Spektrum Industri
Vol. 23, No. 1, 2025, pp. 86-105
ISSN 1693-6590
http://journal3.uad.ac.id/index.php/spektrum

The Analysis of the Digitalization Role on Towards Supply Chain Resilience and Sustainable (Case Study: MSME in Balikpapan City)

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ARTICLE INFO

Article history
Received August 26, 2024
Revised January 7, 2025
Accepted March 11, 2025

Keywords
Digitalization;
Supply chain resilience;
Supply chain sustainability

ABSTRACT

The COVID-19 pandemic has caused significant changes in almost all sectors, including disruptions in the global supply chain. Acceleration of supply chain recovery to create supply chain resilience and sustainability by implementing various strategies, including digitalization. Empirical evidence is still very limited in the literature, especially in studies involving supply chain actors from MSMES with different characteristics and locations. Therefore, this study aims to address this problem by analysis the role of digitalization in improving supply chain resilience and sustainability based on a case study of MSMES in Balikpapan City. Three hypotheses have been proposed to answer the research problem. This study uses the Structural Equation Modelling (SEM) approach with the help of IBM AMOS software version 22 for hypothesis testing. Questionnaires were distributed to 200 MSME actors with different characteristics in Balikpapan City. The results are: (1) the role of digitalization has a significant positive effect on supply chain resilience; (2) the role of digitalization has a positive effect on supply chain resilience; (3) supply chain resilience has a significant positive effect on supply chain sustainability. Despite the differences in characteristics of business models and business sectors, supply chain resilience and sustainability can be improved by using appropriate digital technology in each supply chain. The contributes of this study shows that there is a potential for good supply chain visibility that allows every actor along the supply chain to monitor, transfer, and improve the accuracy of decision making accurately and quickly, to handle any disruptions and improve supply chain sustainability.

1. Introduction

The Covid-19 pandemic is one of human history's most significant sources of disruption. It's not only affected the social aspect and health, but also on the operational aspects of companies, in which global supply chains have also experienced significant disruption. Outbreaks that attack suddenly on a massive scale make almost all companies unable to predict the impact on business and supply chains (Zhao et al., 2023). These events further exacerbate an already complex, vulnerable and uncertain global supply chain network (Tirkolaee et al., 2022). Uncertainty is increasing in logistics operations,

global supply chains, as well as social and ecological fields. Disruptions at supply chain nodes that involve only a few companies can have a ripple effect and result in paralysis of the entire supply chain (Nikookar & Yanadori, 2022). Since the occurrence of the pandemic, the focus of company operations in the current business environment is not only limited to cost efficiency but also how companies can improve resilience capabilities in overcoming disruptions along the supply chain (Ivanov & Dolgui, 2020).

Various measures have been taken to reduce the impact, such as stopping manufacturing and limiting human activities to reduce disruption (Ivanov & Dolgui, 2020). Numbers of problem in companies and supply chains due to the enormous effects have emerged, such as raw material delays, increased logistics costs, production stoppages, decreased market demand, and import and export problems (Hossain et al., 2022; Kazancoglu et al., 2022). These issues negatively impact resilience and sustainable supply chains (Kazancoglu et al., 2022). To mitigate the problems, companies need to reconfigure production systems and supply chain processes (Dolgui et al., 2020). Therefore, increasing supply chain resilience is the most effective way to prevent disruptions by considering sustainability factors without sacrificing future operations (Li et al., 2022).

Resilience and sustainability are two different but related aspects of building a resilient supply chain (Nandi et al., 2021). Sustainability is an important aspect of building resilient supply chains (Dolgui et al., 2020). Moreover, with the commitment to create a sustainable organization, corporate organizations voluntarily adopt sustainable supply chain management, in order to reduce the negative impacts of the supply chain (Xu et al., 2022). By the condition, it is important to understand the relationship between resilience and sustainability of the supply chain. Considerable number of literature has highlighted the importance of resilience and sustainability of the supply chain, but most of them focus on the objective tension between resilience and sustainability of the supply chain, and it should be solved (Sabouhi et al., 2021; Sharma & Mangaraj, 2022), including a positive relationship between those two concepts (Eggert & Hartmann, 2023). As a result, multiple interpretations and ambiguity happened. In addition, only a small number of literature investigate the relationship between the concepts based on empirical evidence. Therefore, this research will be the bridge to fill the gap.

The problems experienced by companies and various supply chains due to the Covid-19 outbreak have contributed to the acceleration of the digitalization process (Sawik, 2022; Zhao et al., 2023). In addition, digitalization has also attracted a lot of attention from practitioners and industry players due to the current rapid industrial revolution (He et al., 2023; Irfan et al., 2022). The results of the study show that the adoption of digital technology can have a positive impact on reducing obstructions (Ivanov et al., 2019; Tasnim, 2020). Experts say that digitalization plays an important role in improving the performance of supply chain resilience in critical conditions and making it possible to quickly recover from the obstructions (Belhadi et al., 2021; Yang et al., 2021). However, the correlation with organizational resilience still needs to be investigated empirically (Schluter et al., 2017; Tasnim, 2020). It aims to produce more measurable and comprehensive results, so that the gap between academics and practitioners can be resolved and turns into a guide for best business practices in the future (Belhadi et al., 2022; Li et al., 2022).

Although digitalization has provided substantial conveniences and benefits for the industry, the potential has not been fully explored. The presence of digitalization is marked by the presence of industry 4.0 with a number of new technologies, such as Big Data Analysis, Blockchain and Artificial Intelligence which have accelerated the process of business model transformation (Dubey et al., 2020; Song et al., 2021). Digitalization is also able to construct organizational capabilities to engage and build trust through integration and sustainability visibility (Kache & Seuring, 2017). Sharma et al. (2022) revealed that there is a relationship between digitalization and sustainability. In addition, experts also revealed that digitalization has an impact on improving sustainable supply chain performance (Dev et al., 2020; Liu et al., 2020; Saberi et al., 2019; Yu et al., 2022). However, only a small part of the existing literature reveals this correlation based on empirical evidence. Therefore, this study was conducted to bridge the gap between digitalization and supply chain sustainability.

This study is focused on investigating the role of digitalization to improve supply chain's resilience and sustainability. Based on literature review, researchers have not found the results of study that examine that matter specifically, including the use of company scale and region. This study begins with a literature study to develop a conceptual model and research hypothesis. Supply chain resilience is measured through its absorption, response, and recovery capacities (Zhao et al., 2023). Sustainable supply chain is measured through economic, social and environmental aspects (Lopez-Castro & Solano-Charris, 2021). Then, the role of digitalization is measured based on digital products and services, digital operating processes and digital business models (Zhao et al., 2023).

Validation of the research model and hypothesis is based on empirical data collected through the survey on Micro, Small and Medium Enterprises (MSMEs) in Balikpapan City. As the main gateway to the new capital city "Ibu Kota Negara", Balikpapan has a strategic role in the regional supply chain which makes the implementation of digitalization in the MSME sector has a direct impact and relevancy. In addition, as the backbone of the regional economy and a significant contributor to employment, MSMEs in Balikpapan City are also more vulnerable to obstructions in the supply chain. The understanding on how digitalization can help MSMEs to increase their resilience is crucial, so that it can have a broader impact on economic, social and environmental aspects. Research in this city is more representative compared to the other cities in East Kalimantan which have more limited infrastructure and technology adoption, including in IKN area which is currently still under construction and with unestablished MSME economic activities. The researchers believe that the findings of this study in general can contribute to increase the knowledge and literature in the field of supply chain digitalization, supply chain resilience, and supply chain sustainability. In addition, this study also bridges the gap in the relationship between supply chain digitalization, supply chain resilience, and supply chain sustainability among MSMEs which is carried out through empirical studies.

2. Method

2.1. Hypothesis Development

2.1.1. Digitalization and Supply Chain Resilience

Digitalization is marked by Industry 4.0, including several new technologies such as Big Data Analysis, Blockchain, and Artificial Intelligence that have accelerated the process of transforming business models. (Dubey et al., 2020; Song et al., 2021). These technologies are gradually accelerating very significant changes along the supply chain (Frank et al., 2019). The application of Blockchain technology is proven to be able to improve the quality of data and information needed by companies to increase supply chain visibility (Rogerson & Parry, 2020). That way, companies can anticipate risks and changes in the business environment and forecast demand accurately, so that supply chain resilience can be materialized (Ye et al., 2022). At the same time, the incorporation of new technologies improves supplier operations, minimizes manufacturing operational risks, and increases resilience along the supply chain (Cavalcante et al., 2019; Ketchen & Craighead, 2020). Therefore, companies with the ability to fully understand the supply chain process, to respond appropriately to risks, and to anticipate possible disruptions are reflecting the characteristics of resilient supply chains. However, empirical evidences are still needed to prove the relevance of the developing theory. Based on the explanation above, the hypothesis proposed is:

H_1: Digitalization has a positive effect on increasing supply chain resilience.

2.1.2. Digitalization and Supply Chain Sustainability

The role of digitalization has become crucial for sustainable supply chain improvement since the significant disruption. In general, a sustainable supply chain is defined as the management of material, information, and capital flows, as well as collaboration along the supply chain by considering three main pillars for long-term interests, consisting of economic, social, and environmental interests (Seuring & Muller, 2008). Specifically, economic aspect refers to financial performance such as revenue, operating costs, and production (Gilani & Sahebi, 2021; Hosseini-Motlagh et al., 2020;

Lopez-Castro & Solano-Charris, 2021), social aspect refers to employment and the effectiveness of employee working time (Gilani & Sahebi, 2021; Hosseini-Motlagh et al., 2020), and environmental aspect refers to the reduction of emissions and carbon, fuel consumption, and environmental ecosystems (Lopez-Castro & Solano-Charris, 2021).

The proper implementation of a sustainable supply chain can create efficient resources, contribute to the social system, and achieve financial goals (Govindan et al., 2020). To achieve these conditions, the role of digitalization is needed because the use of new technologies such as the Internet of Things, Big Data Analysis and Artificial Intelligence in the supply chain can help stakeholders to share the information regarding the growth in economic, environmental, and social conditions in a quick and accurate ways (Liu et al., 2020). The results of the study revealed that the role of digitalization in sharing information and improving supply chain performance has an impact on improving supply chain performance by considering environmental and social implications (Fahimnia et al., 2019; Liu et al., 2020; Saberi et al., 2019). In addition, the study revealed that digitalization has a positive effect on improving sustainable supply chain performance (Dev et al., 2020; Liu et al., 2020; Saberi et al., 2019; Yu et al., 2022). However, further empirical studies are needed on how digitalization plays a role in sustainable supply chains. Based on the description above, the hypothesis proposed is:

H_2: Digitalization has a positive effect on improving sustainable supply chain.

2.1.3. Supply Chain Resilience and Supply Chain Sustainability

Supply chain resilience is defined as how the supply chain can survive in combating vulnerabilities, difficulties and disruptions that occur along the supply chain (Scholten & Schilder, 2015). Mandal (2014) defines supply chain resilience as the ability to operate effectively even when faced with disruptive events. To detect disruptions in the supply chain, companies need to detect and monitor the business environment and make decisions quickly and accurately (Bargoni et al., 2022). Therefore, innovative and dynamic ways of managing supply chain obstruction are highly recommended (McClements et al., 2021; Yin & Ran, 2021). The complex and uncertain nature of the supply chain have affected its resilience and sustainability (Akram et al., 2024). The increasing uncertainty has an impact on the environment and society.

Therefore, resilience and sustainability matters have received special attention among academics and practitioners (Kumar & Singh, 2021). Supply chain resilience is known to help companies overcome obstruction and maintain business continuity in the long term (Vali-Siar & Roghanian, 2022; Vanany et al., 2021). Carter and Rogers (2008) define sustainable supply chains as strategic and transparent integration, and systematic achievement of environmental, social, and economic goals between supply chain actors for the long term. Supply chain resilience and sustainability have been investigated in recent decades (Fahimnia et al., 2019; Ul Akram et al., 2024). In the literature, sustainability focuses on efficiency, while resilience focuses on effectiveness (Negri et al., 2021). However, in some contexts, resilience and sustainability are two different concepts that positively influence each other (Cook & Johannsdottir, 2021; Durmaz et al., 2021; Jabbarzadeh et al., 2018; Pratondo et al., 2021). Creating stability and resilience to disruptions through increased resilience can create a sustainable supply chain (Andres & Marcucci, 2020). However, further studies are needed to investigate the relationship between supply chain resilience and sustainability (Carissimi et al., 2023). From this, the researcher created a model concept in Fig. 1. Based on the explanation above, the hypothesis proposed is:

H_3: Supply chain resilience has a positive effect on sustainable supply chain.

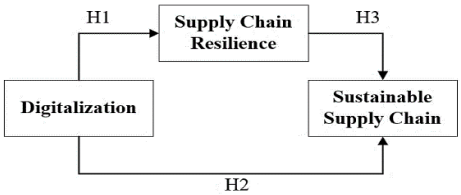

Fig. 1. Conceptual Model

2.2. Questionnaire Design

This research uses a set of questionnaires for data collection. The stages of designing and preparing the research questionnaire are: First, the conceptual framework and measurement indicators were developed based on relevant theories and previous research results; Second, the formulation of research measurement indicators. The process of formulating and validating measurement indicators involved four experts, each of whom came from academics and professional practitioners in the supply chain sector to produce a final version, which was then used as research questionnaire; Third, the questionnaire was arranged into two parts. The first part contains introduction, respondent identity, instructions for filling out the questionnaire and a rating scale. The rating scale uses Likert scale of "1-5" scale, in which "1" indicates strongly disagree and "5" indicates strongly agree. This rating scale was further used to assess respondents for the selected statements in part 2 of the questionnaire. Then, the second part contains indicators and research variables. To make it easier for respondents to fill out the questionnaire, the researcher has simplified each assessment indicator into a statement and uses coherent language for easier comprehension. The indicators and variables used in this study are presented in Table 1 as follows.

Table 1. Indicators and Variables

Variable	Indicator	Definition	Adapted From
Digitalization	Digital products and services	Products and services leveraging digital technology to provide consumers with digital capabilities.	(Ageron et al., 2020; Hallikas et al., 2021)
	Digital operation process	Management and operational models utilizing digital technology, such as digital manufacturing, digital workflows, and more.	(Hallikas et al., 2021)
	Digital business model	Business models leveraging digital technology, such as mass customization, product-service systems, open innovation, and others.	(Hallikas et al., 2021; Zhao et al., 2023)
Supply Chain Resilience	Redundancy	Strategy of adding spare capacity or resources to anticipate disruptions.	(Christopher & Peck, 2004; Singh et al., 2019)
	Supply chain visibility	The supply chain manager's ability to see and identify, including recognizing any supply chain disrupting events.	(Christopher & Peck, 2004; Singh et al., 2019)
	Situational awareness	The ability to anticipate and perceive possible disruption risks refers to an organization's skill in identifying and understanding potential threats that could impact its operations.	(Ivanov, 2022; Zhao et al., 2023)
	Appropriate risk management decisions	Make accurate and prudent decisions to identify, evaluate, and mitigate potential risks that could disrupt the flow of goods and services in the supply chain.	(Choi & Hong, 2002; Singh et al., 2019)
	Agility	The capacity to quickly react to an erratic change in supply and demand refers to a company's ability to adapt promptly and efficiently when there are sudden and unpredictable shifts in the market.	(Christopher & Peck, 2004; Singh et al., 2019)
	Supply chain collaboration	Collaboration is a supply chain operation planned and executed jointly by two or more independent companies to achieve mutual benefits.	(Singh et al., 2019)
	Recovery efficiency	Supply chain resilience refers to the ability to restore operations quickly and use resources sparingly after a disruption.	(Chowdhury & Quaddus, 2017; Vugrin et al., 2011)
	Contingency planning	The process of planning alternative measures that can be taken to address disruptions or unexpected changes that may affect the supply chain. It involves identifying potential risks, determining appropriate responses, and preparing backup strategies to maintain the smooth flow of goods and services.	(Chowdhury & Quaddus, 2017)

Variable	Indicator	Definition	Adapted From
	Knowledge management	The ability to learn from interrupted feedback to gain a greater competitive advantage in the context of supply chain resilience refers to an organization's capacity to analyze disruptions, understand their causes, and extract valuable insights from them.	(Zhao et al., 2023)
Supply Chain Sustainability	Economic		
	Revenue	Income refers to the financial benefits that companies gain through business practices that not only prioritize short-term profitability but also consider environmental and social impacts.	(Gilani & Sahebi, 2021; Zahiri et al., 2017)
	Operating and production costs	The expenditure required to operate and produce goods or services in an environmentally friendly and socially responsible manner. This includes the costs of adopting more efficient technologies, using environmentally friendly raw materials, reducing waste and emissions, and meeting sustainability standards.	(Gilani & Sahebi, 2021; Zahiri et al., 2017)
	Environment		
	Emissions and greenhouse gases in production and transportation activities	The release of gases that contribute to global warming, such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), generated during the production of goods and transportation of products. the focus is on reducing these emissions to minimize negative impacts on climate change. may involve the use of clean technologies, renewable energy sources, fuel efficiency and optimization of transportation routes.	(López-Castro & Solano-Charris, 2021)
	Fuel consumption	The use of fossil or alternative fuels to power transportation and production activities. The focus is on reducing the amount of fuel used to minimize negative environmental impacts, such as greenhouse gas emissions and air pollution.	(Lopez-Castro & Solano-Charris, 2021)
	Environmental ecosystem effects	The impacts that supply chain activities have on the health and balance of natural ecosystems. This includes the effects of production, distribution and consumption on air and water quality, soil and climate change.	(Lopez-Castro & Solano-Charris, 2021)
	Social		
	Job creation	Efforts to provide decent and sustainable employment opportunities throughout supply chain activities. the focus is on creating jobs that not only provide income, but also guarantee safe, fair working conditions, and support employee welfare.	(Lopez-Castro & Solano-Charris, 2021)
	Balanced economic development	An effort to achieve economic growth in harmony with social and environmental goals. meaning creating economic value while maintaining social welfare and environmental sustainability.	(Zahiri et al., 2017)
	Effective working days due to disruptions	How well an organization can maintain productivity and operations during or after a disruption, such as a natural disaster, logistics disruption, or production issue. The goal is to ensure that disruptions do not significantly hamper operations, so productivity remains high and supply chains can continue to function efficiently, supporting overall business sustainability.	(Hosseini-Motlagh et al., 2020)

2.3. Data Collection

The data collection for this study used the survey method. Survey method is known as self-explanatory method that relies on factual data, empirical data collection, and normative statistical analysis to obtain a complete quantitative description (Flynn et al., 1990). By considering the advantages of the survey method, research in the field of supply chain management can gradually

contribute to the development of supply chain management theory, including conceptual validation (Huo et al., 2014). The object of this research is the Micro, Small, and Medium Enterprises (MSMEs) of Balikpapan City.

The considerations of choosing Balikpapan city are: (1) Balikpapan has a strategic position as a buffer city for the new capital city (IKN) in East Kalimantan. As one of the main economic centers in this province, MSMEs in Balikpapan play an important role in supporting local and regional economic activities; (2) the existence of IKN will increase the need for a more efficient and sustainable supply chain, thus placing Balikpapan in a unique position to test and implement the application of digital technology in the supply chain; and (3) by widespread and diverse MSMEs in this city, the results of the study can reflect the challenges and opportunities of digitalization in strengthening the resilience and sustainability of the MSME supply chain.

Based on the searching of information regarding the number of MSME in Balikpapan through the Balikpapan Cooperatives, MSMEs, and Industry Office, the Balikpapan City Central Statistics Agency, and the East Kalimantan Provincial Government official websites, researchers did not find the exact number. However, several online newspapers mentioned that the number of MSMEs in Balikpapan City in 2023 was 73,300. Meanwhile, the number of MSMEs that have Business Identification Number (NIB) is only 12,323. The uncertainty regarding the number of MSME population also affects the accuracy of the required data, such as MSMEs' characteristics, types or fields of business, locations, and profiles. To overcome this limitedness, researchers used direct observation techniques to investigate and identify, including manually recording MSMEs that spread across 6 sub-districts in Balikpapan city.

The sampling technique used was the purposive sampling method. This technique allows researchers to select the samples based on certain criteria that have been determined prior (Prasetyo et al., 2024). The purpose is to ensure that the selected sample holds the relevant skills and experience to answer the research problems (Sugiyono, 2022). Then, the approach used in determining the number of samples is the Lemeshow approach.

This approach is used when the population number is uncertain or widely varied (Lemeshow & David, 1997). By this approach, the number of samples that is 95% reliable are 96 samples. In this study, the number of samples was 200. Because of the incredibly varied research of MSMEs, especially in the role of digitalization on supply chain's resilience and sustainability, using a large number of samples allows researchers to capture more variations, including the capability to provide a better representation for the existing MSMEs. The use of a larger sample allows in-depth exploration on various factors that influence the supply chain. Determining the number of samples is also based on the rule of thumb of SEM analysis, which is the number of question indicators multiplied by a minimum of five (Latan, 2013).

Then, the criteria set for the research sample are MSMEs which were operating before, during, and after the COVID-19 pandemic. The active MSMEs in these three periods (before, during, and after the pandemic) are considered to have diverse experiences related to changes in market conditions and supply chain challenges. It allows the study to observe how the resilience and sustainability of their supply chains are affected by digitalization in different situations.

MSMEs that survive and continue to operate after the pandemic can be a relevant indicator for measuring the resilience and sustainability of the supply chain (Canwat, 2024). In addition, the COVID-19 pandemic brought significant challenges to the supply chain. By selecting MSMEs that run throughout these periods, researchers can explore the role of digitalization in helping MSMEs to adapt to these changes, thereby providing deeper insights into the effectiveness of digitalization. By using these criteria, the study can provide a more comprehensive and in-depth picture of the role of supply chain digitalization on the resilience and sustainability of the MSME supply chain in Balikpapan City.

2.4. Data Analysis

The data processing for this study used Ms. Excel and IBM SPSS Amos version 22. Ms. Excel was used to input, sort, and recapitulate the data from the distribution of research questionnaires. Meanwhile, IBM SPSS Amos was used to process and test the research hypotheses. This research used Structural Equation Modeling (SEM) approach because of its feature that can model the correlation between complex and multivariate variables (Zainal et al., 2021). SEM was chosen as the research approach for its ability to manage, estimate, and describe the correlation and the effect between variables in the proposed model (Abbas, 2020). Before testing the research hypothesis, tests on data normality, construct validity and reliability, and analysis of the proposed model compatibility were conducted (Khan et al., 2021; Sharma et al., 2022).

3. Results and Discussion

3.1. Demographic Characteristics of Respondents

The demographic characteristic of respondents provides an overview of the research respondents. Table 2 overviews the research respondents. The table shows the information of respondents in form of MSMEs' scale, field, and location. The scales of MSMEs are Micro (59%), Small (33%), and Medium (9%). Small-scale MSMEs is dominating MSMEs in Balikpapan City compared to small and medium ones. The fields are Agribusiness (3%), Fashion (3%), Culinary (54%), Services (15%), Beauty (4%), Automotive (2%), and Others (18%). Based on these findings, the number of culinary-based MSMEs is higher than other types of MSMEs which run before, during and after the Covid-19 pandemic. Culinary-based MSMEs in Balikpapan City are one of the most developed sectors, with a significant number of players.

Table 2. Characteristics Demographics of Respondents

Characteristics		Frequency	Percentage
Scale of MSMEs	Micro	117	59%
	Small	65	33%
	Medium	18	9%
	Total	200	100%
MSME Sector	Agribusiness	5	3%
	Fashion	6	3%
	Culinary	107	54%
	Services	29	15%
	Beauty	7	4%
	Printing	7	4%
	Automobile	4	2%
	Others	35	18%
	Total	200	100%
MSME Address	Balikpapan City Sub-district	34	17%
	Sub-district of Central Balikpapan	18	9%
	District of East Balikpapan	15	8%
	West Balikpapan sub-district	20	10%
	District of North Balikpapan	17	9%
	District of South Balikpapan	96	48%
	Total	200	100%

This dominance does not mean to understate the other types of businesses, but rather strengthens the finding that the culinary sector has an important role in the MSME sector of the city. Further, the located MSME addresses are Balikpapan City District (17%), Balikpapan Tengah District (9%),

Balikpapan Timur District (8%), Balikpapan Barat District (10%), Balikpapan Utara District (9%) and Balikpapan Selatan District (48%). The percentage of MSME spread is obtained based on survey methods and direct observation in Balikpapan City. It can be said that Balikpapan Selatan District is the area with the largest number of MSMEs compared to other areas. Based on the characteristics of the respondents obtained can be said that the research sample of the population can be considered representative (Zhao et al., 2023).

3.2. Data Normality

Data normality testing is one of the critical instruments in the basic assumptions of Structural Equation Modeling (SEM), which aims to ensure that each measurement indicator must be normally distributed because this assumption can affect the validity and reliability of the tested construct. Data normality testing uses skewness and kurtosis standard value of ± 2, in which if the processing of skewness and kurtosis values is less than ± 2 then the variable is declared normal and accepted, vice versa (Hair et al., 2010; Singh et al., 2018). The results of data normality testing show that each attribute is standard (< ± 2) based on univariate analysis while the skewness and kurtosis values are more than ± 2 based on multivariate analysis. Thus, bootstrap approach is used for testing the data normality (West et al., 1995). The basic assumption of bootstrap is that the technique does not require the assumption of normality because it utilizes the derivative of original sample to be more robust. Therefore, bootstrap accuracy is quite dependent on the quality of the original data used. One of the data parameters is the numbers of data (Hoyle, 2014). Nevitt and Hancock found that the using of data ratio of 5:1 (the amount of data should be five times larger than the number of attributes) in bootstrapping worked poorly. However, when the sample ratio was increased to 10:1, bootstrapping produced satisfactory results (Nevitt & Hancock, 2000). Based on these assumptions, the research data can be used for further testing and analysis, including research hypothesis testing.

3.3. Validity and Reliability

Table 3, shows the results of validity and reliability testing. Validity testing used Confirmatory Factor Analysis (CFA). The results of CFA showed the adequacy of the indicators and models used (Singh et al., 2018). The standard validity value is more than 0.50. If the value (factor loading) is less than 0.50, the construct is declared invalid and weak to measure the strength of the correlation between latent factors and indicator variables (Hair et al., 2010; Zainal et al., 2021). The validity testing results in table 3 show that the validity of all constructs is above 0.50, thus declared as valid. Furthermore, regarding the reliability testing, the standard reliability value is higher than 0.70 (Fornell & Larcker, 1981). If the reliability construct value is less than 0.70, then the construct is declared irrelevant. Based on the test results in Table 3, all constructs are declared reliable with a value above 0.70.

3.4. Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis is testing on the level of sufficiency and feasibility constructs of the proposed model. The standard CFA value used is 0.50 (Singh et al., 2018; Zainal et al., 2021). From the CFA results, it can be seen the sufficiency of the indicators and the model used (Singh et al., 2018). In Figure 2, the test results show that all constructs have a significance level above 0.50. The modification index is also applied on e1 and e2 for model improvement as seen in the Fig. 2.

3.5. SEM Model Fit Testing

The test on Structural Equation Modeling (SEM) model uses the Goodness of Fit Model criteria. This criterion consists of CMIN / DF (Chi-square Fit Index / Degrees of Freedom), GFI (Goodness-of-Fit Index), AGFI (Adjusted GFI), CFI (Comparative Fit Index), and RMSEA (Root Mean Square Error of Approximation). Of all the criteria, it is not necessary to use all of them to see the suitability of the research model, but it would be better if there were more than one fit criterion test model that meets the standard value (Hu & Bentler, 1999; Widarjono, 2010). It means that if more than one criterion has met the standard, the SEM model is considered to have such a good model fit. Based on the test results shown in Table 4, CMIN/DF (2.220) has met the set standard ($1 \leq x \leq 3$), indicating a good fit. GFI (0.847) and AGFI (0.807) exceed the limit value of 0.80, indicating an acceptable model

fit. CFI (0.919) is slightly below the standard> 0.95, but still shows a fairly adequate fit. RMSEA (0.078) is in the acceptable fit category (<0.08), although it does not reach a very good fit level (<0.05). CFI is the only criteria that has not met the standards. Meanwhile, other goodness of fit criteria has met the SEM model fit criteria standards. Overall, the SEM model shows a fairly good and acceptable fit.

Table 3. Construct Validity and Reliability

Constructs	Factor Loading	FL Squared	Error [εj]	Construct Reliability
1. Digitalization	2.701	2.432	0.568	0.928
D1	0.888	0.789	0.211	
D2	0.898	0.806	0.194	
D3	0.915	0.837	0.163	
2. Supply Chain Resilience	6.294	4.408	4.592	0.896
SCR1	0.679	0.461	0.539	
SCR2	0.693	0.480	0.520	
SCR3	0.671	0.450	0.550	
SCR4	0.696	0.484	0.516	
SCR5	0.723	0.523	0.477	
SCR6	0.686	0.471	0.529	
SCR7	0.667	0.445	0.555	
SCR8	0.752	0.566	0.434	
SCR9	0.727	0.529	0.471	
3. Supply Chain Sustainability	5.639	3.987	4.013	0.888
SSC1	0.754	0.569	0.431	
SSC2	0.679	0.461	0.539	
SSC3	0.743	0.552	0.448	
SSC4	0.763	0.582	0.418	
SSC5	0.689	0.475	0.525	
SSC6	0.679	0.461	0.539	
SSC7	0.667	0.445	0.555	
SSC8	0.665	0.442	0.558	

Table 4. SEM Model Test Result

Criteria	Test Result	Standard Criteria	Source
CMIN/DF	2.220	$1 \leq x \leq 2$ or $1 \leq x \leq 3$	Singh et al., 2018;
GFI	0.847	> 0,80	Singh & Sharma, 2016;
AGFI	0.807	> 0,80	Wagimin et al., 2019;
CFI	0.919	> 0,95	Zainal et al., 2021
RMSEA	0.078	< 0,05 good fit; < 0,08 acceptable fit	

3.6. Hypothesis Test

After conducting a series of tests and analyses including testing the Structural Equation Modeling model, the next step is testing the proposed hypothesis. The proposed hypotheses were three hypotheses (H_1, H_2, and H_3). The results are presented in Table 5.

Table 5. Hypothesis Test Result

Hypothesis	Path coefficient	P-value	Result
H_1 Digitalization → Supply Chain Resilience	0.665	0.002	Significant (p<0.05)
H_2 Digitalization → Sustainable Supply Chain	0.226	0.002	Significant (p<0.05)
H_3 Supply Chain Resilience → Supply Chain Sustainability	0.746	0.001	Significant (p<0.05)

Based on the results shown in Table 5 above, digitalization has a significant positive effect on supply chain resilience ($\beta = 0.665$; $p < 0.002$). The path coefficient value of 0.665 indicates a positive and significant influence, and the p-value is less than 0.05. It means that the proposed research hypothesis H_1 can be accepted. Second, digitalization positively affects supply chain resilience ($\beta = 0.226$; $p < 0.002$). The path coefficient value of 0.226 shows the positive influence, but not significant

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ISSN 1693-6590

enough with p-value of 0.002 ($p<0.05$). It means that the proposed hypothesis H_2 is accepted. Third, supply chain resilience has a significant positive effect on supply chain resilience ($\beta = 0.746$; $p < 0.002$). The path coefficient value obtained was 0.746, indicating a positive and highly significant influence with p-value of 0.001 ($p<0.05$). It means that the proposed hypothesis H_3 is accepted. From these results can be concluded that the entire proposed hypothesis is proven to have positive and significant effects. H_2 is not significant enough although it has positive influence. Thus, all three proposed hypotheses are accepted.

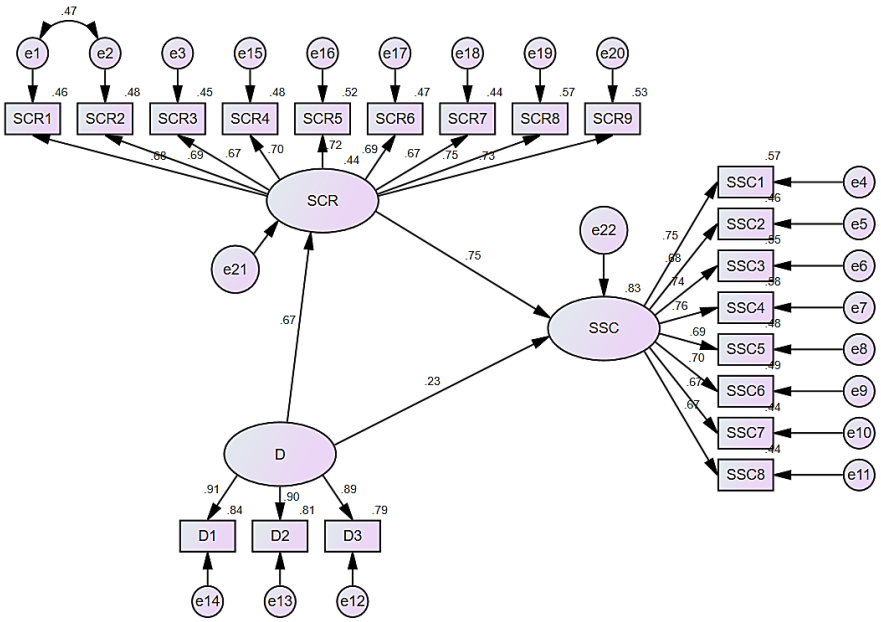

Fig. 2. SEM Model Test Result

This study reveals how digitalization can affect the improvement of supply chain resilience and sustainability. Through empirical study, it takes MSMEs in Balikpapan city as the object of research and proves that supply chain resilience and sustainability can be improved through proper digital implementation in each supply chain, although the characteristics (scale and business field) are different.

First, digitalization has a significant positive influence on supply chain resilience. This research is in line with the findings of several previous studies (Dolgui & Ivanov, 2021; Zhao et al., 2023). Supply chain resilience is explained through 3 aspects: absorption capability, response capability, and recovery capability. Absorbability reflects the company's ability to use resources and absorb or reduce disruptions when critical conditions occur. The transformation of business models into digital-based allows companies to increase supply chain visibility so that data and information sharing with other players in the supply chain becomes faster and more precise (Ivanov, 2021; Ivanov et al., 2022; Zhao et al., 2023). At the same time, optimizing the role of digitalization enables companies to maintain high situational awareness, to reduce supply chain risk, to increase supply chain resilience, and to improve responsiveness (Kache & Seuring, 2017).

Then, responsiveness is identical to the company's ability to make decisions appropriately and quickly in response to any disruptions that occur in the supply chain, including flexible resource optimization and punctual communication with partners during critical conditions (Cabral et al., 2012). Through digital technologies like Big Data Analysis, Internet of Things, and Blockchain, it is possible to integrate data and supply chain business models to make strategic decisions in dealing with any supply chain disruptions, including resource efficiency when risks occur. Finally, the recovery capability reflects the ability of companies and supply chains, to return to their original position quickly or even better, after a shock to the supply chain. Through the use of digital technologies such

as Data Integration, Big Data Analysis, Internet of Things, and Blockchain, the recovery process can be faster than traditional approaches (Zhao et al., 2023). The integration of risk-based data stored in digital technology can be utilized by stakeholders in designing and rebuilding supply chain business models that are more rational and resilient to critical conditions (Belhadi et al., 2021)Thus, this research provides confirmation supported by empirical evidence in which supply chain resilience can be optimized through digitalization or the proper use of digital technology.

Second, digitalization has a positive effect on sustainable supply chains. This finding is in line with several previous studies (Stroumpoulis et al., 2024; Wang et al., 2015). Digital technology nowadays shall be acknowledged to have the important role in the management chain of supply chain. Without the support of digital technology and information systems, it will be challenging for supply chain to achieve the utmost effectiveness and efficiency (Fiorini & Jabbour, 2017). The role of digitalization in transferring information and improving supply chain performance affects improving supply chain performance by considering environmental and social implications (Fahimnia et al., 2019; Liu et al., 2020; Saberi et al., 2019). The results of this study reveal that digitalization has a positive effect on improving sustainable supply chain performance (Dev et al., 2020; Yu et al., 2022). Furthermore, the role of digital technology can improve supply chain sustainability in the aspects of data monitoring and integration, transportation optimization, waste reduction, carbon footprint monitoring, and sustainability improvement (Debnath & Sarkar, 2023; Stroumpoulis et al., 2024; Wang et al., 2020).

Third, supply chain resilience has a significant positive effect on supply chains sustainability. This finding aligns with several previous studies (Fahimnia et al., 2019; Jabbarzadeh et al., 2018; Lopez-Castro & Solano-Charris, 2021). Sustainability and resilience can be linked to each other. Creating environmentally friendly supply chains directly minimizes and possibly eliminates waste which is resulting in leaner supply chains, while resource efficiency enables improvement in supply chain resilience (Fahimnia et al., 2019; Ruiz-Benitez et al., 2018). A resilient supply chain can benefit its players in improving operational performance. When this happens, market share will elevate which leading to increased profits for sustainable development (Mohammed et al., 2023). Sustainable supply chains without good resilience will find it difficult to maintain long-term operation which has the impact on meeting market demand and competitiveness. This connection proves that those two aspects are closely related to each other. Developing the right decision-making system can help develop supply chain resilience without hindering the improvement of supply chain sustainability (Giannakis & Papadopoulos, 2016).

3.7. Managerial Implications

Based on the presented research findings, there are several managerial implications found: First, the results of this study provide a strong foundation for companies, especially MSMEs, to integrate digital technology into all aspects of their supply chain. Investment in digital technology such as Management Information Systems, Big Data Analysis, and the Internet of Things will not only improve operational efficiency but also strengthen supply chain resilience. Companies need to design a comprehensive digitalization strategy, from planning to implementation, and taking the unique characteristics of each business into account, and; Second, companies need to build an adaptive organizational culture to technological change. Human resource training and development are the keys to ensure that the employees have the competencies needed to effectively utilize digital technology. In addition, strong collaboration between various departments within the company is essential to ensure flawless technology integration.

Third, it is important for companies to build strong partnerships with all players in the supply chain. Collaboration with suppliers, distributors, and customers will allow companies to share data, to increase supply chain visibility, and mutually build greater resilience. In addition, companies also need to consider the sustainability aspect in building these partnerships, with the aim of creating an environmentally and socially friendly supply chain. Lastly, continuous measurement and evaluation are essential to ensure the successful implementation of a digitalization strategy. Companies need to set relevant Key Performance Indicators (KPIs) and conduct regular evaluations to identify areas that

need improvement. Thus, companies can keep on improving and adapting to changes in the business environment. Overall, this study highlights the importance of digitalization in improving supply chain resilience and sustainability. The managerial implications obtained from this study can be a guide for companies in formulating more adaptive and sustainable business strategies in the digital era. By effectively integrating digital technology, companies can increase competitiveness, reduce risks, and contribute to sustainable development.

4. Conclusion

This study empirically tests the influence of the role of digitalization on supply chain resilience and sustainability among Micro, Small, and Medium Enterprises in Balikpapan City. Based on the research findings can be concluded that the proposed hypotheses have proven to have a significant positive effect (H_1 = the role of digitalization on supply chain resilience; H_2 = the role of digitalization on supply chain sustainability; and H_3 = resilience to supply chain sustainability), except H_2 which is found to have not a very significant effect. Through the right role of digitalization, the resilience of the MSMEs supply chain can be improved. In addition, increasing the resilience of the MSMEs supply chain also has a significant positive impact on supply chain sustainability. Although the influence of digitalization is not very significant on supply chain sustainability, the impact of digitalization is starting to affect the MSMEs supply chain to improve supply chain sustainability. These findings indicate that digitalization can be an important tool to strengthen the resilience of the MSME supply chain, but requires additional strategies to optimize the impact on economic, social, and environmental sustainability.

Furthermore, this study significantly provides important insights and knowledge that supply chain resilience and sustainability can be improved through optimizing the role of digital, even though the characteristics of the supply chain or business model are different. In addition, supply chain resilience and sustainability are two aspects that are interrelated with each other. If the sustainability of the supply chain resilience is good and strong, thus the long-term supply chain operations can be manifested. This study also becomes the bridge over the limitations on validating the concept of supply chain digitalization, supply chain resilience, and supply chain sustainability through empirical studies, by considering differences in supply chain characteristics. The limitations of this study are expected to direct the research in the future. Further research can expand the scope of case studies by considering differences in regions and the characteristics of business model or venture, the number of subjects, and by exploring other factors that can strengthen the relationship between the three concepts, such as government policy support or human resource capabilities, and comparing the results with other regions that have different digital infrastructure conditions.

Author Contribution: All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.

Funding: This research was funded by the Directorate General of Higher Education, Research and Technology - Ministry of Education, Culture, Research and Technology of The Republic of Indonesia through a research funding program the Beginner Lecture Research (PDP Regular) Funding Scheme for the 2024 Implementation Year, under contract number 113/E5/PG.02.00.PL/2024".

Acknowledgment: we would like express our gratitude to the Directorate General of Higher Education, Research and Technology - Ministry of Education, Culture, Research and Technology of the Republic of Indonesia for providing funds support this research. In addition, we would also like to acknowledge the University of Balikpapan, especially the Department for Research and Community Service that has provided training and provided the necessary facilities during the execution of this research.

Conflicts of Interest: The authors declare no conflict of interest.

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