Jurnal Teknologi Industri Pertanian, 36 (2): 185-196, August 2026
ISSN: 0216-3160 E-ISSN 2252-3901

Available online on
https://journal.ipb.ac.id/index.php/jurnaltin

Research Paper

ARTIFICIAL INTELLIGENCE, HUMAN RESOURCE CAPABILITY AND SUPPLY CHAIN AGILITY FOR RICE SUPPLY CHAIN RESILIENCE

Sonya Mamoriska M. Harahap[1)] *, Nur Damayanti [1)], and Dalili Izni Shafie[2)]

[1)]Management Department, Binus Business School, Binus University
JWC Campus, Jl. Hang Lekir I No. 6, Senayan, Jakarta Selatan 10270, Indonesia
[2)]Faculty of Business and Management, Universiti Teknologi MARA Cawangan Pulau Pinang, Malaysia
*Email: sonya@binus.ac.id

Article Info

Received: March 02, 2026
Revised: June 22, 2026
Accepted: July 28 2026
Published: August 2026

Keywords:

rice supply chain; supply chain resilience; HR capability; artificial intelligence; supply chain agility

ABSTRACT. In the face of rapid digital transformation and increasing supply chain disruptions, strengthening the resilience of rice supply chains has become a strategic priority. This study examines the roles of Human Resource (HR) capabilities and Artificial Intelligence (AI) adoption in enhancing Supply Chain Resilience (SCR), with Supply Chain Agility (SCA) serving as a mediating capability. Survey data were collected from 210 Logistics Service Providers (LSPs) operating within Indonesia's rice supply chain and analyzed using a quantitative approach. The results show that both HR capabilities and AI adoption have positive effects on SCA, which, in turn, significantly enhances SCR. Furthermore, SCA significantly mediates the relationships between HR capability and SCR as well as between AI adoption and SCR. These findings demonstrate that human and digital resources strengthen supply chain resilience through the development of agile capabilities that enable greater responsiveness, adaptability, and operational continuity. In the context of rice logistics, such capabilities enable organizations to respond more effectively to seasonal harvest fluctuations, distribution variability, and environmental uncertainties. This study extends the applicability of the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) to the context of rice supply chain logistics and demonstrates how organizational resources can be transformed into resilience through supply chain agility. The findings also underscore the strategic importance of workforce capability development and AI-enabled digital transformation in building more agile and resilient rice supply chains.

INTRODUCTION

Indonesia's rice industry ecosystem connects multiple actors, ranging from farmers and traders to Logistics Service Provider (LSP) firms and various market intermediaries, spanning upstream production to downstream distribution activities (Saptana *et al.*, 2024). As rice remains a critical commodity for national food security and economic stability, its distribution depends heavily on LSP firms, which serve as key connectors between production regions and consumption centers (Putri, 2025). However, this system is frequently exposed to uncertainties arising from climate variability, infrastructure limitations, transportation disruptions, and fluctuating market demand (Maghfiroh *et al.*, 2023). These challenges require LSP firms to develop resilient operational models that ensure service continuity, maintain competitiveness, and support long-term value creation within the rice agroindustry (Al Khatib *et al.*, 2024; Zheng and Wang, 2025).

Within this rice industry ecosystem, resilience extends beyond operational continuity and reflects a firm's capability to adapt to change and sustain performance over time (Nur and Muafi, 2025; Mawardi *et al.*, 2025). Prior studies indicate that resilience in supply chain-oriented firms depends on their ability to reorganize internal resources and coordination mechanisms in response to environmental disturbances (Li *et al.*, 2025). From a rice industry ecosystem perspective, resilience represents a firm's capacity to sense environmental changes, realign operational strategies, and maintain value creation within

DOI: https://doi.org/10.24961/j.tek.ind.pert.2026.36.2.185

interconnected supply chain networks (Setyorini *et al*., 2025).

Human Resource (HR) capability and digital innovation have emerged as key enablers of such adaptive capability (Yamin *et al*., 2024). Employees represent critical resources in logistics and the rice industry ecosystem, influencing coordination, decision-making, and responsiveness across supply chain networks (Saeed *et al*., 2022). HR practices that promote workforce flexibility, continuous capability development, and performance-oriented incentives strengthen employee competencies that support agile operations (Jian *et al*., 2024). Simultaneously, the adoption of Artificial Intelligence (AI) enhances information processing, demand forecasting, and real-time visibility, enabling LSP firms to adjust logistics processes and service configurations more effectively under conditions of uncertainty (Henny *et al*., 2025; Holloway, 2025). In the rice logistics sector, the adoption of artificial intelligence extends beyond mere predictive analytics. It encompasses the incorporation of AI-powered quality graders, advanced moisture and impurity sensors, as well as computer vision systems integrated into rice milling and warehousing processes. These innovations facilitate ongoing quality evaluations, detection of anomalies in storage conditions, and optimization of routing based on the risk of perishability.

Modern rice warehouses increasingly use IoT-based environmental control systems, such as networked hygrometers, temperature probes, and automatic aeration, to prevent spoilage and maintain grain quality. Studies and prototypes have shown that precise temperature/humidity and storage atmosphere control can suppress mold and maintain rice quality during long-term storage (Wang *et al*., 2025; Suhendro *et al*., 2023).

Data streams from these sensors feed into real-time dashboards and machine learning models that trigger proactive interventions (e.g., ventilation, fumigation windows, or stock rotation), thereby improving decision-making accuracy in LSP operations. IoT-based warehouse system designs and sensor/CNN-based quality monitoring studies demonstrate these mechanisms (Lydia *et al*., 2022; LokeshJoel *et al*., 2023).

On the transportation side, AI-driven dynamic routing and vehicle telematics support agility in fluctuating road and weather conditions. Real-time route research based on deep learning and spatiotemporal graph approaches has demonstrated improvements in resilience and efficiency (Ajayi, 2023; Xue *et al*., 2026).

Predictive maintenance models analyze vibration, engine and coolant temperatures, and fuel efficiency to anticipate breakdowns, reduce delivery delays, and enable higher service reliability during peak harvest times. Evidence from industrial telematics practices reports reduced unplanned downtime and maintenance costs (Coastr, 2025).

Beyond point solutions, the rice logistics sector is gradually adopting Industry 4.0 building blocks, such as RFID-enabled traceability, digital twins to simulate capacity bottlenecks and trade-offs, and blockchain-based provenance to enhance transparency among millers, traders, and public institutions. Recent case studies and reviews support the benefits of traceability and operational review (Jakkhupan *et al*., 2014; Galkin *et al*., 2025; Gonçalves *et al*., 2025).

Upstream-downstream data integration is a differentiator. Upstream actors (farmers and millers) generate signals from satellite-based crop monitoring, drone imagery for yield estimation, and AI-assisted drying control. When viewed through API-driven data layers and interoperable platforms, these signals enhance demand sensing, inventory pre-allocation, and transportation planning for LSPs (Tiwari *et al*., 2024; Li *et al*., 2024; Zhang *et al*., 2024).

Importantly, these technologies contribute to resilience through a dynamic capability pathway: they enhance sensing (early detection of weather risks, storage anomalies, or route disruptions), seizing (rapid decision-making supported by predictive insights), and reconfiguration (rapid rerouting, warehouse relocation, or contract adjustments); this is consistent with evidence of the digital twin of supply chain observability/visibility shaping digital transformation with enhanced resilience (Moshood *et al*., 2021).

SCA represents a dynamic capability that mobilizes organizational resources to reinforce resilience within rice industry supply chains (Wang *et al*., 2025). For LSP firms, agility reflects the ability to sense changes, modify operational processes, and respond rapidly within the rice industry ecosystem (Legg *et al*., 2025). Empirical evidence suggests that agility enhances resilience by enabling firms to absorb shocks, adapt to disruptions, and recover through flexible reconfiguration of resources (Alfaqiyah *et al*., 2025). Despite this, empirical research examining how HR capability and AI adoption jointly foster agility and resilience in commodity-based supply chain ecosystems, particularly in emerging economies, remains limited. Addressing this gap, the present study investigates the influence of HR capability and AI adoption on SCA and SCR among LSP firms operating within Indonesia's rice industry ecosystem.

This study makes several contributions that go beyond the existing literature. First, unlike previous studies examining AI adoption in a general supply chain environment, this study specifically examines the industry-focused digitalization process in the rice logistics ecosystem, an agricultural domain characterized by significant volatility, complex multi-actor coordination, and risks associated with the perishability of rice. Second, while previous research often treats human and digital capabilities as distinct entities, this study provides empirical evidence of their complementary nature, demonstrating how human resource capabilities and AI adoption collaboratively enhance agility in commodity-driven supply chains. Third, this study identifies SCA as a dynamic, mediating capability that transforms human and technological competencies into resilience outcomes, thus offering a new perspective on the operationalization of resilience in agribusiness logistics. These contributions underscore a more cohesive and ecosystem-oriented understanding of resilience that is largely underexplored in the existing literature.

Literature Review

HR capability plays a particularly important role in supply chains characterized by organizational diversity, geographic dispersion, and varying operational contexts. (Saeed *et al.*, 2022; Mursiti *et al.*, 2021). Effective HR capabilities are essential for addressing coordination challenges, integrating heterogeneous workforces, and supporting collaboration across the geographically dispersed supply chain structures (Ajala *et al.*, 2024; Esan *et al.*, 2024). In logistics-intensive rice industries, HR capability extends beyond administrative functions to shape employee skill development, communication quality, and collective responsiveness factors that underpin agile and resilient operations (Erfan, 2024). Managing diverse teams further requires HR capability that balance standardized practices with local adaptation, taking into account cultural norms, regulatory environments, and contextual demands (Novita, 2023; Sangkota *et al.*, 2025).

Given the dynamic and disruption-prone nature of rice industry supply chains, HR capability must proactively cultivate employee adaptability, problem-solving capability, and responsiveness that support both agility and resilience in logistics operations (Holloway, 2025). By strengthening skills, motivation, and cross-functional collaboration, HR capability encourages workforce behaviors that enable rapid detection of change and effective responses to disruptions across the rice supply chain (Jahangir *et al.*, 2025). Digital technologies complement these efforts by bridging spatial and informational gaps, enhancing coordination, and supporting timely decision-making, thereby reinforcing SCA and overall system performance.

H1: HR capability positively influences SCA.

SCA describes a firm's capacity to detect changes in its environment and respond swiftly and flexibly through effective coordination, information sharing, and process reconfiguration. As a dynamic capability, SCA enables firms to reorganize operational activities and resources to support adaptive value creation within complex supply chain systems (Alshaar *et al*., 2024). In the rice industry ecosystem context, such agility allows LSPs to manage volatility arising from climate disturbances, transportation delays, and demand fluctuations by adjusting resource allocation, modifying operational routines, and realigning inter-organizational relationships to maintain stable performance stability (Akram *et al*., 2024).

When rice supply chains experience shocks or unexpected fluctuations, resilience is essential for sustaining system performance. SCR refers to a supply network's ability to anticipate potential disruptions, absorb their impacts, adapt to changing conditions, and restore operations while continuing to deliver value (Adeleye *et al*., 2024). SCA contributes directly to the development of SCR by facilitating rapid sensing, informed decision-making and timely operational adjustments. Through agile processes, LSPs and other supply chain actors are better able to cushion disturbances, reorganize workflows, and preserve service continuity under uncertain conditions (Wieland and Durach, 2021). Accordingly, agility not only enhances short-term operational responsiveness but also functions as a foundational capability for long-term resilience and sustained value creation in the interconnected rice industry ecosystem.

H2: *SCA positively influences SCR*

Beyond HR, digital technologies, particularly Artificial Intelligence (AI), play a critical role in enabling SCA within a complex rice industry ecosystem by enhancing real-time information processing, predictive analytics, and adaptive decision-making (Suganda and Judijanto, 2023). Within the rice industry ecosystem, AI supports LSPs by improving their predictive capabilities, including more accurate demand forecasting and early identification of at-risk shipments. These capabilities increase responsiveness to environmental changes and facilitate agile decision-making in logistics operations (Pasupuleti *et al*., 2024). Prior research demonstrates that AI-driven predictive analytics, machine learning algorithms, and real-time data integration improve operational visibility and allow logistics actors to rapidly adjust processes and service configurations in response to disruptions (Holloway, 2025). By enabling proactive planning, anomaly detection, and coordinated decision-making across supply chain partners, AI enhances the speed, flexibility, and responsiveness of logistics operations, thereby strengthening SCA under conditions of uncertainty.

H3: *AI positively influences SCA*

Although HR capability and AI adoption each contribute to SCA, their influence on SCR is most effectively realized when agility functions as a dynamic capability that transforms these resources into performance outcomes. Workforce agility, defined as the ability of employees, individually and collectively, to adapt, learn, and reposition themselves in response to uncertainty, supports the development of SCA, which subsequently enhances resilience by enabling LSPs to manage disruptions efficiently within the rice industry ecosystem context (Al Hammouri *et al*., 2023; Dewa *et al*., 2024; Yamin *et al*., 2024). Insights from Dynamic Capabilities Theory (DCT) further suggest that agility often serves as a mediating mechanism through which organizational resources, including HR capability and digital technologies, are converted into resilience capabilities across interconnected supply networks. Through this mechanism, firms are better able to absorb shocks, reconfigure operational processes, and maintain stable performance under disruption (Saarinen *et al*., 2024; Wang *et al*., 2025). Accordingly, SCA serves as a critical link between HR capability and enhanced SCR in the rice industry.

H4: *SCA mediates the relationship between HR capability and SCR*

Artificial intelligence (AI) adoption also influences SCR; however, its impact is largely indirect, operating through the enhancement of SCA. While AI improves demand forecasting, real-time monitoring, and scenario evaluation, its contribution to resilience depends on how effectively AI-generated insights, such as predictive demand signals or early warnings of operational abnormalities, are embedded within agile decision-making and operational processes that enable rapid adjustment across the supply chain network (Riad *et al*., 2024; Pan *et al*., 2025; Lin and Zhang, 2025; Tang *et al*., 2025). By increasing the speed, accuracy, and quality of information processing, strengthening coordination among supply chain actors, and supporting adaptive responses, AI enhances SCA and enables LPSs to respond more effectively to disruptions, maintain service continuity, and sustain performance within the rice industry ecosystem (Beta *et al*., 2025; Jones, 2025). These mechanisms underscore the role of SCA as the key pathway through which AI adoption is translated into resilience outcomes. Accordingly, SCA serves as the mediating mechanism linking AI-enabled digital capabilities with enhanced SCR in the rice industry ecosystem.

H5: *SCA mediates the relationship between AI and SCR*

Based on the literature review and hypothesis development, the research framework depicted in Figure 1 illustrates the direct and mediating relationships among HR capability, AI, SCA, and SCR.

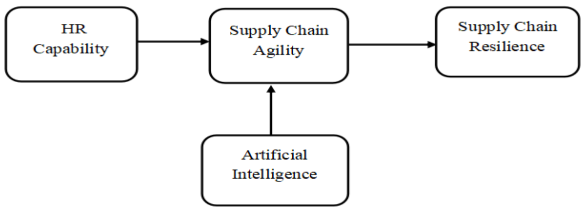

Figure 1. Research framework of AI, HR capability, supply chain agility, and rice supply chain resilience.

RESEARCH AND METHODS

This study employed a structured questionnaire to collect primary data from managerial personnel responsible for HR, supply chain management, and operational functions within LSPs operating in Indonesia. A five-point Likert scale was used to measure all the constructs.

Purposive sampling was applied to ensure that respondents possessed sufficient knowledge of human resource practices and supply chain operations relevant to the research objectives (Elangovan and Sundarave, 2021). In line with Partial Least Squares Structural Equation Modeling (PLS-SEM) guidelines, which recommend a minimum sample size of 100–200 observations or five to ten responses per estimated parameter, a total of 220 valid questionnaires were obtained and deemed adequate for statistical analysis (Hair *et al*., 2019).

PLS-SEM was used to test the measurement and structural models. Reliability and validity were assessed using Cronbach's alpha (>0.70), factor loadings (>0.70), (avege variance extracted AVE (; >0.50), Composite Reliability (>0.70), and discriminant validity via cross-loadings. The measurement items were adapted from prior studies, as shown in Table 1. HR capability was adapted from Hauff *et al*. (2025). The indicators for SCA, SCR, and AI adoption were adapted from Yamin *et al*. (2024).

RESULTS AND DISCUSSIONS

Respondent Profile

A total of 210 valid responses were collected. Table 2 presents the respondents' profiles. Most respondents were aged between 31 and 40 years (42.5%) and 41 and 50 years (42.5%), while 11.5% were aged 51–55 years and 3.5% were below 30 years. The sample was predominantly male (73.9%), with females accounting for 26.1% of the sample. More than half of the respondents held a bachelor's degree (56.2%), followed by diplomas (15.5%), master's degrees (13.3%), high school qualifications (11.5%), and doctoral qualifications (3.5%). In terms of organizational position, managers represented the largest group (59.7%), followed by senior managers/general managers (31.4%) and directors/C-level executives (8.9%). Overall, the sample comprised predominantly middle- and senior-level managers with relatively high educational attainment, indicating their relevance to strategic decisions concerning AI adoption, SCA, and SCR.

Results

The data were analyzed using SmartPLS 4.0 software. The measurement model was first evaluated to assess internal consistency, reliability, convergent validity, and discriminant validity. Internal consistency was examined using item loadings, Cronbach's alpha, and composite reliability, while convergent validity was assessed using the average variance extracted (AVE). Discriminant validity was evaluated to ensure adequate construct distinctiveness. The results indicate that all measurement items satisfied the recommended threshold values, confirming the reliability and validity of the constructs.

Table 1. Operationalization of AI, HR capability, supply chain agility, and rice supply chain resilience

Construct	Code	Measurement Items
Supply Chain Agility	SCA1	This firm has ability to deliver product quickly during disruption
Supply Chain Agility	SCA2	This firm meets evolving customer needs and quickly responds to changes.
Supply Chain Agility	SCA3	This firm is capable to meet customers need without any interruption.
Supply Chain Resilience	SCR1	This firm has ability to deal with unexpected events
Supply Chain Resilience	SCR2	This firm can quickly return its original state after disruption
Supply Chain Resilience	SCR3	During disruption this firm has ability to maintain desired level of control over supply chain functions.
HR Capability	HRC1	The recruitment/selection process for these employees is comprehensive
HR Capability	HRC2	There is continuous training for these employees
HR Capability	HRC3	Compensation/rewards for these employees are based on firm profits
HR Capability	HRC4	Compensation/rewards for these employees include an extensive benefits package
HR Capability	HRC5	These employees have clear career paths in the organization.
HR Capability	HRC6	These employees have long-term perspectives
HR Capability	HRC7	These employees perform jobs that include a wide variety of tasks.
HR Capability	HRC8	These employees work in semi-autonomous work groups.
HR Capability	HRC9	These employees perform jobs that empower them to make decisions.
HR Capability	HRC10	Superiors and employees engage in intensive information exchange.
Artificial Intelligence	AIT1	This firm uses artificial intelligence to track products.
Artificial Intelligence	AIT2	This firm measure uncertainty through artificial intelligence.
Artificial Intelligence	AIT3	Artificial intelligence enables employees to take quick decisions.

 DOI: https://doi.org/10.24961/j.tek.ind.pert.2026.36.2.185

Table 2. Demographic profile of rice supply chain respondents

Age	Frequency	Percentage
< 30 years	8	3.5
31 – 40 years	96	42.5
41 – 50 years	86	42.5
51 – 55 years	20	11.5
Gender	**Frequency**	**Percentage**
Male	167	73.9
Female	43	26.1
Education	**Frequency**	**Percentage**
High School	26	11.5
Diploma	35	15.5
Bachelor Degree	111	56.2
Master	30	13.3
Doctoral	8	3.5
Position	**Frequency**	**Percentage**
Manager	119	59.7
Senior Manager/GM	71	31.4
Director/C-level executive	20	8.9

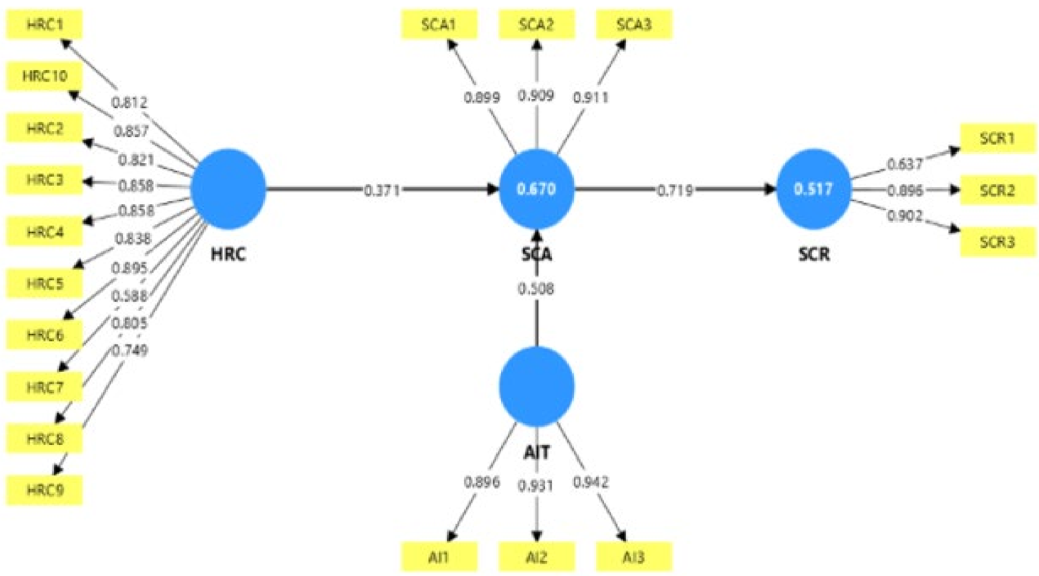

Figure 2. PLS-SEM Model of AI, HR capability, supply chain agility, and rice supply chain resilience

Figure 2 presents the PLS-SEM measurement model, showing that the indicator outer loading values exceed 0.50. According to Ghozali (2016), outer loadings between 0.50 and 0.60 are acceptable, particularly in exploratory research, while Hair *et al.* (2017) suggest that loadings above this threshold are sufficient to support convergent validity.

In addition, as presented in Table 3, the average variance extracted (AVE) values for all latent constructs ranged from 0.60 to 0.80, exceeding the recommended threshold of 0.50, further supporting convergent validity (Hair *et al*., 2020).

Composite reliability values for all constructs range from 0.858 to 0.945, demonstrating a satisfactory level of internal consistency in accordance with the guidelines suggested by Hair *et al*. (2019, 2020). Discriminant validity was assessed using the Fornell–Larcker criterion, which requires the square root of each construct's AVE to be greater than its correlations with other constructs (Henseler, 2018). As shown in

Table 4, all constructs met this criterion, confirming adequate discriminant validity.

The results of the direct effects tested in this study are shown in Table 5. The bootstrapping results from the PLS-SEM analysis indicate a significant positive effect of HR capability on SCA (β = 0.371, t = 3.186, $p < 0.05$). In addition, SCA has a significant positive effect on SCR (β = 0.719, t = 14.511, $p < 0.05$). The findings further show that AI adoption has a significant positive effect on SCA (β = 0.508, t = 4.633, $p < 0.05$). The results of the indirect (mediating) effects are presented in Table 6. The analysis indicates that SCA significantly mediates the relationship between HRC and SCR (β = 0.267, t = 3.460, $p < 0.05$). Similarly, SCA significantly mediated the relationship between AIT and SCR (β = 0.365, t = 3.823, $p < 0.05$).

Discussion

The findings indicate that HR capabilities positively influence SCA. This result supports the Resource-Based View (RBV), which posits that valuable organizational resources, particularly human capital, provide the foundation for developing strategic capabilities. In line with the literature, HR capability facilitates effective coordination, communication, and collaboration across geographically dispersed supply chain operations while enhancing employees' adaptability and responsiveness to changing conditions. This finding is consistent with Yamin *et al.* (2020), who emphasized the role of HR capability in strengthening organizational agility and adaptive performance.

Table 3. Reliability and convergent validity of AI, HR capability, supply chain agility, and rice supply chain resilience constructs

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Artificial Intelligence	0.913	0.914	0.945	0.853
HR capability	0.941	0.945	0.950	0.660
Supply Chain Agility	0.891	0.891	0.932	0.821
Supply Chain Resilience	0.758	0.835	0.858	0.674

Table 4. Discriminant validity (Fornell–Larcker criterion) of AI, HR capability, supply chain agility, and rice supply chain resilience

	AIT	HRC	SCA	SCR
Artificial Intelligence	0.923			
HR capability	0.731	0.812		
Supply Chain Agility	0.779	0.742	0.906	
Supply Chain Resilience	0.836	0.702	0.719	0.821

Note: *p<0.05 (t > 1.645), HRC=HR Capability, AIT=Artificial Intelligence, SCA=Supply Chain Agility, SCR=Supply Chain Resilience.

Table 5. Direct effects of AI, HR capability, supply chain agility, and rice supply chain resilience

Hypothesis	Relationship	Path Coefficient	Standard Deviation	T-Statistic	P-values	Result
H1	HRC → SCA	0.371	0.116	3.186	0.001	Supported
H2	SCA → SCR	0.719	0.049	14.551	0.000	Supported
H3	AIT → SCA	0.508	0.110	4.633	0.000	Supported

Table 6. Mediating effects of supply chain agility in the relationship between AI, HR capability and rice supply chain resilience

Hypothesis	Relationship	Path Coefficient	Standard Deviation	T-Statistic	P-values	Result
H4	HRC → SCA → SCR	0.267	0.077	3.460	0,000	Supported
H5	AIT → SCA → SCR	0.365	0.095	3.823	0,000	Supported

Note: *p<0.05 (t > 1.645), HRC=HR capability, AIT=Artificial Intelligence, SCA=Supply Chain Agility, SCR=Supply Chain Resilience

In the context of rice logistics, where firms frequently face fluctuations in supply availability, transportation constraints, seasonal harvest cycles, and distribution challenges, HR capability enables employees to respond more effectively through cross-functional coordination, problem solving, and timely operational adjustments. These capabilities enhance organizational flexibility and support the development of agile supply chain processes that are essential for managing uncertainties and maintaining operational continuity.

The results also show that AI adoption enhances the SCA. AI technologies improve information visibility, forecasting accuracy, and operational monitoring, enabling organizations to process information more effectively and respond more quickly to changes. This finding is consistent with previous studies cited in this research that identified AI and digital technologies as important drivers of agility and responsiveness. In the context of rice logistics, AI-supported decision-making can improve inventory planning, transportation scheduling, shipment monitoring and coordination among supply chain partners. By supporting predictive analytics, real-time information processing, and proactive decision-making, AI enables organizations to make faster operational adjustments and respond more effectively to disruptions and demand fluctuations, thereby strengthening SCA.

The significant relationship between SCA and SCR further supports DCT, which suggests that resilience is achieved through an organization's ability to sense changes, reconfigure resources, and adapt operations when disruptions occur. The findings indicate that agile organizations are better able to anticipate and respond to unexpected events through rapid decision-making, effective coordination, information sharing, and timely operational adjustments. This result is consistent with prior resilience studies discussed in the literature review, which identify agility as a critical capability for managing uncertainty and sustaining operational performance under disruptive conditions. In the context of rice logistics, where operations are frequently affected by harvest seasonality, weather variability, transportation disruptions, and infrastructure limitations, agility enables firms to adjust resource allocation, modify operational processes, and maintain reliable product flow. As a result, SCA not only enhances short-term responsiveness but also strengthens the ability of organizations to absorb disruptions, adapt to changing conditions, and sustain service continuity over time.

The mediating role of SCA provides further evidence that organizational resources contribute to resilience through capabilities development. The significant indirect effects suggest that both HR capability and AI adoption enhance resilience by strengthening the organization's ability to respond, adapt, and reconfigure operations under changing conditions. This finding is consistent with DCT, which emphasizes the importance of transforming organizational resources into capabilities that support adaptation and operational responsiveness. In line with the arguments developed in the literature review, SCA enables firms to translate workforce adaptability, digital insights, and enhanced coordination into effective responses to disruptions. Through agile processes, organizations are better able to absorb shocks, adjust operational activities, and maintain service continuity under uncertainty. The findings therefore reinforce the role of SCA as a key mechanism linking human and technological resources to resilience outcomes within the rice supply chain.

Overall, the findings confirm the applicability of the RBV and DCT in explaining resilience development within rice supply chains. Consistent with prior studies conducted in manufacturing, technology-intensive, and broader supply chain contexts, the results demonstrate that human and digital resources contribute to resilience through the development of agile capabilities. While previous studies have largely focused on manufacturing and high-technology environments, this study contributes by providing empirical evidence from the rice logistics sector, where operational conditions are shaped by harvest seasonality, quality preservation requirements and environmental uncertainty. Therefore, the findings extend the empirical scope of RBV and DCT and demonstrate the relevance of the resource capability resilience pathway in an agro-industrial setting, which has been relatively underexplored in SCR research.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study examines the roles of HR capability, AI adoption, and SCA in strengthening SCR within Indonesia's rice supply chain. The findings indicate that both HR capability and AI adoption positively contribute to SCA, which in turn enhances SCR. The results further demonstrate that SCA mediates the relationship between HR capability and resilience, as well as between AI adoption and resilience, highlighting the importance of agility as a capability that enables organizations to respond effectively to disruptions and operational uncertainty.

This study contributes to the SCR literature by confirming the applicability of the RBV and DCT in the context of rice logistics. The findings suggest that human and digital resources contribute to resilience through the development of agile capabilities that support adaptation, coordination, and operational responsiveness. While previous studies have primarily focused on manufacturing and technology-intensive sectors, this study extends the empirical evidence to the rice supply chain, a strategic agro-industrial sector characterized by harvest seasonality, quality preservation requirements, and environmental uncertainty. This study broadens the understanding of the resource–capability–resilience pathway in an underexplored supply chain context.

Recommendations

The findings offer several managerial and policy implications for logistics service providers (LSPs) and other stakeholders involved in Indonesia's rice supply chain. First, HR capability should be treated as a core component of supply chain strategy rather than merely a supporting function. Investments in workforce skills, cross-functional coordination, and flexible work practices can strengthen employee responsiveness and decision-making speed, which are essential for enhancing SCA. These capabilities are particularly important for managing seasonal harvest cycles, fluctuating volumes, and weather-related disruptions in rice distribution. By improving workforce adaptability, LSPs can more effectively adjust transportation schedules, inventory allocation, and service levels in response to changing operational conditions, thereby strengthening SCR.

Second, organizations should accelerate the adoption of AI-enabled technologies to improve visibility, forecasting accuracy, and coordination across logistics operations. AI applications in demand forecasting, route optimization, inventory management, and real-time monitoring can support faster and more informed decision-making, enabling organizations to respond more effectively to disruptions and changing market conditions. To maximize benefits, AI initiatives should be integrated into operational processes and supported by employees who possess the skills necessary to interpret and act upon AI-generated insights. More importantly, managers should view SCA as a strategic capability rather than as an operational response to disruptions. Efforts to strengthen HR capability and AI adoption should therefore be aligned with broader initiatives aimed at enhancing organizational responsiveness, flexibility, and coordination across the supply chain, thereby contributing to long-term resilience.

Third, from a policy perspective, government agencies and industry stakeholders should support the development of digital infrastructure, data-sharing platforms, and workforce upskilling programs that facilitate the adoption of advanced technologies throughout the rice supply chain. Such initiatives can strengthen organizational agility and improve the overall resilience of the sector to future disruptions.

Despite these contributions, this study has several limitations. The analysis focused on LSP's, which may limit the generalizability of the findings to other actors within the rice supply chain, such as farmers, millers, wholesalers, and retailers. In addition, the cross-sectional research design limits causal inference, while the use of self-reported data may introduce response bias. Future research could incorporate multiple supply chain actors, employ longitudinal research designs, and examine additional digital technologies such as the Internet of Things, blockchain, and digital twins. Further studies may also explore governance mechanisms, inter-organizational collaboration, and sustainability outcomes to provide a more comprehensive understanding of resilience development within agro-industrial supply chains.

REFERENCES

Adeleye RA, Oyeyemi OP, Asuzu OF, Awonuga KF, Bello BG. 2024. Advanced analytics in supply chain resilience: A comparative review of African and USA practices. *International Journal of Management and Entrepreneurship Research*. 6(2): 296–306.

Ajala OA, Jacks BS, Lottu OA, Okafor ES. 2024. Conceptualizing ICT entrepreneurship ecosystems: African and US tech hubs. *World Journal of Advanced Research and Reviews*. 21(3): 387–393.

Ajayi, OA. 2023. Real-time route optimization in logistics: A deep learning approach. *World Journal of Advanced Research and Reviews*. 19(3): 1719–1722.

Akram MU, Islam N, Chauhan C, Yaqub MZ. 2024. Resilience and agility in sustainable supply chains: A relational and dynamic capabilities view. *Journal of Business Research*. 183(114855):1-12.

Alfaqiyah E, Alzubi A, Aljuhmani HY, Öz T. 2025. How industry 4.0 technologies enhance supply chain resilience: The interplay of agility, adaptability, and customer integration in manufacturing firms. *Sustainability*. 17(7922):1-30

Al Hammouri S, Bin S, and Mohammed H. 2023. The influence of agile HRMS on organizational performance: The case of Dubai government. *Uncertain Supply Chain Management*. 11: 1519–1526.

Al Khatib I, Ndiaye M, and Acquaye AA. 2024. Enhancing resilience in logistics-based business models amid disruptions: A qualitative exploration of the UAE market. *International Journal of Service Science, Management, Engineering, and Technology*. 15(1): 1–23.

Alshaar AK and Alkshali SJ. 2024. Fostering supply chain agility: The power of dynamic capabilities. *International Journal of Academic Research in Business and Social Sciences*. 14(6): 58–74.

Beta K, Nagaraj SS, and Weerasinghe TD. 2025. The role of artificial intelligence on supply chain resilience. *Journal of Enterprise Information Management*. 38(3): 950–973.

Chin WW. 2010. How to write up and report PLS analyses. In Esposito Vinzi V, Chin WW, Henseler J, Wang H (ed.). *Handbook of Partial Least Squares: Concepts, Methods and Applications*. Berlin: Springer. 655–690.

Coastr. 2025. How telematics data analytics powers predictive maintenance and prevents downtime. https://www.coastr.com/blog/how-telematics-data-analytics-powers-predictive-maintenance-and-prevents-downtime [February 26, 2026].

Dewa PK, Afiah IN, and Umam R. 2024. Relationship between organizational learning and supply chain agility on organizational performance: A quantitative study in fashion SMEs. *Jurnal Optimasi Sistem Industri*. 23(1): 46–60.

Elangovan N and Sundaravel E. 2021. Method of preparing a document for survey instrument validation by experts. *MethodsX*. 8(101326): 1-9.

Erfan M. 2024. The impact of cross-cultural management on global collaboration and performance. *Advances in Human Resource Management Research*. 2(2): 102–112.

Esan O, Ajayi FA, and Olawale O. 2024. Human resource strategies for resilient supply chains in logistics and transportation: A critical review. *International Journal of Science and Research Archive*. 12(1): 82–102.

Galkin A, Samchuk G, Kopytkov D, Thompson RG. 2025. Digital twins in logistics: a comprehensive bibliometric analysis for advancing smart cities and sustainable development. *Discover Sustainability*. 6(853): 1-25.

Ghozali I. 2016. *Aplikasi Analisis Multivariate Dengan Program IBM SPSS 23*. Edisi 8. Semarang: Universitas Diponegoro.

Gonçalves C, Fernandes J, and Brites C. 2025. Blockchain-enabled traceability in the rice supply chain: Insights from the TRACE-RICE Project. *Foods*. 14(21): 3711.

Hair JF, Hult GTM, Ringle CM, Sarstedt M, Danks NP, Ray S. 2020. Confirmatory composite analysis using partial least squares: Setting the record straight. *Review of Managerial Science*. 15(5): 1075–1123.

Hair JF, Black WC, Babin BJ, Anderson RE. 2019. *Multivariate Data Analysis*. 8th ed. Boston: Cengage.

Hair JF, Hult GTM, Ringle CM, Sarstedt M. 2017. *A Primer on Partial Least Squares Structural Equation Modeling (Pls-Sem)*. 2nd ed. Thousand Oaks, CA: Sage Publications.

Hauff S, Richter NF, and Ringle CM. 2025. Human resource management systems research: How to gain impactful insights through formative measurement and hierarchical component models. *International Journal of Human Resource Management*. 36(4): 611–635.

Henny H, Qosidah N, and Wardi A. 2025. Building resilience through AI: Predictive analytics for supply chain risk management in the post-COVID global market. *Dinamika: Jurnal Manajemen Sosial Ekonomi*. 5(1): 201–212.

Holloway S. 2025. Exploring the impact of emerging technologies on supply chain resilience and agility. *Preprints.org*. https:// doi: 10.20944/preprints202502.0777.v1

Jahangir S, Xie R, Iqbal A, Hussain M. 2025. The influence of sustainable human resource management practices on logistics agility: The mediating role of artificial intelligence. *Sustainability*. 17(7): 3099.

Jakkhupan W, Arch-int S, and Li Y. 2014. An RFID-based traceability system: A case study of rice supply chain. *Telecommunication Systems*. 58: 149–159.

Jian W, Orlina-Ursula D, and Regua R. 2024. The role of strategic human resource management in achieving organizational agility. *International Journal of Science and Engineering Applications*. 13(8): 47–51.

Jones J. 2025. The role of AI in enhancing supply chain resilience: Insights from industry experts. *Preprints.org*. https://doi: 10.20944/preprints202504.0741.v1

Legg M, Silver RA, and Park S. 2025. Weathering the storm: Dynamic capabilities and supply chain agility in supply chain resilience. *Logistics*. 9(4): 136.

Li J, Wang W, Sheng Y, Anwar S, Su X, Nian Y, Yue H, Ma Q, Liu J, Li X. 2024. Rice yield estimation based on cumulative time series vegetation indices of UAV MS and RGB Images. *Agronomy*. 14(12): 2956.

Li Y, Xia X, Wang C, Huang Q. 2025. Manufacturing supply chain resilience amid global value chain reconfiguration: An enhanced bibliometric–systematic literature review. *Systems*. 13(10): 873.

Lin L and Zhang X. 2025. Research on the impact of enterprise artificial intelligence on supply chain resilience: Empirical evidence from Chinese listed companies. *Sustainability*. 17(19): 8576.

Lokesh Joel B, Lavanya G, Pratyusha M, Siraj MMA. 2023. Quality grain checking system using IoT and machine learning. *International Journal of Creative Research Thoughts*. 11(6): 759-764.

Lydia J, Monisha R, and Murugan R. 2022. Automated food grain monitoring system for warehouse using IOT. *Measurement: Sensors*. 24(100472): 1-10.

Maghfiroh N, Bantacut T, and Anggraeni E. 2023. Sustainable value of rice supply chain: A systematic literature review and research agenda. *Jurnal Teknologi Industri Pertanian*. 33(1): 70–95.

Mawardi AAK, Farida L, Endhiarto T, Apriliana T. 2025. Resilient MSMEs in the digital era: Managing environmental uncertainty through dynamic capabilities. *BISMA (Bisnis dan Manajemen)*. 18(1): 131–158.

Moshood TD, Nawanir G, Sorooshian S, Okfalisa. 2021. Digital twins driven supply chain visibility within logistics: A new paradigm for future logistics. *Applied System Innovation*. 4(2): 29.

Mursiti, Sailah I, Marimin, Romli M, Denni A. 2021. Strategi pengembangan sumber daya manusia yang berdaya saing dan berkelanjutan pada agroindustri tebu: tinjauan literatur dan agenda penelitian mendatang. *Jurnal Teknologi Industri Pertanian*. 31(2): 129–142.

Novita D. 2023. Strategic human resource management in international business: A case study of multinational companies. *International Journal of Economic Literature*. 1(1): 1–11.

Nur SA and Muafi M. 2025. Link between dynamic capability and sustainable entrepreneurship: The mediation role of digital networking. *Jurnal Siasat Bisnis*. 29(1): 1–14.

Pan H, Zou N, Wang R, Ma J, Liu D. 2025. Artificial intelligence usage and supply chain resilience: An organizational information processing theory perspective. *Systems*. 13(9): 724.

Pasupuleti V, Thuraka B, Kodete CS, Malisetty S. 2024. Enhancing supply chain agility and sustainability through machine learning: Optimization techniques for logistics and inventory management. *Logistics*. 8(3): 73.

Putri ASD. 2025. Literature study: Optimization strategy of rice supply chain management in regions. *Tekmapro*. 20(1): 285-302.

Riad M, Naimi M, and Okar C. 2024. Enhancing supply chain resilience through AI: Developing a comprehensive conceptual framework for AI implementation and supply chain optimization. *Logistics*. 8(4): 111.

Saeed G, Ellahi A, Bakhsh K, Ishfaq U, Ullah M, Shaheen I. 2022. Effect of human resource capabilities, supply chain coordination, and responsiveness on supply chain resilience. *Indian Journal of Economics and Business*. 21(1): 343–359.

Saarinen L, Oddsdottir H, and Rehman O. 2024. Resilience through appropriate response: A simulation study of disruptions and response strategies-case COVID-19 and the grocery supply chain. *Operations Management Research*. 17(3): 1078–1099.

Sangkota M, Idris I, and Adam RP. 2025. Agile human resource management adaptation and local culture in multinational companies. *Jurnal Ilmiah Manajemen Kesatuan*. 13(5): 3701–3712.

Saptana S, Ar-Rozi AM, Perwira AD, Raharjo AS. 2024. Rice supply-chain management performance and business ecosystem support in Klaten District. BIO Web of Conferences. 119. https://doi.org/10.1051/bioconf/202411902002.

Setyorini R, Rahayu A, Wibowo LA, Sultan MA. 2025. Capability-based pathways to performance: The mediating role of resilience and value realization in agri-supply chains. *Jurnal Ilmiah Manajemen Kesatuan*. 13(5): 3651–3662.

Suhendro B, Hidayat MFN, Hamadi H, Harsono D. 2023. Smart prototype design of rice atorage system based on Internet of Things. *Res Militaris*, 13(2): 5252-5262.

Suganda FR and Judijanto L. 2023. The role of digital technologies in transforming global supply chain operations. *Sinergi International Journal of Logistics*. 1(3): 146–158.

Tang H, Wu K, and Zhou J. 2025. Smarter supply chains, stronger resilience? The impact of AI on preparation, response, and recovery. *Economics Letters*.254.https://doi.org/10.1016/j.econlet.2025.112488.

Tiwari V, Thorp K, Tulbure, MG, Gray J, Kamruzzaman M, Krupnik, TJ. 2024. Advancing food security: Rice yield estimation framework using time-series satellite data and machine learning.*PLOSONE*,19(12).https://doi.org/10.1371/journal.pone.0309982

Wang M, Hill A, Liu Y, Hwang KS, Lim MK. 2025. Supply chain digitalization and agility: How does firm innovation matter in companies? *Journal of BusinessLogistics*.46(1).https://doi.org/10.1111/jbl.70007.

Wang S, Zhao Y, Lv H, Qi, T. Song, Y. (2025). A study on the application of CO_2-modified atmosphere combined with temperature-control technology in rice warehouse storage. *Foods*. 14(18). https://doi.org/10.3390/foods14183217.

Wieland A and Durach CF. 2021. Two perspectives on supply chain resilience. *Journal of Business Logistics*. 42(3): 315–322.

Xue Z, Zhao S, Qi Y, Zeng X, Yu Z. 2026. Resilient routing: Risk-aware dynamic routing in smart logistics via spatiotemporal graph learning. *arXiv preprint*. https://arxiv.org/abs/2601.13632.

Yamin MA, Almuteri SD, Bogari KJ, Ashi AK. 2024. The influence of strategic human resource management and artificial intelligence in determining supply chain agility and supply chain resilience. *Sustainability*. 16(7): 2688.

Zhang Y, Fang Z, Li C, Li C. 2024. Deep-learning-based model predictive control of an industrial-scale multistate counter-flow paddy drying process. *Foods* 13(1). https://doi.org/10.3390/foods13010043.

Zheng D and Wang T. 2025. Supply chain resilience, logistics efficiency, and enterprise competitiveness. *Finance Research Letters*. 79: 107335.