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THE IMPACT OF DIGITAL TRANSFORMATION ON THE PRODUCTIVITY

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ABSTRACT

Digital transformation has become a strategic imperative for the manufacturing industry to enhance competitiveness in the era of the Fourth Industrial Revolution. This study aims to analyze the impact of digital transformation on the productivity of the manufacturing sector in Indonesia in 2023. A quantitative approach was employed, using a survey of medium and large-scale manufacturing companies selected through stratified random sampling. Digital transformation was measured using four indicators: operational technology, information technology, analytics technology, and business process digitalization. Meanwhile, productivity was assessed through labor productivity, capital productivity, operational efficiency, and Total Factor Productivity. The results of multiple regression analysis indicate that digital transformation has a positive and significant effect on manufacturing productivity. Information technology emerged as the indicator with the greatest impact, followed by operational technology, business process digitalization, and analytics technology. This study contributes to the literature by providing comprehensive empirical evidence on the impact of digital transformation on manufacturing productivity in a developing economy. It also offers practical implications for industry players and policymakers in designing effective digital transformation strategies to boost the productivity of Indonesia's manufacturing sector.

***Keywords**: Digital Transformation; Manufacturing Productivity*

A. INTRODUCTION

The Industry 4.0 revolution has changed the global competitive landscape by massively integrating digital technology into manufacturing processes. Digital transformation, characterized by the adoption of *the Internet of Things (IoT), big data analytics, artificial intelligence, cloud computing, and cyber-physical systems,* has become a necessity for the manufacturing industry in many countries (Bappenas, 2022). This phenomenon has not only changed the way production is carried out, but has also revolutionized the entire industrial value chain from upstream to downstream. Developed countries such as Germany with Industry 4.0, the United States with the Advanced Manufacturing Partnership, and Japan with Society 5.0 have demonstrated that digital transformation can significantly improve the productivity, efficiency, and competitiveness of the medium-scale manufacturing industry. Amid increasingly intense global competition, the ability to adopt and implement digital technology has become a primary determinant of the success of a country's manufacturing industry (Kementerian Koordinasi Bidang Perekonomian, 2023).(Bappenas, 2022)(Kementerian Koordinasi Bidang Perekonomian, 2023)

Indonesia, as a country whose manufacturing sector contributes significantly to the national economy, faces unique challenges and opportunities in this era of digital transformation. The Indonesian manufacturing industry has long been the backbone of the economy, with a consistent contribution to Gross Domestic Product (GDP) and substantial labor absorption (Bank Indonesia, 2022). In 2023, Indonesia had 32,193 medium and large-scale manufacturing business units spread across various regions. The food and beverage industry, the basic metal industry, and the chemical and chemical products industry were the main contributors, with shares of 21.04 percent, 17.56 percent, and 7.87 percent of total national manufacturing production, respectively (Bappenas, 2022). The sheer scale and complexity of Indonesia's manufacturing sector underscore the urgency of understanding how digital transformation can be optimized to improve productivity and competitiveness in the global market.(Bank Indonesia, 2022)(Bappenas, 2022)

Empirical data show that the adoption of digital technology in Indonesia's manufacturing sector has accelerated considerably in recent years. Investment in information and communication technology in the manufacturing sector increased by 15 percent in 2023 compared to the previous year, indicating industry players' awareness of and commitment to the importance of digital transformation (Chairina & Yusri, 2023). Through the Making Indonesia 4.0 program, the Indonesian government designated 14 companies as National Lighthouses of Industry 4.0 between 2019 and 2022, serving as beacons for the implementation of industrial transformation and as inspiration for other manufacturing companies. However, the level of digital technology penetration across industrial scales in manufacturing still shows a fairly wide gap, particularly between large industries and medium and small industries. According to a survey by the Ministry of Industry (2024), only about 20% of manufacturing companies in Indonesia have adopted Industry 4.0 technology. This phenomenon raises an important question about how digital transformation affects productivity across the different segments of Indonesia's

manufacturing industry (Roida Purba & Hendra Ibrahim, 2024).(Chairina & Yusri, 2023)(Roida Purba & Hendra Ibrahim, 2024)

The productivity of Indonesia's manufacturing sector in 2023 shows interesting dynamics that merit deeper study. Non-oil and gas processing industry growth reached 4.81 percent in 2023, with a projected target of 5.80 percent for 2024. The manufacturing production index shows varying growth trends across subsectors, reflecting heterogeneity in technology adoption and operational efficiency (Suryadi & Nasution, 2023). Some industries that have comprehensively adopted digital technology, such as the automotive and electronics industries, show higher productivity gains than industries that still rely on conventional methods. However, aggregate data do not yet fully explain the causal mechanism between the implementation of specific digital technologies and productivity improvements at the firm and industry levels (Akhmad & Purnomo, 2021).(Suryadi & Nasution, 2023)(Akhmad & Purnomo, 2021)

Previous studies have explored the relationship between digital technology and manufacturing industry performance from various perspectives (Alayida et al., 2023; Kurniawan et al., 2021; Putri et al., 2022). Studies in developed countries show that the adoption of Industry 4.0 technologies such as *IoT* and robotics is consistently positively correlated with increased productivity, reduced operational costs, and improved product quality (Duila, 2023). In developing countries, studies show that contextual factors such as the readiness of digital infrastructure, the availability of skilled human resources, and government policy support play a significant moderating role (Kurniawan & Ramdani Yaspi, 2023). Several studies in Indonesia have identified that the implementation of Enterprise Resource Planning (ERP) systems, Manufacturing Execution Systems (MES), and automation technology yields measurable operational efficiency. However, comprehensive studies that systematically analyze the impact of multiple digital transformation indicators on the productivity of Indonesia's manufacturing sector, taking into account the specific industry context, business scale, and stage of technology adoption, remain limited (Abi et al., 2022; Cahyaningtyas et al., 2023; Siska et al., 2023).(Alayida et al., 2023; Kurniawan et al., 2021; Putri et al., 2022)(Duila, 2023)(Kurniawan & Ramdani Yaspi, 2023)(Abi et al., 2022; Cahyaningtyas et al., 2023; Siska et al., 2023)

The gap in the literature becomes even clearer when observing the complexity of implementing digital transformation in Indonesia's manufacturing industry. Most previous studies tend to be descriptive or to focus on individual company case studies, making them difficult to generalize to the manufacturing industry as a whole (Yani et al., 2021). In addition, most studies use a *cross-sectional* approach that cannot capture the temporal dynamics of a digital transformation process that unfolds gradually. Important aspects such as the organizational learning curve, the *lag* period between technology investment and the realization of productivity gains, and the interaction among the various digital transformation indicators (technology, processes, and human resources) have not been well mapped in the Indonesian context. Further research on how different types of digital technology affect specific productivity indicators such as *output* per worker, production capacity utilization,

and raw material efficiency still requires further investigation.(Ni Made Marta Yani et al., 2021)

The high heterogeneity in Indonesia in terms of industrial scale, geographic location, and level of technological maturity adds complexity to understanding the impact of digital transformation. Indonesia's manufacturing industry is not concentrated only on the island of Java, but is also spread across various regions with differing levels of digital infrastructure readiness. These regional differences have the potential to produce significant variation in the ability to adopt technology and realize productivity benefits. On the other hand, differences in business scale among large, medium, and small industries also create different challenges and opportunities in implementing digital solutions. Large industries may have the financial and technical resources to adopt sophisticated integrated systems, whereas medium-sized industries face capital constraints and a limited supply of expert personnel. Research on how these contextual factors influence the effectiveness of digital transformation in improving productivity is crucial for formulating well-targeted strategies (Chairina & Yusri, 2023; Kalimantoro et al., 2023; Roida Purba & Hendra Ibrahim, 2024).(Chairina & Yusri, 2023; Kalimantoro et al., 2023; Roida Purba & Hendra Ibrahim, 2024)

The urgency of this research is further heightened by the Indonesian government's ambitious targets to increase the growth of the manufacturing sector and to position Indonesia as a competitive global production base. The Making Indonesia 4.0 program has set a digital transformation roadmap with specific targets that require empirical evidence to ensure the effectiveness of its implementation. In the context of regional competition, other ASEAN countries such as Thailand, Vietnam, and Malaysia are also aggressively attracting manufacturing investment by offering increasingly mature digital ecosystems. Without a comprehensive understanding of how digital transformation can effectively increase productivity, Indonesia risks falling behind in regional and global competition. Therefore, research that yields in-depth insights and practical recommendations on effective digital transformation strategies is greatly needed. This study uses a quantitative approach to productivity and digital technology adoption data. The analysis focuses on several digital transformation indicators, including operational technology (automation, *IoT*, and robotics), information technology (ERP, MES, and analytics), as well as business process transformation and human resource capability development. By identifying the enablers of and barriers to digital transformation and measuring their impact on various productivity indicators, this study is expected to provide comprehensive and contextual guidance for accelerating digital transformation in Indonesia's manufacturing industry sector.

B. LITERATURE REVIEW

Operational technologies such as automation, robotics, and *IoT* sensors directly intervene in production processes on the factory floor. Automation reduces dependence on manual labor for repetitive tasks, increases production speed, and minimizes quality variability (Alayida et al., 2023). Robotics enables consistent, high-precision operations over long periods without fatigue. *IoT* sensors provide real-time visibility into machine conditions and production processes, enabling

proactive intervention before problems develop into production disruptions (Suryadi & Nasution, 2023). Based on these arguments, the following hypothesis is proposed: (Alayida et al., 2023)(Suryadi & Nasution, 2023)The adoption of operational technology has a positive effect on manufacturing industry productivity (H_1).

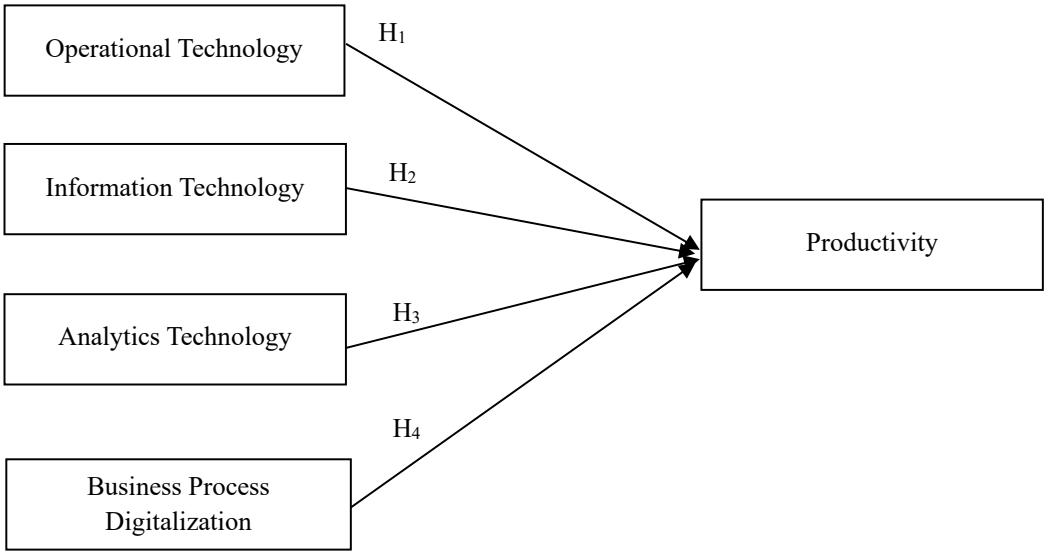
Integrating information and communication technology (ICT) across inventory management, sales, and finance helps streamline essential administrative tasks while driving operational efficiency and firm productivity (Sovania, 2025). Enterprise information technology systems such as ERP, MES, and SCM integrate information across organizational functions, eliminate information silos, and improve coordination. ERP facilitates more accurate production planning based on real-time demand data, reducing inventory holding costs and stockouts (Roida Purba & Hendra Ibrahim, 2024). MES optimizes production scheduling and resource allocation based on priorities and available capacity. SCM improves procurement and distribution efficiency through *end-to-end* supply chain visibility. This information integration reduces *lead time,* improves capacity utilization, and minimizes waste, which in aggregate increases productivity (Tambunan, 2021). Integrating information and communication technology (ICT) across inventory management, sales, and finance helps streamline essential administrative tasks while driving operational efficiency and firm productivity (Sovania, 2025). Thus: (Roida Purba & Hendra Ibrahim, 2024)(Tambunan, 2021) The adoption of information technology has a positive effect on manufacturing industry productivity (H_2).

Analytics technology turns operational data into actionable insights that support evidence-based decision-making. Big data analytics identifies patterns and trends in production processes that go undetected through manual observation. Machine learning enables predictive maintenance that anticipates machine failures before they occur, reducing unplanned downtime that harms productivity (Suryadi & Nasution, 2023). AI-powered quality control detects defects with higher accuracy than manual inspection, reducing rework and waste. Analytics-based process optimization improves production parameters such as yield rate and throughput. Therefore: (Suryadi & Nasution, 2023)The adoption of analytics technology has a positive effect on manufacturing industry productivity (H_3).

Business process digitalization transforms manual, paper-based workflows into automated, integrated, and transparent digital processes. Digitalization reduces business process cycle times by eliminating non-value-added activities such as manual data entry and the transfer of physical documents (Widyawati & Paramartha, 2021). Digitized approval and coordination processes increase the speed of response to operational changes and problems. Digitalization also improves traceability and accountability, facilitating continuous improvement based on historical data. This business process efficiency indirectly supports the efficiency of production operations (Duila, 2023). Based on this reasoning: (Widyawati & Paramartha, 2021)(Duila, 2023) Business process digitalization has a positive effect on manufacturing industry productivity (H_4).

Based on these hypotheses, it can be concluded that manufacturing industry productivity is positively influenced by four main dimensions of digital

transformation, namely the adoption of operational technology that optimizes production processes, the adoption of information technology that improves data integration and communication, the adoption of analytics technology that supports data-driven decision-making, and business process digitalization that streamlines operational workflows. These four dimensions are interrelated and contribute to improving efficiency, output quality, and the overall competitiveness of the manufacturing industry, and can be illustrated as follows:



Source: Research Results, 2025

Figure 1.
Research Framework

C. RESEARCH METHOD

This study uses a quantitative approach with an explanatory research design that aims to analyze the causal relationship between digital transformation and manufacturing industry productivity in Indonesia. The study population consists of medium and large-scale manufacturing companies in Indonesia registered with Statistics Indonesia (BPS) in 2023. The sampling technique used stratified random sampling, with stratification based on industry subsector, business scale, and geographic location (Java and outside Java). The sample size was set at 350 companies with a 95% confidence level and a 5% margin of error. The dependent variable is productivity, measured through: (1) labor productivity (output per worker), (2) capital productivity (output per asset), (3) operational efficiency (capacity utilization and cycle time), and (4) Total Factor Productivity. The independent variable is digital transformation, which comprises the following indicators: (1) operational technology adoption (automation, robotics, *IoT*), (2) information technology adoption (ERP, MES, SCM), (3) analytics technology adoption (big data, AI, machine learning), and (4) business process digitalization.

The control variables include company size, company age, industry subsector, and geographic location. Data were collected through a structured survey using a

validated questionnaire. Respondents were middle-to-senior-level managers who understand the company's operations and the implementation of digital technology. Secondary data were obtained from BPS, the Ministry of Industry, and BKPM (the Investment Coordinating Board) for validation and triangulation of the primary data. Data analysis used descriptive statistics to describe the sample profile and the level of technology adoption. Multiple regression analysis with the Ordinary Least Squares (OLS) method was used to test the relationship between digital transformation and productivity while controlling for confounding variables. To address potential endogeneity, Instrumental Variable (IV) regression was used with regional digital infrastructure as the instrument. Propensity Score Matching (PSM) was applied to compare productivity between companies that adopt digital technology intensively and those that do not. Robustness tests were conducted using alternative model specifications to ensure the consistency of the findings. Construct validity was tested using Confirmatory Factor Analysis (CFA), and instrument reliability was tested using Cronbach's alpha ($\alpha > 0.70$). A pilot test was conducted on 30 companies before the main survey. Common method bias was mitigated through the separation of variable measurement in the questionnaire, the combination of primary and secondary data, and Harman's single-factor test.

D. RESULTS AND DISCUSSION

Results

This study groups the data based on the profile of the businesses under study. This grouping covers several important aspects such as business scale, operating location, industry subsector, and company age. The purpose of this division is to provide a comprehensive picture of the diversity of characteristics of the companies participating in the study. The details of each category are presented as follows:

Table 1.
Characteristics of Research Respondents

Characteristic	Category	Number	Percentage (%)
Business Scale	Medium Industry	168	48.0
	Large Industry	182	52.0
Location	Java Island	245	70.0
	Outside Java	105	30.0
Subsector	Food & Beverage	78	22.3
	Metal & Electronics	94	26.9
	Textile & Garment	56	16.0
	Chemical & Pharmaceutical	63	18.0
	Automotive	59	16.8
Company Age	< 10 years	84	24.0
	10-20 years	147	42.0
	> 20 years	119	34.0
Total		350	100.0

Source: Research Results, 2025

Based on Table 1, the majority of respondents in this study come from large industries, at 52%, while the remaining 48% are medium industries. In terms of location, 70% of respondents are located on the island of Java, showing the geographic dominance of this region as a center of industrial activity, while the remaining 30% are spread outside Java. By subsector, the largest share of respondents comes from the metal and electronics subsector (26.9%), followed by food and beverage (22.3%), chemical and pharmaceutical (18.0%), automotive (16.8%), and textile and garment (16.0%). In terms of company age, the majority fall within the 10–20 year range (42%), followed by companies that have been established for more than 20 years (34%), and companies less than 10 years old (24%).

Table 2.
Digital Technology Adoption Level by Indicator

Digital Transformation	Mean	SD	Min	Max	Dominant Category
Operational Technology	3.42	1.18	1.00	5.00	Moderate
- Automation Systems	3.65	1.15	1.00	5.00	Moderate-High
- Robotics	2.89	1.34	1.00	5.00	Moderate
- *IoT* Sensors	3.71	1.22	1.00	5.00	Moderate-High
Information Technology	3.78	1.05	1.00	5.00	Moderate-High
- ERP System	4.12	1.02	1.00	5.00	High
- MES	3.58	1.18	1.00	5.00	Moderate
- SCM System	3.65	1.09	1.00	5.00	Moderate-High
Analytics Technology	3.15	1.28	1.00	5.00	Moderate
- Big Data Analytics	3.34	1.31	1.00	5.00	Moderate
- AI/Machine Learning	2.78	1.42	1.00	5.00	Low-Moderate
- Predictive Maintenance	3.33	1.29	1.00	5.00	Moderate
Business Process Digitalization	3.56	1.12	1.00	5.00	Moderate
Digital Transformation Index	3.48	0.98	1.25	5.00	Moderate

Source: Research Results, 2025

Based on Table 2, the level of digital technology adoption by companies falls predominantly in the "moderate" category, with an average digital transformation index of 3.48 on a scale of 1 to 5. Operational technology has an average score of 3.42, reflecting moderate implementation, with automation systems (3.65) and *IoT* sensors (3.71) in the moderate-to-high category, while robotics remains relatively low (2.89). In terms of information technology, the adoption level is higher, with an average of 3.78. ERP systems have the highest score (4.12), indicating high adoption, while MES (3.58) and SCM (3.65) fall in the moderate-to-high category. Meanwhile, analytics technology remains in the moderate category, with an average score of 3.15. Although big data analytics (3.34) and predictive maintenance (3.33) are reasonably well adopted, the application of AI/Machine Learning (2.78) remains in the low-to-moderate category, indicating potential for further development. Business process digitalization also shows an average score of 3.56, indicating fairly even adoption across business lines.

Table 3.
Descriptive Statistics of Productivity Indicators

Productivity	Mean	SD	Min	Max	Unit
Labor Productivity	487.5	183.4	156.0	1,245.0	IDR million/worker
Capital Productivity	1.84	0.67	0.45	4.32	Ratio
Capacity Utilization	74.3	12.8	35.0	98.0	%
Cycle Time Efficiency	3.68	0.89	1.50	5.00	Scale 1-5
Total Factor Productivity	2.76	0.94	0.82	5.45	Index

Source: Research Results, 2025

Based on Table 3, the companies' productivity indicators show considerable variation among respondents. Labor productivity averages IDR 487.5 million per worker, with a fairly high standard deviation (IDR 183.4 million), indicating inequality in labor efficiency among companies, with a minimum value of only IDR 156 million and a maximum of IDR 1,245 million per worker. Capital productivity has an average ratio of 1.84, indicating reasonably optimal use of capital relative to output, although the range of values is quite wide (0.45 to 4.32). Capacity utilization shows a fairly good level of use of machinery or production facilities, with an average of 74.3%, but still shows significant variation (SD 12.8%), indicating that some companies have not yet maximized their production capacity efficiently. Cycle time efficiency has an average score of 3.68 (on a 1–5 scale), reflecting a moderate-to-high level of production process efficiency. Meanwhile, Total Factor Productivity (TFP), as a composite indicator of the efficiency of all production inputs, shows an average value of 2.76, with a fairly wide range (0.82 to 5.45), indicating that some companies have succeeded in integrating production factors efficiently, while others still lag behind.

Table 4.
Instrument Reliability and Validity Test Results

Construct	Cronbach's Alpha	CR	AVE	Status
Operational Technology	0.876	0.881	0.651	Valid & Reliable
Information Technology	0.892	0.895	0.682	Valid & Reliable
Analytics Technology	0.901	0.906	0.708	Valid & Reliable
Business Process Digitalization	0.854	0.859	0.604	Valid & Reliable
Productivity	0.883	0.887	0.665	Valid & Reliable

Source: Research Results, 2025

Based on Table 4, all constructs in the research instrument meet the criteria for good validity and reliability. The Cronbach's Alpha values for all constructs are above 0.85, indicating a high level of internal consistency, with the highest value for the Analytics Technology construct (0.901) and the lowest for Business Process Digitalization (0.854), which still falls in the highly reliable category. In addition, the Composite Reliability (CR) values for all constructs also exceed the minimum threshold of 0.70, indicating that the instrument can be trusted to measure the intended constructs. Meanwhile, the Average Variance Extracted (AVE) values are all above 0.60, indicating that more than 60% of the variance of the indicators can be explained by the corresponding latent construct. Thus, the instrument used in

this study is declared valid and reliable, and suitable for use in the subsequent analysis.

Table 5.
Correlation Matrix among Variables

Variable	1	2	3	4	5	6	7	8
1. Labor Productivity	1							
2. Capital Productivity	0.685	1						
3. TFP	0.792	0.748	1					
4. Operational Tech.	0.548	0.472	0.623	1				
5. Information Tech.	0.612	0.534	0.681	0.697	1			
6. Analytics Tech.	0.489	0.418	0.556	0.643	0.712	1		
7. Process Digitalization	0.524	0.465	0.598	0.718	0.765	0.689	1	
8. Company Size	0.387	0.312	0.425	0.456	0.489	0.423	0.441	1

Source: Research Results, 2025

Based on Table 5, the correlation matrix results show that:

a. Operational Technology Adoption Has a Positive Effect on Manufacturing Industry Productivity, with correlation values of 0.548 for labor productivity, 0.472 for capital productivity, and 0.623 for Total Factor Productivity (TFP).
b. Information Technology Adoption Has a Positive Effect on Manufacturing Industry Productivity, with correlation values of 0.612 for labor productivity, 0.534 for capital productivity, and 0.681 for TFP.
c. Analytics Technology Adoption Has a Positive Effect on Manufacturing Industry Productivity, with correlations of 0.489 for labor productivity, 0.418 for capital productivity, and 0.556 for TFP.
d. Business Process Digitalization Has a Positive Effect on Manufacturing Industry Productivity, with correlation values of 0.524 for labor productivity, 0.465 for capital productivity, and 0.598 for TFP.

Discussion

1. Operational Technology Adoption Has a Positive Effect on Manufacturing Industry Productivity

The findings demonstrate that operational technology adoption has a positive relationship with manufacturing industry productivity. This indicates that the implementation of advanced production technologies, such as automated machinery, Computer Numerical Control (CNC) systems, digital monitoring equipment, and computerized quality-control systems, contributes to more efficient and consistent manufacturing operations. These technologies enable manufacturing companies to improve production accuracy, minimize human errors, reduce machine downtime, and optimize the utilization of production resources. Consequently, operational technology adoption supports productivity improvements by increasing production efficiency and reducing operational waste.

This finding can be explained through the Resource-Based View (RBV), which considers technological resources and capabilities as important sources of organizational competitive advantage. From this perspective, operational

technologies represent strategic resources that enable manufacturing firms to develop more efficient production processes and improve their ability to utilize existing resources. Furthermore, the Dynamic Capabilities Theory explains that firms can improve their productivity by continuously adapting and reconfiguring their technological resources in response to changes in production requirements and market conditions. Therefore, the productivity benefits of operational technology adoption are not limited to the replacement of conventional machinery but also involve the development of more responsive, accurate, and integrated production systems.

The finding is consistent with Jing, (2024), who examined intelligent manufacturing in Chinese manufacturing companies and demonstrated the relevance of integrating advanced manufacturing technologies with digital technologies to improve labor productivity. Similarly, Bodendorf et al., (2023) found that Industry 4.0 technology adoption positively influences labor productivity among Italian manufacturing micro, small, and medium-sized enterprises. Their findings indicate that technological adoption improves productivity through cost efficiency, knowledge creation, and stronger organizational and supplier integration. In addition, Saraswat & Choudhari, (2025) demonstrated the productivity implications of providing real-time digital feedback to manufacturing workers through smartwatch technology, highlighting the importance of digital monitoring and operational feedback in manufacturing activities.

Compared with these previous studies, the present research provides additional evidence by examining operational technology adoption as a distinct dimension of digital transformation and relating it to manufacturing productivity, particularly Total Factor Productivity (TFP). This perspective emphasizes that operational technologies contribute not only to labor efficiency but also to the more effective utilization of multiple production inputs simultaneously. Thus, the findings support H1 and reinforce the argument that operational technology adoption is an important driver of manufacturing industry productivity.

2. Information Technology Adoption Has a Positive Effect on Manufacturing Industry Productivity

The findings indicate that information technology adoption positively influences manufacturing industry productivity. This suggests that the implementation of integrated information systems, including Enterprise Resource Planning (ERP), cloud computing, and other digital information-management platforms, enables manufacturing companies to coordinate organizational activities more effectively. Information technology facilitates the integration of production, procurement, inventory, finance, and distribution information, allowing managers to access accurate and timely information for operational planning and decision-making. Through improved information accessibility and communication, manufacturing firms can reduce information-processing delays, minimize coordination problems, and improve the allocation of organizational resources.

This relationship can be explained through Information Processing Theory, which argues that organizational effectiveness depends on the ability of information-processing systems to address the complexity and uncertainty of

organizational activities. Manufacturing companies operate in environments that require continuous coordination between different departments and production functions. Information technology adoption increases organizational information-processing capacity by facilitating the collection, integration, and distribution of relevant information. Furthermore, the Resource-Based View explains that information systems become valuable organizational resources when they are effectively integrated with human capabilities and business processes. Therefore, information technology adoption can improve productivity by strengthening organizational coordination and supporting more informed managerial decisions.

These findings are supported by Saraswat & Choudhari, (2025), who investigated ERP adoption and enterprise productivity and found that ERP implementation generated positive productivity effects, with the magnitude depending on the technological environment in which firms operate. Similarly, Aisha et al., (2025), demonstrated that the interaction between ERP systems and innovation contributes to the development of business intelligence capabilities and improves organizational performance. Their findings highlight the importance of integrating enterprise information systems with organizational innovation to obtain greater benefits from digital technologies. Furthermore Rossini et al., (2024) found that digital transformation positively affects supply chain performance among Chinese manufacturing firms, with supply chain integration partially mediating this relationship.

The present findings extend these studies by identifying information technology adoption as an important technological dimension associated with manufacturing productivity, rather than examining digital transformation only as a general organizational concept. In particular, the results suggest that integrated information systems play an important role in improving productivity through organizational coordination, information transparency, and resource-allocation efficiency. This provides an important explanation of why information technology adoption may generate substantial productivity benefits in manufacturing environments, where production activities depend heavily on accurate information exchange across organizational functions. Therefore, H2 is supported, indicating that information technology adoption has a positive effect on manufacturing industry productivity.

3. Analytics Technology Adoption Has a Positive Effect on Manufacturing Industry Productivity

The findings reveal that analytics technology adoption has a positive relationship with manufacturing industry productivity. This indicates that the utilization of data analytics, business intelligence platforms, predictive analytics, and other data-processing technologies enables manufacturing companies to transform operational data into meaningful information for improving production decisions. Through analytical capabilities, companies can identify production bottlenecks, monitor equipment performance, detect operational inefficiencies, improve demand forecasting, and anticipate potential disruptions. These capabilities support more accurate production planning and enable managers to

make decisions based on actual operational conditions rather than relying exclusively on experience or intuition.

The relationship can be explained through the Dynamic Capabilities Theory, particularly the organizational ability to sense opportunities and threats, seize opportunities through informed decisions, and reconfigure resources to improve organizational performance. Analytics technology strengthens these capabilities by enabling companies to identify operational problems, recognize emerging production patterns, and respond to changes in production requirements. In addition, the Resource-Based View considers data, analytical infrastructure, and analytical expertise as valuable organizational resources that can generate productivity advantages when effectively combined with existing production capabilities. Consequently, analytics technology contributes to manufacturing productivity by improving the quality of managerial decisions and supporting the continuous optimization of production activities.

These findings are consistent with the research conducted by Saraswat & Choudhari, (2025), who examined the integration of big data analytics and cloud computing into existing enterprise systems in a manufacturing company. Their study highlights how big data analytics enables organizations to extract previously unexplored information, support managerial decision-making, and improve organizational performance through integration with existing ERP systems. Similarly, Arabia et al., (2025) emphasizes that process analytics can identify inefficiencies, strengthen supply chain integration, and improve operational coordination. The study also highlights the importance of intelligent information systems and analytical capabilities in supporting organizational performance.

The present study provides additional evidence by examining analytics technology adoption as an independent dimension of digital transformation and relating it directly to manufacturing productivity. Unlike studies that primarily investigate analytics in the context of supply chain integration or general organizational performance, this research emphasizes its contribution to the productivity of manufacturing operations. The findings also suggest that the productivity benefits of analytics technology depend not only on the availability of analytical tools but also on data quality, employees' analytical competencies, and the organization's ability to translate analytical insights into operational improvements. This interpretation highlights the importance of developing human capabilities alongside technological investments. Therefore, H3 is supported, demonstrating that analytics technology adoption positively contributes to manufacturing industry productivity.

4. Business Process Digitalization Has a Positive Effect on Manufacturing Industry Productivity

The findings demonstrate that business process digitalization has a positive relationship with manufacturing industry productivity. This indicates that the digitalization of organizational processes contributes to productivity improvements by connecting and coordinating activities across production, inventory management, procurement, distribution, and supply chain operations. The implementation of digital workflows and integrated business platforms reduces

manual administrative activities, minimizes information duplication, improves process transparency, and facilitates faster coordination between departments. As a result, manufacturing companies can manage operational activities more efficiently and reduce delays throughout the production and distribution processes.

This relationship can be explained through the Resource-Based View and Information Processing Theory. From the Resource-Based View perspective, digitally integrated business processes represent organizational capabilities that allow companies to utilize technological resources more effectively and develop operational advantages. Meanwhile, Information Processing Theory suggests that digitalized processes improve the flow of information between interdependent organizational units, reducing coordination difficulties and enabling more effective responses to operational uncertainty. Business process digitalization therefore contributes to productivity not simply by converting manual activities into digital formats but by improving the integration, synchronization, and efficiency of organizational processes.

The findings are consistent with Bodendorf et al., (2023) and Jing, (2024), who demonstrated that digital transformation positively affects supply chain performance in Chinese manufacturing firms, with supply chain integration serving as a partial mediating mechanism. Their research indicates that digital technologies create greater organizational value when they facilitate coordination and integration across supply chain activities. Similarly, Bhatti et al., (2025), in their empirical investigation of manufacturing firms, found that the coordination of internal and external electronic supply chain practices contributes to improved operational and business performance. Their study, grounded in Coordination Theory, emphasizes that the integration of digital business activities is essential for obtaining performance benefits from electronic supply chain adoption. Furthermore, research by He et al. (2024) demonstrated that digital transformation contributes to improved supply chain efficiency by reducing demand uncertainty and raw material disruption risks.

In addition, the findings are supported by Pratamansyah, (2024), which emphasizes the importance of integrating digital technologies into manufacturing processes to improve operational efficiency. This perspective highlights that digitalization should be implemented through a process-oriented approach rather than as isolated technological investments.

The contribution of the present study lies in demonstrating the relationship between business process digitalization and manufacturing productivity as a specific dimension of digital transformation. While previous studies have primarily emphasized supply chain performance, organizational performance, or operational efficiency, this research connects business process digitalization with broader manufacturing productivity. This is particularly relevant because the integration of production, inventory, and supply chain processes can improve the utilization of labor, capital, and other production resources simultaneously. Therefore, H4 is supported, indicating that business process digitalization positively contributes to manufacturing industry productivity.

E. CONCLUSION

This study demonstrates that digital transformation contributes significantly to manufacturing productivity, with information technology adoption exerting the strongest influence on Total Factor Productivity, followed by operational technology, business process digitalization, and analytics technology. These findings highlight the importance of integrating digital technologies to optimize production factors, improve operational efficiency, and strengthen data-driven decision-making. The study contributes to the understanding of digital transformation as a synergistic capability rather than an isolated technological investment, while emphasizing the importance of employee digital competencies, organizational readiness, and effective change management in maximizing productivity gains. Practically, manufacturing companies should prioritize integrated information systems, strengthen automation and quality control, and implement continuous digital skills development aligned with business processes. Future research should expand the coverage of manufacturing sectors and incorporate external factors, such as government policies and global market dynamics, to provide a more comprehensive understanding of the relationship between digital transformation and productivity across different industrial contexts.

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