THE EFFECT OF DIGITAL TECHNOLOGY ON THE OPERATIONAL PERFORMANCE OF MSMEs ON E-COMMERCE PLATFORMS THROUGH THE MEDIATING ROLE OF SUPPLY CHAIN INTEGRATION

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Abstract

This study aims to analyze the impact of digital technology on the operational performance of Micro, Small, and Medium Enterprises (MSMEs) on e-commerce platforms with supply chain integration mediation. The digital technologies referred to include the Internet of Things (IoT) and Artificial Intelligence (AI), which play a role in improving the efficiency and effectiveness of business processes. This study uses a quantitative approach with a survey method of 198 MSME players in Indonesia who run their businesses through e-commerce platforms. Data analysis was performed using the Partial Least Squares-Structural Equation Modeling (PLS-SEM) method through SmartPLS software. The results show that digital technology has a positive impact on supply chain integration, both internally, with suppliers, and with customers. Supply chain integration has also been proven to have a significant impact on improving the operational performance of MSMEs. In addition, the supply chain integration variable acts as a mediator between digital technology and operational performance. These findings confirm that the application of digital technology supported by strong supply chain integration can drive increased efficiency, responsiveness, and competitiveness of MSMEs in the digital era.

Keywords: Digital Technology, Internet of Things, Artificial Intelligence, Supply Chain Integration, Operational Performance, SMEs, E-Commerce

INTRODUCTION

Globalization and digitalization have changed the business landscape (Vărzaru & Bocean, 2024), driving the 64.2 million MSMEs in Indonesia that account for 61.07% of the GDP and employ 97% of the workforce (Kemenkeu, 2023). MSME participation in digital platforms has increased, boosted by 75% internet penetration and the rapid growth of e-commerce (Badan Pusat Statistik, 2025). However, they continue to face challenges in literacy, infrastructure, and operations. The application of IoT and AI enhances connectivity, accuracy, and automation (Ben-Daya et al., 2019), bringing competitiveness to the MSME. Digital technology also enhances performance through Supply Chain Integration (SCI), with coordination and responsiveness among stakeholders being promoted (Cui et al., 2023; De Vass et al., 2018), while AI-based supply chains can cut costs by as much as 15% (World Economic Forum, 2025).

Although several in-depth studies have discussed the role of e-commerce in improving business performance, there are still gaps in research, especially in the context of MSMEs in Indonesia. Jain et al. (2021) explain the importance of e-commerce as a facilitator, its benefits, and challenges, but do not discuss the mediating role of supply chain integration. Research by Ernawan et al. (2022) discusses the application of IoT in improving internal supply chain performance in Indonesian organizations, but the objects analyzed are only large-scale companies, do not include the MSME sector, and do not consider the combinative role of IoT and AI in strengthening MSME supply chain integration, a technology currently being researched. This study focuses on how digital technology collaboration, such as IoT and AI, can influence the performance of MSMEs operating their businesses on e-commerce platforms through Supply Chain Integration, particularly in Indonesia. Further research by Liu & Chiu, (2021) discusses the application of artificial intelligence (AI) in supply chain management (SCM) based on 123 empirical studies published up to 2024. The scope of the study was limited to the manufacturing sector, so the results do not fully represent other sectors such as healthcare, energy, retail logistics, or humanitarian supply chains. Most of the data also came from case studies in Europe and Asia, so the results of the study cannot necessarily be generalized to the context of other developing countries.

Nevertheless, limited studies investigate the interplay of IoT, AI, and SCI as a mediator; thus, this study seeks to explore their impact on MSME operational performance in the e-commerce environment of Indonesia.

Based on the results of the study, digital technology has a positive effect on operational performance through internal integration. This study is in line with (Liu & Chiu, 2021), who state that the adoption of digital technology in internal integration will optimize operational performance. The results of the study also prove that digital technology has a positive contribution to operational performance mediated by supplier integration. Strategic collaboration with suppliers through the adoption of digital technology will improve operational performance. For example, systems created through IoT and AI for the exchange of access between companies and suppliers include production requirement data and efficient delivery routes. This can prevent unexpected costs and delays in the delivery of raw materials. These findings are in line with research conducted by (Ernawan et al., 2022), which states that digital technologies such as IoT can improve supplier integration, which in turn will affect operational performance. This study also shows that customer integration mediates the effect of digital technology on operational performance. This is in line with research by

(Nazir & Fan, 2024), which states that the adoption of digital technology will support the creation of customer interactions, enabling managers to increase customer satisfaction by adjusting products to demand and optimizing the delivery process.

REVIEW OF LITERATURE

Contingency theory emerged in 1950 through the innovative work of Joan Woodward, Burns, and Stalker. There is a discussion of the technological approach in contingency theory introduced by Joan Woodward. According to Joan Woodward (1958), the technological approach emphasizes the importance of compatibility between organizational structure and technical systems (Nassou & Bennani, 2024). In this study, contingency theory is used as a basis for understanding that the role of digital technology (IoT and AI) in improving the performance of MSMEs is largely determined by other factors, such as internal organizational capabilities. Technology is not universal; its value lies in its ability to integrate processes and support operational elements, especially in the context of supply chain structure and integration processes. Therefore, supply chain integration (SCI) serves as a key contingency factor that bridges the utilization of digital technology and improved performance.

Referring to a previous study conducted by Cui et al. (2023), this study shows that digital technology does not have a direct impact on corporate resilience, but rather through supply chain integration as a mediating mechanism. Information complexity also strengthens the relationship. In the study by Fatorachian & Kazemi, (2021), it was also shown that Industry 4.0 can revolutionize the supply chain with comprehensive integration, transparency, and automation, thereby promoting increased responsiveness, flexibility, quality, and efficiency. Meanwhile, research by Ernawan et al., (2022) supports other studies by stating that the application of IoT in internal supply chains can improve competitive performance, especially in the era of e-commerce.

RESEARCH METHOD

This study uses a quantitative approach to examine the relationship between variables covering digital technology, supply chain integration, and the operational performance of MSMEs on e-commerce platforms in Indonesia using a survey method. Primary data was obtained by distributing online questionnaires using Google Forms to MSME players who had been operating for at least one year on e-commerce platforms. The sampling technique used purposive sampling, with a total of 198 respondents who met the assessment criteria. The measurement instrument in this study used a five-point Likert scale, ranging from “strongly disagree” to “strongly agree.” A pilot test for validity and reliability was conducted using SPSS software, and the results showed that all question items were valid and reliable. Data analysis in this study used the Partial Least Squares Structural Equation Modeling (PLS-SEM) method with the help of SmartPLS software. The analysis was carried out through measurement model testing (outer model) to assess the validity and reliability of the construct. In addition, structural testing (inner model) was also conducted to test the relationship between latent variables. Furthermore, descriptive analysis was also conducted to describe the characteristics of the respondents and research variables in general.

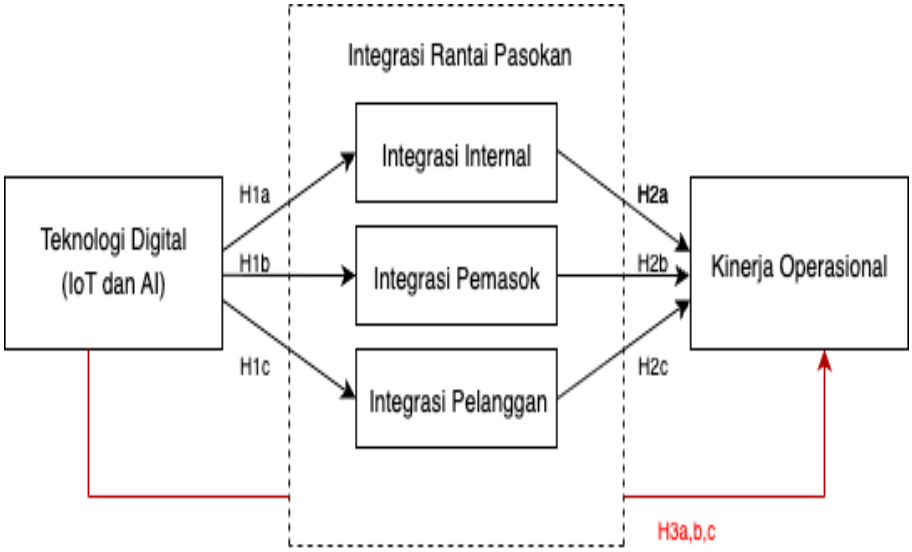
Research Hypothesis

This research aims to analyze the influence of digital technology on operational performance mediated by supply chain integration. Based on the literature review and previous research, the hypothesis proposed in this research is as follows:

- H1a: Digital technology has a positive effect on internal integration.
- H1b: Digital technology has a positive effect on supplier integration.
- H1c: Digital technology has a positive effect on customer integration.
- H2a: Internal integration has a positive effect on operational performance.
- H2b: Supplier integration has a positive effect on operational performance.
- H2c: Customer integration has a positive effect on operational performance.
- H3a: Internal integration mediates the relationship between digital technology and operational performance.
- H3b: Supplier integration mediates the relationship between digital technology and operational performance.
- H3c: Customer integration mediates the relationship between digital technology and operational performance.

Research Model

Figure 1.
Research Model



RESULTS AND DISCUSSION

Research Sample Description

This study recruited 198 MSME entrepreneurs from across Indonesia who do business on e-commerce platforms. The data were collected through online questionnaires sent via WhatsApp, email, and web surveys, as well as by direct visits.

Table 1.
Description of Research Sample

Characteristics	Category	Number	Percentage
Gender	Male	102	51.5%

	Female	96	48.5%
	Total	**198**	**100%**
Type of Business	Food and Beverage	24	12.1%
	Fashion and Accessories	41	20.7%
	Beauty	32	16.2%
	Automotive	41	20.7%
	Health	27	13.6%
	Handicrafts and Souvenirs	33	16.7%
	Total	**198**	**100%**
Initial Capital	Rp 1 million – Rp 20 million	35	17.7%
	Rp 21 million – Rp 40 million	53	26.8%
	Rp 41 million – Rp 60 million	74	37.3%
	> Rp 60 million	36	18.2%
	Total	**198**	**100%**
Annual Sales Turnover	< Rp 50 million	53	26.8%
	Rp 50 million – Rp 99 million	85	42.9%
	Rp 100 million – Rp 299 million	51	25.8%
	> Rp 300 million	9	4.5%
	Total	**198**	**100%**
Business Duration	1 year	20	10.1%
	2 – 5 years	58	29.3%
	6 – 10 years	89	44.9%
	> 10 years	31	15.7%
	Total	**198**	**100%**
Business Location	Central Java	29	14.6%
	West Java	29	14.6%
	East Java	29	14.6%
	DKI Jakarta	27	13.6%
	Yogyakarta	30	15.2%
	Sumatra	27	13.6%
	Kalimantan	27	13.6%
	Total	**198**	**100%**

Source: Processed Primary Data (2025)

Measurement Model Testing (Outer Model)

Convergent Validity Test

Two items to be considered when testing for convergent validity are Outer Loading and Average Variance Extracted (AVE). Hair et al., (2014) state that if the AVE value is 0.50 and above, then the research results will be accepted as valid.

Figure 2.
Outer Measurement Model

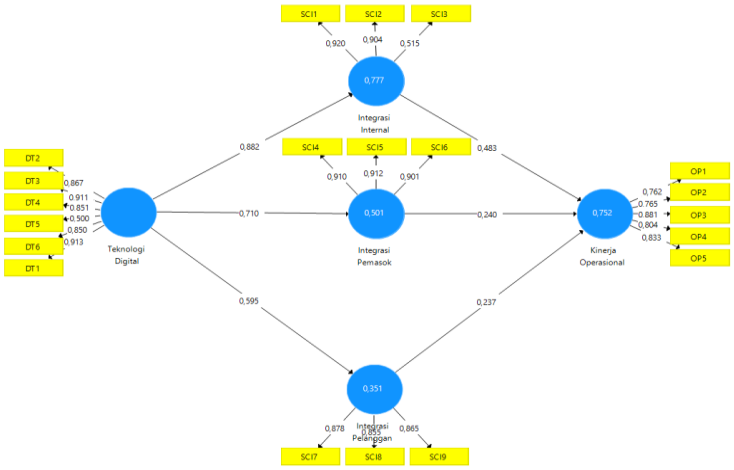


Table 2.
Outer Loading

	Internal Integration	Customer Integration	Supplier Integration	Operational Performance	Digital Technology
DT2					0,867
DT3					0,911
DT4					0,851
DT5					0,500
DT6					0,850
OP1				0,762	
OP2				0,765	
OP3				0,881	
OP4				0,804	
OP5				0,833	
SCI1	0,920				
SCI2	0,904				
SCI3	0,515				
SCI4			0,910		
SCI5			0,912		
SCI6			0,901		
SCI7		0,878			
SCI8		0,855			
SCI9		0,865			
DT1					0,913

Source: Data Processing (2025)

According to Table 2, all indicators have satisfied all the criteria mentioned above (>0.50). Therefore, all the indicators can be said to have good loading factor values.

Table 3.
Average Variance Extracted

	Average Variance Extracted (AVE)
Internal Integration	0,643
Customer Integration	0,750
Supplier Integration	0,823
Operational Performance	0,656
Digital Technology	0,685

Source: Data Processing (2025)

Table 3 requires all the AVE to be more than 0.50, which suggests that the convergent validity is good, as all the indicators are well represented by their constructs.

Discriminant Validity Test

Table 4.
Discriminant Validity of the Fornell-Larcker Criterion

	Internal Integration	Customer Integration	Supplier Integration	Operational Performance	Digital Technology
Internal Integration	0,802				
Customer Integration	0,628	0,866			
Supplier Integration	0,759	0,775	0,907		
Operational Performance	0,814	0,727	0,791	0,810	
Digital Technology	0,882	0,595	0,710	0,793	0,828

Source: Data Processing (2025)

In Table 4, it can be seen that all constructs fulfill the Fornell-Larcker criteria, namely the AVE square root (0.802-0.907) is greater than the correlations, which confirms the good discriminant validity.

Table 5.
Cross Loading

	Internal Integration	Customer Integration	Supplier Integration	Operational Performance	Digital Technology
DT2	0,831	0,433	0,664	0,703	0,867
DT3	0,813	0,528	0,692	0,724	0,911
DT4	0,673	0,534	0,559	0,621	0,851
DT5	0,438	0,484	0,285	0,506	0,500
DT6	0,731	0,484	0,606	0,651	0,850
OP1	0,607	0,669	0,719	0,762	0,541
OP2	0,631	0,791	0,708	0,765	0,529
OP3	0,722	0,583	0,619	0,881	0,761
OP4	0,675	0,395	0,568	0,804	0,692
OP5	0,656	0,450	0,561	0,833	0,696
SCI1	0,920	0,455	0,656	0,699	0,811

SCI2	0,904	0,459	0,657	0,706	0,839
SCI3	0,515	0,705	0,508	0,550	0,385
SCI4	0,685	0,716	0,910	0,752	0,644
SCI5	0,713	0,712	0,912	0,697	0,669
SCI6	0,667	0,682	0,901	0,702	0,619
SCI7	0,537	0,878	0,713	0,624	0,542
SCI8	0,586	0,855	0,681	0,644	0,540
SCI9	0,505	0,865	0,616	0,619	0,460
DT1	0,817	0,525	0,632	0,709	0,913

Source: Data Processing (2025)

Table 5 shows that the index has a high correlation with its own constructs even more, which suggests the good discriminant validity established (Henseler et al., 2015).

Reliability Test

All constructs meet reliability criteria; their Cronbach's alpha and CR are above 0.40 (Noor, 2017).

Table 6.
Cronbach's Alpha dan Composite Reliability

	Cronbach's Alpha	Composite Reliability
Internal Integration	0,694	0,836
Customer Integration	0,833	0,900
Supplier Integration	0,893	0,933
Operational Performance	0,868	0,905
Digital Technology	0,901	0,927

Source: Data Processing (2025)

Structural Model Testing (Inner Model)

The R^2 values were estimated for the dependent factors, and path coefficients were extended for independent variables.

Collinearity Test

Collinearity testing is one approach to structural model testing, which tests the relationship between latent variables. In the context of PLS-SEM, a tolerance value of 0.20 or lower than a VIF value of 5 is acceptable. Higher values indicate potential collinearity problems (Hair et al., 2014).

Table 7.
Inner VIF Values

	Internal Integration	Customer Integration	Supplier Integration	Operational Performance	Digital Technology
Internal Integration				2,377	
Customer Integration				2,531	
Supplier Integration				3,613	
Operational Performance					
Digital Technology	1,000	1,000	1,000		

Source: Data Processing (2025)

Coefficient of Determination (R-Square)

Table 8.
Result R-Square

	R Square	R Square Adjusted
Internal Integration	0,778	0,777
Customer Integration	0,354	0,351
Supplier Integration	0,504	0,501
Operational Performance	0,755	0,752

Source: Data Processing (2025)

The markers for each case are shown by Internal Integration (77.7%), Customer Integration (35.1%), Supplier Integration (50.1%), and Operational Performance (75.2%). All these areas are marked by external influences.

Predictive Relevance (Q-Square)

The Q-square evaluates the extent of preloaded endogenous variables that are theoretically dependent (greater than zero) (Hair et al., 2016).

Table 9.
Result Q-Square

	SSO	SSE	Q^2 (=1-SSE/SSO)
Internal Integration	594,000	300,394	0,494
Customer Integration	594,000	440,586	0,258
Supplier Integration	594,000	350,726	0,410
Operational Performance	990,000	514,824	0,480
Digital Technology	1188,000	1188,000	

Source: Data Processing (2025)

As shown in Table 9, the Q-square values for this study were found to be 0.494(Internal), 0.258(Customer), 0.410(Supplier), and 0.480 (Operational Performance), thereby confirming some fairly good predictive relevance. Digital Technology has a $Q^2 = 0$ because it is a dependent variable.

Hypothesis Testing

Supporting all hypotheses with a T value over 1.96 and a P-value less than 0.05, the results obtained from bootstrapping have been corroborated (Hair et al., 2016).

Table 10.
Path Coefficient Results

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Conclusion
Digital Technology -> Internal Integration	0,882	0,882	0,019	47,512	**0,000**	**H1a Supported**
Digital Technology -> Supplier Integration	0,710	0,702	0,057	12,498	**0,000**	**H1b Supported**

Digital Technology -> Customer Integration	0,595	0,587	0,061	9,713	**0,000**	**H1c Supported**
Internal Integration -> Operational Performance	0,483	0,482	0,055	8,812	**0,000**	**H2a Supported**
Supplier Integration -> Operational Performance	0,240	0,236	0,073	3,306	**0,001**	**H2b Supported**
Customer Integration -> Operational Performance	0,237	0,245	0,060	3,960	**0,000**	**H2c Supported**
Digital Technology -> Internal Integration -> Operational Performance	0,426	0,426	0,050	8,556	**0,000**	**H3a Supported**
Digital Technology -> Supplier Integration -> Operational Performance	0,171	0,167	0,057	2,982	**0,003**	**H3b Supported**
Digital Technology -> Customer Integration -> Operational Performance	0,141	0,144	0,036	3,907	**0,000**	**H3c Supported**

Source: Data Processing (2025)

H1a: The effect of digital technology on internal integration is positive (P = 0.000; T = 47.512).

H1b: Digital technology positively enhances supplier integration (P=0.000; T=12.498).

H1c: Digital technology has a positive and significant influence on customer integration (p = 0.000; t = 9.713).

H2a: Internal integration enhances operational performance (P = 0.000; T = 8.812).

H2b: Supplier integration has a statistically significant impact on operational performance (P = 0.001; T = 3.306).

H2c: There is a positive operational performance effect by customer integration (P=0.000; T=3.960).

H3a: Digital technology influences operational performance via internal integration (P = 0.000; T = 8.556) while intervening as a very significant effect.

H3b: Supplier integration (P = 0.003; T = 2.982) is a positive means through which digital technology impacts operational performance.
H3c: Digital technology successfully elevates organizational operational performance in terms of customer integration (P = 0.000; T = 3.907).

CONCLUSION

With the advent of digital technologies, supply chain integration-internal, supplier, and customer- has greatly improved MSME performance within the e-commerce industry in Indonesia. SCI serves as a mediator for the impact of technology on performance, following Contingency Theory. In practice, MSMEs should enhance their digital infrastructure through ERP, IoT, and AI systems to increase efficiency. Future research should investigate other technologies like big data, cloud computing, and blockchain using longitudinal methods.

REFERENCES

Badan Pusat Statistik. (2025). *STATISTIK TELEKOMUNIKASI INDONESIA*.

Ben-Daya, M., Hassini, E., & Bahroun, Z. (2019). Internet of things and supply chain management: A literature review. *International Journal of Production Research*, *57*(15–16), 4719–4742. https://doi.org/10.1080/00207543.2017.1402140

Cui, L., Wu, H., Wu, L., Kumar, A., & Tan, K. H. (2023). Investigating the relationship between digital technologies, supply chain integration and firm resilience in the context of COVID-19. *Annals of Operations Research*, *327*(2), 825–853. https://doi.org/10.1007/s10479-022-04735-y

De Vass, T., Shee, H., & Miah, S. J. (2018). The effect of "Internet of Things" on supply chain integration and performance: An organisational capability perspective. *Australasian Journal of Information Systems*, *22*. https://doi.org/10.3127/ajis.v22i0.1734

Ernawan, Y., Wijaya, C., & Indriati, F. (2022). *Application of Internet of Things to Ensure Improved Performance within the Internal Supply Chain Unit of an Organization*.

F. Hair Jr, J., Sarstedt, M., Hopkins, L., & G. Kuppelwieser, V. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review*, *26*(2), 106–121. https://doi.org/10.1108/EBR-10-2013-0128

Fatorachian, H., & Kazemi, H. (2021). Impact of Industry 4.0 on supply chain performance. *Production Planning & Control*, *32*(1), 63–81. https://doi.org/10.1080/09537287.2020.1712487

Hair, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2016). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. SAGE Publications.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Isbahi, M. B., Zuana, M. M. M., & Toha, M. (2024). The Multi-Social Relation of the Cattle Industry in the Plaosan Subdistrict Animal Market of Magetan Regency. *Malacca: Journal of Management and Business Development* , *1*(1), 31–46. https://doi.org/10.69965/malacca.v1i1.51

Kemenkeu, D. (2023, July 15). *UMKM Hebat, Perekonomian Nasional Meningkat*. DJPb | Direktorat Jenderal Perbendaharaan Kementerian Keuangan RI. https://djpb.kemenkeu.go.id/portal/id/berita/lainnya/opini/4133-umkm-hebat,-perekonomian-nasional-meningkat.html

Liu, K. P., & Chiu, W. (2021). Supply Chain 4.0: The impact of supply chain digitalization and integration on firm performance. *Asian Journal of Business Ethics*, *10*(2), 371–389. https://doi.org/10.1007/s13520-021-00137-8

Nassou, Y., & Bennani, Z. (2024). Contingency Theory in Management: Conceptual Phases and Strategic Link with Performance Measurement Systems. *European Journal of Arts, Humanities and Social Sciences*, *1*(3), 183–187. https://doi.org/10.59324/ejahss.2024.1(3).16

Nazir, H., & Fan, J. (2024). Revolutionizing Retail: Examining the Influence of Blockchain-Enabled IoT Capabilities on Sustainable Firm Performance. *Sustainability*, *16*(9), 3534. https://doi.org/10.3390/su16093534

Noor, J. (2017). *Metodologi Penelitian: Skripsi, Tesis, Disertasi, dan Karya Ilmiah*. Kencana.

Vărzaru, A. A., & Bocean, C. G. (2024). Digital Transformation and Innovation: The Influence of Digital Technologies on Turnover from Innovation Activities and Types of Innovation. *Systems*, *12*(9), 359. https://doi.org/10.3390/systems12090359

Vipin Jain, Satyendra Arya, B. M. (2021). An Overview of Electronic Commerce (e-Commerce). *Journal of Contemporary Issues in Business and Government*, *27*(3). https://doi.org/10.47750/cibg.2021.27.03.090