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Bridging Sustainability and Risk Management to Competitive Advantage through Supply Chain Innovation

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Abstract:- This study aims to examine and analyze the effect of sustainable supply chain management and risk management capability on competitive advantage, with supply chain innovation as a mediating variable, in medium- and large-scale companies in Makassar City. The research employed a quantitative explanatory design, involving 42 respondents consisting of managers, supervisors, and operational staff familiar with their companies' supply chain practices. Data were analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM). Sustainable supply chain management (β = 0.399; p = 0.007) and risk management capability (β = 0.445; p = 0.001) had a positive and significant effect on supply chain innovation. However, neither had a direct effect on competitive advantage. Conversely, supply chain innovation had a positive and significant effect on competitive advantage (β = 0.673; p = 0.000). Furthermore, supply chain innovation significantly mediated the relationship between sustainable supply chain management and competitive advantage (β = 0.269; p = 0.030), as well as between risk management capability and competitive advantage (β = 0.300; p = 0.011). These findings highlight that medium- and large-scale companies in Makassar can enhance competitiveness through sustainable supply chain practices and effective risk management, with supply chain innovation serving as a key driver.

Keywords*: Sustainable supply chain management, risk management capability, supply chain innovation, competitive advantage*

1. Introduction

In recent decades, the business environment has been increasingly shaped by global dynamics such as digital transformation, climate change, geopolitical tensions, and rising social and environmental awareness among consumers. These dynamics not only create opportunities but also pose significant challenges for firms of all sizes. As a result, businesses are under pressure to adopt strategies that are not only economically efficient but also socially and environmentally sustainable.

Sustainability has therefore become a central theme in modern supply chain management (SCM). Rather than focusing solely on cost efficiency and distribution speed, supply chains are now expected to integrate sustainability principles throughout their processes, from raw material sourcing to post-consumption activities. Reports from the United Nations Global Compact (2022) and the Carbon Disclosure Project (2024) highlight that supply chain-related emissions can be up to 26 times higher than direct operational emissions, underlining the importance of sustainable supply chain management (SSCM) in achieving global climate goals. Furthermore, firms that implement sustainable practices tend to demonstrate stronger resilience and competitiveness. Alongside sustainability, risk management capability has emerged as a critical determinant of supply chain performance in an increasingly volatile environment. Firms must be able to anticipate, absorb, and recover from disruptions to maintain operational continuity. Prior studies suggest that robust risk management capability can enhance adaptive responses and long-term competitiveness (Afraz et al., 2021). Moreover, effective risk management often lays the foundation for supply chain innovation (SCI), enabling firms to respond to uncertainty through digital technologies, collaborative models, and new business processes.

Despite the growing importance of SSCM, risk management, and innovation, empirical findings on their direct effects on competitive advantage remain inconsistent. Some studies report that SSCM significantly enhances competitive advantage (Hasanah & Fauziyah, 2020; Shebeshe & Sharma, 2024), while others find no such effect (Vargas et al., 2018; Razzak, 2023). Similarly, evidence regarding the impact of risk management capability on competitiveness is mixed (Afraz et al., 2021; Fadhiela & Ringo, 2024; Nguyen, 2023). These inconsistencies highlight the need to examine potential mediating mechanisms that can better explain how SSCM and risk management capability contribute to firm competitiveness.In this regard, supply chain innovation is proposed as a strategic mediator. SCI enables firms to translate sustainability practices and risk management capability into tangible competitive advantage by fostering flexibility, responsiveness, and efficiency. However, limited empirical studies, especially in developing countries, have explored this mediating role. In the context of medium and large-scale firms in Makassar, Indonesia, structural challenges such as limited technological infrastructure and managerial capabilities further complicate the integration of sustainability, risk management, and innovation strategies.

To address these gaps, the present study investigates the following research questions:

RQ 1. Does SSCM influence SCI in medium and large-scale firms in Makassar?
RQ 2. Does RMC influence SCI in medium and large-scale firms in Makassar?
RQ 3. Does SSCM influence competitive advantage in medium and large-scale firms in Makassar?
RQ 4. Does RMC influence competitive advantage in medium and large-scale firms in Makassar?
RQ 5. Does SCI influence competitive advantage in medium and large-scale firms in Makassar?
RQ 6. Does SCI mediate the relationship between SSCM and competitive advantage in medium and large-scale firms in Makassar?
RQ 7. Does SCI mediate the relationship between RMC and competitive advantage in medium and large-scale firms in Makassar?

In line with these research questions, the objectives of this study are to examine and analyze the effects of SSCM and RMC on SCI and competitive advantage, as well as to assess the mediating role of SCI in these relationships. This research is expected to provide both theoretical and practical contributions. Theoretically, it enriches the body of knowledge on supply chain management by integrating sustainability, risk management, and innovation into a unified framework for competitive advantage. Practically, the findings may serve as strategic insights for managers and decision-makers of medium and large-scale firms in Makassar to strengthen their supply chain strategies in an increasingly complex and uncertain market environment.

2. Theoretical background

2.1 Sustainable Supply Chain Management: Supply chain refers to the interconnected relationships among firms involving the flows of goods, capital, and information from suppliers to final consumers (Maisaroh, 2021). Supply chain management (SCM) emphasizes the integrated coordination of these flows to enhance efficiency and customer satisfaction while fostering collaboration through effective information and knowledge sharing (Karim et al., 2024). In the global business landscape, however, SCM increasingly needs to incorporate sustainability principles in order to address environmental, social, and economic challenges. Sustainable Supply Chain Management (SSCM) has emerged as a central concept, defined as the management of material, information, and capital flows across the supply chain while integrating the three dimensions of sustainability: economic, social, and environmental (Mastos & Gotzamani, 2022). The primary objective is to establish supply chains that are efficient, profitable, and sustainable, ensuring long-term stakeholder value. Shebeshe & Sharma (2024) similarly emphasize that SSCM coordinates these three aspects to optimize economic performance while maintaining social and environmental balance.

Each dimension plays a distinct role. The environmental dimension focuses on minimizing negative ecological impacts through carbon reduction, resource efficiency, and waste recycling (Razzak, 2023). The social dimension underscores human rights, labor welfare, and community interests, often operationalized through supplier standards such as SA8000 and support for local partners (Lee, 2021; Razzak, 2023).

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Vol. 36 Issue 1, 2026, Pages 4588-4596

Finally, the economic dimension stresses profitability and efficiency, positioning sustainability-driven practices such as green technology adoption as competitive strategies rather than mere ethical obligations (Kuwornu et al., 2023; Maisaroh, 2021).

The Triple Bottom Line (TBL) framework introduced by Elkington in the 1990s further reinforces the integration of profit, people, and planet within SSCM (Shtawi et al., 2023). This perspective encourages firms to evaluate success holistically by including social and environmental outcomes alongside financial measures. In doing so, SSCM becomes not only a pathway to sustainable operations but also a source of long-term competitive advantage and stakeholder trust (Lee, 2021; Shebeshe & Sharma, 2024).

2.2 Risk Management Capabilities: Risk management in supply chains refers to approaches aimed at identifying potential sources of risk and implementing appropriate strategies to reduce their impact. (Afraz et al., 2021) define supply chain risk management as the identification of potential risk sources and the application of coordinated strategies among supply chain members to reduce vulnerabilities. As globalization and digitalization expand, supply chain risk management has become increasingly complex. According to Ali et al., (2023), this concept is not entirely new since firms inevitably face risks in their operations. However, with the growing complexity of supply chains in the era of Industry 4.0, risk management requires more effective capabilities (Verhoef et al., 2021). Such capabilities, known as Risk Management Capabilities (RMC), refer to the firm's ability to identify, assess, manage, and mitigate risks that may influence supply chain operations and performance (Nguyen, 2023).

The scope of RMC in the literature is commonly categorized into two key approaches: robustness and resilience (Taleghani & Shadpour, 2024). Robustness refers to the ability to effectively handle potential future scenarios by maintaining stable supply chain functions despite disruptions. It reflects flexibility in keeping multiple options open for decision-making under various possible conditions (Nguyen, 2023). Resilience, on the other hand, is defined as the ability of a system to return to its original state or transition to a new, more desirable state after disruptions (El Baz & Ruel, 2021). Supply chain resilience can be achieved through strategies such as agility, visibility, redundancy, responsiveness, flexibility, and collaboration (Taleghani & Shadpour, 2024). By proactively configuring and managing resources through risk management practices, firms can either reduce supply chain disruptions and maintain planned performance (robustness) or recover performance after absorbing the impacts of disruptions (resilience). As highlighted by Ayesha et al. (2023), effective supply chain risk management requires a combination of preventive measures and readiness to respond to unexpected events.

2.3 Supply Chain Innovation: Supply chain innovation has become a crucial driver of competitiveness and resilience in an increasingly uncertain business environment. It refers to the adoption of new techniques, methods, or investments to reduce risks and improve a firm's ability to handle disruptions (Shamout, 2019). More broadly, supply chain innovation can be seen as a complex process that provides solutions for customers in dynamic environments. It involves both internal and external changes that generate new value for stakeholders, emphasizing that innovation is not limited to technology but also reflects strategic approaches to sustainable value creation (Firmansyah & Siagian, 2022).

The primary goal of supply chain innovation is to deliver effective solutions for end-users while managing internal and external uncertainties (Mehregan et al., 2023). In today's competitive landscape, firms that adopt innovation-oriented strategies are more likely to achieve superior performance compared to those relying on conventional practices. In this sense, supply chain innovation resonates with Schumpeter's notion of creative destruction, whereby old systems are continuously replaced by new economic structures (Taleghani & Shadpour, 2024). By integrating knowledge, technology, economics, and management from ideation to implementation, innovation reflects a paradigm shift in business models and operational practices (Rhazzi & Dhiba, 2022). Supply chain innovation may take various forms, ranging from process improvements to technological advancements, new business models, and organizational changes. Process innovation involves improving logistics and operational efficiency through the introduction of new methods or procedures, thereby enhancing service quality and reducing costs (Kwak et al., 2018; Shamout, 2019). Technological innovation encompasses the use of advanced tools such as real-time tracking systems, predictive analytics, and automation, which enhance visibility and decision-making speed (Shamout, 2019). Business model innovation focuses on rethinking value creation and distribution strategies, for instance through just-in-time practices or new supplier partnerships, to improve flexibility and competitiveness (Firmansyah & Siagian, 2022). Finally, organizational innovation refers to changes in structures, policies, and management practices that enable faster decision-making, improved coordination, and stronger collaboration within the supply chain network (Rasib et al., 2021).As markets, products, and customer demands evolve rapidly, firms must embrace supply chain innovation to remain competitive. Kwak et al. (2018) argue that innovation allows firms to adapt swiftly to changes in products, services, and customer needs. This is consistent with prior research highlighting innovation as a key factor in enhancing competitiveness and sustainability (Kwak et al., 2018). Hence, supply chain innovation is not merely a strategic option but a necessity for firms seeking to thrive in today's turbulent market environment.

2.4 Competitive Advantage: Competitive advantage is a key determinant of business success, allowing firms to deliver greater value through lower costs or superior offerings compared to competitors (Momaya, 2019; Razzak, 2023). It is achieved when resources are valuable, rare, inimitable, and non-substitutable, forming the basis for sustained superiority. Beyond cost leadership and differentiation Razzak (2023), competitive advantage is closely tied to value creation, where firms generate higher economic value than rivals by combining efficiency with product quality (Mukhsin & Suryanto, 2022).

Recent studies emphasize innovation and dynamic capabilities as critical drivers. Firms that continuously adapt through technology adoption, product development, and service improvement are more likely to sustain competitiveness (Hasanah & Fauziyah, 2020; Shebeshe & Sharma, 2024). Indicators commonly used include lower costs, superior quality, timely delivery, product innovation, and customer satisfaction (Putri et al., 2024; Siagian et al., 2022).

In supply chain contexts, competitive advantage stems from integrated practices and innovations that enhance efficiency, flexibility, and responsiveness. It reflects not a single factor but the combination of cost efficiency, innovation, service quality, and operational agility that enables firms to maintain strong market positions over time (Javid & Amini, 2023; Kwak et al., 2018; Taleghani & Shadpour, 2024).

2.5 The Resource-Based View (RBV) The Resource-Based View (RBV) emphasizes that competitive advantage arises from a firm's ability to acquire and utilize resources that are valuable, rare, inimitable, and non-substitutable (VRIN) (Llach et al., 2025). Originating from Wernerfelt and formalized by Barney, RBV shifted strategic management from focusing solely on external industry factors to internal assets and capabilities. These resources include both tangible assets and intangible elements such as knowledge, reputation, and organizational culture, which together determine a firm's ability to achieve above-average returns.

While RBV provides a strong foundation for explaining firm heterogeneity, critics argue that its static nature limits its applicability in dynamic environments. Firms with similar resources may not achieve the same outcomes due to external pressures such as competition and regulation (Salazar & Armando, 2017). This limitation gave rise to the Dynamic Capabilities View (DCV), which highlights the importance of reconfiguring and adapting resources to sustain advantage in rapidly changing markets.

In its evolution, RBV has expanded into the broader Resource-Based Theory (RBT), incorporating extensions such as the knowledge-based view and the natural resource-based view (Razzak, 2023). Despite critiques, RBV remains a central framework in strategic management, explaining how firms leverage internal strengths to build and sustain long-term competitiveness.

A 25-year-old Yamani male patient, not known to have any medical illness and surgical free, came to the emergency department complaining of right-sided abdominal pain for 10 days. The history was unclear because the patient was anxious, but mainly he complained of abdominal pain

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
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Vol. 36 Issue 1, 2026, Pages 4588-4596

for 10 days. He described this pain in the right upper quadrant, which started gradually, did not radiate, was on and off, and was progressive over time. There were no reliving or aggravating factors. He described that pain was associated with obistation for 7 days. He was nauseated but denied any history of vomiting or change in bowel habit. He also reported decreases in appetite, loss of weight, and fatigue. According to his complaint, the fatigue lasted one month, and in the last ten days, he started complaining of abdominal pain. He denied subjective fever, night sweats, or eating from outside. There was no family history of bowel disease or malignancy. He had no sick contact and no traveling history. There was no previous similar complaint or alternative bowel habits.

3. Hypothesis development

3.1 Sustainable Supply Chain Management and Supply Chain Innovation: Sustainable supply chain management (SSCM) is a strategic approach that integrates economic, social, and environmental considerations into the management of material, information, and resource flows across the supply chain. Within the lens of Dynamic Capabilities Theory (DCT), SSCM enables firms to reconfigure internal and external resources to respond effectively to environmental changes through continuous innovation (Krishnan et al., 2021). Beyond operational efficiency, SSCM emphasizes environmental and social responsibility, which in turn encourages firms to adopt innovative practices across the supply chain (R. Chen, 2024). Empirical evidence supports the positive linkage between SSCM and supply chain innovation. Krishnan et al. (2021) show that collaboration in sustainable supply chains generates diverse innovations with economic, social, and environmental impact. Tebaldi et al. (2018) underline that sustainable supply chain innovation emerges from collaboration among supply chain actors, enabling efficiency and improved performance. Zangara & Filice (2024) highlight the role of social sustainability in enriching innovative practices, particularly through workforce empowerment and knowledge acquisition. In addition,Chen (2024) emphasizes SSCM as a catalyst for innovation by promoting transparency, technology adoption, and efficient logistics.Taken together, these insights indicate that SSCM is a key driver of innovation within supply chains. By embedding sustainability principles, firms not only comply with ethical and regulatory requirements but also create added value through adaptive products, processes, and technologies. Hence, the following hypothesis is proposed:

H1: Sustainable supply chain management positively influences supply chain innovation.

3.2 The Effect of Risk Management Capability on Supply Chain Innovation: Supply Chain Risk Management (SCRM) capability reflects a firm's competence in identifying, analyzing, and responding to risks within supply chain operations. From the Resource-Based View (RBV), this capability is considered valuable, rare, inimitable, and non-substitutable, enabling firms to foster innovation through adaptive responses to external uncertainties (Ba Awain et al., 2025). Rather than serving merely as a defensive mechanism, SCRM acts as a catalyst for innovation by creating conditions that encourage proactive solutions. Empirical studies confirm the positive link between SCRM and innovation. Foli et al. (2024) found that stronger SCRM capabilities enhance firms' ability to manage risks in innovative activities, thereby improving innovation performance. Odimarha et al. (2024) emphasized the role of predictive and automated technologies in enabling proactive responses to disruptions, while Atadoga et al. (2024) highlighted the contribution of artificial intelligence to resilience and predictive decision-making. Similarly, Ba Awain et al. (2025) demonstrated that SCRM capability supports product and process innovation, particularly under market disruptions and environmental uncertainty.

Based on these arguments, the following hypothesis is proposed:

H2: Risk management capability has a positive effect on supply chain innovation.

3.3 The Effect of Sustainable Supply Chain Management on Competitive Advantage: Sustainable Supply Chain Management (SSCM) extends traditional supply chain practices by incorporating economic, social, and environmental dimensions into business operations. From the Resource-Based View (RBV), SSCM practices such as supplier collaboration, resource efficiency, and eco-friendly innovation, represent valuable, rare, inimitable, and non-substitutable resources that can drive competitive advantage (Hasanah & Fauziyah, 2020; Mukhsin & Suryanto, 2022). By embedding sustainability into their supply chains, firms enhance operational efficiency while simultaneously creating value that rivals find difficult to imitate. Empirical studies provide strong evidence for this relationship. Razzak (2023) argued that SSCM adoption yields long-term benefits such as improved stakeholder perceptions, regulatory support, and lower financing costs. Akter et al. (2020) emphasized that sustainability-oriented practices strengthen corporate reputation, while Panigrahi et al.2019) highlighted that rising consumer awareness of sustainability issues pressures firms to integrate such practices into their supply chains. Similarly, Shebeshe & Sharma (2024) found that SSCM indicators, including collaboration, communication, and customer relationships, directly enhance competitive outcomes like quality, delivery reliability, and speed to market.

Taken together, these insights suggest that SSCM creates strategic value both directly, through improved efficiency, and indirectly, through stakeholder recognition and stronger market positioning. Accordingly, the following hypothesis is proposed:

H3: Sustainable supply chain management has a positive effect on competitive advantage.

3.4 The Effect of Risk Management Capability on Competitive Advantage: Risk management capability has become a critical factor in shaping competitive advantage, particularly in today's volatile and uncertain business environment. From the Resource-Based View (RBV), such capability is considered a valuable, rare, inimitable, and non-substitutable resource that enables firms to achieve sustainable advantage. Specifically, robustness (the ability to withstand disruptions) and resilience (the ability to recover and adapt) are strategic dimensions of risk management that support value creation and long-term competitiveness (Afraz et al., 2021; Taleghani & Shadpour, 2024).

Empirical studies confirm the positive link between risk management capability and competitive advantage. Afraz et al. (2021) and (Fadhiela & Ringo, 2024) demonstrated that both robustness and resilience significantly strengthen competitive positioning. Taleghani & Shadpour (2024) further highlighted that firms with stronger resilience tend to outperform competitors in dynamic markets. Similarly, Nguyen (2023) found that overall risk management capability has a direct positive impact on competitiveness, while Putranto & Nursyamsiah (2023) emphasized the role of risk culture, supply chain collaboration, and adaptive leadership in enhancing resilience and sustaining advantage. Pu et al. (2023) also stressed that supply chain resilience should not only be viewed as risk mitigation but as a long-term strategy that fosters sustainable competitiveness.

Based on these theoretical and empirical insights, it can be concluded that firms with strong risk management capabilities are better positioned to adapt to environmental changes, maintain operational continuity, and deliver unique and sustainable value to customers. Accordingly, the following hypothesis is proposed:

H4: Risk management capability has a positive effect on competitive advantage.

3.5 The Effect of Supply Chain Innovation on Competitive Advantage: Supply chain innovation refers to systematic efforts to develop new ideas, processes, and technologies within supply chain activities to improve efficiency, effectiveness, and value creation. From the Resource-Based View (RBV), competitive advantage can be achieved when firms possess unique, valuable, and hard-to-imitate capabilities. In this regard, supply chain innovation is considered a strategic capability that enables firms to respond rapidly to market changes, develop distinctive operational processes, and deliver sustainable value to customers (Afraz et al., 2021; Nguyen, 2023).

Empirical evidence supports the positive association between supply chain innovation and competitive advantage. Afraz et al. (2021), Nguyen (2023), and (Taleghani & Shadpour, 2024) consistently found that innovation significantly enhances firm competitiveness. Supply chain innovation has been shown to drive new product development, improve service quality, reduce lead time, and increase operational efficiency and

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
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reliability (Mehregan et al., 2023). The adoption of digital technologies for monitoring and planning also strengthens firms' ability to adapt to dynamic market conditions. Chen (2019) further emphasized that innovation in the supply chain allows firms to build new capabilities that improve overall performance and long-term success.

Taken together, these insights suggest that supply chain innovation provides firms with adaptive and responsive capabilities essential for achieving competitive advantage. By fostering differentiation, cost efficiency, and customer satisfaction, supply chain innovation becomes a key driver of sustainable competitiveness. Therefore, the following hypothesis is proposed:

H5: Supply chain innovation has a positive effect on competitive advantage.

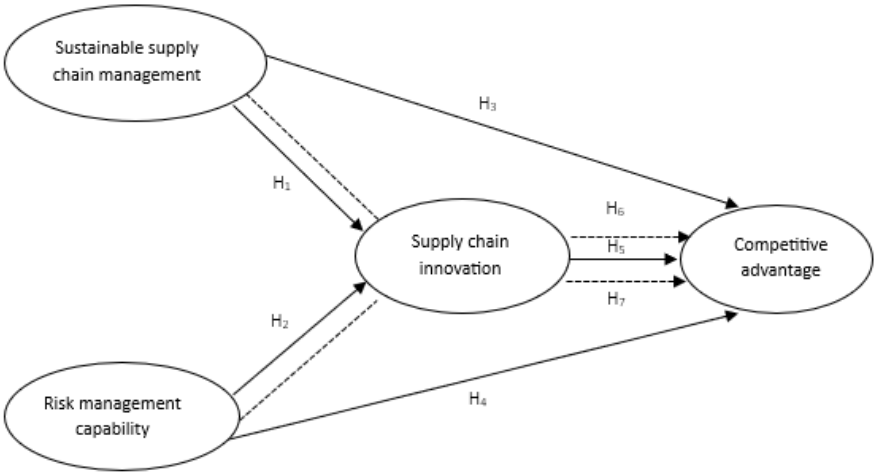
3.6 The Mediating Role of Supply Chain Innovation: Supply chain innovation is a strategic response to market dynamics, environmental pressures, and evolving customer demands. As Shan et al. (2020) argued, collaborative supply chain innovation enhances dynamic capabilities and supports sustainable performance. Such innovation can take the form of technological, managerial, or market-oriented initiatives developed jointly with supply chain partners. In this sense, innovation not only strengthens adaptability and operational efficiency but also transforms strategic inputs into tangible competitive advantage. Empirical studies highlight the mediating role of supply chain innovation in linking management practices with firm performance. Novitasari & Agustia (2021) found that green innovation mediates the relationship between green supply chain management and firm performance, while Olaleye & Mosleh (2025) demonstrated that green innovation mediates the effect of supply chain integration on sustainable supply chain performance. Similarly, Shan et al. (2020) showed that collaborative innovation drives sustainable performance through enhanced dynamic capabilities. In the context of risk management, Jerome et al. (2024) emphasized that digital innovations such as big data analytics and track-and-trace systems serve as mechanisms that connect risk management practices with competitive advantage.Based on these insights, supply chain innovation is positioned as a bridge linking sustainable supply chain management and risk management capability to competitive advantage. Firms that successfully embed innovation in their supply chain activities are better able to transform sustainability and risk management practices into sources of competitiveness. Therefore, the following hypotheses are proposed:

H6: Supply chain innovation mediates the relationship between sustainable supply chain management and competitive advantage.

H7: Supply chain innovation mediates the relationship between risk management capability and competitive advantage.

As a result, the research model used in this study is shown in Fig. 1.

Figure 1: The research model



4. Methodology

4.1 Survey and Measures

This study employs a quantitative research approach, which provides an objective and systematic assessment of relationships among variables using numerical data analyzed through statistical techniques. The research aims to examine how Sustainable Supply Chain Management (X1) and Risk Management Capability (X2) influence Competitive Advantage (Y), with Supply Chain Innovation (Z) serving as a mediating variable. Accordingly, the study follows an explanatory and correlational research design, focusing on causal relationships and the strength and direction of associations among the variables.

The research was conducted in Makassar City, South Sulawesi, Indonesia, a metropolitan area with significant economic activity and a diverse industrial landscape, including medium and large-scale firms. Data collection occurred over one month in July 2025 through structured questionnaires distributed to managers and other relevant personnel. The sample comprised 42 respondents, selected using convenience sampling, following the 10-times rule for PLS-SEM as suggested by Hair et al. (2017). This sample size exceeds the minimum requirement, ensuring reliable parameter estimation and model stability.

The primary data were collected via a five-point Likert scale questionnaire, covering the four main variables: Sustainable Supply Chain Management, Risk Management Capability, Supply Chain Innovation, and Competitive Advantage. Secondary data were obtained from relevant documents and literature to support the theoretical framework and contextual understanding.

4.2 Empirical Strategy

The empirical analysis was conducted using PLS-SEM via SmartPLS software, which is suitable for complex models with relatively small sample sizes and non-normal data distributions. The analysis proceeded in two main stages: (1) Measurement Model (Outer Model). Assessment: Ensured that all constructs were valid and reliable, including both convergent and discriminant validity checks, as well as internal consistency measures. (2) Structural Model (Inner Model). Assessment: Tested hypothesized relationships among variables, including direct effects of X1 and X2 on Y and indirect effects mediated by Z. Mediation analysis followed guidelines to evaluate the strength and significance of indirect paths.

Descriptive statistics were also presented to provide context for the dataset. All procedures adhered to contemporary quantitative methodology standards (Hair et al., 2017; Henseler et al., 2016; Sarstedt et al., 2017), ensuring robust and interpretable results for understanding the role of sustainable supply chain practices, risk management capability, and innovation in enhancing competitive advantage.

5. Results

5.1. Sample characteristics

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1, 2026, Pages 4588-4596

The study involved 42 respondents from medium and large-scale companies operating in Makassar City. Respondents were selected based on their direct or indirect involvement in managing operational activities, innovation initiatives, and supply chain management within their organizations. Therefore, the participants represented individuals with sufficient understanding of business processes and active roles in both strategic decision-making and operational implementation.

The sample characteristics were described according to the following indicators: (1) gender, (2) age, (3) level of education, (4) position within the company, (5) type of industry, and (6) number of employees. These variables provide a detailed profile of the respondents, ensuring that the data reflect a comprehensive view of the human resources involved in supply chain, risk management, and innovation practices within medium- and large-scale firms in Makassar.

Detailed distributions and descriptive statistics for each characteristic are presented in the subsequent sections.

Table 1: Participant information

Characteristics		Frequency	Percentage (%)
Gender	Male	24	57,14
	Female	18	42,86
Age	< 25	9	21,43
	25 – 34	25	59,52
	35 – 45	7	16,67
	> 45	1	2,38
Level of Education	Undergraduate	6	14,29
	Graduate	35	83,33
	Master	1	2,38
Position within The Company	Operational Manager	13	30,95
	Risk Manager	1	2,38
	Supervisor	13	30,95
	Operational/Production/Logistics Staff	12	28,57
	Others	3	7,14
Type of Industry	Manufacturing	9	21,43
	Construction	12	28,57
	Retail	11	26,19
	Food & Beverage	6	14,29
	Services (Courier/Logistics)	4	9,52
Number of Employees	20–99 employees	37	88,10
	More than 99 employees	5	11,90

5.2. Descriptive Statistics

Table 2: Mean and standard deviation

Variable	Indicators	Mean	St. Dev
Sustainable supply chain management	SSCM 1	3,98	0,81
	SSCM 2	4,10	0,79
	SSCM 3	4,12	0,86
	SSCM 4	4,29	0,74
	SSCM 5	4,45	0,59
	SSCM 6	4,14	0,68
	SSCM 7	4,26	0,67
	SSCM 8	4,55	0,50
	SSCM 9	4,31	0,75
Mean SSCM	-	4,24	0,71
Risk management capability	RMC 1	4,36	0,69
	RMC 2	4,29	0,71
	RMC 3	4,36	0,76
	RMC 4	4,24	0,73
	RMC 5	4,33	0,61
	RMC 6	4,26	0,67
	RMC 7	4,31	0,64
	RMC 8	4,33	0,61
Mean RMC	-	4,31	0,67
Supply chain innovation	SCI 1	4,07	0,78
	SCI 2	4,21	0,81
	SCI 3	4,55	0,55
	SCI 4	4,10	0,82
	SCI 5	4,31	0,72
Mean SCI	-	4,25	0,73
Competitive advantage	CA 1	4,17	0,62
	CA 2	4,43	0,63
	CA 3	4,38	0,76
	CA 4	4,57	0,59
Mean CA	-	4,39	0,65

The descriptive statistics indicate that respondents hold positive perceptions toward sustainable supply chain management, risk management capability, supply chain innovation, and competitive advantage, providing a solid basis for further analysis using Structural Equation Modeling (SEM) to examine the hypothesized relationships among these constructs.

5.3. Measurement Model Evaluation (Outer Model)

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1, 2026, Pages 4588-4596

Tabel 3: Indicators Loadings and Reliability/Validity

Variable	Indicators	Loading Factor	Reliability and Validity
Sustainable supply chain management	SSCM 1	0,817	α= 0,916 CR= 0,930 AVE= 0,598
	SSCM 2	0,853	
	SSCM 3	0,732	
	SSCM 4	0,760	
	SSCM 5	0,734	
	SSCM 6	0,742	
	SSCM 7	0,760	
	SSCM 8	0,770	
	SSCM 9	0,783	
Risk management capability	RMC 1	0,742	α= 0,916 CR= 0,931 AVE= 0,631
	RMC 2	0,856	
	RMC 3	0,828	
	RMC 4	0,733	
	RMC 5	0,806	
	RMC 6	0,886	
	RMC 7	0,737	
	RMC 8	0,748	
Supply chain innovation	SCI 1	0,820	α= 0,843 CR= 0,888 AVE= 0,613
	SCI 2	0,716	
	SCI 3	0,765	
	SCI 4	0,838	
	SCI 5	0,771	
Competitive advantage	CA 1	0,737	α= 0,833 CR= 0,889 AVE= 0,667
	CA 2	0,817	
	CA 3	0,854	
	CA 4	0,852	

Table 3 presents the indicator loadings and the corresponding reliability and validity measures for each construct. All indicators met the recommended thresholds for loading factor and reliability, confirming that the measurement model is adequate for further structural analysis.

Tabel 4: Discriminant Validity: Fornell Larcker Criterion

	Supply chain innovation	Risk management capability	Competitive advantage	Sustainable supply chain management
Supply chain innovation	0,783			
Risk management capability	0,753	0,794		
Competitive advantage	0,745	0,581	0,816	
Sustainable supply chain management	0,743	0,772	0,598	0,773

Discriminant validity was confirmed as all constructs met the Fornell-Larcker criterion (see Table 4), indicating adequate construct distinctiveness.

5.4 Structural Model Evaluation (Inner Model)

Tabel 5: Inner Model (R^2 & f^2)

Endogenous Variable	R^2	Exogenous Variable	f^2	Category
Supply chain innovation	0,632	Risk management capability	0,217	Medium
		Sustainable supply chain management	0,175	Medium
Competitive advantage	0,559	Supply chain innovation	0,379	Large
		Sustainable supply chain management	0,008	Small
		Risk management capability	0,000	Negligible / Not significant

Table 5 shows that 63.2% of the variance in Supply Chain Innovation and 55.9% in Competitive Advantage are explained by the exogenous variables, with medium to large effect sizes for most paths, while some direct effects on Competitive Advantage are small or negligible.

5.5.Hypothesis testing

Tabel 6: Direct Hypotheses Testing

Hypothesis	Path	β	t-value	p-value	Result
H1	SSCM → SCI	0,399	2,708	0,007	Supported
H2	RMC → SCI	0,445	3,223	0,001	Supported
H3	SSCM → CA	0,102	0,598	0,550	Not supported
H4	RMC → CA	-0,005	0,024	0,981	Not supported
H5	SCI → CA	0,673	3,865	0,000	Supported

Tabel 7: Indirect Hypotheses Testing

Hypothesis	Path	β	t-value	p-value	Result
H6	SSCM → SCI → CA	0,269	2,175	0,030	Supported
H7	RMC → SCI → CA	0,300	2,544	0,011	Supported

6. Discussion and implications

The findings of this study highlight that sustainable supply chain management (SSCM) and risk management capability (RMC) are critical drivers of supply chain innovation (SCI), which in turn enhances competitive advantage (CA). These results align with Dynamic Capabilities Theory (DCT), which emphasizes that firms must integrate, build, and reconfigure internal and external resources to respond rapidly to environmental changes through continuous innovation (Krishnan et al., 2021). In the context of SSCM, implementing sustainability across economic, social, and and environmental dimensions encourages firms to innovate and maintain competitiveness while meeting stakeholder expectations (Chen, 2024). Empirical evidence supports these mechanisms. Collaboration in sustainable supply chains fosters innovations that impact products, processes, and organizational practices (Krishnan et al., 2021; Tebaldi et al., 2018; Zangara & Filice, 2024). In Makassar, medium and large-scale firms face regulatory pressures, consumer demands, and competitive market conditions, all of which drive the integration of sustainability principles with innovation. Consequently, H1, stating that SSCM positively affects SCI, is supported.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1, 2026, Pages 4588-4596

Similarly, RMC provides firms with robustness and resilience, enabling proactive responses to market disruptions. Empirical studies show that risk management enhances innovation performance through technology adoption, predictive systems, and partner collaboration (Odimarha et al., 2024; Atadoga et al., 2024; Ba Awain et al., 2025; Foli et al., 2024). In Makassar, firms with strong RMC are better positioned to adapt processes and products innovatively, confirming H2.

Despite the positive role of SSCM and RMC in driving innovation, their direct effects on competitive advantage are not significant (H3 and H4). SSCM practices may focus on compliance and operational efficiency, while RMC ensures stability rather than differentiation. These results are consistent with studies showing that sustainability and risk management alone do not guarantee observable competitive benefits (Vargas et al., 2018; Fadhiela & Ringo, 2024; Razzak, 2023).

On the other hand, SCI has a strong positive effect on CA (H5). Innovation enables firms to differentiate products, improve efficiency, enhance service quality, and create sustainable value, aligning with the Resource-Based View (RBV) (Afraz et al., 2021; Nguyen, 2023; Taleghani & Shadpour, 2024). Importantly, SCI serves as a mediator translating SSCM and RMC into competitive advantage. Sustainability and risk management provide valuable and unique resources, but innovation is the mechanism through which these resources generate tangible market benefits (Novitasari & Agustia, 2021; Olaleye & Mosleh, 2025). This mediating role is particularly relevant in Makassar, where firms face volatile supply conditions, infrastructure limitations, and rising customer expectations, supporting H6 and H7.

Practically, these findings suggest that firms should integrate SSCM and RMC with innovation strategies. Investments in technology, human resources, R&D, and collaborative networks enable firms to convert sustainability and risk management capabilities into distinctive competitive advantages. In essence, sustainability and risk management are strategic foundations, but innovation is the bridge that transforms these capabilities into real market value and resilience.

6.1. Theoretical implications

This study offers several theoretical contributions to the fields of supply chain management, innovation, and risk management. It highlights the mediating role of supply chain innovation, showing that sustainable supply chain management and risk management capability alone do not directly enhance competitive advantage, thus supporting the Resource-Based View (RBV) by emphasizing the importance of leveraging unique resources like innovation. The findings also advance understanding of how sustainability practices in supply chains drive process, product, and technological innovations beyond mere regulatory compliance. Furthermore, the study provides new empirical insights by examining the interplay of SSCM, SCI, and RMC in medium and large-scale firms in Makassar, a context that remains underexplored. Lastly, it reinforces risk management theory by demonstrating that risk management capabilities can stimulate innovation in response to market and supply chain uncertainties, linking risk management with strategic innovation.

6.2 Managerial and Policy Implications

Beyond theoretical contributions, this study provides practical insights for managers and policymakers. First, firms should integrate sustainability programs with innovation strategies, ensuring that eco-friendly practices and energy efficiency are complemented by product and process innovations to create competitive value. Second, proactive risk management is essential, enabling companies not only to minimize losses but also to leverage risk information to generate innovation opportunities. Third, embedding sustainability and innovation into core business strategies facilitates the achievement of competitive advantage and serves as a basis for designing policies and programs that support continuous and sustainable innovation. Finally, governments and relevant institutions can use these findings to formulate policies that encourage the integration of sustainability and innovation in the industrial sector, such as tax incentives, training programs, or R&D support for firms actively implementing sustainable and innovative practices.

7. Conclusion, limitations and future work

Based on the data analysis and discussion, the study draws several conclusions. First, sustainable supply chain management (SSCM) and risk management capability (RMC) positively influence supply chain innovation (SCI), indicating that better sustainability practices and effective risk management encourage firms to innovate in both processes and products. Second, SSCM and RMC do not directly affect competitive advantage (CA), suggesting that sustainability and risk management alone are insufficient to generate observable competitive benefits. Third, SCI positively impacts CA, acting as a critical mediator that translates SSCM and RMC into tangible market advantages. In other words, sustainability and risk management serve as strategic foundations, while innovation is the mechanism through which firms achieve competitive advantage. These findings highlight the importance of integrating SSCM and RMC with innovation strategies to strengthen market competitiveness.

This study has several limitations that should be considered when interpreting the results. First, the sample size was relatively small (42 firms), which may limit the generalizability of the findings. Second, the cross-sectional research design captures data at a single point in time, preventing analysis of long-term dynamics or temporal changes. Third, data were collected through self-reported questionnaires, which may introduce subjective bias. Fourth, the study covered multiple industrial sectors in Makassar, potentially introducing heterogeneity that limits sector-specific insights. Finally, the research focused only on SSCM, SCI, RMC, and CA, without considering other factors such as digital technology, organizational culture, or government policies that might influence competitive advantage.

For future research, it is recommended to expand the sample size and include additional mediating or moderating variables, such as digital technology adoption or organizational culture. Studies could also explore different sectors or regions to enhance contextual understanding. Moreover, adopting a mixed-method approach could provide a more comprehensive analysis of the dynamic relationships among SSCM, RMC, SCI, and CA over time.

Conflict of Interest

The authors affirm that no financial conflicts of interest.

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