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LEVERAGING INNOVATION TO ENHANCE SUPPLY CHAIN PERFORMANCE IN INDONESIAN MANUFACTURING: THE ROLES OF TECHNOLOGY, QUALITY MANAGEMENT, AND OPERATIONAL CAPABILITY

MEMANFAATKAN INOVASI UNTUK MENINGKATKAN KINERJA RANTAI PASOKAN DI SEKTOR MANUFAKTUR INDONESIA PERAN TEKNOLOGI, MANAJEMEN KUALITAS, DAN KEMAMPUAN OPERASIONAL

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ABSTRACT

Indonesia's manufacturing sector faces significant challenges due to deficiencies in quality management and information technology (IT) innovation. The objectives of this research are to analyze the influence of Supply Chain Operational Abilities, Supply Chain Technology and Quality Management on Innovation Capability. Also investigate the mediation effect of Innovation Capability on the impact of Supply Chain Operational Abilities, Supply Chain Technology, and Quality Management on Supply Chain Performance. This study is quantitative research and, based on its objectives, it belongs to the type of explanatory research. The population of this research is the supply chain department employees in manufacturing companies in Indonesia with 330 respondents as the research sample. This research uses partial least squares-structural equation model (PLS-SEM) regression analysis to test the hypothesis. Research results demonstrated that Supply Chain Operational Abilities and Supply Chain Technology have a significant positive effect on Supply Chain Performance, but Quality Management does not significantly affect Supply Chain Performance directly. Innovation Capability serves as a significant mediator for the impact of Supply Chain Operational Abilities, Supply Chain Technology and quality management on Supply Chain Performance.

Keywords: *Supply Chain Technology, Supply Chain Performance*

ABSTRAK

Sektor manufaktur Indonesia menghadapi tantangan yang signifikan karena kekurangan dalam manajemen mutu dan inovasi teknologi informasi (TI). Tujuan dari penelitian ini adalah untuk menganalisis pengaruh Kemampuan Operasional Rantai Pasok, Teknologi Rantai Pasok dan Manajemen Mutu terhadap Kemampuan Inovasi. Juga menyelidiki efek mediasi Kemampuan Inovasi pada dampak Kemampuan Operasional Rantai Pasok, Teknologi Rantai Pasok, dan Manajemen Mutu terhadap Kinerja Rantai Pasok. Penelitian ini merupakan penelitian kuantitatif dan, berdasarkan tujuannya, termasuk dalam jenis penelitian eksplanatif. Populasi penelitian ini adalah karyawan departemen rantai pasok di perusahaan manufaktur di Indonesia dengan 330 responden sebagai sampel penelitian. Penelitian ini menggunakan analisis regresi partial least squares-structural equality model (PLS-SEM) untuk menguji hipotesis. Hasil penelitian menunjukkan bahwa Kemampuan Operasional Rantai Pasok dan Teknologi Rantai Pasok memiliki efek positif yang signifikan terhadap Kinerja Rantai Pasok, tetapi Manajemen Mutu tidak secara signifikan mempengaruhi Kinerja Rantai Pasok secara langsung. Kemampuan Inovasi berfungsi sebagai mediator yang signifikan untuk dampak Kemampuan Operasional Rantai Pasok, Teknologi Rantai Pasok dan manajemen mutu terhadap Kinerja Rantai Pasok.

Kata Kunci: Teknologi Rantai Pasok, Kinerja Rantai Pasok

INTRODUCTION

The development of advanced generative AI technology is surprising the business world today, including the world's supply chain. With rapidly developing capabilities in the areas of data analysis, automation, machine learning, the Internet of Things (IoT), blockchain, and more, 'smart' supply chains are an emerging condition as economic activity recovers in the new normal era. Through 2024, 50% of supply chain organizations will invest in applications that support artificial intelligence and advanced analytics capabilities. It is even predicted that by

2024, 50% of supply chain organizations will invest in applications that support artificial intelligence and advanced analytics capabilities. (https://kpmg.com/).

Indonesia's manufacturing industry is one of the key drivers of the country's economic growth. It contributed 16.1% to Indonesia's GDP in the third quarter of 2022 and is expected to continue to grow in the coming years (https://investinasia.id/). The performance of Indonesia's manufacturing sector is getting better at the close of 2023, marking an expansion in the last 28 consecutive months and industry players' optimism regarding sales prospects in 2024 is also getting stronger (https://www.antaranews.com/). However, the manufacturing industry faces serious challenges in its supply chain management.

Several ongoing challenges continue to test a company's ability to produce quality products with cost, place, and time efficiency. Various literature identifies numerous inhibiting factors, such as the company's technological culture, technological paradoxes, lack of technological expertise, underutilization of technology, and incompatible technological systems that continue to affect the implementation of supply chain technology. Additionally, the lack of compatible communication structures affects the development of a collaborative culture. (Chauhan et al., 2022; Hong et al., 2019; Song et al., 2017).

In this study, the focus will be on examining the influence of supply chain capability, quality management, and supply chain technology on supply chain performance with innovation capability as an intervening variable. This model elucidates the mechanism of influence between supply chain capabilities and company performance, which is still subject to debate. (Omar et al., 2006) concluded that supply chain capability is not significantly related to supply chain performance. This finding differs from the results of other studies (Kumar & Nath Banerjee, 2014) there is a need for a study that can elucidate the mechanism of influence between supply chain capability and supply chain performance. Hence, this model tests a model that involves supply chain capability, quality management, supply chain technology, and innovation capability as intervening variables. (Singhry, 2015)

There are differences in the results regarding the influence of quality management on supply chain performance. It is mentioned that. (Casadesús & de Castro, 2005) There is no consensus regarding these findings. The findings of this research underline that it cannot be assured that quality management practices fully support supply chain performance. Quality management itself encompasses not only value systems but is also supported by techniques and tools. The implementation of quality management is related to organizational change management, thus requiring steps to be applied within the company. (Vanichchinchai & Igel, 2011)

Although recent studies have acknowledged the importance of supply chain technology (e.g., Industry 4.0 tools) and quality management practices, they often overlook how these factors interact with innovation capability to drive supply chain performance. Studies like those by Singhry (2015) and Abdallah et al. (2021) show that while technology and quality management are essential, innovation capability may serve as a critical link that translates these capabilities into measurable performance gains. However, few studies investigate this mediating role in Indonesia or similar ASEAN contexts, where supply chain resiliency and adaptability are increasingly vital.

In this research, the variable of Supply Chain Technology is also included. Statements from various experts suggest that new technologies create strategic opportunities for organizations to build competitive advantages across various functional management areas, including supply chain management. However, the level of success depends on the selection of the appropriate technology for its implementation, and the availability of the right organizational infrastructure, culture, and management policies. (Fosso Wamba et al., 2015). More specifically, it can be stated that supply chain technology is a dynamic capability that must be actively built, integrated, and reconfigured by companies to enhance their performance.(Teece, 2010). This technology influences the transformation and distribution of materials and goods. (Meybodi, 2013). It helps the supply chain to reduce transaction costs and communication. This enhances product quality and on-time delivery, and facilitates real-time information sharing, thereby improving company performance. (Kamariah Kamaruddin & Mohamed Udin, 2009).

Literature Review and Research Framework

The performance of a company is an intriguing theme for management experts. Hence, it is not surprising that many scholars contribute various definitions of company performance. According to Elizabeth, company performance is a benchmark used to measure the level of management success in optimizing financial resources, especially in investment management efforts aimed at creating profits for shareholders. (Ruggiero & Cupertino, 2018). This means that company performance reflects the success of resource management within the company.

The level of supply chain capability in meeting consumer needs while considering key performance indicators appropriate for specific time and cost is referred to as supply chain performance. (Peningkatan Konsumsi Ikan di Kota Depok et al., 2012). Supply chain performance is a measure of activities related to the flow of goods, information, and funds from suppliers to end consumers.

Sofjan (2014) suggests that supply chain performance is measured by inventory serving operational activities as a buffer. Where inventory at each stage is related to money, it is crucial for operations at each stage to be synchronized to minimize buffer inventory. A common measure to evaluate efficiency is the size of inventory turnover and supply lead time. For culinary business practitioners, assessing performance can be used as a tool to strategize their business operations.

Rajaguru & Matanda (2019) define capabilities as "attributes, abilities, organizational processes, knowledge, and skills that enable a company to achieve superior performance and sustainable competitive advantage compared to competitors." According to Chen et al. (2009), supply chain capabilities provide a critical link between supply chain process integration and organizational performance. Supply chain capabilities refer to an organization's ability to utilize internal and external resources to facilitate supply chain performance (Bharadwaj, 2000; Wu et al., 2006)

Wu et al. (2006) Identify supply chain capabilities in terms of an organization's ability to share information resources, coordinate supply chain processes, and respond to the demands of supply chain partners and end consumers. This study, consistent with Wu et al. (2006), conceptualizes supply chain capabilities as a second-level construct consisting of information sharing, supply chain coordination, and supply chain responsiveness.

Technology has played a significant role in supply chain (SC) activities. This is because SC requires technological support to enhance traceability and transparency (Akkermans et al., 2003). Collins et al. (2010) highlight that SCT can assist company SCs in becoming more effective and efficient. SCT also helps companies become more competitive in the market. However, Mangir, Othman, & Udin (2016) argue that companies in Malaysia still face significant challenges to remain competitive and are still seeking potential opportunities to grow in an environment of uncertain and boundary-less markets.

Supply chain technology (SCT) is an innovation that can influence organizational productivity, competitiveness, and flexibility, and has been recognized in the field of SCM. (Deitz et al., 2009). It has been emphasized that SCT provides a significant impact in enhancing company performance when such technological effectiveness meets organizational goals. (Collins et al., 2010). Singhry (2015) Stated that supply chain technology is the integration of advanced manufacturing technology and information technology.

Another factor that also can enhance supply chain performance is quality management. According to (Gaspersz, 2011), quality management can be referred to as the entirety of management functions that establish quality policies, objectives, and responsibilities, and implement them through quality management tools. All these activities are carried out to meet the needs and expectations of customers. The implementation of quality management requires participation from all members of the organization to achieve the organization's goals.

Total Quality Management is a management system that encompasses all elements within a company, whether in the goods or services sector, to improve quality, efficiency, and effectiveness of production both in industrial environments and other institutions. (Tatang Ibrahim, 2021). With the implementation of Total Quality Management, continuous improvement focusing on customer satisfaction is expected to be achieved.

Supply chain technology, supply chain operational ability and quality management can have a direct effect or indirect effect on supply chain performance through innovation capability. According to Nugroho et al. (2013), capability can be defined as a company's capacity to utilize integrated resources to achieve desired goals. Capabilities enable a company to create and exploit external opportunities and develop sustainable advantages. Core capabilities can also be defined as determinants of long-term success, or as a value chain, including primary and supporting activities that create customer value.

According to Tatiek (2010), innovation capability is the ability to apply creativity to solve problems and seize opportunities to improve performance. Another opinion on innovation capability is provided by Terziovski (2010) in Nugroho (2013), who argue that this capability provides the potential for effective innovation. However, this concept is not simple or single-factored, as it also involves many management aspects such as leadership, technical aspects, strategic resource allocation, market knowledge, and others. Therefore, this research framework can be drawn as follows:

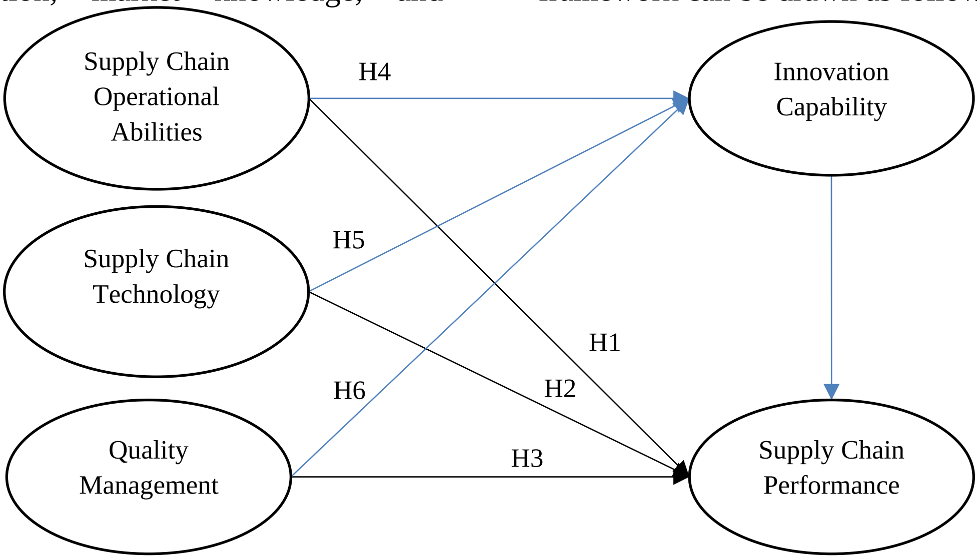


Figure 1. Research Framework

With:

Direct Effect

Indirect Effect (Mediated Effect)

RESEARCH METHODS

This study is quantitative research and, based on its objectives, it belongs to the type of explanatory research, which aims to test the influence among hypothesized variables (Casula et al., 2021) The study will examine the hypothesis regarding the influence of the independent variables, namely supply chain operational abilities, supply chain technology, and quality management, on the dependent variable, namely supply chain performance, which is mediated by innovation capabilities.

While Conceptual and Operational Definitions of research Variables are presented in the following table:

Table 1. Conceptual and Operationalization of Variable

Variable	**Dimension**	**Operationalization of Variable**	***Scale***
Supply Chain Operational Abilities	Information Exchange	• My Business Unit exchanges more information with our partners than our competitors do with their partners • Information flows more freely between my Business Unit than between our competitors and their partners. • My Business Unit benefits more from our information exchange with our partners	(Wu et al., 2006) Likert Scale 1-5

Variable	**Dimension**	**Operationalization of Variable**	***Scale***
		than our competitors do from their partners • Our information exchange with our partners is superior to our competitors' exchange with their brand partners	
	Coordination	• My Business Unit is more efficient in coordinating activities with the company's partners than the company's competitors with their partners • My Business Unit performs transaction follow-up activities with the company's partners more efficiently than the company's competitors with their partners. • My Business Unit spends less time coordinating transactions with the company's partners than the company's competitors with their partners. • My Business Unit has reduced coordination costs more than the company's competitors • My Business Unit can perform coordination activities at a lower cost than the company's competitors	
	Activity Integration	• My Business Unit develops strategic plans in collaboration with corporate partners. • My Business Unit actively collaborates in forecasting and planning with corporate partners • My Business Unit projects future demand and plans collaboratively with corporate partners	

Variable	**Dimension**	**Operationalization of Variable**	***Scale***
		• Collaboration in forecasting and planning demand with corporate partners is always carried out in my Business Unit • My Business Unit always estimates and plans activities collaboratively with corporate partners	
	Responsiveness	• Compared to competitors, our supply chain responds to changing customer and supplier needs more quickly and effectively. • Compared to competitors, our supply chain responds to changing competitor strategies more quickly and effectively. • Compared to competitors, our supply chain develops and markets new products more quickly and effectively. • In most markets, our supply chain competes effectively • Relationships with our partners have improved our supply chain's responsiveness to market changes through collaboration	
Supply Chain Technology	Advanced manufacturing technology	• Companies use computer-aided engineering (CAE) • Companies use computer-aided design • Companies use computer numerically controlled machine tools • Companies use computer-aided inspection (CAI) • Companies use automated guided vehicles (AGVs) • Companies use automated material handling systems	(Singhry, 2015) Likert Scale 1-5

Variable	**Dimension**	**Operationalization of Variable**	***Scale***
	Information technology	• Companies use automated storage • There is a direct computer-to-computer connection with the company's key supply chain partners • The company's IT systems are compatible with the company's supply chain partners' systems • The company's IT systems can be seamlessly connected with the supply chain partners' systems • The company sends information to the company's key customers electronically • The company receives information from the company's customers electronically	
Quality Management	Quality Management Process	• The plan do check act cycle is implemented and used for continuous quality improvement. • Quality data or reports are used to assist decision-making. • Staff members are involved in various quality management processes and know how to evaluate them. • The quality of service or product in this institution is determined; • service quality has been evaluated through recording errors or complaints; • Annual monitoring services are conducted through internal and external client satisfaction surveys.	(Chansatitporn & Pobkeeree, 2019) Likert Scale 1-5

Variable	**Dimension**	**Operationalization of Variable**	***Scale***
Innovation Capabilities	Quality Management Performance	• Annual training on quality management is provided to all staff • The company always makes a report on the implementation of quality assurance every year • This institution considers client needs systematically; • The company ensures that all stages of service delivery are tested and well coordinated. • The company uses statistics to help evaluate quality control and quality assurance and encourages quality improvement. • The company analyzes management to improve services • Companies have developed greater ability to select partners with whom to collaborate • Companies have developed greater ability to learn from previous collaboration experiences • Companies have developed a greater ability to apply the concept of continuous improvement while maintaining a customer focus. • Companies have developed a greater ability to understand the interconnection of supply chain management with other disciplines. • Companies have developed a greater ability to manage incremental improvements and changes to their	(Singhry, 2015) Likert Scale 1-5

Variable	**Dimension**	**Operationalization of Variable**	***Scale***
Supply Chain Performance		products, processes, and systems. • Supply chain helps us reduce production costs • Supply chain helps us reduce total costs • Supply chain helps us reduce inventory costs • Supply chain helps companies improve customer responsiveness/service • Supply chain helps companies deliver products on time • Supply chain helps us reduce stock-out rates • Supply chain helps companies increase market share	(Singhry, 2015) Likert Scale 1-5

According to Sekaran & Bougie (2017), "population is the entire group of people, events, or objects that researchers want to investigate". The population of this research is the supply chain department employees in manufacturing companies in Indonesia.

The sample is a part of the number and characteristics possessed by the population. If the population is large, and it is not feasible for the researcher to study all aspects of the population, the researcher will take a sample from that population. (Sugiyono, 2016).

A sample is a part of the population that has specific characteristics or conditions to be studied. Therefore, the sample taken from the population must truly represent it. The sample size used in Structural Equation Modeling (SEM) research is a minimum of 330 samples. (Ferdinand, 2006). However, according to (Solimun, 2002), guidelines for determining the sample size for SEM are:

1. When estimating parameters using maximum likelihood estimation, the recommended sample size is between 300 to 350, with a minimum sample of 275.
2. Equal to 5 to 10 times the number of indicators of the overall variables.

The data collection technique uses a survey method with a data collection tool in the form of a questionnaire in Bahasa Indonesia. The questionnaire is designed using Google Forms and consists of six sections: respondent characteristics, assessment of dynamic capabilities, assessment of strategic digital orientation, assessment of company readiness, assessment of digital innovation, and assessment of company performance. The questionnaire is measured using a Likert scale.

The analysis method used in this study is Structural Equation Modeling (SEM) as it can explain relationships among multiple variables. (Hair et al., 2019).

RESULTS AND DISCUSSIONS

1. Characteristic of Research Respondent

All research respondents hold positions as managers or higher, work at companies that produce goods, and are permanent employees. Other characteristics of the research respondents include socioeconomic status, domicile, and gender. The gender distribution is heavily skewed towards male respondents, who constitute 83% of the sample. This imbalance in managerial roles could have implications for innovation capability within the FMCG sector. Gender diversity is often linked to a wider range of perspectives, which can foster innovative problem-solving and adaptability. In male-dominated environments, there might be a tendency toward traditional approaches, which could hinder the adoption of new technologies and quality management practices.

Furthermore, research has shown that diversity in management is essential for creating dynamic capabilities, particularly in fostering a culture of innovation. The lack of gender diversity in this sample may impact the operational effectiveness and adaptability required for complex supply chain functions, as well as the successful implementation of advanced supply chain technologies.

The pie chart in figure 2 illustrates the gender distribution of the respondents:

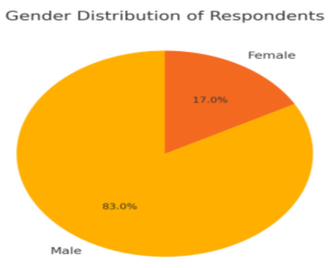
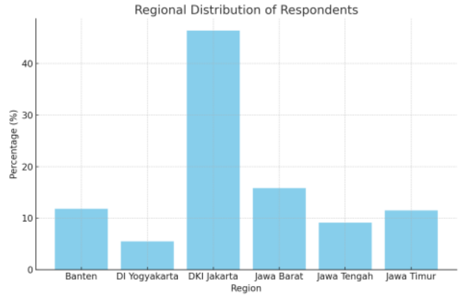


Figure 2. Gender distribution of respondents

The regional distribution reveals a significant concentration of respondents in DKI Jakarta (46.4%), followed by Jawa Barat and Banten. This concentration suggests that managerial talent and resources are centralized in Jakarta and nearby regions, likely due to the infrastructure, access to advanced technology, and skilled workforce available in these urban areas. These regions are better positioned to leverage technological advancements and enhance supply chain performance through innovation.

In contrast, respondents from rural areas, such as Jawa Tengah and DI Yogyakarta, may face greater challenges in adopting new supply chain technologies. Limited access to skilled personnel and technological infrastructure in rural regions could hinder the operational capabilities and innovation potential necessary for optimizing supply chain performance. The challenges observed in rural settings, as highlighted in your study, indicate a need for region-specific strategies to bridge performance gaps.

The bar chart below shows the distribution of respondents by region:



Memanfaatkan inovasi untuk meningkatkan kinerja rantai pasokan di sektor manufaktur indonesia peran teknologi, manajemen kualitas, dan kemampuan Operasionalin summary, the demographic analysis reveals significant insights into the regional and gender distributions within FMCG managerial roles. The concentration of managerial talent in Jakarta and surrounding regions aligns with higher operational and innovation capabilities in these areas, while rural regions may require additional support to achieve comparable supply chain performance. The gender imbalance in managerial positions could limit the diversity-driven innovation needed to adopt new supply chain technologies effectively. To address these disparities, FMCG companies should consider strategies that promote gender diversity and support rural regions in enhancing their operational and innovation capabilities. By understanding these demographic trends, companies can better align their efforts to improve supply chain performance, particularly through the integration of advanced technologies and robust quality management systems.

2. Partial Least Square Analysis

The data processing technique using the Partial Least Squares (PLS)-based Structural Equation Modeling (SEM) method requires two stages to assess the Fit Model of a research model (Ghozali, 2019). These stages are as follows:

a. Outer Model Analysis or Research Measurement Model

1) Outer Loading

In refining the model, indicators across all constructs were carefully evaluated for removal based on their contribution to reliability, discriminant validity, and multicollinearity, as measured by Variance Inflation Factor (VIF) values. By retaining only the indicators with high outer loadings, the model achieves a more focused measurement of each construct, reducing redundancy and ensuring that each construct remains both distinct and reliable.

For Innovation Capabilities (IC), the indicators IC2, IC4, and IC5 were retained due to their high outer loadings, all above 0.80, which indicates strong alignment with the core dimensions of innovation. Indicators like IC1 and IC3 were removed, as their lower loadings suggested they contributed less consistently to the construct. This selective retention strengthens the construct's reliability by focusing on indicators that best represent the capability to innovate, learn, and collaborate effectively. Additionally, removing these lower-loading indicators helps to enhance discriminant validity, as it minimizes overlap with other constructs that could blur the unique aspects of innovation capabilities.

In Supply Chain Performance (PSC), only PSC1, PSC5, PSC6, and PSC7 were maintained. These indicators exhibited strong outer loadings, signifying their crucial role in capturing the construct's core components, such as cost efficiency, timely delivery, and market responsiveness. Indicators like PSC2, PSC3, and PSC4 were excluded, as their relatively lower loadings made them less essential to the construct's overall integrity. By refining the construct to focus on the strongest indicators, the model not only boosts reliability but also reduces multicollinearity risks, as confirmed by improved VIF values. The elimination of these weaker indicators ensures that Supply Chain Performance remains a distinct and clear measure, free from the redundancies that could undermine its interpretive power.

Quality Management (QM) was similarly refined by retaining indicators QM2, QM3, QM6, and QM8, each of which demonstrated high loadings and strong alignment with the quality management construct. Indicators with lower loadings, such as QM4 and QM5, were removed to reduce measurement overlap and multicollinearity, thus enhancing the distinctiveness of Quality Management. The retained indicators effectively capture the essence of quality practices, such as continuous improvement and adherence to standards, making the construct a robust measure of quality management efforts within the supply chain. This refinement process reinforces discriminant validity, ensuring that Quality Management is a separate construct that measures quality-related processes without interference from other dimensions.

In the case of Supply Chain Operational Capabilities (SCO), only SCO10, SCO11, SCO12, SCO16, and SCO4 were retained. Indicators with lower outer loadings, such as SCO7 and SCO8, were removed as they did not meet the threshold for reliable measurement and posed risks of multicollinearity, which could compromise the precision of the construct. The selected indicators focus on essential operational aspects like strategic alignment and collaborative planning, which are critical to operational success. By excluding weaker indicators, the model enhances the internal consistency and clarity of Supply Chain Operational Capabilities, allowing it to stand as a unique construct that is effectively differentiated from others.

Finally, for Supply Chain Technology (SCT), the retained indicators—SCT1, SCT2, SCT7, SCT8, and SCT9—exhibited high outer loadings, suggesting they are core measures of the construct. Indicators like SCT5 and SCT6 were removed due to their lower loadings, which could dilute the construct's specificity and introduce unwanted multicollinearity. By focusing on indicators that directly reflect technological integration and communication capabilities within the supply chain, the model strengthens both reliability and discriminant validity, ensuring that Supply Chain Technology is measured precisely and without overlap with other constructs.

In summary, the refined model excludes lower-loading indicators from each construct to maximize clarity, reliability, and distinctiveness. This selective retention minimizes multicollinearity, as evidenced by acceptable VIF values, and strengthens discriminant validity by ensuring each construct captures a unique aspect of the supply chain framework. Through this careful refinement process, the model achieves a robust structure where each construct is accurately represented by its most impactful indicators, thus enhancing the validity of the study's findings and ensuring confidence in the interpretation of results.

Table 2. Outer Loadings (Measurement Model) Pilot Data

	Innovation Capability	Quality Management	Supply Chain Operational Abilities	Supply Chain Performance	Supply Chain Technology	Result
IC2	0,841					Reliable
IC4	0,878					Reliable
IC5	0,863					Reliable
PSC1				0,802		Reliable
PSC5				0,893		Reliable
PSC6				0,875		Reliable
PSC7				0,861		Reliable
QM2		0,860				Reliable
QM3		0,864				Reliable
QM6		0,854				Reliable
QM8		0,863				Reliable
SCO10			0,859			Reliable

	Innovation Capability	Quality Management	Supply Chain Operational Abilities	Supply Chain Performance	Supply Chain Technology	Result
SCO11			0,846			Reliable
SCO12			0,862			Reliable
SCO16			0,874			Reliable
SCO4			0,841			Reliable
SCT1					0,823	Reliable
SCT2					0,875	Reliable
SCT7					0,899	Reliable
SCT8					0,849	Reliable
SCT9					0,840	Reliable

The processing results using SmartPLS can be seen in Table 1. The outer model values or correlations between constructs and variables initially already satisfy convergent validity because all indicators with loading factor values above 0.80.

*2) **Construct Reliability and Validity***

The analysis of Construct Reliability and Validity for this model, as indicated by Cronbach's Alpha and Composite Reliability values, confirms that each construct achieves a high level of internal consistency, deeming them all reliable. Both Cronbach's Alpha and Composite Reliability values exceed the standard threshold of 0.70, ensuring that each construct is measured precisely and consistently. This high reliability is essential for the accuracy and interpretability of the model, as it indicates that the indicators within each construct are well-aligned and cohesively represent the intended concepts.

Table 3. Composite Reliability and Average Variance Extracted

	Cronbach's alpha	Composite reliability	Result
Innovation Capabilities	0,825	0,827	Reliable
Quality Management	0,883	0,883	Reliable
Supply Chain Operational Capabilities	0,909	0,910	Reliable
Supply Chain Performance	0,881	0,884	Reliable
Supply Chain Technology	0,910	0,913	Reliable

For Innovation Capabilities, Cronbach's Alpha is 0.825 and the Composite Reliability is 0.827, showing that the indicators are effectively capturing the innovation processes within the supply chain. Quality Management also exhibits high reliability with both Cronbach's Alpha and Composite Reliability values at 0.883, signifying that the construct accurately measures the quality practices and standards. Similarly, Supply Chain Operational Capabilities achieve strong internal consistency with a Cronbach's Alpha of 0.909 and Composite Reliability of 0.910, demonstrating that the indicators reliably represent core operational capabilities, such as responsiveness and efficiency in supply chain operations.

Supply Chain Performance has a Cronbach's Alpha of 0.881 and Composite Reliability of 0.884, reflecting that the indicators reliably measure key performance outcomes like cost reduction and timely delivery. Finally, Supply Chain Technology shows the highest reliability with a Cronbach's Alpha of 0.910 and Composite Reliability of 0.913, confirming that the indicators consistently capture aspects of technology integration and communication within the supply chain.

Each construct exhibits high reliability, as evidenced by both Cronbach's Alpha and Composite Reliability values above 0.80, which supports the model's robustness and credibility. This level of internal consistency minimizes measurement error and ensures that the constructs provide a precise and dependable assessment of the relationships among Innovation Capabilities, Quality Management, Operational Capabilities, Performance, and Technology in the supply chain context.

3) Convergent Validity

The Convergent Validity of the model, as assessed by the Average Variance Extracted (AVE) values, confirms that each construct meets the required threshold for validity. An AVE value of 0.50 or higher is generally considered acceptable, indicating that the construct explains at least 50% of the variance in its indicators. High AVE values support convergent validity, demonstrating that the indicators within each construct are well-aligned and measure the same underlying concept effectively.

Table 4. Convergent Validity

	Average variance extracted (AVE)	**Result**
Innovation Capabilities	0,741	Valid
Quality Management	0,740	Valid
Supply Chain Operational Capabilities	0,734	Valid
Supply Chain Performance	0,737	Valid
Supply Chain Technology	0,736	Valid

Based on the table, all constructs exceed the AVE threshold of 0.50, with values ranging from **0.734** to **0.741**. Innovation Capabilities has an AVE of 0.741, showing that 74.1% of the variance in its indicators is due to the construct itself, rather than measurement error. This high AVE indicates a strong level of consistency among the indicators for Innovation Capabilities, reflecting effective measurement of innovation-related processes within the supply chain. Quality Management similarly shows a high AVE of **0.740**, confirming that the indicators effectively capture quality practices and standards with minimal error, thus reinforcing the construct's validity.

Supply Chain Operational Capabilities have an AVE of **0.734**, meaning that 73.4% of the variance in its indicators is attributable to the construct. This high value suggests that the indicators reliably measure operational capabilities, such as efficiency and responsiveness in the supply chain. Supply Chain Performance and Supply Chain Technology have AVE values of **0.737** and **0.736** respectively, demonstrating that their indicators are well-correlated and consistently capture performance outcomes and technological integration within the supply chain.

In conclusion, the AVE values confirm that each construct has strong convergent validity. This means that each set of indicators accurately reflects its intended construct, ensuring the internal consistency and reliability of the model. The high AVE values across all constructs provide confidence that the model effectively captures key aspects of Innovation Capabilities, Quality Management, Operational Capabilities, Performance, and Technology, supporting the robustness of the research findings.

4) Discriminant Validity

The **Fornell-Larcker Criterion** is a method used to evaluate discriminant validity, which determines whether conceptually distinct constructs are also statistically distinct. Discriminant validity ensures that each construct in a model measures a unique concept and is not excessively correlated with other constructs. According to the Fornell-Larcker Criterion, a construct demonstrates discriminant validity if the square root of the Average Variance Extracted (AVE) for each construct is greater than its correlations with any other constructs in the model. This method is widely used in structural equation modelling (SEM) to confirm that each construct is independent and distinct from the others.

Table 5. Fornell-Larcker Criterition (Cross Loading)

	Innovation Capabilities	**Quality Management**	**Supply Chain Operational Capabilities**	**Supply Chain Performance**	**Supply Chain Technology**
Innovation Capabilities	0,861				
Quality Management	0,841	0,860			
Supply Chain Operational Capabilities	0,750	0,725	0,857		
Supply Chain Performance	0,850	0,794	0,837	0,859	
Supply Chain Technology	0,847	0,832	0,764	0,803	0,858

In Table 5, For Innovation Capabilities, the square root AVE of **0.861** is greater than its correlations with other constructs, such as Quality Management (0.841) and Supply Chain Performance (0.850), which confirms its distinct role in measuring innovation-related aspects within the supply chain. Similarly, Quality Management has a square root AVE of **0.860**, surpassing its correlations with other constructs, thereby affirming that it specifically captures quality practices and standards without interference from other dimensions. Supply Chain Operational Capabilities demonstrate a square root AVE of **0.857**, greater than its correlations with constructs like Supply Chain Performance **(0.837)** and Supply Chain Technology **(0.803)**, which underscores that operational capabilities are measured independently. Additionally, Supply Chain Performance has a square root AVE of **0.859**, which exceeds its correlations with constructs such as Innovation Capabilities **(0.850)** and Supply Chain Technology **(0.837)**. This high value reinforces that performance outcomes are uniquely captured by this construct. Finally, Supply Chain Technology shows a square root AVE of **0.858**, greater than its correlations with other constructs, ensuring it remains a distinct measure of technological integration and application within the supply chain.

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Management (0.841) and Supply Chain Performance (0.850), which confirms its distinct role in measuring innovation-related aspects within the supply chain. Similarly, Quality Management has a square root AVE of **0.860**, surpassing its correlations with other constructs, thereby affirming that it specifically captures quality practices and standards without interference from other dimensions. Supply Chain Operational Capabilities demonstrate a square root AVE of **0.857**, greater than its correlations with constructs like Supply Chain Performance **(0.837)** and Supply Chain Technology **(0.803)**, which underscores that operational capabilities are measured independently. Additionally, Supply Chain Performance has a square root AVE of **0.859**, which exceeds its correlations with constructs such as Innovation Capabilities **(0.850)** and Supply Chain Technology **(0.837)**. This high value reinforces that performance outcomes are uniquely captured by this construct. Finally, Supply Chain Technology shows a square root AVE of **0.858**, greater than its correlations with other constructs, ensuring it remains a distinct measure of technological integration and application within the supply chain.

Overall, the Fornell-Larcker Criterion results validate that each construct in the model has discriminant validity, indicating that they represent separate and unique dimensions. This level of distinctiveness strengthens the model's reliability and ensures that each construct can be accurately interpreted in terms of its specific impact on the supply chain framework, supporting the robustness of the study's findings.

b. Inner Model

The testing of the inner model or structural model is conducted to observe the relationships between constructs, significance values, and R-square of the research model. The structural model is evaluated using R-square for the dependent constructs and the significance of the coefficients of structural path parameters. In Analyzing the Inner model parameters that are used are the *Variance Inflation Factor (Inner VIF*), R-*square*, *f-square*, Q-*square*, and Q-*square prediction.*

c. Inner VIF

The use of Inner VIF in model analysis is essential to verify that constructs in the model are not overly redundant or collinear. By keeping Inner VIF values below the threshold of 5, the model ensures that each construct explains unique variance in the inner model, which improves the precision of coefficient estimates and the reliability of interpretations. In this model, all constructs meet the VIF requirement, confirming that multicollinearity is at an acceptable level. This strengthens the model's structural validity, ensuring that relationships between constructs are not artificially inflated by high correlations, thereby supporting accurate hypothesis testing and conclusions.

Table 6. Inner VIF

	Innovation Capabilities	**Quality Management**	**Supply Chain Operational Capabilities**	**Supply Chain Performance**	**Supply Chain Technology**
Innovation Capabilities				4,720	
Quality Management	3,469			4,206	
Supply Chain Operational Capabilities	2,561			2,686	
Supply Chain Performance					
Supply Chain Technology	3,956			4,689	

The Inner Variance Inflation Factor (VIF) analysis confirms that multicollinearity among the constructs in the model is within acceptable limits, with all VIF values below the critical threshold of 5. This threshold is typically used to ensure that constructs do not overlap excessively, allowing each one to maintain a distinct role in explaining variance without redundancy. For instance, Innovation Capabilities has VIF values of **4.720** with Supply Chain Performance and **3.956** with Supply Chain Technology, suggesting that while it shares some variance with these constructs, it still contributes unique explanatory power within the model.

Similarly, Quality Management shows VIF values of **3.469** with Innovation Capabilities and **4.206** with Supply Chain Performance, indicating an acceptable level of multicollinearity. These values reflect that Quality Management is sufficiently distinct, capturing unique aspects of quality practices without significant overlap with other constructs. Supply Chain Operational Capabilities have lower VIF values of **2.561** with Innovation Capabilities and **2.686** with Supply Chain Performance, highlighting that it provides independent information focused on operational efficiency and responsiveness within the model.

Finally, Supply Chain Technology exhibits VIF values of **3.956** with Innovation Capabilities and **4.689** with Supply Chain Performance. Although these values are slightly higher, they remain below the threshold of concern, affirming that Supply Chain Technology maintains its unique role, particularly in capturing aspects of technological integration. Overall, the VIF values confirm that each construct contributes distinct information to the model, supporting its structural validity and enhancing the reliability of the study's conclusions.

d. Coefficient of Determinant (R-Square)

The testing of the inner model or structural model is conducted to observe the relationships between constructs, significance values, and R-square of the research model. The structural model is evaluated using R-square for the dependent constructs and the significance of the coefficients of structural path parameters.

Table 7. R-square

	R-square	R-square adjusted
Innovation Capabilities	0,788	0,786
Supply Chain Performance	0,819	0,817

The R-squared values in this table represent the proportion of variance in each dependent construct that is explained by the independent variables in the model. An R-Square value close to 1 indicates strong explanatory power, while a lower value would suggest that the model explains less of the variance in the dependent variable. The Adjusted R-Square corrects for the number of predictors in the model, providing a more accurate estimate, especially when multiple predictors are involved.

For Innovation Capabilities, the R-Square value is 0.788, meaning that 78.8% of the variance in Innovation Capabilities is explained by the independent variables included in the model. The adjusted R-Square of 0.786 shows only a slight reduction, indicating that the number of predictors does not overly inflate the explanatory power. This high R-Square value suggests that the predictors in the model are highly effective in explaining variations in Innovation Capabilities, capturing key elements that drive innovation within the supply chain.

Supply Chain Performance has an R-Square of 0.819, meaning that 81.9% of the variance in this construct is accounted for by the model. The adjusted R-squared is 0.817, which again indicates minimal adjustment and reflects a strong fit. This high R-Square value implies that the independent variables are highly predictive of Supply Chain Performance, encompassing key factors that contribute to performance outcomes, such as operational efficiency and technological integration.

In summary, both Innovation Capabilities and Supply Chain Performance have high R-Square values, indicating that the model explains a substantial portion of the variance in these constructs. This strong explanatory power suggests that the chosen predictors are highly relevant and that the model is well-suited for analyzing the dynamics within the supply chain framework. The high R-Square values provide confidence in the model's capacity to capture essential aspects of Innovation Capabilities and Supply Chain Performance effectively.

e. Hypotheses Testing

The significance of the estimated parameters provides valueable information about the relationships between research variables. The basis used in testing hypotheses is the values found in the output result for inner weights, which can be seen in the following image and table:

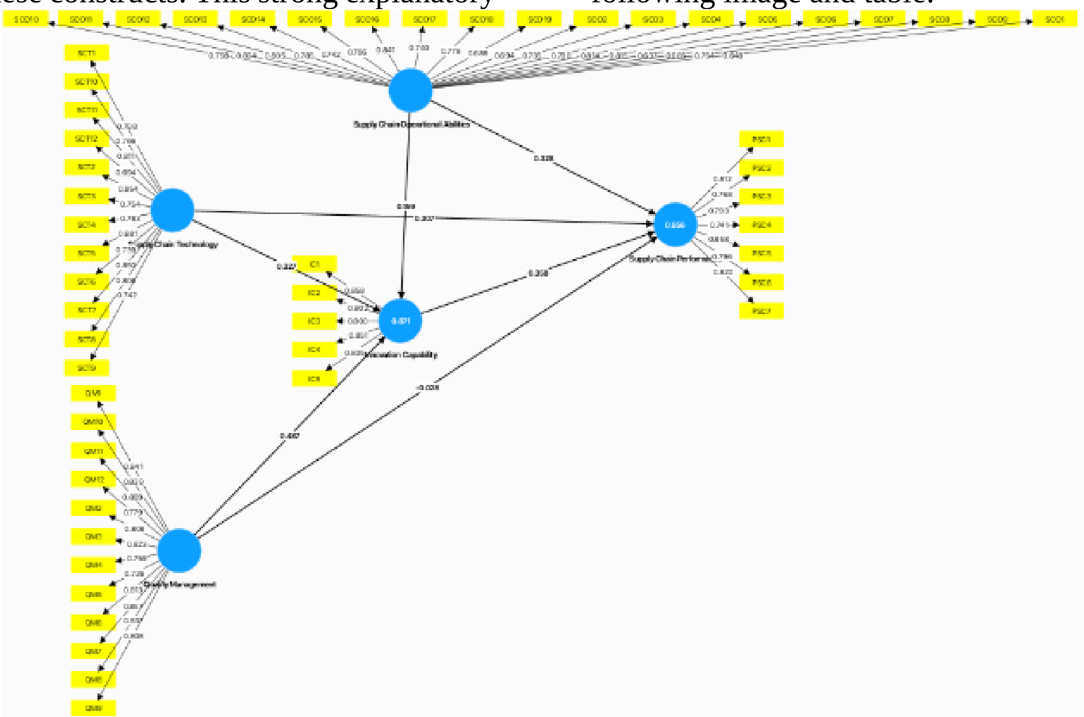

Figure 4. Hypoteses Testing

Table 8. Result For Inner Weights

	Path	Standardized Coefficient	T statistics	P value	Significance	Result
H1	Supply Chain Operational Abilities -> Supply Chain Performance	0,416	6,759	0.000	Significant	Supported
H2	Supply Chain Technology -> Supply Chain Performance	0,054	0,762	0.223	Not Significant	Not Supported
H3	Quality Management -> Supply Chain Performance	0,114	1,718	0.043	Significant	Supported

	Path	Standardized Coefficient	T statistics	P value	Significance	Result
H4	Supply Chain Operational abilities -> Innovation Capabilities -> Supply Chain Performance	0,065	3,933	0.000	Significant	Supported
H5	Supply Chain Technology -> Innovation Capabilities -> Supply Chain Performance s	0,156	5,135	0.000	Significant	Supported
H6	Quality Management -> Innovation Capabilities -> Supply	0,157	4,636	0.000	Significant	Supported

The hypotheses testing results presented in Table 7 provide a comprehensive view of the relationships between various constructs within the model, shedding light on both direct and indirect effects on Supply Chain Performance. Each hypothesis was evaluated based on the Standardized Coefficient, T-statistics, and P-values, with significance determined at a threshold of $p < 0.05$. The findings indicate that the majority of hypothesized relationships are significant, underscoring the intricate interdependencies between supply chain operational abilities, technology, quality management, innovation capabilities, and overall performance.

H1. Influence of supply chain operational abilities with supply chain performance, which posits that supply chain operational abilities positively influence supply chain performance, is supported. With a standardized coefficient of 0.416 and a T-statistic of 6.759 ($p = 0.000$), this path is highly significant, suggesting that enhancing operational capabilities—such as agility, responsiveness, and efficient resource management—has a direct and substantial impact on performance outcomes. This finding highlights the critical role of operational abilities in driving performance improvements and reinforces the importance of operational efficiency as a cornerstone of supply chain success.

H2, influence supply chain technology with supply chain performance, which hypothesized a direct positive relationship between supply chain technology and supply chain performance, is not supported. This path has a low standardized coefficient of 0.054, a T-statistic of 0.762, and a p-value of 0.223, indicating that the relationship is not statistically significant. The lack of significance suggests that supply chain technology, when considered in isolation, may not directly translate into performance gains. This could imply that technology's impact on performance is more nuanced, possibly requiring complementary factors like operational capabilities or innovation to unlock its full potential. It points to the idea that technology alone may not be sufficient to drive performance improvements but could play a vital role when integrated into a broader strategic framework.

H3, influence of quality management on supply chain performance, examines the effect of quality management on supply chain performance, and is supported with a standardized coefficient of 0.114, a T-statistic of 1.718, and a p-value of 0.043. This significance underscores that effective quality management practices, such as maintaining high standards, continuous monitoring, and consistent improvement processes, contribute positively to performance outcomes. This relationship suggests that quality management serves as a foundational element within the supply chain, directly enhancing the reliability and efficiency of operations, which subsequently drives performance improvements.

H4, influence supply chain operational abilities on supply chain performance mediated by innovation capabilities. Proposes that Supply Chain Operational Abilities enhance Innovation Capabilities, which in turn positively affect Supply Chain Performance. This hypothesis is supported, by a standardized coefficient of 0.065, a T-statistic of 3.933, and a p-value of 0.000, indicating a significant indirect effect. This finding highlights that operational capabilities play an important role in fostering innovation within the supply chain. By streamlining operations and enabling efficient resource allocation, these capabilities create an environment conducive to innovation, which then positively impacts overall performance. This underscores the indirect pathway through which operational strengths contribute to performance by nurturing a culture of innovation.

H5 influence supply chain technology on supply chain performance mediated by innovation capabilities. Explores the indirect effect of Supply Chain Technology on Supply Chain Performance through Innovation Capabilities. Supported by a standardized coefficient of 0.156, a T-statistic of 5.135, and a p-value of 0.000, this finding suggests that while technology may not directly impact performance, it significantly enhances innovation, which subsequently leads to improved performance outcomes. This indicates that technology serves as a critical enabler of innovation within the supply chain, providing tools and systems that facilitate new processes, products, and efficiencies. In this indirect role, technology supports a culture of continuous improvement and adaptation, ultimately contributing to performance gains.

H6 influence quality management on supply chain performance mediated by innovation capabilities. Hypothesizes that quality management positively impacts innovation capabilities, which then enhances supply chain performance. This hypothesis is supported, by a standardized coefficient of 0.157, a T-statistic of 4.636, and a p-value of 0.000. This significant relationship suggests that quality management practices not only contribute directly to performance (as seen in H3) but also foster an environment that encourages innovation. By ensuring high standards and systematic improvements, quality management establishes a stable and supportive foundation for innovative thinking and experimentation, which further benefits supply chain performance.

The hypotheses testing results demonstrate that Supply Chain Operational Abilities and Quality Management have both direct and indirect positive effects on Supply Chain Performance. Although Supply Chain Technology does not show a direct effect on performance, its impact is mediated through Innovation Capabilities, suggesting its role as a crucial enabler of innovation within the supply chain. These findings provide valuable insights into the pathways through which operational strengths, technology, and quality practices drive performance, emphasizing the need for an integrated approach to supply chain management that leverages both direct and indirect relationships to achieve optimal performance outcomes.

Table 9. Q^2predict

	Q^2predict
IC2	0,495
IC4	0,659
IC5	0,574
PSC1	0,518
PSC5	0,642

PSC6	0,622
PSC7	0,495

The **Q² Predict** values indicate that the model demonstrates moderate to high predictive relevance for specific indicators related to Innovation Capabilities and Supply Chain Performance. For Innovation Capabilities, indicators such as **IC4** (Q^2 = 0.659) and **IC5** (Q^2 = 0.574) show strong predictive relevance, suggesting that the model effectively captures and predicts changes within these areas, while **IC2** (Q^2 = 0.495) indicates moderate predictive accuracy. In terms of Supply Chain Performance, indicators **PSC5** (Q^2 = 0.642) and **PSC6** (Q^2 = 0.622) exhibit high predictive values, highlighting the model's robustness in forecasting aspects tied to these performance measures. **PSC1** (Q^2 = 0.518) also shows good predictive power, and **PSC7** (Q^2 = 0.495) reflects moderate predictiveness. Overall, the model's strong predictive relevance for these key indicators underlines its reliability in anticipating variations in Innovation Capabilities and Supply Chain Performance, providing confidence that the model is a robust tool for strategic forecasting and decision-making in supply chain management.

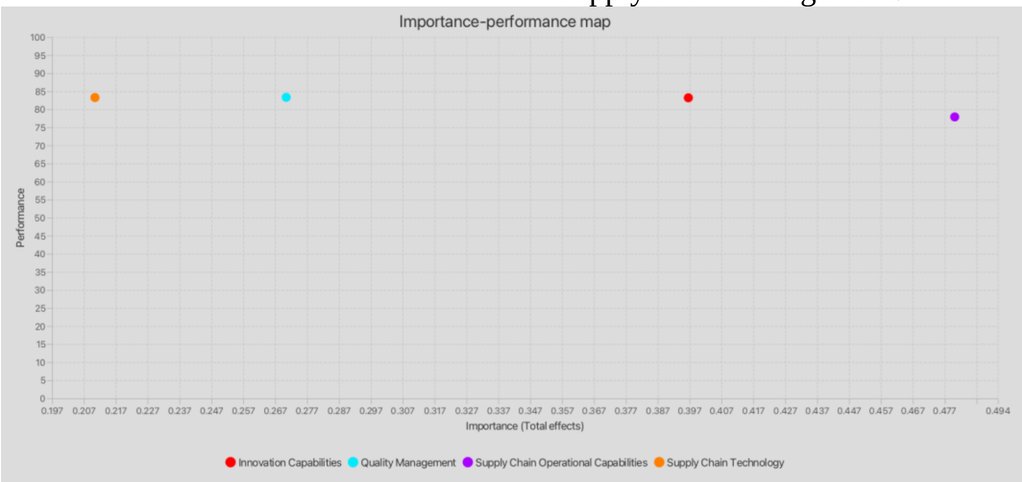

Figure 5. The Importance-Performance Map Analysis (IPMA)

The Importance-Performance Map Analysis (IPMA) reveals key insights into which constructs most significantly impact Supply Chain Performance and where improvements could be most beneficial. Supply Chain Operational Capabilities and Innovation Capabilities are shown to have the highest importance in driving performance but are currently performing at a moderate level. This suggests that these areas present the greatest opportunities for improvement; by enhancing operational efficiency and innovation efforts, the organization could substantially boost its supply chain performance.

In contrast, Supply Chain Technology and Quality Management are performing well, with high-performance scores, yet they have relatively moderate importance in the overall model. This indicates that while these areas contribute positively, they are less critical to achieving major performance gains compared to operational and innovation capabilities. Therefore, prioritizing improvements in operational and innovation capabilities would likely yield the most significant impact on overall supply chain performance.

CONCLUSION AND SUGGESTION

Based on the results of the study, several important conclusions can be drawn. First, supply chain operational capability has a significant positive influence on supply chain performance (H1 supported), which confirms the importance of strong operational capability in improving performance outcomes in the supply chain. Secondly, supply chain technology also shows a significant positive impact on supply chain performance (H2 supported), which indicates that the integration of advanced technology is essential to optimize performance in the supply chain process. However, quality management did not have a significant effect on supply chain performance directly (H3 not supported), which suggests that in this context, quality management itself may not contribute directly to performance improvement, in contrast to some previous studies that reported a positive effect. Furthermore, innovation capability serves as a significant mediator in the relationship between supply chain operational capability and supply chain performance (H4 supported).

Innovation capability also mediates the effect of supply chain technology on supply chain performance (H5 supported), indicating that technology adoption combined with innovation-based practices has the potential for better performance. Finally, innovation capability significantly mediates the effect of quality management on supply chain performance (H6 supported), indicating that while quality management may not have a direct impact on performance, its effectiveness can be improved through innovation.

Overall, this study emphasizes the role of innovation capability in amplifying the positive impact of operational capability, technology, and quality management on supply chain performance. The findings provide practical insights for the Indonesian manufacturing sector, suggesting the importance of building a culture of innovation to maximize the benefits of operational and quality improvements in the supply chain. For future research, it is recommended to add other variables that affect supply chain performance, such as the relationship between suppliers and buyers, environmental factors, and information sharing. In addition, studies can also be developed involving companies with different characteristics to assess how different organizational factors, such as size or industry type, interact with supply chain innovation and performance.

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