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OPTIMIZING SUSTAINABLE SUPPLY CHAIN PERFORMANCE THROUGH TECHNOLOGICAL INNOVATION : A CASE STUDY OF AI CHATBOT ADOPTION IN PT. LION PARCEL CENTER

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Abstract : Supply chains greatly affect the environment through carbon emissions and waste generated from production, transportation, and distribution. These negative impacts can be reduced by implementing sustainable supply chain performance (SSCP), which manages and optimizes the entire supply chain process by considering environmental, social, and economic aspects. Industry 4.0 has opened up various opportunities with internet-based technology, along with challenges for logistics companies. The presence of AI Chatbot (AIC) can improve SSCP by increasing visibility and operational efficiency in the form of better management at every stage of the supply chain, automating ordering, managing inventory in real-time, and providing predictive analysis for better decision making. Therefore, this study investigates the role of AIC in SCV and IC towards SSCP. This research uses PT Lion Parcel, which adopted an AI chatbot named Liona, as a case study to measure the influence of AIC on Sustainable Supply Chain Performance (SSCP). Based on Dynamic Capability theory (DC) theory, this study involved 91 respondents from employees, and used Structural Equation Modeling with SMART-PLS 4.0 to investigate the role of AIC in improving supply chain visibility (SCV) and Innovation Capability (IC) towards SSCP performance.

Keyword : *AI Chatbot (AIC), Sustainable Supply Chain Performance (SSCP), Supply Chain Visibility (SCV), Innovation Capability (IC)*

1. Introduction

Sustainable supply chain processes involve excellence in materials management, manufacturing, and distribution, focusing on affective distribution while balancing economic, environmental, and social considerations. The significance of sustainability in the supply chain is that it can reduce production costs and minimize environmental impacts, ultimately driving economic growth and opening up opportunities in local and global markets. A Sustainable Supply Chain (SSC) can reduce production costs, minimize environmental impacts, and promote economic growth, thereby opening up new

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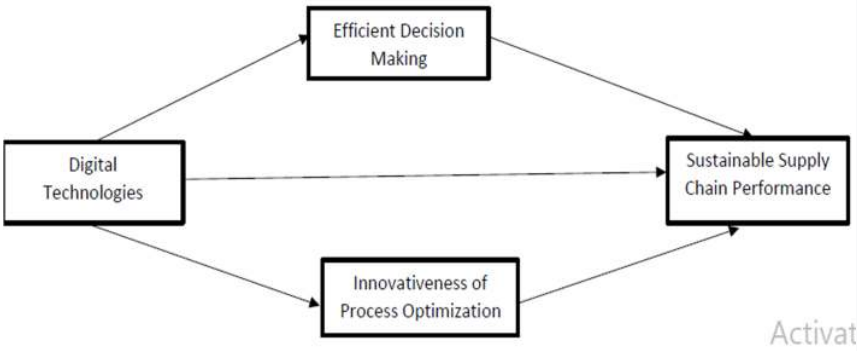
opportunities. Developing countries need more growth and stability in their markets, with freight forwarders playing an important role in maintaining sustainable development.

In the long run, the inability to adapt to sustainability demands may result in a loss of competitiveness, as consumers and investors increasingly factor sustainability into their decisions. Therefore, companies need to improve operating efficiency and reduce negative impacts on the environment and society by adopting appropriate technologies and sustainable procurement practices.

As shown in figure 1.1 according to (Ma, 2023) Digital technologies play an important role in efficient decision making and innovation in process optimization which ultimately contributes to sustainable supply chain performance. Digital Technologies are key factors that influence the efficiency of decision making and innovativeness of process optimization. Both of these factors contribute directly to sustainable supply chain performance.

Tabel 1.1 The Impact of Digital Technology on Supply Chain Sustainability



Sumber : Ma,2023

On the other hand, internet-enabled technologies seperti Internet of Things (IoT), Industrial Internet of Thinks (IoT), robotics, dan Artificial Intelligence (AI) automation are changing manufacturing activities in the 4.0 era. AI Chatbot (AIC) can help PT.Lion Parcel with managing their online customers with affective and productive human interaction. These well-known AI applications include.

Previous research shows that there are issues related to supply chain management, sustainability, information technology, artificial intelligence, and other factors that affect company performance (Panigrahi et al., 2023). By examining the role of AI and advanced computing (AIC) in handling real-time customer responses and associated logistics and supply chain operations, organizations can leverage AIC to

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tackle the emerging challenges of Industry 4.0. Industry 4.0 symbolizes the fourth industrial revolution, and the goal of Industry 4.0 is to increase the level of automation and data exchange in manufacturing technology (Manajemen et al., 2023)

PT Lion Parcel is a logistics company that is part of the Lion Group, one of the largest transportation conglomerates in Indonesia. Logistics is the process of planning, executing, and controlling efficient two-way flows with the goal of recovering value or proper disposal of secondary products (Adhi & Rahayu, 2018). As a freight forwarding company operating both domestically and overseas, it has adopted an AIC technology called (Liona) to improve operational performance and achieve sustainability in its supply chain. (Stocks, 2016). PT Lion Parcel needs to face significant challenges in the 4.0 era. in balancing operational efficiency and sustainability in its supply chain amidst increasing environmental concerns and competitive pressures. Despite having adopted AI Chatbots (AIC) technology to automate communication and information management, there is an urgent need to evaluate and optimize the affectiveness of this technology in improving the supply chain.

Collaboration in supply chains using AIC has become essential for businesses, especially for PT Lion Parcel, to establish a robust supply chain. Given the large operational capacities, logistics and supply chain management face many complexities. AIC has the potential to be a key asset in logistics and SCM, particularly by enhancing customer experience. PT Lion Parcel can boost its conversion rate optimization through AIC utilization. AIC's rapid response capability can streamline logistics operations, leading to increased service and supplier engagement, thereby enhancing supply chain performance. Additionally, AIC can automate order placements, manage logistics, and oversee post-production sales. It also assists in the deployment and recovery of resources within the supply chain. The proactive and responsive nature of AIC contributes to delivering affective solutions for supply chain challenges. Moreover, AIC can support inventory management by overseeing stock-keeping units (SKUs).

Dynamic capability theory (DC) helps PT Lion Parcel integrate, build, and reconfigure internal, external resources and competencies to address new challenges and reshape them quickly to meet the changing business environment (Teece et al., 2009). Examining how AIC influences real-time customer response and logistics management, as well as supply chain operations, reveals that PT Lion Parcel can leverage AIC to tackle the new challenges of Industry 4.0. Investigating the role of AIC in overcoming these challenges presents a compelling area for further study.

This study used structural equation modeling (SEM) with SM-PLS 4.0 to uncover relationships and patterns, forming the foundation for new hypotheses and theories. It examines how AI Chatbots (AIC) impact Supply Chain Visibility (SCV) and Innovation Capability (IC) in relation to Sustainable Supply Chain Performance (SSCP). The research aims to show how AIC can enhance supply chain sustainability, boost operational

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efficiency, and improve customer satisfaction, while supporting broader environmental objectives for PT. Lion Parcel (Astuti et al., 2024). In addition, the supply chain is also one of the important services that must be satisfactory for consumers (Ramadhan et al., 2020).

2. Literature review

2.1 Adoptions AI Chatbot (AIC)

Adelia, states that AI Chatbots use natural language understanding, machine learning, and big data analysis to enhance operational efficiency through conversational systems (Loyalty & On, 2024). Matusin, describes AI Chatbots as virtual robots that simulate human conversation, acting as digital assistants that quickly understand and respond to user requests. This technology streamlines business operations and reduces customer service costs.(Alghiffari & Matusin, 2023). According to Krispimandoyo, artificial intelligence (AI) not only plays a role in understanding and managing brand image, but also has a close relationship with supply chain visibility and innovation capability. In the context of supply chain visibility, AI enables companies to collect and analyze real-time data from various points in the supply chain, which helps improve transparency, efficiency, and responsiveness to changes in market demand (Krisprimandoyo, 2023).
According to the previously mentioned researcher, AI Chatbot Adoptions (AIC) is a critical technology for improving the responsiveness and efficiency of business operations. AI enables companies to improve supply chain visibility, optimize business processes, and respond more quickly and accurately to changes in market demand. It is linked to sustainability supply chain performance due to AI's ability to understand natural language and analyze big data in real time. AI helps in finding the best places to improve sustainability, reduce environmental impact, and improve sustainability performance.

2.2 Manufacturing Sustainable Supply Chain Performance (SSCP)

According to Sholeh, Sustainable Manufacturing Supply Chain Performance (SSCP) is the measurement of supply chain performance by considering environmental aspects. The SCOR version 12.0 model, known as sustainable SCOR, provides a framework for measuring supply chain performance with a focus on sustainability. Sustainable SCOR includes categories such as materials, recycled inputs, recovered inputs, energy, water, emissions, and waste. The main objective is to improve the transparency, efficiency, and responsiveness of the supply chain by taking into account environmental aspects, which in turn promotes lean construction and operational efficiency (Sholeh et al., 2020). According to Dio, Sustainable Manufacturing Supply Chain Performance (SSCP) is an evaluation of how manufacturing supply chains can operate in a more environmentally, socially, and economically friendly way. Its main focus is to minimize

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environmental impacts, improve social conditions along the supply chain, and achieve long-term economic sustainability (Dio et al., 2021).

According to previous researchers, Sustainable Manufacturing Supply Chain Performance (SSCP) is an evaluation concept that considers environmental, social, and economic factors in the manufacturing supply chain. The goal is to optimize operations in an environmentally friendly way, support good social conditions, and achieve long-term economic sustainability.

2.3 Supply Chain Visibility (SCV)

According to Razak, Supply Chain Visibility (SCV) is the ability to efficiently monitor and observe the flow of goods, information, and finances throughout the supply chain. With SCV, companies can improve inventory management, reduce the risk of overstocks or shortages, and increase responsiveness to changes in demand and supply conditions. (Razak et al., 2024).. According to Cheah Shu Wen, Supply Chain Visibility (SCV) is the ability to efficiently monitor and observe the flow of goods, information, and finances throughout the supply chain. With SCV, companies can improve inventory management, reduce the risk of overstocks or shortages, and increase responsiveness to changes in demand and supply conditions (WEN, 2023).

According to previously mentioned researchers, Supply chain visibility (SCV) is the ability to efficiently monitor and manage the flow of goods, information, and finances throughout the supply chain. By improving SCV, companies can optimize inventory management, reduce the risk of unbalanced stock (both excess and shortage), and improve responsiveness to changes in demand and supply chain conditions. In relation to sustainable supply chain performance, SCV shows that with better visibility into supply chain operations and flows, companies can more easily find ways to improve energy efficiency, reduce environmental impacts, and manage waste. This enables companies to more efficiently incorporate sustainable practices into their supply chain strategies and helps them achieve their long-term sustainability goals.

2.4 Innovation Capability (IC)

According to Boen, Innovation Capability is the Marketing Capability owned by the company. Thus, innovation can be considered as an organizational capability, because it is the act of developing existing resources with new capabilities to create value (Boen et al., 2016). (Boen et al., 2016). According to Mishra Innovation capability is all processes, systems, and organizations that can be utilized in the innovation process in the company. (Mishra, 2017). Quoting an explanation from Ananda, Innovation Capability (IC) is described as the company's ability to acquire and assimilate new knowledge and to transfer this knowledge into new products or services. (Ananda et al.,

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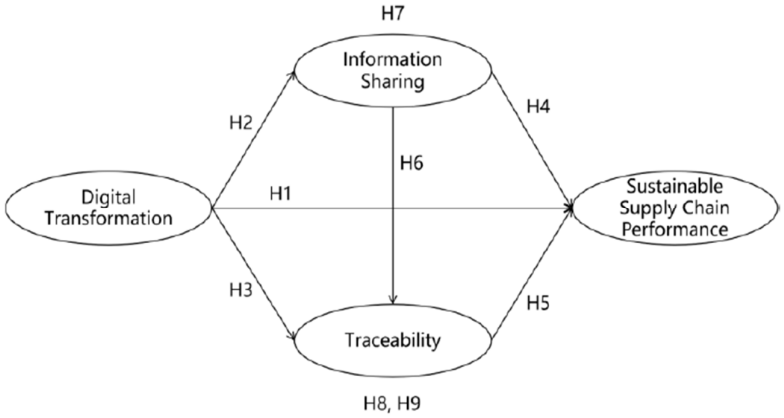
2023). To create innovation, agencies must have the ability to be new and creative and learn unique ways of working (Eri & Wahyu, 2024).

According to the previously mentioned researchers, the ability to develop and implement new innovations in products, services and business processes includes the ability to acquire and assimilate new knowledge and transform this knowledge into market-acceptable added value. In relation to supply chain sustainability performance, strong IC can be a key factor in improving supply chain sustainability performance. Companies with good innovation capabilities can find and implement new sustainable solutions in their supply chains, which include using new processes and technologies to lower environmental impacts, improve energy efficiency and promote sustainable practices. Therefore, affective IC can go a long way in achieving a company's overall sustainability goals.

To provide a clearer picture of the relationship between the various elements discussed, the following conceptual framework in figure 2.1 links the adoption of digital transformation with supply chain sustainability performance through information sharing and traceability.



Source : Dopemu, 2023

The conceptual framework in figure 2.1 above according to (Dopemu, 2023) shows the relationship between digital transformation, information sharing, traceability, and supply chain sustainability performance. Digital transformation significantly affects information sharing and traceability, which in turn positively impacts sustainable supply chain performance. In this regard, the adoption of AI technologies, such as chatbots, enhances companies' ability to share information and trace their supply chains more efficiently, which helps improve overall performance in terms of sustainability.

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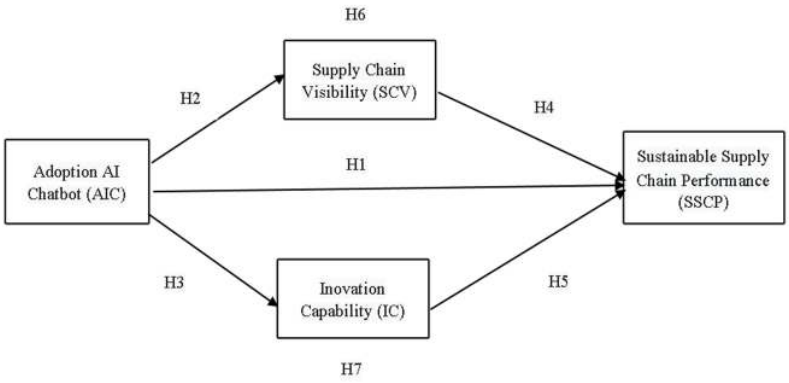

H1 : AI Chatbot adoption (AIC) affects Sustainable Supply Chain Performance (SSCP).
H2 : AI adoption has a significant influence on Supply Chain Visibility (SCV).
H3 : AIC adoption affects Innovation Capability (IC) in Supply Chain.
H4 : Supply Chain Visibility (SCV) has a significant effect on Sustainable Supply Chain Performance (SSCP).
H5: Innovation Capability (IC) has a significant influence on Sustainable Supply Chain Performance (SSCP).
H6 : Mediating effect of Supply Chain Visibility (SCV) between AI Chatbot Adoption (AIC) and Sustainable Supply Chain Performance (SSCP).
H7 : Mediating effect of Innovation Capability (IC) between AI Chatbot Adoption (AIC) and Sustainable Supply Chain Performance (SSCP).

3. Research Method

This study employs a quantitative design to test how AI Chatbot (AIC) adoption affects Sustainable Supply Chain Performance (SSCP) at PT Lion Parcel, examining the roles of Supply Chain Visibility (SCV) and Innovation Capability (IC) as mediators. The research targets 91 employees using AI Chatbot (Liona) at PT Lion Parcel, selected through purposive sampling. Data was gathered via a Likert scale questionnaire assessing perceptions of AIC, SCV, IC, and SSCP.
The sample size determination in this study refers to the Cohen, Manion, and Morrison table. This table can be seen in table 3.1. The Cohen Manion and Morrison table determines the

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predicted population in sampling up to 1 million population members. This table details the research confidence levels of 90%, 95%, and 99% where each level has a different number of samples. It also specifies the research confidence intervals (α) of 0.1, 0.05, and 0.01.

Table 3.1 Population & Confidence Level

Population	Confidence level 90 per cent			Confidence level 95 per cent			Confidence level 99 per cent		
	Confi-dence	Confi-dence	Confi-dence	Confi-dence	Confi-dence	Confi-dence	Confi-dence	Confi-dence	Confi-dence
30	27	28	29	28	29	29	29	29	30
50	42	45	47	44	46	48	46	48	49
75	59	64	68	63	67	70	67	70	72
100	73	81	88	79	86	91	87	91	95
120	83	94	104	91	100	108	102	108	113
150	97	111	125	108	120	132	122	131	139
200	115	136	158	132	150	168	154	168	180
250	130	157	188	151	176	203	182	201	220
300	143	176	215	168	200	234	207	233	258
350	153	192	239	183	221	264	229	262	294
400	162	206	262	196	240	291	250	289	329
450	170	219	282	207	257	317	268	314	362
500	176	230	301	217	273	340	285	337	393
600	187	249	335	234	300	384	315	380	453
650	192	257	350	241	312	404	328	400	481
700	196	265	364	248	323	423	341	418	507
800	203	278	389	260	343	457	363	452	558
900	209	289	411	269	360	468	382	482	605
1,000	214	298	431	278	375	516	399	509	648
1,100	218	307	448	285	388	542	414	534	689
1,200	222	314	464	291	400	565	427	556	727
1,300	225	321	478	297	411	586	439	577	762
1,400	228	326	491	301	420	606	450	596	796
1,500	230	331	503	306	429	624	460	613	827
2,000	240	351	549	322	462	696	498	683	959
2,500	246	364	581	333	484	749	524	733	1,061
5,000	258	392	657	357	536	879	586	859	1,347
7,500	263	403	687	365	556	934	610	911	1,480
10,000	265	408	703	370	566	964	622	939	1,556
20,000	269	417	729	377	583	1,013	642	986	1,688
30,000	270	419	738	379	588	1,030	649	1,002	1,737
40,000	270	421	742	381	591	1,039	653	1,011	1,762
50,000	271	422	745	381	593	1,045	655	1,016	1,778
100,000	272	424	751	383	597	1,056	659	1,026	1,810
150,000	272	424	752	383	598	1,060	661	1,030	1,821
200,000	272	424	753	383	598	1,061	661	1,031	1,826
250,000	272	425	754	384	599	1,063	662	1,033	1,830
500,000	272	425	755	384	600	1,065	663	1,035	1,837
1,000,000	272	425	756	384	600	1,066	663	1,036	1,840

Source: Cohen, Manion, Morrison

In this table, the leftmost column is the population column, the second column is the 90% confidence level of the study which has sub-columns alpha (α) 0.1, 0.05, and 0.01 (from left to right). Likewise, the next columns. The target population of this study amounted to 200 people, so to get a 95% confidence level with an alpha (α) value of 0.05, the respondents to be involved at this stage were 91 respondents.

This technique was chosen because the selected sample met specific criteria relevant to the research objectives. Data was collected through a questionnaire using a Likert scale to

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measure respondents' perceptions of the research variables, namely, AIC, SCV, IC, and SSCP.

To test the hypotheses, this study proposes several main hypotheses as follows :

H1 : AI Chatbot adoption (AIC) affects Sustainable Supply Chain Performance (SSCP).

Adoption AIC dan SCV

By incorporating AIC, businesses can assist in the analysis of customer feedback and market trends, guiding more relevant and customized product innovations. Supply chain management also leverages AIC to optimize logistics and procurement processes. AIC can help forecast product demand, arrange deliveries, and optimize inventory more accurately. (Firdaus, 2023). AIC's learning and intelligence capabilities help organizations adapt to changing customer needs, while advanced SCV technology enables real-time monitoring of supply chain operations. This improves decision-making, risk management, and responsiveness, allowing companies to optimize processes, identify bottlenecks, and adapt to market demands, thus gaining a sustainable competitive advantage (Panigrahi et al., 2023).

H2 : AI adoption has a significant influence on Supply Chain Visibility (SCV).

Adoption AIC dan IC

Based on the arguments proposed by the author, AIC plays a role in increasing the company's IC. With AIC, companies can acquire and assimilate new knowledge that is then transformed into new products or services. Strong innovation capabilities allow companies to create new sustainable supply chain solutions, such as processes and technologies that reduce environmental impact and improve energy efficiency. Implementing AI Chatbots (AIC) enhances these capabilities by boosting manufacturing efficiency through AI-driven industrial robots (InRos). This encourages further technological advancement and investment in AI, driving ongoing process innovation and strengthening market competitiveness (Panigrahi et al., 2023).

H3 : AIC adoption affects Innovation Capability (IC) in Supply Chain.

Effect of IC and SCV on SSCP

Cutting-edge technology, process enhancements, and collaboration fuel supply chain innovation, leading to more sustainable practices, reduced waste, and greater resource efficiency. SCV through real-time data analysis helps companies identify risks and opportunities, streamline logistics, and make data-driven decisions, enhancing overall sustainable supply chain performance (SSCP) (Panigrahi et al., 2023). It is also crucial for AICs to develop digital talent and culture through training and organizational culture change that supports continuous innovation. Adoption of digital supply chain solutions provides

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competitive advantage and long-term value to businesses and has a positive impact on climate change and corporate sustainability (Putri et al., 2024).

Moreover, the trust and transparency enabled by AI enhance supply chain management practices and support sustainable performance. Efficient information sharing is crucial for managerial functions, with supply chain visibility (SCV) playing a key role in supply chain management (SCM). The purpose of information is as one of the considerations in making decisions, as a solution to problems that arise, and as a way to identify opportunities (Santosa et al., 2022). SCV has demonstrated a significant influence on performance. This study seeks to assess the mediating role of SCV in the relationship between AIC and SSCP. While IC advances processes and encourages collaboration, it helps companies create more environmentally friendly and efficient solutions. This not only reduces environmental impact but also boosts resource efficiency, contributing to overall sustainable supply chain performance. A strong IC helps companies stay competitive and resilient in the face of climate change and sustainability demands. Companies that want to survive are encouraged to develop their own strategies to answer business challenges as the company develops (Wullur & Wardaya, 2015).

H4 : Supply Chain Visibility (SCV) has a significant effect on sustainable Supply Chain Performance (SSCP).

H5: Innovation Capability (IC) has a significant influence on Sustainable Supply Chain Performance (SSCP).

H6 : Mediating effect of Supply Chain Visibility (SCV) between AI Chatbot Adoption (AIC) and Sustainable Supply Chain Performance (SSCP).

Mediating Effects of SCV and IC between AIC and SSCP

AI-driven technologies play a vital role in enhancing supply chain visibility (SCV) by facilitating real-time data sharing, improving communication, and optimizing the flow of information among supply chain partners. This enhanced visibility enables organizations to make informed decisions, identify potential risks, and quickly respond to disruptions, ultimately boosting the overall efficiency and resilience of the supply chain. As highlighted by Deng and Noorliza, organizations are becoming increasingly conscious of the importance of resilience and intellectual capital (IC) in today's competitive and sustainable business environment. The visibility offered by AIC empowers companies to build stronger relationships with key stakeholders through complete transparency (Panigrahi et al., 2023). The increased SCV gained from AIC enables companies to identify risks and opportunities more accurately. This not only helps in better decision-making, but also enables optimization of logistics processes, such as route planning and inventory management. With better visibility, companies can improve operational efficiency, reduce costs, and accelerate responses to market changes or disruptions in the supply chain. The mediating affect of SCV between AIC and SSCP also includes improved sustainability. With improved visibility,

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companies can implement more sustainable practices, such as waste reduction and energy efficiency. SCV provides critical information that enables companies to make more sustainability-oriented decisions, which ultimately improves sustainable supply chain performance. As such, SCV is a key factor linking AIC adoption to the achievement of sustainability goals in supply chains.

H7 : The mediating effect of Innovation Capability (IC) between AI Chatbot Adoption (AIC) and Sustainable Supply Chain Performance (SSCP).

4. Result And Discussion

Testing the Measurement Model (Outer Model)

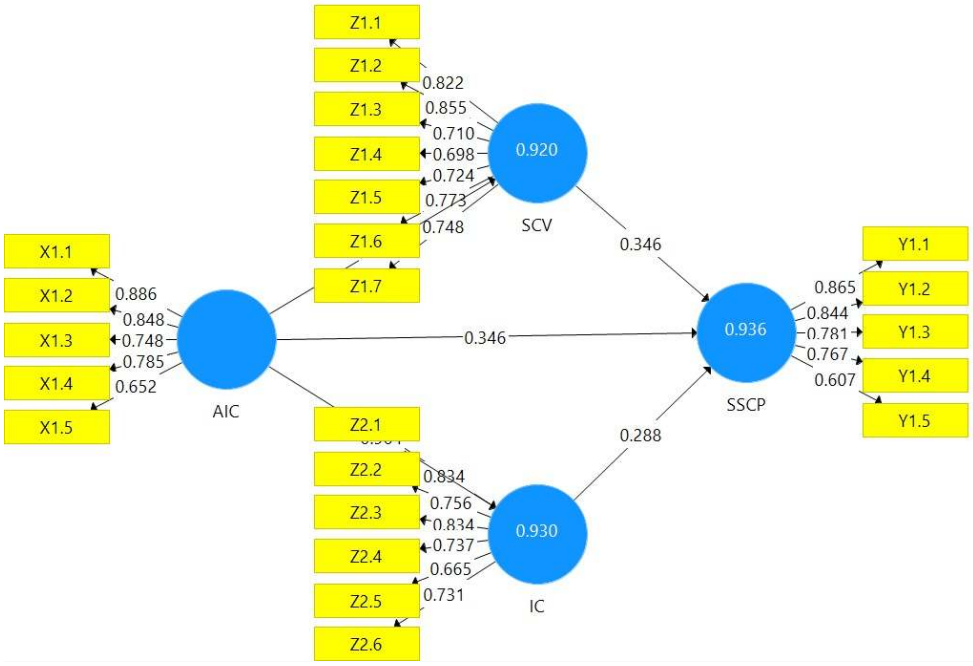

Figure 4.1 Outer Model

Figure 4.1 shows that all factor loading indicators are above 0.6, with the highest value reaching 0.886 for indicator X1.1 and the lowest 0.607 for indicator Y1.5. This indicates that all constructs in this model meet the requirements of convergent validity, which means

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that each indicator effectively reflects the measured construct. Thus, this model is considered valid and reliable for measuring the relationship between existing constructs.

Discriminant Validity Test Results

Tabel 4.1 Discriminant Validity

	AIC	IC	SCV	SSCP
AIC	0,788			
IC	0,964	0,762		
SCV	0,959	0,971	0,764	
SSCP	0,955	0,957	0,957	0,778

Table 4.1 shows the results of the discriminant validity assessment by comparing the square root of the Average Variance Extracted (AVE) for each latent construct with its correlation values with other constructs. The findings indicate that the square root of the AVE for each construct exceeds the correlation values with other constructs. Specifically, AIC has a square root AVE of 0.788, which is higher than its correlations with IC (0.964), SCV (0.959), and SSCP (0.955). IC has a square root AVE of 0.762, which is greater than its correlations with AIC (0.964), SCV (0.971), and SSCP (0.957). SCV has a square root AVE of 0.764, surpassing its correlations with AIC (0.959), IC (0.971), and SSCP (0.957). SSCP has a square root AVE of 0.778, higher than its correlations with AIC (0.955), IC (0.957), and SCV (0.957). These results demonstrate that all constructs in the model possess strong discriminant validity, indicating that each latent construct is distinct and affectively measures its intended dimension.

Composite Reliability Test Results

A composite reliability value of > 0.6 is considered evidence of good composite reliability**.**

Tabel 4.2 Reliability Test

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
AIC	0,843	0,854	0,890	0,621
IC	0,854	0,862	0,892	0,580
SCV	0,880	0,887	0,907	0,583
SSCP	0,832	0,846	0,883	0,605

Cronbach Alpha

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Cronbach's Alpha shows that the reliability of the AIC (α) variable is 0.843, which indicates high reliability, IC (α) is 0.854, which indicates high reliability, SCV (α) variable is 0.880, which indicates very high reliability, and SSCP (α) variable is 0.832, which indicates high reliability. (Fikri & Rini, 2023).

Evaluation of the Structural Model (Inner Model)

Tabel 4.3 R-Square

	R Square	R Square Adjusted
IC	0,930	0,929
SCV	0,920	0,919
SSCP	0,936	0,934

Table 4.3 shows that this model has a very good correlation. Based on the results of the table, the value of the IC (Innovation Capability) variable contributed 0.930 or 93.0% to the formation of the trend of the variable in question, SCV (Supply Chain Visibilty) contributed 0.920 or 92.0%, and SSCP (Sustainable Supply Chain Performance) contributed 0.936 or 93.6%. The remaining 7.0% to 6.4% is obtained from the influence of additional factors not discussed in this study. (Yusmanita et al., 2024).

Tabel 4.4 Result

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
AIC -> IC	0,964	0,963	0,010	91,919	0,000
AIC -> SCV	0,959	0,958	0,011	83,684	0,000
AIC -> SSCP	0,346	0,375	0,166	2,089	0,037
IC -> SSCP	0,288	0,278	0,154	1,871	0,062
SCV -> SSCP	0,346	0,324	0,181	1,914	0,056

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
AIC -> IC -> SSCP	0,277	0,268	0,148	1,876	0,061
AIC -> SCV -> SSCP	0,331	0,311	0,173	1,919	0,056

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Tabel 4.5 Q-Square

	RMSE	MAE	MAPE	Q²_predict
Z2.4	0,730	0,596	18,837	0,484
Z2.2	0,701	0,598	21,837	0,548
Z2.3	0,640	0,534	17,638	0,644
Z2.6	0,709	0,593	17,588	0,379
Z2.5	0,647	0,557	15,557	0,361
Z2.1	0,628	0,551	18,871	0,678
Z1.4	0,673	0,587	16,760	0,364
Z1.2	0,619	0,539	18,068	0,703
Z1.5	0,744	0,640	20,011	0,408
Z1.7	0,671	0,587	16,069	0,384
Z1.1	0,672	0,575	20,653	0,636
Z1.3	0,642	0,558	17,362	0,548
Z1.6	0,475	0,391	9,786	0,569
Y1.1	0,609	0,504	16,631	0,665
Y1.5	0,702	0,577	18,447	0,275
Y1.3	0,728	0,588	20,232	0,524
Y1.2	0,666	0,556	20,825	0,676
Y1.4	0,660	0,567	16,362	0,509

	RMSE	MAE	Q²_predict
IC	0,282	0,208	0,927
SCV	0,296	0,233	0,919
SSCP	0,312	0,201	0,909

All five assessment variables above do not all show significance, with significance values as follows:

1. The AIC variable on IC shows a significant effect with a significant value of 0.000 <0.05. In addition, the Q²_predict value of 0.927 shows a significant positive effect.
2. The AIC variable on SCV also shows a significant effect with a significant value of 0.000 <0.05. In addition, the Q²_predict value of 0.919 shows a significant positive effect.
3. The AIC variable on SSCP shows a significant effect with a significant value of 0.037 <0.05. The Q²_predict value of 0.909 indicates a significant positive effect.

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4. The IC variable on SSCP is not significant with a significant value of 0.062> 0.05. However, the Q^2_predict value of 0.909 still shows a positive influence, although not significant.
5. The SCV variable on SSCP is not significant with a significant value of 0.056> 0.05. However, the Q^2_predict value of 0.909 indicates a positive influence, although not significant.

This sentence shows that despite the presence of insignificant variables, the overall model still has good predictive relevance, with the Q-square value indicating strong predictive ability.

5. Conclusion

This research significantly contributes to understanding the relationship between AI chatbot adoption and sustainable supply chain performance, providing valuable insights for the logistics industry. The results show that there is a significant positive relationship between AI technology adoption and sustainable supply chain performance improvement. In addition, the mediating affects of IC and SCV variables also play an important role in strengthening this relationship.

This study also presents empirical evidence that strengthening innovation capability and supply chain visibility are critical to improving sustainable supply chain performance. This is in line with existing literature and highlights the importance of new technology adoption, especially in the face of modern industrial challenges.

However, this study also has some limitations, such as the limited scale of the study to a specific industry and the lack of longitudinal data for long-term analysis. Therefore, further research is needed to extend these findings and provide more comprehensive insights into the relationship between AI technology, innovation, and sustainable supply chain performance in various other industry contexts.

6. Implication

Heoretical Implications

This study contributes to the existing literature by demonstrating the role of AI Chatbots (AIC) as a crucial factor in enhancing supply chain visibility (SCV) and innovation capability (IC). It bridges the gap between AI adoption and sustainable supply chain performance (SSCP), highlighting the dynamic capabilities theory in the context of Industry 4.0. The research provides empirical evidence on how SCV and IC act as mediators between AIC adoption and SSCP. This offers a nuanced understanding of the mechanisms through which AI technologies can influence sustainability outcomes, enriching the theoretical discourse on technology adoption in supply chains.

Practical Implications

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The findings recommend that logistics companies strategically implement AI technologies like chatbots to enhance supply chain processes, achieve operational efficiency, and contribute to sustainability. Innovation capabilities and supply chain visibility as these are key to realizing the full benefits of AI adoption. This approach can lead to significant improvements in both performance and sustainability, offering a competitive advantage in the logistics industry.

7. Research Limination

This study has several limitations, including the specific focus on PT. Lion Parcel, which may limit generalizability. Future research should explore a broader range of industries to validate these findings. Second, the study relies on a survey with a questionnaire as the primary data collection instrument. Using a questionnaire as the sole data source has drawbacks, such as the potential for bias from respondents who may not be completely honest or may not fully understand the questions asked. This could affect the validity and reliability of the data obtained.

Third, the study has a limited time frame, only depicting conditions at the time of the research. The dynamics in AI adoption and changes in supply chain sustainability performance may not be fully reflected in this study. Further research with a longer time frame or a longitudinal approach could provide a better understanding of the long-term impact of AI chatbots.

Finally, limitations in measuring intermediary variables such as supply chain visibility and innovation capability may not cover all relevant aspects in the context of AI chatbot adoption. While this study provides important initial insights, further research is needed to examine additional variables or use more comprehensive

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