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The Effect of Supply Chain Digitalization on Supply Chain Performance Mediated by Supply Chain Traceability, Agility, Integration, and Efficiency in Pertamina EP Regional 2

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ABSTRACT

Supply chain digital transformation has become a strategic imperative for organizations operating in highly complex and risk-intensive environments, including the upstream oil and gas industry. This study aims to examine the effect of supply chain digitalization on supply chain performance and the mediating roles of traceability, agility, integration, and efficiency. A quantitative approach was employed using a survey of Supply Chain Management personnel at PT Pertamina EP Regional 2, and the data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results reveal that supply chain digitalization does not directly affect supply chain performance but has significant effects on traceability, agility, integration, and efficiency. These four capabilities significantly mediate the relationship between digitalization and supply chain performance. The study concludes that digitalization functions as a strategic enabler that enhances performance through the development of supply chain capabilities rather than through direct effects.

INTRODUCTION

Supply chain digital transformation has become a strategic issue in modern operations management, particularly in organizations characterized by high levels of complexity and risk. The development of digital technologies, such as electronic transaction systems, data analytics, and integrated information platforms, has driven fundamental changes in how organizations manage the flows of materials, information, and decision-making across supply networks. Digitalization is considered capable of enhancing organizational information-processing capacity, reducing information asymmetry, and accelerating coordination among supply chain actors (Zhou et al., 2023). Nevertheless, the implementation of digitalization does not always lead to immediate performance improvements, particularly in large organizations with complex bureaucratic structures and stringent regulatory requirements.

From a theoretical perspective, Organizational Information Processing Theory explains that increasing environmental uncertainty must be accompanied by enhanced information-

processing capacity to maintain organizational performance (Galbraith, 1973). Supply chain digitalization enhances this capacity; however, its benefits largely depend on an organization's ability to translate information into operational capabilities. The Resource-Based View also emphasizes that digital technology constitutes a valuable resource, but it does not automatically generate a competitive advantage without the support of appropriate capabilities (Barney, 1991). Accordingly, supply chain performance is viewed as the outcome of the interaction between digital technology and an organization's supply chain capabilities.

Several empirical studies have demonstrated that supply chain digitalization influences performance through indirect mechanisms. (Zhou et al., 2023) found that supply chain traceability and agility mediate the relationship between digitalization and performance, while (Salamah et al., 2024) identified integration and efficiency as the primary pathways explaining this relationship. Other studies have emphasized that supply chain visibility and post-disruption resilience also play important roles in linking digitalization to performance (Al Tera et al., 2024). Nevertheless, most of these studies have been conducted in manufacturing or service industries in developed countries, resulting in a limited understanding of how these mechanisms operate in industries characterized by high levels of risk and stringent regulatory requirements.

The upstream oil and gas industry has distinctive characteristics, including dependence on critical materials, operational uncertainty, and stringent supply reliability requirements. In this context, the Supply Chain Management function is expected not only to achieve efficiency but also to ensure traceability, responsiveness, and cross-functional integration. Supply chain digitalization has therefore become a strategic priority. However, empirical evidence regarding how digitalization influences performance through supply chain capabilities remains limited, particularly in large organizations in Indonesia. This research gap highlights the need for studies that examine not only the direct effect of digitalization on performance but also the mediating role of supply chain capabilities.

Based on this rationale, this study aims to analyze the effect of supply chain digitalization on supply chain performance by examining the mediating roles of supply chain traceability, agility, integration, and efficiency within the Supply Chain Management function of PT Pertamina EP Regional 2. Conceptually, this study develops a framework that positions digitalization as a strategic enabler that strengthens supply chain capabilities, which subsequently contribute to improved performance. Accordingly, this study hypothesizes that supply chain digitalization positively influences supply chain traceability, agility, integration, and efficiency, and that these four capabilities mediate the relationship between digitalization and supply chain performance.

RESEARCH METHOD

This study employs a quantitative approach with an explanatory research design to examine the causal relationship between supply chain digitalization and supply chain performance, as well as the mediating roles of relevant variables. The research model is developed based on a conceptual framework linking Supply Chain Digitalization to Supply

Chain Performance, mediated by Supply Chain Traceability, Supply Chain Agility, Supply Chain Integration, and Supply Chain Efficiency. The study uses primary data collected directly from respondents through a structured questionnaire survey. The research was conducted within the Supply Chain Management function of PT Pertamina EP Regional 2 in 2025.

The research model is a causal model comprising one exogenous variable, one endogenous variable, and four mediating variables. Supply chain digitalization is positioned as the independent variable that influences supply chain performance both directly and indirectly through supply chain traceability, agility, integration, and efficiency. The model is designed to examine direct effects and mediation mechanisms simultaneously using the structural equation modeling approach.

The research subjects consist of employees directly involved in Supply Chain Management activities at PT Pertamina EP Regional 2, including planning, procurement, logistics, and material management functions. Respondents were selected based on their relevant knowledge and experience regarding the implementation of digitalization and supply chain performance within the organization.

Research data were collected using a closed-ended questionnaire with a five-point Likert scale designed to measure respondents' perceptions of each research construct. The research instrument was developed based on indicators previously employed and validated in earlier studies and subsequently adapted to the organizational context. Supply chain digitalization was measured using indicators of the adoption and intensity of digital transaction system usage. Supply chain traceability, agility, integration, efficiency, and performance were measured using indicators representing operational capabilities and supply chain performance outcomes.

Data collection was conducted through an electronic questionnaire survey distributed to the respondents. This method was selected to obtain data efficiently from respondents across various organizational units. Before completing the questionnaire, all respondents were informed of the research objectives and assured of the confidentiality of their data.

The research procedure began with the development of the research instrument based on a literature review and the conceptual framework. A limited pilot test was then conducted to ensure the clarity and consistency of the questionnaire items. Once the instrument was deemed appropriate, the questionnaire was distributed to the research respondents. The collected data subsequently underwent screening, coding, and processing before being subjected to further analysis.

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with the assistance of appropriate statistical software. This method was selected because it can examine complex causal relationships and mediation effects simultaneously without requiring normally distributed data. The analysis was conducted in two stages: measurement model evaluation to assess construct validity and reliability, followed by structural model evaluation to test the research hypotheses and examine the relationships among the variables.

RESULT AND DISCUSSION

This section presents the empirical findings obtained from the analysis of survey data collected within the Supply Chain Management function of PT Pertamina EP Regional 2. Data analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the causal relationships among variables and the mediating effects within the research model.

The measurement model was evaluated to ensure that the constructs used in this study met the required validity and reliability criteria. The test results indicated that all indicators had adequate factor loadings and consistently represented their respective constructs. Furthermore, the construct reliability values were within acceptable ranges, indicating that the research instrument was suitable for evaluating the structural model.

The structural model was evaluated to examine the relationships among the variables in the research framework. This evaluation included the direct effect of supply chain digitalization on supply chain performance and its indirect effects through the mediating variables of supply chain traceability, agility, integration, and efficiency.

The results revealed that supply chain digitalization did not have a statistically significant direct effect on supply chain performance. This finding indicates that increased adoption and intensity of digital system usage do not automatically lead to improved performance unless accompanied by the strengthening of supply chain operational capabilities.

In contrast, supply chain digitalization was found to have positive and statistically significant effects on supply chain traceability, agility, integration, and efficiency. These findings indicate that digitalization plays an important role in enhancing the visibility of material and information flows, accelerating responses to changing requirements, strengthening coordination across functions and partners, and improving supply chain process efficiency.

Furthermore, the mediation analysis demonstrated that supply chain traceability, agility, integration, and efficiency significantly mediated the relationship between digitalization and supply chain performance. Therefore, improvements in supply chain performance occur through indirect mechanisms, whereby digitalization is successfully translated into effective operational capabilities.

A summary of the hypothesis testing results is systematically presented in Table 2 to provide a comprehensive overview of the direction of the relationships and the corresponding decisions regarding the research hypotheses.

Overall, the empirical findings indicate that supply chain digitalization functions as an enabler of capabilities rather than a direct driver of performance. The research model confirms that traceability, agility, integration, and efficiency constitute the primary mechanisms linking digitalization to supply chain performance. These findings provide empirical evidence that the success of digital transformation in Supply Chain Management depends largely on an organization's ability to translate technology into valuable operational capabilities.

Discussion

The findings indicate that supply chain digitalization does not have a direct effect on supply chain performance but exerts a significant impact through supply chain traceability, agility, integration, and efficiency. This finding suggests that the mere presence of digital technology is insufficient to improve performance, particularly in organizations characterized by complex structures and demanding operational requirements. Conceptually, this finding can be explained through Organizational Information Processing Theory, which asserts that increased information-processing capacity translates into improved performance only when organizations can effectively utilize the information in their decision-making processes (Galbraith, 1973).

The absence of a statistically significant direct effect of digitalization on performance indicates that digitalization functions primarily as an enabler rather than a direct determinant of performance. The Resource-Based View explains that digital technology constitutes a valuable resource but does not automatically generate competitive advantage unless it is combined with relevant organizational capabilities (Barney, 1991). In the empirical context of this study, the digital systems used within the Supply Chain Management function primarily support operational processes, while performance improvements are achieved only when these systems are successfully translated into tangible operational capabilities.

The positive effect of digitalization on supply chain traceability demonstrates that digital technology is effective in enhancing end-to-end visibility across material and information flows. This finding is consistent with (Zhou et al., 2023) who emphasized that digitalization enhances tracking capabilities and transparency, thereby reducing information asymmetry and uncertainty. In organizations handling critical materials and operating under high-risk conditions, improved traceability provides an essential foundation for ensuring operational reliability and risk control. Accordingly, traceability serves as an initial mechanism through which digitalization generates added value for performance.

Furthermore, the significant effect of digitalization on supply chain agility indicates that digital systems accelerate the processes of sensing and responding to changes in demand and supply conditions. This finding is consistent with (Zhou et al., 2023) who identified agility as an important mediator between digitalization and performance, particularly in dynamic environments. Digitalization enables organizations to respond more rapidly to changes; however, its impact on performance becomes evident only when these responses are translated into appropriate operational decisions.

The findings also demonstrate that supply chain integration plays a central role in linking digitalization to performance. Digitalization strengthens information sharing and cross-functional coordination, ultimately improving process alignment. This finding supports the results of (Salamah et al., 2024) who emphasized that integration serves as a key mediator in the relationship between digitalization and performance. In the empirical context of this study, integration is particularly important because supply chain activities involve multiple functions and stakeholders. Without strong integration, the benefits of digitalization tend to remain fragmented.

Supply chain efficiency was also found to represent a significant mediating pathway. Digitalization helps reduce processing time, improve planning accuracy, and optimize resource utilization. This finding is consistent with (Al Tera et al., 2024) who demonstrated that digitalization enhances efficiency through improved visibility and coordination. Efficiency represents one of the most tangible manifestations of converting technology into measurable performance, particularly in organizations that require stringent cost control and operational reliability.

The principal novelty of this study lies in the simultaneous examination of four supply chain capabilities as mediating mechanisms within an integrated model, particularly in the context of Indonesia's upstream oil and gas industry. Unlike previous studies that have tended to examine mediators separately or focus on manufacturing and service sectors, this study demonstrates that digitalization contributes to performance when organizations develop traceability, agility, integration, and efficiency as complementary capabilities. Thus, this study expands the understanding of how supply chain digitalization should be managed to generate sustainable performance improvements.

CONCLUSION

This study concludes that supply chain digitalization does not automatically improve supply chain performance; rather, it generates value when effectively translated into operational capabilities. Digitalization functions as a strategic enabler that strengthens supply chain traceability, agility, integration, and efficiency, which subsequently serve as the primary mechanisms for performance improvement. These findings indicate that supply chain performance is not a direct outcome of technology adoption but a consequence of an organization's ability to leverage technology to develop capabilities that are relevant to operational complexity and dynamics. Accordingly, this study establishes that the success of supply chain digital transformation is largely determined by the alignment of technology, processes, and organizational capabilities, particularly in large organizations operating under high-risk conditions and stringent regulatory requirements.

Based on these findings, future research is recommended to expand the research context and design to develop a more comprehensive understanding of supply chain digitalization dynamics. A longitudinal approach could help capture changes in capabilities and performance over the long term, while extending the research to other sectors or organizations could improve the generalizability of the findings. Future researchers are also encouraged to incorporate additional variables, such as supply chain risk management, digital culture, and organizational readiness, to enrich the conceptual model. From a practical perspective, organizations adopting supply chain digitalization should prioritize the simultaneous strengthening of traceability, agility, integration, and efficiency capabilities. They should also ensure that technology implementation is accompanied by process improvements and human resource competency development so that the benefits of digitalization can be realized optimally.

Table 1. Validity Test

Variable	Indicator	Statement Item	Outer Loading	AVE	Composite Reliability
Supply Chain Digitalization	SCD1	Many of our suppliers conduct transactions through digital supply chain systems.	0.944	0.877	0.973
	SCD2	Many of our users conduct transactions through digital supply chain systems.	0.919		
	SCD3	Our suppliers conduct transactions through digital supply chain systems frequently.	0.930		
	SCD4	A large volume of transactions is conducted with our suppliers through digital supply chain systems.	0.957		
	SCD5	Many transaction activities are conducted with our suppliers through digital supply chain systems.	0.934		
Supply Chain Traceability	SCT1	We clearly know the sources of our raw materials	0.856		
	SCT2	We are involved in the procurement process for goods and services	0.416		
	SCT3	We can trace the origins of purchases throughout the supply chain	0.843		
	SCT4	We know the materials or elements contained in purchased components	0.829		
Revision					
Supply Chain Traceability	SCT1	We clearly know the sources of our raw materials.	0.870	0.734	0.892
	SCT3	We can trace the origins of purchases throughout the supply chain.	0.859		
	SCT4	We know the materials or elements contained in purchased components.	0.840		
Supply Chain Agility	SCA1	We can adjust our requirements for goods and services according to customer demand.	0.947	0.730	0.915
	SCA2		0.915		
	SCA3	We can respond quickly to new market developments.	0.928		

	SCA4	We can respond quickly to significant increases and decreases in demand. We can adjust our product portfolio to meet market needs.	0.959		
Supply Chain Integration	SCI1	Kami membagikan informasi kepada supplier utama melalui teknologi informasi.	0.681		
	SCI2		0.818		
	SCI3	Kami memiliki tingkat kemitraan strategis yang tinggi dengan supplier.	0.838		
	SCI4	Kami memiliki tingkat perencanaan bersama yang tinggi untuk mendapatkan proses pemesanan cepat (inbound) dengan supplier.	0.820		
	SCI5	Supplier kami memberikan informasi kepada kami dalam proses produksi dan pengadaan.	0.687		
	SCI6		0.869		
	SCI7	Supplier kami terlibat dalam proses pengembangan produk kami.	0.781		
	SCI8	Kami memiliki tingkat tinggi dalam berbagi informasi dengan pelanggan utama terkait informasi pasar.	0.902		
	SCI9	Kami membagikan informasi kepada pelanggan utama melalui teknologi informasi.	0.837		
	SCI10	Kami memiliki tingkat perencanaan bersama dan peramalan yang tinggi dengan pelanggan utama untuk mengantisipasi visibilitas permintaan. Pelanggan kami memberikan informasi kepada kami dalam proses pengadaan dan operasional Perusahaan. Pelanggan kami terlibat dalam proses pengembangan layanan kami.	0.853		
Revision					
Supply Chain	SCI2	We have a high level of strategic partnership with our suppliers.	0.813	0.716	0.953
	SCI3		0.868		

Integration	SCI4	We have a high level of joint planning with suppliers to achieve faster inbound ordering processes.	0.821		
	SCI6	Our suppliers provide us with information during production and procurement processes.	0.873		
	SCI7	We have a high level of information sharing with our key customers regarding market information.	0.760		
	SCI8	We share information with our key customers through information technology.	0.915		
	SCI9	We have a high level of joint planning and forecasting with our key customers to anticipate demand visibility.	0.849		
	SCI10	Our customers provide us with information regarding our procurement and operational processes.	0.861		
		Our customers are involved in the development of our services.			
Supply Chain Efficiency	SCE1	We can improve operational efficiency with suppliers.	0.841	0.760	0.940
	SCE2	We can manage inventory jointly with suppliers.	0.854		
	SCE3	We can manage facility material requirements planning.	0.898		
	SCE4	We can manage production control with suppliers.	0.844		
	SCE5	We can efficiently coordinate production and information with all suppliers and product lines.	0.918		
Supply Chain Performance	SCP1	Our supply chain can introduce new products to users quickly.	0.823	0.658	0.939
	SCP2	Our supply chain can modify products to meet users' needs.	0.740		
	SCP3	Our supply chain can deliver defect-free products to end users.	0.734		
	SCP4		0.824		

SCP5	Our supply chain can provide value-added services to end users.	0.870
SCP6	Our supply chain can deliver products quickly.	0.859
SCP7	Our supply chain can deliver products to end users on time.	0.752
SCP8	The length of our supply chain process cycle has decreased.	0.873
	Our supply chain can deliver the correct quantities to end users.	

Source: Researcher-processed data (2026).

Table 2. Research Hypothesis Testing Results

Hypothesis		Coefficient	T-statistic	P-value	Results
Supply chain digitalization has a positive effect on supply chain performance.	H1	0.009	0.178	0.429	Hypothesis Not Supported
Supply chain digitalization has a positive effect on supply chain traceability.	H2	0.417	7.957	0.000	Hypothesis Supported
Supply chain digitalization has a positive effect on supply chain agility.	H3	0.409	6.015	0.000	Hypothesis Supported
Supply chain digitalization has a positive effect on supply chain integration.	H4	0.369	5.934	0.000	Hypothesis Supported
Supply chain digitalization has a positive effect on supply chain efficiency.	H5	0.468	7.741	0.000	Hypothesis Supported
Supply chain traceability mediates the relationship between supply chain digitalization and supply chain performance.	H6	0.001	0.051	0.480	Hypothesis Not Supported
Supply chain agility mediates the relationship between supply chain digitalization and supply chain performance.	H7	0.189	4.769	0.000	Hypothesis Supported
Supply chain integration mediates the relationship between supply chain digitalization and supply chain performance.	H8	0.039	0.761	0.224	Hypothesis Not Supported

Supply chain efficiency mediates the relationship between supply chain digitalization and supply chain performance.	H9	0.167	2.573	0.005	Hypothesis Supported

Source: Researcher-processed data (2026).

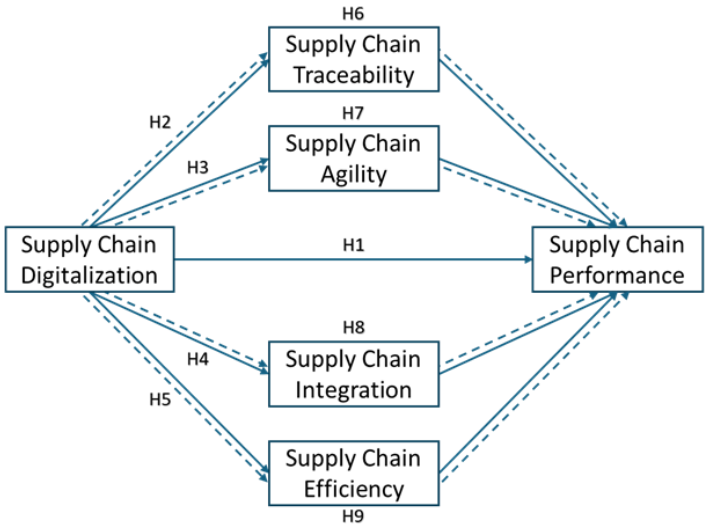


Figure 1. Research Model

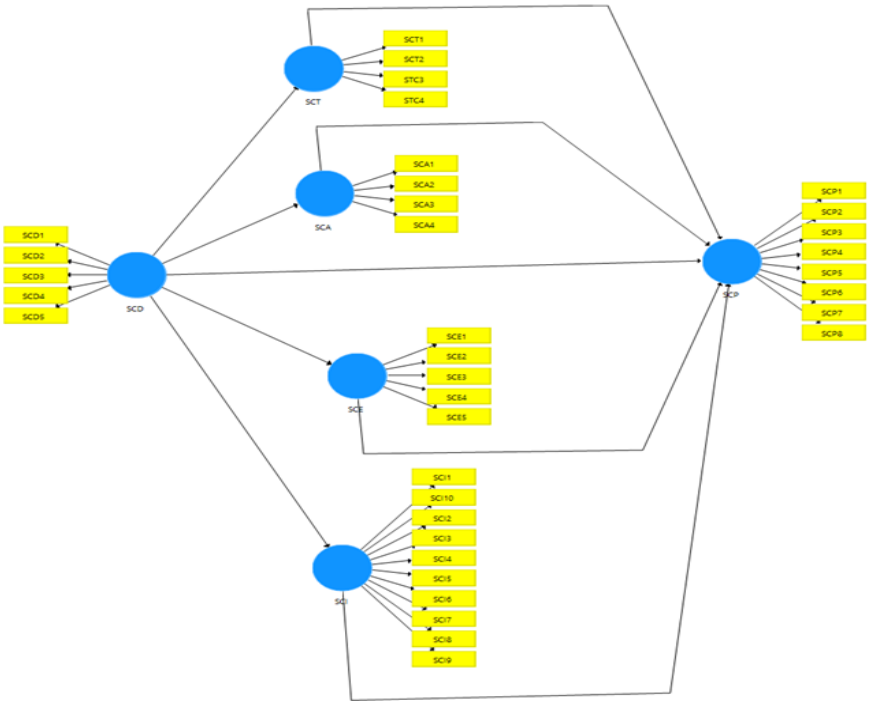


Figure 2. Initial PLS-SEM Model

Source: Researcher-processed data (2026).

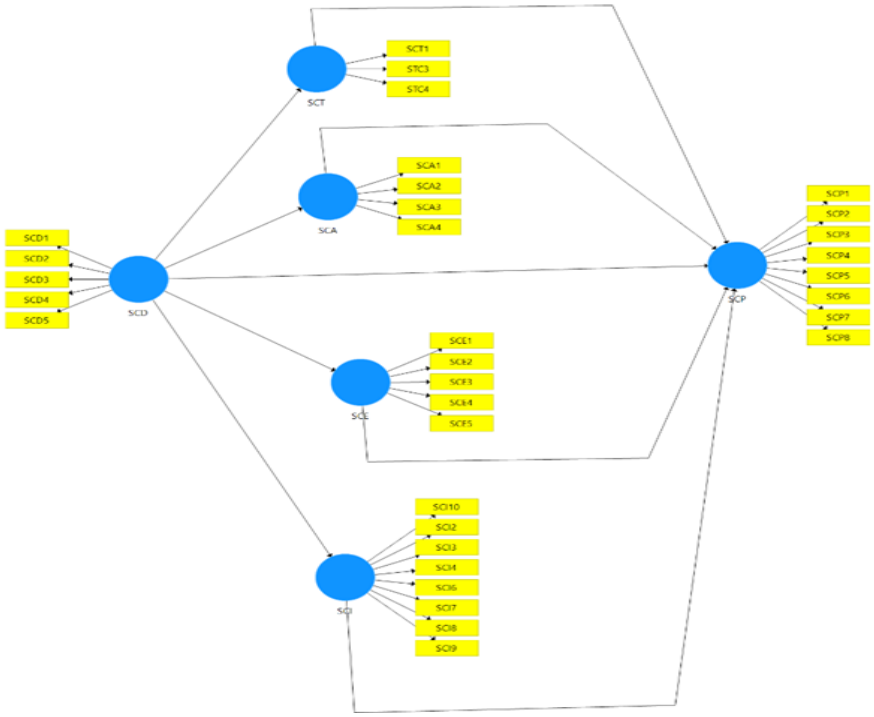


Figure 3. Revised PLS-SEM Model
Source: Researcher-processed data (2026).

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