SUSTAINABLE DIGITAL FOOD SUPPLY CHAIN IN INDONESIA

Bayu Sumantri[1)]

[1)] Doctor of Agricultural Science, Universitas Padjadjaran
bayu22001@mail.unpad.ac.id

ABSTRACT

Sustainability in the food supply chain is a top priority for various global and local entities, including companies, governments, non-profit organizations, academic institutions, and society. For example, in the 1990s, collaboration between civil society groups and the corporate world aimed to promote sustainability across global supply chains. This is achieved by creating formal organizations that set sustainability standards in sectors such as organic food, fair trade, forestry, and fisheries. The partnership highlights the need for collective action among supply chain participants to effectively address economic, social, and environmental challenges. This article discusses digital food supply chain sustainability research development through a systematic literature review and the influencing factors influencing digital food supply chain business performance. The method used is a mixed method, where in this research, a literature review was used using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Structural Equation Modeling (SEM) methods. The results show that research on digital supply chain sustainability began in 1998. From 2007 to 2019, the number of journal articles discussing digital supply chain sustainability relatively increased. From 2020 until now, it has decreased. This may happen because the COVID-19 pandemic started in 2020, and researchers may have difficulty conducting such multidisciplinary research. In addition, the SEM results show that only the economic sustainability variable positively and significantly influences the technological sustainability dimension variables and digital food supply chain business performance. In contrast, the other variables show a negative influence.

Keywords: *sustainability*, *digital food supply chain, food supply chain*, *review, structural equation modelling*

1. INTRODUCTION

The sustainability of the agri-food supply chain is essential on the international and national policy agenda for companies, governments, non-profit organizations, academia, and society (Miranda and Dries, 2022). An example is that in the 1990s, civil society organizations partnered with businesses to create green global supply chains by establishing formal sustainability standard-setting organizations in sectors including organic food, fair trade, forestry, and fisheries (Gale, et al., 2017). This is because problems such as economic (Ma and Zhang, 2022), social (Roßmann, et al., 2017), and natural disasters (Papadopoulos, et al., 2016) cannot be resolved without involving cooperation among supply chain actors (Pederneiras, et al., 2021).

Most recent definitions of sustainable supply chains tend to include the three pillars of the triple bottom line definition (Negri, et al., 2021). Sustainability combines three core dimensions, namely, economic, environmental, and social (Miranda and Dries, 2021, Valinejad and Rahmani, 2018). In fact, since 2019, the dimensions of sustainability include economic, environmental, social, technological and institutional (Purvis, et al., 2019). Even Rezghdeh and Shokouhyar (2020) divided sustainability into 6 dimensions with additional

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techniques. Whatever it is, sustainability in the food supply chain is an important thing to do (Dairy Road Map, 2008; Glover, et al., 2014).

Research by Sharma, et al. (2020) and Kittipanya and Tan (2019) linked sustainability to digital supply chains. Sustainability discussed in the 3 articles is social, economic, and environmental sustainability. At the same time, the theme of digital technology in the food supply chain sector starts from production, processing, logistics, and sales to promotion. A key finding is the importance of low-cost digital technologies (including freeware and social media) that can support flexibility, collaboration, visibility, and agility in decision-making. Meanwhile, institutional and technological sustainability in digital food supply chains is still very limitedly researched. Indeed, this paper confirmed five dimensions of sustainability that affected the digital food supply chain.

This study primarily contributes to the digital food supply chain literature by identifying and analyzing sustainability dimensions in digital food supply chains. In assessing research on the dimensions of sustainability in digital food supply chains, this systematic review uses the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Structural Equation Modeling (SEM) approaches. This review article offers an up-to-date perspective and synthesis of empirical evidence on the study of sustainability dimensions in digital food supply chains. Knowledge identification and synthesis help identify research, practice, and policy gaps and produce relevant recommendations. Therefore, the following two questions will be answered in this review: (1) How is research on sustainability dimensions in digital food supply chains developing? (2) What sustainability factors influence the business performance of the digital food supply chain in Indonesia?

2. RESEARCH METODOLOGY

The research design in this study emphasizes analyzing the resilience of the inclusive fresh product supply chain in more detail and depth. The research location was determined purposefully based on participants who had attended training related to technology, such as smart farming, digital marketing, farming on the cloud, etc., at the UPT BPPSDMP Ministry of Agriculture (table 1).

Tabel 1. Sebaran Responden

No.	Province	Respondent
1.	West Java	90
2.	Central Java	5
3.	South Sumatera	1
4.	South Sulawesi	1
5.	Aceh	2
6.	South Kalimantan	1
Total		**100**

The keywords used in this research were Scopus, Ebsco Host, Agecon Search, and WUR Library databases. The keywords used in code A are digitalisation OR smart OR automation OR precision OR technology OR technological to describe derivatives of digitalization. Code B uses the keywords food OR agriculture OR agriprocessing OR agribusiness OR agrifood OR agri-food OR agricultural OR "fresh product*" to describe derivatives from the agricultural sector. The keywords supply chain*" OR "value chain*" OR "supply chain management*" OR logistic in code C describe derivatives of the supply chain and, finally, sustain OR sustainability to describe all dimensions of sustainability. Meanwhile, using a combination of codes A to D, the results showed that Ebsco Host provided the most articles, namely 693 articles without any specific filter, and 126 by filtering only journal articles in the form of articles and English, even though the percentage was the smallest, namely only 18% of the comparison. Number of journals filtered by total journal articles. Meanwhile, the least number of journal articles used after filtering was Agecon Search. The Agecon Search database only includes journal articles from the agricultural sector, unlike the Ebsco Host, Scopus, Science Direct,

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or Web of Science databases, which filter multidisciplinary research. Finally, the total number of journal articles obtained was 287 (table 2).

Table 2. Keywords Used in Various Databases

Code	Keywords	SCOPUS	EBSCO Host	Agecon Search	WUR Library
A	digitalisation OR smart OR automation OR precision OR technology OR technological	759.000	1.549.487	1.082	10.152.957
B	food OR agriculture OR agriprocessing OR agribusiness OR agrifood OR agri-food OR agricultural OR "fresh product*"	2.300.989	815.791	543	4.991.910
C	"supply chain*" OR "value chain*" OR "supply chain management*" OR logistic	763.437	147.188	597	1.010.424
D	sustain OR sustainability	412.301	70.553	1.063	2.028.242
E	A AND B AND C AND D	217	693	51	49
F	LIMIT (Only Article Journal and English Language)	107	126	18	36

Initially, the literature search totaled 287 articles, but using Mendeley, nine duplicate articles were found. The search results use a combination of keywords, then filtered based on title, abstract, keywords, and journal articles in the form of literature reviews during the identification stage. Furthermore, journal articles that did not discuss the food supply chain were eliminated during the screening stage. At that stage, 142 journals did not discuss the food supply chain. The remaining 94 articles were reprocessed at the eligibility stage because the remaining 48 journal articles did not discuss digital technology for the food supply chain. The backward and forward citations were carried out using Scopus and Ebsco Host to obtain 47 journal articles on sustainability in the food supply chain at the included stage. In the end, a total of 93 journal articles were reviewed.

Table 3. Latent and Indicator Variabel (Manifest)

Latent Variabel	Indicator Variabel	Code	Reference(s)
Economy (η_1)	Cost reduction	X1_1	Pacheco. Et al. (2021)
	Cost efficiency	X1_2	Pacheco. Et al. (2021)
	Market access	X1_3	Qureshi, et al. (2021)
	Resource optimization	X1_4	Berni, et al. (2020)
	Value chain integration	X1_5	Chae, et al. (2020)
Environment (ξ_4)	Waste reduction	X2	Hoek and Harrison (2020)
Institutional (η_3)	Collaboration	Y1	Du and Liu (2020)
Social (ξ_5)	Community engagement	X3	Al-Salti and Preece (2020)
Technology (η_4)	Technological awareness	Y2	Singh, et al. (2021); Sundarakani and Venkantesh (2021); Xiong, et al. (2021); Tang (2020); Tapscoot and Tapscoot (2017)
Business Performance (η_5)	Profitability	Y3	Gunther and Kettner (2020)

Next, to answer the aim of analyzing the factors that influence the sustainability of the digital food supply chain in Indonesia using the PLS-SEM method, compared to other correlation and multivariate analyses, the PLS-SEM method has advantages when the complex structural model includes many constructs, indicators, and/or relationship models (Hair, et al., 2006). The indicators (manifests) are presented in table 3.

The PLS-SEM model in this study consists of three exogenous latent variables, three endogenous latent variables, and 10 observed or indicator variables. The relationships between variables and the structural and measurement models are depicted in the form of a path diagram in figure 1.

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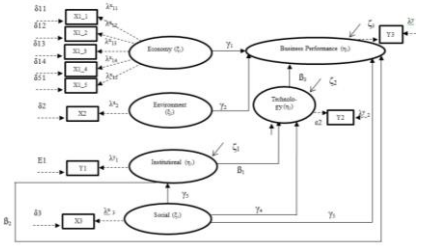

Figure 1. Path Diagram

3. RELATED RESEARCH/LITERATUR REVIEW

Research by Sharma, et al. (2020) and Kittipanya and Tan (2019) link sustainability to digital supply chains. The sustainability reviewed in the 3 articles is social, economic, and environmental sustainability, while the theme of digital technology in the food supply chain sector is from production, processing, logistics, and sales to promotion. A key finding is the importance of low-cost digital technologies (including freeware and social media) that can support flexibility, collaboration, visibility, and agility for decision-making. Meanwhile, research conducted by Nørremark, et al. (2022), Ciruela, et al. (2020), and Sharma, et al. (2020) does not contain sustainability in digital food supply chains but rather explains the optimization and performance of logistics route planning, the digitalization of agricultural cooperation in the context of smart agriculture, and the role of robots in supporting logistics. Parthiban, et al. (2021) only explain sustainability in the agroforestry industry supply chain, where creating a value chain in industrial agroforestry is initially demonstrated on 200 ha of agricultural land through technological interventions (not digital technology, but cultivation technology), organization and marketing (table 4).

Table 4. Differences in Journal Articles Relevant to This Review Article

Author(s)	*Content Analysis (Y/N)*	*Article Time Span (Year)*	*Food Supply Chain (Y/N)*	*Digital Food Supply Chain (Y/N)*					*Sustainability Digital Food Supply Chain (Y/N)*	
				Production	*Processing*	*Transportation*	*Sale*	*Promotion*	*3 Indicators*	*5 Indicators*
Nørremark, et al. (2022)	Y	-	Y	N	N	Y	N	N	N	N
Villareal (2021)	Y	-	Y	N	N	N	Y	Y	Y	N
Parthiban, et al. (2021)	Y	-	Y	N	N	N	N	N	Y	N
Sharma, et al. (2020)	Y	2002-2018	Y	Y	Y	Y	N	N	Y	N
Sharma, et al. (2020)	Y	1994-2019	Y	Y	N	Y	N	N	N	N
Ciruela, et al. (2020)	Y	-	Y	Y	Y	Y	Y	Y	N	N
Moreno, et al. (2020)	Y	-	Y	N	N	N	N	N	N	N
Kittipanya dan Tan (2019)	Y	-	Y	Y	N	N	N	N	Y	N
Sylim, et al. (2018)	Y	-	N	N	N	Y	N	N	N	N
Schader, et al. (2014)	Y	-	Y	N	N	N	N	N	N	N
This article	**Y**	**1998-2022**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**N**	**Y**

4. RESULTS AND DISCUSSION

4.1. Sustainability in Digital Food Supply Chains

Research on digital supply chain sustainability began in 1998, pioneered by Clarke (1998) regarding virtual logistics to increase food company revenues. Then, there was a hiatus for seven years from 1999 to 2006. From 2007 to 2019, there was a

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relative increase in journal articles discussing the sustainability of digital supply chains. From 2020 until now, it has decreased. This could be because the COVID-19 pandemic began in 2020, and researchers may have difficulty carrying out this multidisciplinary research.

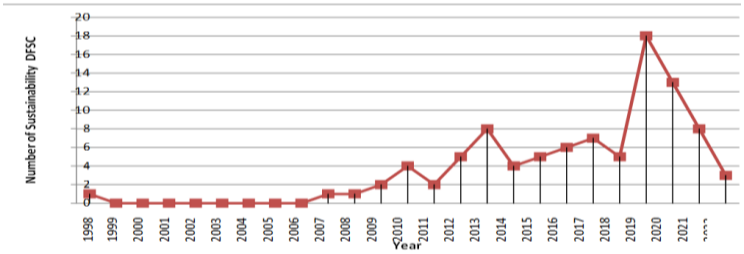

Figure 2. Digital Food Supply Chain Publications per Year

4.2. Discussion of Models from SEM Results Using Smart-PLS

Figure 3 below shows the results of the structural model estimation using SMART-PLS. The results show that the economic dimension variable (X1) positively and significantly influences the digital food supply chain business performance variable (Y3) with an influence of 0.140. So, when the digital food supply chain increases attention to economic sustainability, it will improve the performance of digital food supply chain businesses (Y3). This is also in line with what was expressed by Parrag, et al. (2022) and Rahimifard, et al. (2022) that a digitally driven food supply chain will be able to increase business profits so that the business can continue to run.

Apart from that, the economic dimension variable (X1) positively and significantly influences the technology dimension variable (Y2), with an influence of 0.214. When sustainability in the economic dimension increases, sustainability in the technological dimension will increase. This is due to cost efficiency due to the technology used (World Bank, 2016).

Then, the environmental dimension variable (X2) negatively and significantly influences the technology dimension variable (Y2), which influences -0.104. So, when the environmental dimension increases, the technological dimension in the digital food supply chain will decrease. Integrating environmental factors often drives the need for more advanced technologies to overcome sustainability challenges and improve operational efficiency (Silva, et al., 2022). This could be because food supply chains that are run digitally in developing countries do not yet pay attention to environmental sustainability because although digitalization can increase efficiency and responsiveness in food supply chains, this process requires a lot of resources and takes time, thus preventing attention to environmental problems (Nguyen, et al., 2023; Mogale, et al., 2022).

The social dimension variable (X3) has a negative and significant influence on the institutional dimension variables (Y1), technological dimension (Y2), and profits (Y3) with effects of -0.025, -0.093, and -0.080, respectively. So when the social dimension increases, the institutional, technological and profit dimensions of the digital food supply chain will also decrease.

As the social dimension increases in digital food supply chains, the institutional dimension decreases due to small agricultural enterprises' emphasis on maintaining social identity in the supply chain. These businesses are socialized through their networks, guiding their business processes rather than focusing on adoption attributes such as relative advantage and complexity (Tsai et al., 2021). In addition, applying digital technology in the agri-food sector supply chain can lead to two different approaches: digitalization and digital transformation (DT). Companies wishing to implement DT must select and incorporate digital technologies that fit their DT strategy while ensuring senior management leadership and staff

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involvement (Ali, et al., 2021). This shift towards a more socialized approach may eclipse traditional institutional aspects of digital food supply chains.

As the social dimension increases in digital food supply chains, profitability may decrease due to various factors. Research shows that companies in the agri-food sector face challenges in implementing digital technologies, leading to two different approaches: digitalization and digital transformation (DT) (Ribeiro and Navarrete, 2023). Additionally, agri-food companies in Eastern Europe show higher sensitivity to social innovation as a digital transformation factor, indicating a potential trade-off between social incentives and profitability (Barcellos, et al., 2023). In addition, the emergence of social selling, especially during the COVID-19 pandemic, can create risks related to the mishandling of goods, which can impact the profitability of the food sector (Ali and Govindan, 2021). Therefore, the link between social aspects and digitalization in the food supply chain can harm profitability.

The institutional dimension variable (Y1) has a negative and significant influence on the technology dimension variable (Y2) and the profit variable (Y3), with an influence of -0.058 and -0.033. So, when institutional desire increases its attention to the digital food supply chain, it will reduce the technological dimensions and profits in the digital food supply chain. The decreasing technological poverty dimension in the digital food supply chain when the institutional poverty dimension increases is caused by complexity and trade-offs between economic, environmental and social factors (Reddy, et al., 2022). Although digital technology can support extinction initiatives, it can also have unintended negative consequences, resulting in technological extinction (Zoric, et al., 2023). In addition, challenges and obstacles in integrating digital technology for sustainability in supply chains can hinder improvements in technological sustainability aspects (Maha and Akram, 2022; Kenea, 2022). Poor coordination, information transfer problems, food loss, and contamination can destroy and disrupt traditional food supply chains, affecting technology cessation in digital transformation (Maha and Akram, 2022). Therefore, carefully considering all dimensions and consequences is essential to achieve the intended benefits and reduce undesirable adverse impacts in the digital food supply chain.

Additionally, as the institutional dimension of poverty increases in digital food supply chains, profitability decreases due to various factors. Factors such as poor coordination among supply chain participants, food losses, transaction costs, and external elements significantly impact the desirability and functioning of food supply chains (Silva, et al., 2023). In addition, the complexity of food supply chains, which are influenced by poverty factors such as the number of elements, unpredictable variability, and resilience, can increase challenges in maintaining profitability (Zoric, et al., 2023). Additionally, efficient supply chain management, including cold storage and warehousing systems, is critical to ensure fair distribution of crops and food grains, thereby impacting profitability in digital food supply chains (Reddy, et al., 2022). Therefore, addressing these challenges through digitalization and improved coordination is critical to increasing profitability in digital food supply chains.

The technology dimension variable (Y2) negatively and significantly influences the profit variable (Y3), with an influence of -0.112. So when technological variables increase, the profits of digitally driven food supply chains will be reduced. As the dimension of technology availability increases in digital food supply chains, profitability may decrease due to various factors. Factors such as poor coordination between participants, food loss, transaction costs, and control problems significantly impact the viability and functioning of food supply chains (Silva, et al., 2023). Additionally, the complexity associated with technological advances in digital food supply chains, including the need for organizational capacity, supporting technology, and traceability processes, can lead to increased costs and operational challenges, thereby affecting profitability (Zoric, et al., 2023). In addition, the concentration of value in the final link of the food production chain due

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to market failures can hinder profitability, especially for small farmers, even though digital technology has potential benefits in increasing market demand and access (Roosevelt, et al., 2022). Therefore, while technological advances can increase poverty, they can also introduce complexity and costs that impact profitability in digital food supply chains.

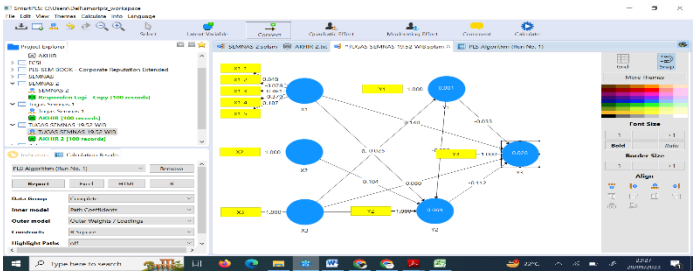

Figure 3. Structural Model Estimation Results

5. CONCLUSION

The results show that research on digital supply chain sustainability began in 1998. From 2007 to 2019, there was a relative increase in journal articles discussing the sustainability of digital supply chains. From 2020 until now, it has decreased. This could be because the COVID-19 pandemic began in 2020, and researchers may have difficulty carrying out this multidisciplinary research. Besides that, SEM results show that only economic variables have a positive and significant influence on the technological dimension variables and business performance in the form of profits, while the other variables show a negative influence.

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