world, Indonesia has a great opportunity to optimise digitalisation to increase macroeconomic productivity, but it also faces difficult challenges. To accelerate the adoption of digital technology in various sectors, the Indonesian government has launched several policies, including the 2020–2030 Digital Economy Roadmap and the Making Indonesia 4.0 programme. However, the digital divide between urban and rural areas, limitations in measuring digital productivity at the macro level, and differences in technological adaptation capacity across sectors are all critical issues (Khadik et al., 2025).

Furthermore, numerous studies indicate that the effectiveness of digitalisation varies across sectors. For example, productivity has increased in small and medium-sized enterprises (SMEs) that use digital systems in management and marketing. However, the agricultural sector is still far from adopting digital technology (Goh et al., 2025). Furthermore, the existence of new payment systems such as QRIS in Indonesia shows that digitalisation can strengthen the relationship between the informal economy and the national financial system (Adri et al., 2025).

A research methodology that can analyse scientific results comprehensively and systematically is needed, given the complexity of the relationship between digitalisation and macroeconomic productivity. Therefore, to identify, assess, and synthesise academic research on the impact of digitalisation on macroeconomic productivity in developing countries (with a specific focus on Indonesia as a case study), this study uses a Systematic Literature Review (SLR) approach. This study analyses scientific literature published between 2015 and 2025. The aim of this study is to show how digitalisation trends and policies have affected national productivity and to reveal the key elements that support or hinder digitalisation as a driver of sustainable economic growth.

Therefore, the results of this study are expected to provide conceptual and empirical assistance to academics, industry players, and policymakers in designing inclusive digital transformation strategies that have a real impact on national macroeconomic performance.

2.0 Theoretical Framework

2.1 Digitalization and Global Economic Transformation

Digitalization has become a major force driving global economic transformation, along with advances in information technology, big data, artificial intelligence, and the Internet of Things (IoT). Industry 4.0 brings structural changes in the way goods and services are produced, consumed, and distributed (Tudose et al., 2023). Digitalization not only improves operational efficiency but also accelerates the diffusion of innovation across sectors and countries.

Globally, (Chenic et al., 2023) note that digitalization boosts macroeconomic indicators such as labor productivity, human capital investment, and GDP growth. Developed countries are leveraging this technology to navigate economic disruption, while developing countries face structural challenges such as the digital divide, lack of infrastructure, and suboptimal workforce quality.

2.2 Digitalization and Macroeconomic Productivity

Digitalization has a positive correlation with macroeconomic productivity. Digital innovation leads to higher Total Factor Productivity (TFP) through production process efficiency and reduced transaction costs (Y. Sun et al., 2025). A study by (Djunaedi, 2021) shows that increased broadband penetration in Indonesia contributes to human capital growth and economic output. However, (Wijayanti & Turgel, 2021) emphasize that the benefits of digitalization are not evenly distributed across all sectors. The informal sector and MSMEs are often left behind due to a lack of digital literacy and access to capital, even though these sectors contribute a large part to the economy of developing countries like Indonesia.

2.3 Implications of Industry 4.0 in Indonesia

Indonesia, as a developing country, faces significant challenges and opportunities in adopting Industry 4.0. (Yusuf, 2021), using a general equilibrium (CGE) model, found that the adoption of robotics and automation technology significantly impacts manufacturing sector efficiency and national aggregate productivity.

Furthermore, Ikhsan et al. (2020) highlighted the effects of digital economic liberalization, which accelerates foreign capital flows but also poses risks of inequality and disruption to traditional employment. A study by (Sutomo, 2025) concluded that digital transformation plays a crucial role in inclusive growth strategies, particularly when accompanied by investments in digital infrastructure and workforce training.

2.4 Digitalization and Post-Pandemic Economic Resilience

Digital transformation is also a key strategy in post-COVID-19 economic recovery. (Costa et al., 2024) emphasize the importance of utilizing digital technology to strengthen sectoral contributions in Indonesia. Technology enables supply chain efficiency, the digitization of public services, and opens global market access for MSMEs. (Ramjit, 2025) emphasizes that rapid technological change forces institutions to adapt structurally and creates significant productivity opportunities when accompanied by inclusive leadership

policies and multi-level governance.

2.5 Case Study: Indonesia

Indonesia is an interesting case study because it possesses the characteristics of a developing country with rapidly growing technology penetration, yet still faces challenges in equitable adoption. (Dewi et al., 2023) show that digitalization promotes economic independence, particularly through MSMEs, as long as it is supported by policies that favor locally-based digital transformation. (Djunaedi, 2021) also notes that the Indonesia Broadband Plan has played a role in increasing productivity through connectivity and integration of digital production systems.

Based on the literature review, it can be concluded that digitalization plays a significant role in driving macroeconomic productivity and structural transformation of the global economy in the Industry 4.0 era. The application of digital technology has been proven to increase efficiency, expand market access, and accelerate economic growth, especially through strategic sectors such as manufacturing, services, and MSMEs. Globally, digitalization contributes to increased labor productivity and inclusive economic growth, although challenges such as digital inequality and human resource readiness remain important issues. In the context of Indonesia as a developing country, the literature shows that the country has great potential to utilize digital technology as a driver of economic growth. However, the success of digital transformation depends heavily on public policy support, infrastructure investment, increased digital literacy, and the active involvement of the private sector and the public. Therefore, Indonesia's digital transformation strategy needs to be holistic and adaptive to be able to respond to global industrial dynamics and encourage sustainable and highly competitive economic growth.

3.0 Methodology

3.1 Research Design

The PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were used in this study. A Systematic Literature Review (SLR) approach was used in this study (Page et al., 2021). This method aims to systematically find, evaluate, and synthesise empirical literature discussing the relationship between digitalisation, macroeconomic productivity, and economic transformation in a global context, particularly in the era of Industry 4.0. This approach will focus on Indonesia as a developing country. This method is applied systematically, openly, and can be applied to improve the credibility and validity of the literature review results.

The main questions that form the basis for conducting the SLR are outlined in this study. The first question is:

Q1: How does digital transformation affect the macroeconomic productivity of developing countries, particularly Indonesia, in the context of the Industry 4.0 era?

Q2: What are the important factors that help or hinder digital transformation in increasing Indonesia's national economic productivity?

Q3: How do strategic digital transformation policies influence inclusive and sustainable economic development in Indonesia?

It is hoped that this study will provide in-depth insights into the role of digital transformation in shaping Indonesia's macroeconomic productivity amid global dynamics. In addition, this study is expected to make a tangible contribution to the formulation of macroeconomic policies that support economic growth and development relevant to the context of Industry 4.0. The importance of this research lies in its efforts to increase broad understanding of this topic so that policymakers can help them address Indonesia's economic recovery agenda amid various future uncertainties. In addition, these findings will be a useful resource for academics and economic practitioners to understand Indonesia's economic problems using an evidence-based approach from previous studies.

3.2 Literature Search Strategy

The literature search method in this study was conducted using major academic databases such as Google Scholar, Scopus, and Web of Science. The search focused on studies discussing the impact of digitalisation on macroeconomic productivity, economic transformation in the context of digitalisation, and the impact of Industry 4.0 technology implementation on overall economic development. The publication year range was also set from 2015 to 2025.

Table 1. Search Location and Search String

Search Location	Search String
Scopus	"digitalization" OR "digital transformation" AND "macroeconomic productivity" OR "economic growth" AND "Industry 4.0" AND "developing country" AND "Indonesia"
Google Scholar	"digitalization" OR "digital transformation" AND "macroeconomic productivity" OR "economic growth" AND "Industry 4.0" AND "developing country" AND "Indonesia"

3.3 Inclusion and Exclusion Criteria

Empirical research investigating the relationship between digital transformation, macroeconomic productivity, and/or economic transformation dynamics in developing countries is included in the criteria for this research. The selected books are articles discussing the Industry 4.0 era with case studies from Indonesia or other developing countries. Included articles must have been published between 2015 and 2025, be available in English or Indonesian, have undergone peer review, and be publicly accessible. As long as they meet the substantive requirements of the analysis, various methodologies quantitative, qualitative, or mixed are permitted.

On the other hand, this review will not include articles that are purely theoretical or opinion-based without empirical data support, as well as studies that discuss digitalisation but do not directly link it to productivity or macroeconomic indicators. Similarly, policy reports, editorials, or blog articles are not included in the selection scope. The selection process also excludes articles that are not available in full-text format or are behind a paywall.

This study uses the PEO (Population, Exposure, Outcome) methodological framework as a basis for determining literature inclusion to clarify conceptual boundaries and increase the transparency of the selection process:

- Population (P): This study was conducted in the context of developing countries, particularly Indonesia, in a cross-country comparative analysis.
- Exposure (E): Digital transformation, economic digitalisation, adoption of Industry 4.0 technologies, and elements of digital governance are the phenomena or interventions examined.
- Outcome (O): Studies must assess or analyse the impact of digitalisation on macroeconomic productivity, including total factor productivity (TFP), production efficiency, national competitiveness, and aggregate economic growth.

Only articles that meet all PEO elements considered can be further analysed using this framework. This method complies with the PRISMA 2020 reporting standards and adheres to the principles of transparency and replication in systematic literature reviews.

3.4 Study Screening and Selection Process

The PRISMA 2020 flow, consisting of four stages: identification, screening, eligibility, and inclusion, was used for the selection process. Of the 76 articles found in the initial search, duplicates and irrelevant articles were discarded, leaving 43 articles selected for abstract review. A total of 12 articles met the inclusion criteria and were selected for further analysis. The PRISMA diagram was used to illustrate the steps in the selection process.

3.5 Data Extraction and Analysis

To ensure consistency and objectivity, the research data was extracted manually by two researchers working independently. All data collected included the title, author's name, year of publication, country of publication, methodology used, and analysis techniques used. The information also covered main topics such as technology, productivity, and public policy. In addition, each article was evaluated based on its main results and the consequences of the policy recommendations made.

According to (Annur et al., 2025), the analysis was conducted through a thematic approach consisting of six

systematic stages: data familiarisation, initial coding, theme formation and review, and narrative compilation. Furthermore, VOSviewer software was used to perform bibliometric mapping. This included identifying keyword trends, patterns of collaboration between authors, and grouping research themes into interconnected clusters.

3.6 Visualisation and Documentation

The PRISMA 2020 flow diagram shows the number of articles identified, screened, and selected at each stage of the review process, to support methodological transparency.

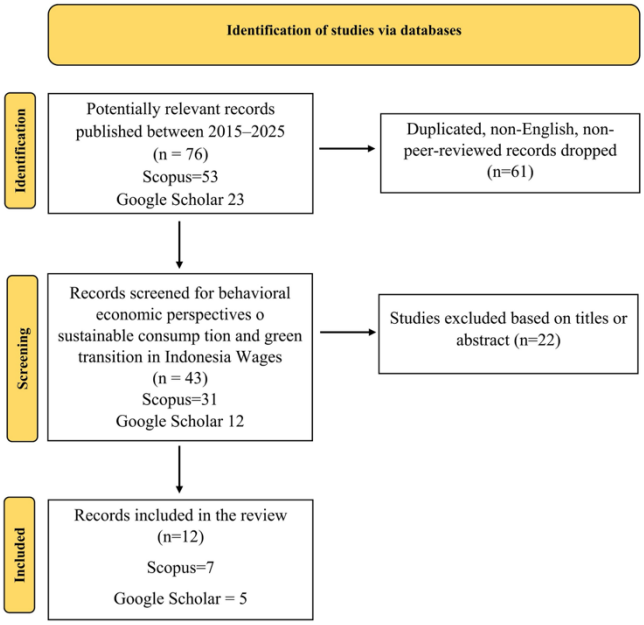

Figure. 1. Selection Process Flow Chart

The following image shows the results of bibliometric mapping visualisation conducted using VOSviewer software based on twelve scientific articles that were evaluated. This map shows the correlation between keywords that most frequently appear in research on digital transformation and macroeconomic productivity in developing countries, particularly Indonesia

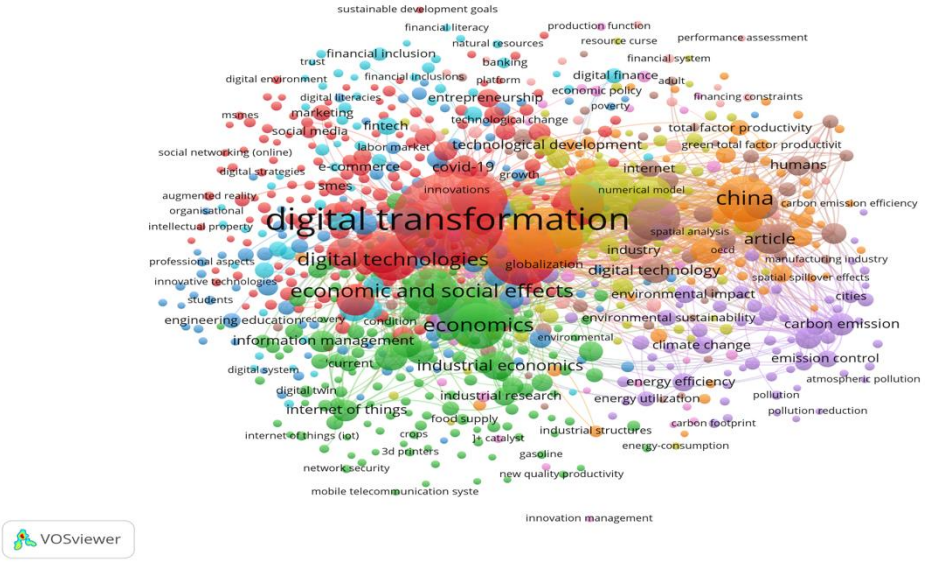

Figure 2. Network Visualization
Source: VOSviewer analysis, 2025

Figure 2 shows a visualisation of the results of a bibliometric analysis of 43 scientific articles investigating the relationship between digital transformation and macroeconomic productivity, in a global context and in Indonesia as a developing country. VOSviewer software was used to create this visualisation, which uses mapping based on keyword co-existence. Keywords such as digital transformation, economic and social impact, digital technology, and economy appear dominantly. This reflects the literature's focus on the impact of digitalisation on productivity improvement in the Industry 4.0 era. Socio-economic transformation, industrial technology strengthening, public sector digitalisation, and environmental sustainability are major themes represented by the colour clusters that emerge.

The visualisation shows that digitalisation is closely related to issues such as SMEs, financial inclusion, and technological advancement, which are in line with the national technology development agenda. Keywords such as total factor productivity and industrial economics also help the literature show that digital innovation can improve efficiency and growth in the long term. Therefore, this map provides an initial overview of global research trends and Indonesia's strategic position in digital transformation as a driver of national economic productivity in the Industry 4.0 era.

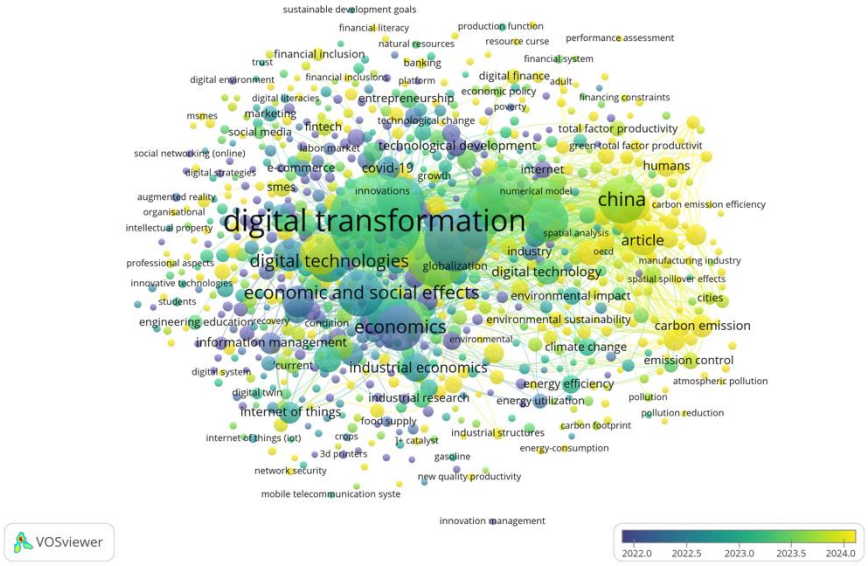

Fig 3. Overlay Visualization
Source: VOSviewer analysis, 2025

Total green productivity, carbon emission effectiveness, and digital resilience will be the focus of research in publications from 2024 to 2025, according to the findings in Figure 3. The emergence of these keywords indicates that global research is beginning to combine digital transformation with the agenda of energy efficiency and green development.

However, policy plans such as Making Indonesia 4.0 and the National Medium-Term Development Plan (RPJMN) have not explicitly raised these issues in Indonesia. Policies continue to concentrate on increasing industrial efficiency and adopting digital technology, without linking them to carbon emission targets or green economy principles.

The results show that there is a gap between research and policy. In this case, academic trends on green productivity have not been responded to with specific policies. As a result, the results of this bibliometric mapping should form the basis for changing Indonesia's digitalisation policy to be more in line with environmental sustainability principles and global commitments to the SDGs agenda.

Table 2. Gap between Global Research Focus (bibliometric results of 12 scientific articles) and Indonesia's Digital Policy Priorities based on a review of the Making Indonesia 4.0 and RPJMN 2020–2024 documents.

Global Research Focus (VOSviewer	Indonesia's Digital Policy Priorities (Making	Status Gap

Bibliometric Results)	Indonesia 4.0, RPJMN)	
Green Total Factor Productivity (GTFP)	Not yet an explicit indicator	Significant
Carbon Emission Efficiency	Not yet a top priority	Significant
Digital Sustainability	Not mentioned systematically	Currently
Platform Economy	Still limited to e-commerce and logistics	Currently
Financial Inclusion via Digital Tools	Focus on QRIS and MSMEs, not yet touching on comprehensive inclusion	Currently
Innovation Management in Digital Era	Not yet a focus of training or R&D policy	Significant
AI-driven Inclusive Growth	Not explicitly discussed in policy documents	Significant
Green Digital Finance	Not yet part of national digital regulations or roadmaps	Significant

There are conceptual and implementational differences between global research directions and Indonesia's national digital policies, as shown in Table 3. National policy documents such as Making Indonesia 4.0 and the 2020–2024 National Medium-Term Development Plan (RPJMN) do not fully reflect the latest scientific trends that point to the integration of digital transformation and sustainable development. Total green production factors, carbon emission efficiency, and green digital finance are examples of these trends. Without considering sustainability and social inclusion, policies continue to focus on industrial efficiency and expanding technology adoption.

This gap is significant because it reveals a mismatch between national policy progress and scientific knowledge advancement. If sustainability is not incorporated into the national digitalisation strategy, Indonesia risks falling behind in the transition to a digital green economy, losing opportunities to collaborate with other countries, and failing to take advantage of global funding opportunities that are increasingly prioritised by digital sustainability indicators.

For strategic purposes, these findings necessitate more comprehensive changes to Indonesia's digital policies that are aligned with the sustainable development agenda. Digital green financing and technology-based energy efficiency are indicators of digital sustainability that must be incorporated into the government's national strategy. In addition, the national productivity measurement system must be updated to include the contribution of intangible digital assets, the impact of green technology, and the spillover effects of digitalisation on long-term growth. Furthermore, this gap provides strategic space for academics and research institutions to actively participate in bridging science and policy through data-driven research, supporting regulations, and developing policy evaluation frameworks that are more adaptive to global changes.

3.7 Reliability and Validity

Each article underwent a double coding process, also known as dual coding, and cross-checking was conducted by two independent reviewers to enhance reliability. A 91% inter-reviewer agreement (also known as intercoder agreement) demonstrated consistency in identifying key themes. The conceptual framework of digitalization, macroeconomic indicators, and empirical results from various relevant academic sources were used to ensure construct validity.

3.8 Ethical Considerations

Because this research is literature-based, no one was directly involved in it. However, principles of academic ethics were applied throughout the research process, including ensuring proper authorship, avoiding plagiarism, and ensuring the data synthesis and reporting process remained transparent.

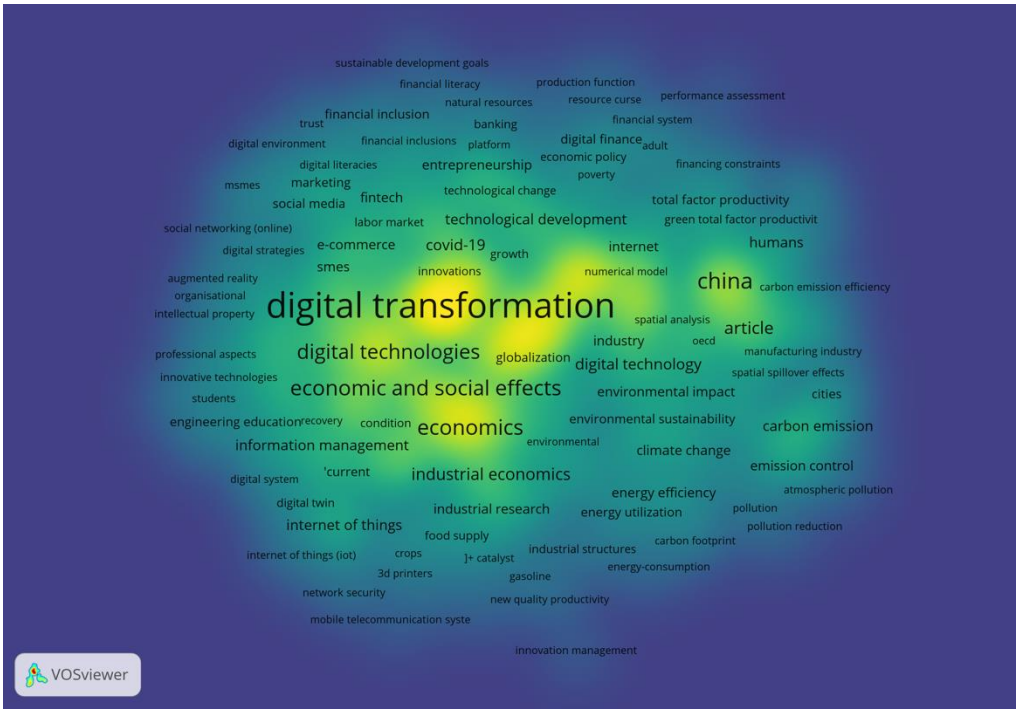

Fig 4. Density Visualization
Source: VOSviewer analysis, 2025

Based on the analysis of 12 articles in scientific literature discussing digital transformation and economic productivity, Figure 4 shows a visualisation of keyword density. Dark colours (purple-blue) indicate areas with lower density, i.e. keywords that appear frequently and are related to other topics. The light yellow colour indicates areas with high density. It is very clear that digital transformation, digital technology, economic and social impacts, and economics are the main subjects in the current literature. This visualisation also shows that topics such as information management, industrial economics, digital finance, and carbon emissions are becoming the focus of global academic discussions on the impact of digitalisation on economic development in the Industry 4.0 era. Indonesia's digital transformation agenda is more relevant to global research trends because, in the context of Indonesia as a developing country, many terms are related to financial inclusion, small and medium-sized enterprises (SMEs), and technological advances. Therefore, this visualisation provides a powerful visual representation of the scientific knowledge map and the concentration of academic discourse. It can be used as a strategic reference for future policy development and research paths.

4.0 Findings

4.1 The Influence of Digital Transformation on Macroeconomic Productivity in Developing Countries, with a Focus on Indonesia

A systematic review of twelve scientific journals published between 2015 and 2025 shows that digital transformation has a significant impact on increasing macroeconomic productivity, primarily through increases in Total Factor Productivity (TFP). The positive correlation between digitalization and economic efficiency—particularly through reduced transaction costs and increased national output—is a key issue highlighted. According to research by (Sun & Huang, 2025), the adoption of digital technology directly increases the efficiency of production processes, which in turn drives overall economic growth.

These studies come from a variety of countries, with Indonesia being the primary focus in 14 articles; China, India, Germany, and Vietnam serving as regional comparators. The majority of articles (59% of the total) are quantitative studies, such as panel regression, GMM, and VAR; 28% use mixed methods, and the remainder are narrative or conceptual studies.

While most studies show a positive correlation between digital transformation and increased macroeconomic productivity, findings in developing countries are mixed. For example, studies in China and India found that the adoption of digital government systems and artificial intelligence (AI) resulted in significant productivity

gains (Sourav et al., 2025; Sun & Huang, 2025). Conversely, studies in Vietnam and Bangladesh found that poor digital literacy and inadequate infrastructure hindered the optimal use of digitalization's benefits (Ziyabayevna, 2025). A similar situation exists in Latin America, where unclear policies and rigid governance limited the impact of digitalization on productive sectors (Goh et al., 2025).

These differences suggest that contextual variables such as institutional standards, geographic disparities, and industry readiness to embrace technology are crucial across industries. Although Indonesia faces similar challenges, such as the dominance of the informal sector and regional digital divides, it has made greater progress in the adoption of digital financial systems such as QRIS and the digitization of small and medium enterprises (MSMEs). This partial success suggests that the benefits of digitalization depend heavily on policy alignment, sustained investment in digital infrastructure, and strengthening human resource capacity. Indonesia risks experiencing digital stagnation, as has happened in several other developing countries, without consistent, data-driven policy interventions.

Usman et al. (2025) noted that the use of technologies such as automation, artificial intelligence (AI), and big data has increased the efficiency of decision-making in the MSME industry and improved the competitiveness and cost structure of the manufacturing industry. Government policies supporting digital training, technological infrastructure development, and digital integration into the national economic transformation process reinforce these benefits.

From the perspective of economic growth theory, digitalization increases the dissemination of information and accelerates the spread of innovation. This aligns with the residual structure of the Solow Model and endogenous growth theory (Romer, 1989), which positions technology and innovation as the primary drivers of long-term productivity in digital economic development.

In growth theory, Total Factor Productivity (TFP) is described as the total efficiency in the use of production factors, such as capital and labor. Digitalization contributes to capital growth through two main channels: strengthening human capital and increasing investment in digital infrastructure, software, automation systems, and other Industry 4.0 technologies. Consistent with the assumptions of the Solow model, TFP increases mechanistically as a result of exponential increases in output without proportional increases in inputs.

Second, implementing digital technology will require new skills, changes in organizational culture, and a shift in workforce structure to accommodate more knowledge-intensive jobs. This supports (Romer, 1989) endogenous growth theory, which emphasizes that learning and innovation are sources of long-term growth.

Digitalization, technological capital, and the quality of human capital are crucial in explaining productivity differences between sectors and countries. Countries that fail to enhance human capacity risk experiencing digital stagnation, where technology investments are not followed by productivity gains due to institutional or workforce unpreparedness.

4.2 Enabling and Inhibiting Factors of Digital Transformation in Enhancing Economic Productivity in Indonesia

Structural changes are occurring in various developing countries, including Indonesia, as a result of digital transformation. A study (Depari, 2024) shows that digital governance and business analytics have improved the efficiency of public services and enhanced collaboration with the private sector in Southeast Asia. E-government, a digital tax system, and national logistics integration based on real-time data accelerate evidence-based decision-making in Indonesia.

Digital infrastructure readiness, technologically literate human resource capabilities, and progressive policy support are some of the components that enhance the effectiveness of digitalization. Conversely, major obstacles to optimizing digital transformation include digital divides across regions, limited digital literacy, and the formal-informal economic dualism. According to (Yan et al., 2025), Indonesia's digital maritime industry was able to adapt more quickly to the global crisis, demonstrating the strategic role of digitalization in building macroeconomic resilience.

As an illustration, (Usman et al., 2025) stated that digitalization of the MSME sector improves management efficiency: "The use of digital platforms such as cloud-based accounting applications has been shown to accelerate decision-making and improve inventory management."

4.3 Strategic Policy Implications of Digital Transformation for Sustainable and Inclusive Economic Growth

Digitalization not only impacts efficiency and productivity but also plays a role in increasing global economic competitiveness. Studies by (Sun & Huang, 2025; Ziyabayevna, 2025) show that countries with mature digitalization strategies achieve high performance in TFP indicators, high-tech exports, and foreign direct investment (FDI). In Indonesia, the adoption of digital technology in export sectors such as digital agriculture, smart logistics, and fintech systems has increased trade efficiency and attracted foreign investors. A study by (Kaprata & Kume, 2025) also emphasized that an inclusive digital approach creates a balanced development between growth and equity.

Although various strategic policies such as Making Indonesia 4.0, the digitalization of tax services, and the expansion of QRIS (Qualifying Indonesia System) have been launched, implementation on the ground still faces serious challenges. A field study conducted by (Hapiz et al., 2025) showed that digital adoption by MSMEs is still limited to marketing and payment functions, while integration into digital supply chains and cloud-based management systems remains minimal due to a lack of technological literacy and limited infrastructure.

Furthermore, a report by (Nurhayati & Ridwan, 2025) revealed that local bureaucracies have not fully adapted to the digitalization process, particularly in data integration across government sectors. Many e-government initiatives are unsustainable because they rely on political support from regional heads, rather than permanent institutions. This indicates institutional fragility that hinders the scalability of digitalization programs.

Other challenges include resistance of the conventional workforce to automation, disparities in the quality of digital training between regions, and misalignment between private sector digital innovation and outdated regulations. These findings emphasize that successful digital transformation is not sufficient through formal policies alone; it requires social readiness, institutional capacity, and a comprehensive change in organizational culture.

Furthermore, digitalization directly contributes to the achievement of the Sustainable Development Goals (SDGs) through increased financial inclusion, empowerment of the informal sector, and the creation of new types of jobs in the digital sector. Therefore, digital transformation is not only an instrument for economic efficiency but also a key pillar of national development based on innovation and technological inclusion.

4.4 Discussion: Interpretation of Findings and Critical Analysis

Digitalization increases productivity and efficiency, enhancing economic competitiveness worldwide. According to studies (Sun & Huang, 2025; Ziyabayevna, 2025), TFP indicators, high-tech exports, and foreign direct investment (FDI) inflows increase in countries with mature digitalization strategies.

The Indonesian export sector has embraced digital technologies such as digital agriculture, smart logistics, and fintech systems, which have boosted trade and attracted foreign investors. Inclusive digital approaches result in balanced development between growth and equity, according to research (Kaprata & Kume, 2025).

Despite the launch of various strategic policies such as the digitization of tax services, the expansion of QRIS (Qualifying Indonesia 4.0), and Making Indonesia 4.0, implementation on the ground still faces numerous challenges. (Hapiz et al., 2025) conducted a field study that showed that digital adoption by MSMEs remains limited to marketing and payment functions. Due to technological unfamiliarity and limited infrastructure, integration into digital supply chains and cloud-based management systems remains minimal.

Furthermore, a report by (Nurhayati & Ridwan, 2025) shows that local bureaucracies have not fully adapted to the digitalization process, particularly regarding data integration across government sectors. Many e-government efforts have failed because they rely on political support from regional heads rather than permanent institutions. This suggests that institutional flaws hamper the scalability of digitalization programs.

Furthermore, several issues remain. For example, the conventional workforce resists automation, there are differences in the quality of digital training across regions, and there is a misalignment between outdated regulations and private sector digital innovation. The results indicate that digital transformation requires changes in organizational culture, social readiness, and institutional capacity to succeed.

Furthermore, digitalization directly contributes to the achievement of the Sustainable Development Goals (SDGs) by increasing financial inclusion, stimulating the informal sector, and creating new jobs in the

digital sector. Therefore, digital transformation is not only a tool for increasing economic efficiency but also a crucial part of national development, which relies on technological inclusion and innovation.

5.0 Implications for Economic Policy and Development Strategy

5.1 Theoretical Implications

This analysis helps enrich the theory of macroeconomic productivity and digital economy studies by demonstrating that technology adoption is not the sole factor driving productivity gains; it is the result of systemic relationships between digital infrastructure, human capital development, institutional capacity, and public policy governance. This study supports the notion that digital transformation is a structural phenomenon that simultaneously impacts multiple layers of economic interaction (Goubran & Mohareb, 2025). Furthermore, these findings strengthen the relevance of cross-country theories such as the innovation-driven endogenous growth theory, the technology-human skills complementarity model, and the disruption-job creation framework. These theories suggest that new digitalization, combined with institutional reforms and investments in inclusive human capital development, will boost productivity in Indonesia (Mahmood et al., 2025).

An approach sensitive to structural conditions such as the digital divide, the formal-informal economic dualism, and regional inequality is crucial in the Indonesian context. Therefore, the theoretical contribution of this review is the development of macroeconomic growth models that are more responsive to changes occurring in developing countries.

5.2 Practical and Policy Implications

From a policy perspective, this research offers several important recommendations for the Indonesian government and policy-making institutions in the ASEAN region:

1. Strategic Alignment
   For technology adoption to directly contribute to increased productivity, job creation, and sustainable growth, digital transformation must be aligned with macroeconomic planning.
2. Human Capital Investment
   Especially for traditional sectors and underdeveloped regions, policies that prioritize education reform, digital literacy, and workforce retraining are needed.
3. Modernization of Public Institutions
   To create an inclusive and productive digital ecosystem, digital transformation must be accompanied by institutional strengthening through e-government, data-driven governance, and regulatory reform.
4. Incentives for the Private Sector
   By providing financial incentives, supporting innovation, and providing digital transformation training, the government should encourage small and medium enterprises (SMEs) to adopt Industry 4.0 technologies.
5. Measurement System Reform
   The contribution of intangible assets, digital platform productivity, and digital spillover impacts to national economic calculations require improvements to the national statistical system.

5.3 Research to Policy Gap

The results of the bibliometric analysis presented previously indicate that the global research focus on digital transformation in recent years has increased on sustainability aspects. Topics such as green total factor productivity (GTFP), carbon emission efficiency, and digital independence have gained popularity in recent scientific journals. The emergence of these keywords indicates that the international academic community is beginning to consider digitalization in relation to economic efficiency and the transition to a long-term economy focused on more environmentally friendly and low-carbon outcomes.

However, the results of policy mapping indicate that the focus of national policies remains on manufacturing sector efficiency, increasing the adoption of digital technology, and integrating MSMEs into the e-commerce ecosystem and digital financial system. Strategic documents such as Making Indonesia 4.0 and the 2020–2024 National Medium-Term Development Plan (RPJMN) have not systematically described these sustainability elements. This method is crucial, but it does not fully meet the global research objectives that prioritize sustainable digitalization.

There is a significant gap between the national policy agenda and the progress of the scientific literature, as shown in the table "Gap between Global Research Focus and Indonesia's Digital Policy Priorities." A gap between research and government could hamper Indonesia's efforts to address the challenges of climate change, the global demand for a green economy, and the economic opportunities based on environmentally friendly innovation. Therefore, an urgent strategic step is to incorporate a sustainability perspective into digital transformation policies to bridge the gap and ensure long-term policy relevance.

6.0 Conclusion

According to this analysis, the digital shift in Industry 4.0 has become a key driver of economic restructuring worldwide, with a significant impact on macroeconomic productivity, cross-sector efficiency, and the direction of public policy. Digitalization is a systemic phenomenon involving technological innovation, human capital, institutional reform, and social sustainability. It is more than just a technical process. Developing countries like Indonesia still face structural challenges such as the digital divide, economic dualism, and a lack of innovation capabilities. However, countries with strong infrastructure and institutional capacity are able to achieve greater productivity gains in a global context.

Three urgent practical policy recommendations are made to address these disparities and ensure that digitalization truly fosters inclusive and sustainable economic growth. First, national digital transformation plans must be aligned with the green development agenda and global sustainability indicators, such as energy efficiency and carbon-focused innovation. Second, to prepare human capital for technology adaptation, substantial investment in digital literacy and workforce retraining is crucial, especially in traditional sectors and disadvantaged regions. Third, national productivity measurement systems must be updated to include the contributions of digital assets, economic platforms, and the indirect growth impacts of digital transformation.

Future research should focus on developing a digital policy evaluation framework more suited to the context of developing countries, incorporating economic, social, and environmental aspects. Long-term, microdata-based research from strategic sectors would also be helpful in identifying patterns of technology adoption and local constraints. Further research is expected to strengthen the link between scientific research and adaptive policy formulation in addressing the challenges of the era of sustainable digitalization by combining empirical analysis and policy reflection.

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