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Digital Transformation and Process Integration: Enhancing Supply Chain Resilience in Thailand's Wholesale and Distribution Sector

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Abstract

Purpose: Digital transformation has become a crucial factor in enhancing supply chain resilience, especially in Thailand's wholesale and distribution sector. This study investigates the impact of digital transformation on supply chain integration, focusing on three key areas: information flow, physical flow, and financial flow, and examines their effects on resilience and operational performance. **Research Design, Data, and Methodology:** A quantitative approach was adopted, surveying 415 supply chain professionals, managers, and executives from firms undergoing digital transformation. Purposive and convenience sampling techniques ensured representation across industries. Data were analyzed using Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM). **Results:** The findings reveal that digital transformation significantly improves integration in information, physical, and financial flows. However, only physical and financial flow integration positively impact supply chain resilience, while information flow integration does not. Furthermore, supply chain resilience is found to have a significant positive effect on operational performance. **Conclusions:** This study offers valuable managerial insights for leveraging digital transformation to enhance supply chain integration and resilience, thereby improving operational performance in Thailand's wholesale and distribution sector. These results highlight the importance of prioritizing physical and financial flow integration to build a resilient and high-performing supply chain.

Keywords : Digital Transformation, Supply Chain Resilience, Process Integration, Operational Performance, Wholesale and Distribution

JEL Classification Code : M10, M31, L61, L62, O30

1. Introduction

Thailand's wholesale and distribution sector plays a crucial role in the nation's economy, facilitating the movement of goods across various industries, including fast-moving consumer goods (FMCG), electronics, and apparel. However, despite these advancements, the sector faces ongoing challenges such as complex regulatory frameworks and extended shipping durations, which can account for up to 20% of logistical inefficiencies (Cichosz et al., 2020).

In response to these challenges, digital transformation has emerged as a key driver of efficiency and resilience in Thailand's wholesale and distribution sector. The increasing adoption of digital tools, including artificial intelligence (AI), Internet of Things (IoT), and blockchain, is enabling

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firms to optimize supply chain operations by integrating information, physical, and financial flows (Suali et al., 2024).

Given this landscape, understanding how digital transformation influences supply chain integration and resilience is essential for improving operational performance in Thailand's wholesale and distribution sector. This study examines the extent to which digital transformation facilitates information, physical, and financial flow integration and its subsequent impact on supply chain resilience and operational performance.

While digital transformation is increasingly being integrated into supply chain management through technologies such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT), there remains a limited understanding of how digitalization influences process integration across information, physical, and financial flows within Thailand's wholesale and distribution sector.

This study addresses a critical research gap by examining the relationship between digital transformation and supply chain resilience through the lens of process integration. While previous studies have explored digitalization in supply chains globally, limited research has specifically focused on Thailand's wholesale and distribution industry, where technological adoption varies widely across firms (Suali et al., 2024). Understanding how digital transformation impacts information, physical, and financial flow integration can provide valuable insights for enhancing supply chain resilience and operational performance. The findings of this study will contribute to both theoretical and practical discussions on supply chain digitalization, offering implications for businesses seeking to strengthen their supply chains against future disruptions. Therefore, the study aims to (1) examine the impact of digital transformation on the integration of supply chain processes, (2) assess the influence of process integration on supply chain resilience, and (3) evaluate the effect of supply chain resilience on operational performance in Thailand's wholesale and distribution sector.

2. Literature Review

2.1. Digital transformation

Digital transformation (DT) has become a pivotal strategy for enhancing information flow integration within supply chains by streamlining data exchange and improving decision-making capabilities. The adoption of advanced technologies such as blockchain and digital twins optimizes data management, storage, and sharing, leading to greater efficiency (Liu et al., 2022). Additionally, research highlights that traditional supply chain systems face challenges like security and privacy concerns, which can be mitigated through digital transformation initiatives that enhance the robustness of information flows (Pennekamp et al., 2023). Industry 4.0 technologies, including the Internet of Things (IoT) and big data analytics, further facilitate real-time data exchange and processing, contributing to seamless integration across supply chains (Franceli & Turri, 2021). These advancements underscore the significant role of digital transformation in strengthening information flow integration, ultimately improving supply chain agility and operational performance.

Digital transformation plays a pivotal role in enhancing both physical and financial flow integration within supply chains by eliminating structural barriers and fostering seamless coordination among supply chain partners. According to digital empowerment theory, digital transformation enhances an organization's ability to manage information, material, and financial resources efficiently (Yuan et al., 2024). In terms of physical flow integration, digital technologies such as IoT and blockchain significantly improve the visibility and traceability of goods, reducing disruptions and optimizing logistics (Yang et al., 2021). By standardizing information-sharing interfaces, digital transformation also ensures real-time synchronization of material flows, leading to improved supply chain responsiveness (Pournader et al., 2020). Likewise, financial flow integration remains a challenge, as organizations are often hesitant to share financial data with upstream and downstream partners due to security concerns (McCormack & Johnson, 2002). However, digital transformation offers a solution by providing secure financial platforms that align financial transactions with information and material flows, ultimately enhancing supply chain efficiency (Ning & Yuan, 2021). Research has demonstrated that industrial platforms leveraging digital transformation successfully integrate financial flows, fostering better collaboration and reducing financial bottlenecks (Ning & Yuan, 2021). Thus, digital transformation is a key enabler of physical and financial flow integration, improving visibility, security, and overall supply chain resilience. Therefore, this study put forwards below hypotheses:

H1: Digital transformation has a significant effect on information flow integration.

H2: Digital transformation has a significant effect on physical flow integration.

H3: Digital transformation has a significant effect on financial flow integration.

2.2. Supply Chain Process Integration

Supply chain integration has long been a focal point in supply chain management research, traditionally examined through internal and external integration (Piprani et al., 2020;

Tan et al., 2023). However, recent studies emphasize a more granular approach, viewing integration through the lens of supply chain processes to better capture its complexities (Rajaguru & Matanda, 2019). This perspective defines supply chain process integration as a multidimensional construct comprising information flow integration, physical flow integration, and financial flow integration, each playing a crucial role in enhancing overall supply chain efficiency and resilience (Rai et al., 2006).

2.2.1. Information Flow Integration

Information flow integration plays a critical role in enhancing supply chain resilience by enabling real-time data sharing, improving decision-making, and fostering adaptability in dynamic environments (Sheffi & Rice, 2005). Prior studies highlight that seamless information flow across supply chain partners reduces uncertainties and enhances coordination, leading to greater responsiveness to disruptions (Huo et al., 2016). Effective information integration ensures that supply chain members have access to accurate demand forecasts, inventory levels, and customer orders, facilitating proactive risk mitigation and operational efficiency (Yuan et al., 2022). Additionally, digital technologies such as blockchain and cloud-based systems strengthen information transparency and traceability, further supporting supply chain resilience by reducing the risk of misinformation and enhancing trust among partners (Pournader et al., 2020). Rajaguru and Matanda (2019) argue that well-integrated information flows contribute to supply chain agility, allowing firms to quickly adapt to market fluctuations and recover from disruptions more efficiently. Thus, integrating information flows is a fundamental strategy for improving supply chain resilience, reducing vulnerabilities, and maintaining business continuity in uncertain environments. Based on previous studies, the following hypothesis is proposed:

H4: Information flow integration has a significant effect on supply chain resilience.

2.2.2. Physical Flow Integration

Physical flow integration refers to the seamless coordination and movement of goods and materials across different stages of the supply chain (Camarinha-Matos et al., 2019). This integration is crucial for enhancing supply chain resilience, as it ensures smooth and timely product delivery, reduces stockouts, and minimizes disruptions (Jüttner et al., 2003). By synchronizing the physical flow of materials, firms can respond more effectively to external shocks, such as natural disasters or supply shortages (Ponis & Koronis, 2012). Research has shown that high levels of physical flow integration allow for real-time monitoring, better inventory management, and a more flexible response to unforeseen events, thereby increasing the supply chain's ability to absorb and recover from disruptions (Yuan et al., 2024). Consequently, organizations that invest in physical flow integration are better positioned to maintain operational continuity and ensure long-term supply chain resilience (Christopher & Peck, 2004). Therefore, it is proposed that:

H5: Physical flow integration has a significant effect on supply chain resilience.

2.2.3. Financial Flow Integration

Financial flow integration involves the alignment and coordination of financial transactions, including payments, invoicing, and cash flow management, across the supply chain (Goh et al., 2017). This integration plays a critical role in enhancing supply chain resilience by ensuring that financial resources are readily available to mitigate disruptions and maintain operations during periods of uncertainty (Choi & Linton, 2011). Effective financial flow integration enables firms to quickly adapt to changes in demand, secure funding for risk management initiatives, and maintain financial liquidity in times of supply chain shocks (Yuan et al., 2022). Research indicates that firms with strong financial flow integration can achieve greater flexibility in their operations, reduce the impact of disruptions, and accelerate recovery processes, thereby strengthening overall supply chain resilience (Ivanov et al., 2017). Thus, organizations that invest in improving financial flow integration are more likely to withstand external challenges and maintain operational continuity. Building on this, the study proposes the following hypothesis:

H6: Financial flow integration has a significant effect on supply chain resilience.

2.3. Supply Chain Resilience

Supply chain resilience refers to the ability of a supply chain to adapt to and recover from disruptions, ensuring continuous operations and minimizing the impact of unforeseen events (Ponis & Koronis, 2012). Research has demonstrated that resilient supply chains can maintain service levels, reduce operational risks, and improve overall efficiency during disruptions (Hohenstein et al., 2015). By leveraging flexibility, risk management strategies, and real-time monitoring, resilient supply chains are better equipped to minimize downtime and optimize resource utilization, leading to enhanced operational performance (Wieland & Wallenburg, 2013). Studies have further indicated that firms with higher levels of resilience are able to achieve higher levels of operational performance, including cost-effectiveness, production quality, and customer satisfaction (Vongurai, 2022). Therefore, resilience not only helps companies recover from disruptions but also contributes significantly to their long-term operational success. Based on the above discussions, a hypothesis can be developed:

H7: Supply chain resilience has a significant effect on operational performance.

2.4. Operational Performance

Operational performance refers to a company's ability to efficiently and effectively manage its resources, processes, and capabilities to achieve organizational goals and create value (Vongurai, 2022). Scholars have emphasized that operational performance is a multidimensional construct encompassing factors such as cost efficiency, quality, speed, flexibility, and innovation (Huo et al., 2016; Rajaguru & Matanda, 2019). It has been widely acknowledged that operational performance is influenced by various internal and external factors, including supply chain integration, information sharing, and digital transformation (Yuan & Li, 2022). In particular, studies show that enhanced collaboration within the supply chain and the adoption of advanced technologies such as blockchain and digital twins have significant positive effects on improving operational performance (Liu et al., 2022; Pournader et al., 2020). Furthermore, resilient supply chains, which focus on flexibility and risk management, have been shown to play a crucial role in maintaining and improving operational performance, especially during disruptions (Christopher & Peck, 2004; Ponis & Koronis, 2012). As organizations strive for operational excellence, the integration of digital tools and the development of resilience capabilities have become essential strategies for improving operational performance in today's dynamic business environment (Vongurai, 2024).

3. Research Methods and Materials

3.1. Research Framework and Hypotheses

The research framework in this study is adapted from the theoretical models of previous works by Vongurai (2022) and Yuan et al. (2024). The framework builds on Vongurai's (2022) exploration of operational performance in the e-commerce distribution sector in Thailand, with a focus on factors like digital transformation and process integration. Additionally, Yuan et al.'s (2024) work on the effects of digital transformation on supply chain resilience, including the moderated and mediated effects, provides a solid foundation for developing the conceptual framework in this study. The model incorporates key factors such as digital transformation, information, physical and financial flow integration, and supply chain resilience to understand their impact on operational performance within Thailand's wholesale and distribution sector. Accordingly, the following framework and hypotheses are proposed, and a summary of the previous research that informed the model is presented in the Figure 1 and Table 1 per below:

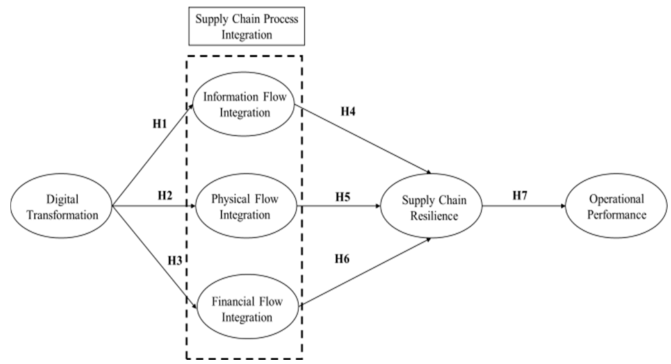

Figure 1: Conceptual Framework

H1: Digital transformation has a significant effect on information flow integration.
H2: Digital transformation has a significant effect on physical flow integration.
H3: Digital transformation has a significant effect on financial flow integration.
H4: Information flow integration has a significant effect on supply chain resilience.
H5: Physical flow integration has a significant effect on supply chain resilience.
H6: Financial flow integration has a significant effect on supply chain resilience.
H7: Supply chain resilience has a significant effect on operational performance.

Table 1: Summary of Previous Research

Author & Year	Key Variables	Research Finding
Vongurai (2022)	Analytics capabilities, Supply chain disruption orientation, Innovation capability, Operational performance	"Analytics capabilities significantly affect supply chain disruption orientation and resilience. Operational performance is influenced by supply chain disruption, supplier quality management, and innovation capability. Digital supply chain and resilience have no significant effect on operational performance."
Yuan et al. (2024)	Digital transformation, Supply chain resilience, Supply chain process integration (information, physical, financial), Environmental uncertainty	"Digital transformation significantly impacts supply chain resilience. Supply chain process integration mediates this relationship, and environmental uncertainty moderates the effect."

3.2. Methodology

The research utilizes a quantitative methodology with a questionnaire-based survey. The survey is structured into three sections: screening questions (2), Likert scale items (26), ranging from “strongly disagree” (1) to “strongly agree” (5), and demographic information (8), such as gender, age, income, education level, job role, and etc. The target population for this study consists of supply chain professionals, managers, and executives in wholesale and distribution businesses in Thailand that have either undergone or are in the process of digital transformation in their supply chain operations. The participants include Supply Chain Managers, Operations Managers, IT/Digital Transformation Leaders, Procurement and Logistics Officers, and Finance and Accounting Managers (for financial flow integration). Before data collection, the Item–Objective Congruence (IOC) index was calculated with the evaluation of four experts in logistics, resulting in a score of 0.5 or higher for all items. A pilot test involving 50 participants confirmed that the constructs met reliability standards, with Cronbach’s Alpha values exceeding 0.70 (Nunnally & Bernstein, 1994). The survey was then distributed to 415 participants at the managerial level or above. SPSS and SPSS AMOS were used for data analysis, with Confirmatory Factor Analysis (CFA) conducted to assess reliability, validity, and goodness-of-fit indices. Structural Equation Modeling (SEM) was applied to evaluate the model’s goodness-of-fit and test the hypotheses.

3.3. Population and Sample Size

This research targets supply chain professionals, managers, and executives from firms in Thailand's wholesale and distribution sector that are undergoing digital transformation in their supply chain operations. Key roles include Supply Chain Managers, Operations Managers, IT/Digital Transformation Leaders, Procurement and Logistics Officers, and Finance and Accounting Managers (for financial flow integration). A total of 415 valid responses were collected from a survey distributed to 650 participants, exceeding the minimum sample size of 200 recommended by Kline (2011) for complex models. This sample ensures a diverse representation of expertise and provides the necessary data to analyze the impact of digital transformation on supply chain resilience and operational performance.

3.4. Sampling Technique

Data for this study were collected using purposive and convenience sampling techniques to ensure representation across key supply chain roles in Thailand's wholesale and distribution sector. Purposive sampling targeted professionals with expertise in supply chain management, such as Supply Chain Managers, Operations Managers, IT/Digital Transformation Leaders, and Finance Managers, ensuring relevant insights into digital transformation. Convenience sampling facilitated access to participants from firms undergoing digital transformation, allowing for efficient data collection. The data collection process took place from June to September 2024, resulting in 415 valid responses, providing a diverse and industry-relevant sample for analyzing the impact of digital transformation on supply chain resilience.

4. Results and Discussion

4.1. Demographic Profile

The demographic characteristics of the 415 participants in this study, primarily supply chain professionals, managers, and executives from the wholesale and distribution sector in Thailand, reveal a diverse sample. The majority of participants were male (55.4%), aged between 25-44 years (65%), and held a bachelor’s degree (60.2%). Most respondents had 4-10 years of experience in the sector (55.4%) and worked in large organizations (49.4%). Regarding job roles, middle management was most represented (36.1%), followed by operational/technical staff (28.9%). Geographically, a significant portion of the sample operated in the Bangkok Metropolitan Area (48.2%). The main products distributed by these companies included consumer goods (28.9%), electronics (24.1%), and industrial equipment (19.3%). This varied demographic profile provides a comprehensive representation of professionals involved in digital transformation within Thailand’s supply chain sector.

Table 2: Demographic Profile (n=415)

Demographic Questions	Response Options	Frequency (n=415)	Percentage (%)
1. Gender	Male	230	55.40%
	Female	170	40.90%
	Other	5	1.20%
	Prefer not to say	10	2.40%
2. Age Group	18-24	40	9.60%
	25-34	120	28.90%
	35-44	150	36.10%
	45-54	70	16.90%
	55 or older	35	8.40%
3. Level of Education	High school or equivalent	20	4.80%
	Bachelor’s degree	250	60.20%
	Master’s degree	120	28.90%
	Doctoral degree	10	2.40%
	Other (please specify)	15	3.60%

Demographic Questions	Response Options	Frequency (n=415)	Percentage (%)
4. Years of Service	Less than 1 year	30	7.20%
	1-3 years	100	24.10%
	4-6 years	110	26.50%
	7-10 years	120	28.90%
	More than 10 years	55	13.30%
5. Firm Size	Small (1-50 employees)	60	14.50%
	Medium (51-200 employees)	150	36.10%
	Large (201+ employees)	205	49.40%
6. Job Position	Top Management (CEO, COO, etc.)	50	12.00%
	Middle Management	150	36.10%
	Operational/Technical staff	120	28.90%
	IT/Technology staff	75	18.10%
	Other (please specify)	20	4.80%
7. A Firm in Which Region of Thailand	Bangkok Metropolitan Area	200	48.20%
	Central Thailand	85	20.50%
	Northern Thailand	50	12.00%
	Southern Thailand	50	12.00%
	Northeastern Thailand	30	7.20%
8. Main Product or Service	Consumer goods	120	28.90%
	Industrial equipment	80	19.30%
	Electronics	100	24.10%
	Food and beverage	70	16.90%
	Healthcare products	30	7.20%
	Other (please specify)	15	3.60%

4.2. Confirmatory Factor Analysis (CFA)

The CFA results for the variables in this study in Table 3 demonstrate strong measurement validity based on established criteria. Cronbach's Alpha values for all variables ranged from 0.781 to 0.889, surpassing the accepted threshold of 0.70, indicating good internal consistency (Nunnally & Bernstein, 1994). The factor loadings ranged from 0.648 to 0.868, all exceeding the minimum acceptable value of 0.5, which is consistent with Fornell and Larcker's (1981) recommendations for acceptable loadings. Composite reliability (CR) values ranged from 0.782 to 0.890, all above the threshold of 0.7, meeting the criteria for construct reliability (Fornell & Larcker, 1981). Additionally, average variance extracted (AVE) values ranged from 0.465 to 0.729, all above the 0.4 threshold, fulfilling the criteria for convergent validity (Fornell & Larcker, 1981). The results, therefore, support the convergent and discriminant validity of the measurement model, confirming the reliability and robustness of the constructs used in this study.

Table 3: Confirmatory Factor Analysis Result, Composite Reliability (CR) and Average Variance Extracted (AVE)

Variables	Source of Questionnaire (Measurement Indicator)	No. of Item	Cronbach's Alpha	Factors Loading	CR	AVE
Digital Transformation (DT)	Yuan et al. (2024)	4	0.792	0.648-0.728	0.794	0.491
Information Flow Integration (IFI)	Yuan et al. (2024)	4	0.823	0.694-0.816	0.823	0.539
Physical Flow Integration (PFI)	Yuan et al. (2024)	4	0.781	0.661-0.868	0.782	0.473
Financial Flow Integration (FFI)	Yuan et al. (2024)	3	0.889	0.845-0.868	0.890	0.729
Supply Chain Resilience (SCR)	Vongurai (2022)	6	0.839	0.649-0.715	0.839	0.465
Operational Performance (OP)	Vongurai (2022)	5	0.866	0.691-0.806	0.867	0.567

Note: CR = Composite Reliability, AVE = Average Variance Extracted

The correlation matrix presented in Table 4 shows the relationships between the study variables, with the diagonal values representing the square root of the average variance extracted (AVE) for each construct. The square roots of the AVE for each variable (e.g., 0.682 for SCR, 0.701 for DT, etc.) are greater than the off-diagonal correlation values, confirming the discriminant validity of the constructs (Jaruwanakul, 2023). The correlation values between the constructs are below the threshold of 0.80, suggesting that there are no issues with multicollinearity (Studenmund, 1992). These results indicate that the variables in the model are distinct and do not suffer from excessive intercorrelation, thus ensuring the robustness of the measurement model.

Table 4: Discriminant Validity

	SCR	DT	FFI	PFI	IFI	OP
SCR	**0.682**					
DT	0.552	**0.701**				
FFI	0.612	0.575	**0.854**			
PFI	0.596	0.543	0.671	**0.688**		
IFI	0.232	0.242	0.322	0.225	**0.734**	
OP	0.305	0.143	0.290	0.414	0.117	**0.753**

Note: The diagonally listed value is the AVE square roots of the variables

The measurement model demonstrates an acceptable fit based on the model fit indices in Table 5. The CMIN/DF value of 1.251 is well below the threshold of 3.00 (Hair et al., 2006), indicating a good model fit. Additionally, all other fit indices exceed the recommended values, including the GFI (0.939), AGFI (0.924), NFI (0.926), CFI (0.984), and TLI (0.982), all of which are greater than 0.90 (Arbuckle, 1995; Hair et al., 2006). Furthermore, the RMSEA value of 0.025 is well below the cutoff of 0.05 (Browne & Cudeck, 1993), further confirming a good fit. Overall, these results suggest that the measurement model is robust and well-suited for the data analysis.

Table 5: Goodness of Fit of Measurement Model

Index	Acceptable Values	Measurement Model
		Statistical Values
CMIN/DF	< 3.00 (Hair et al., 2006)	355.317/284 = 1.251
GFI	≥ 0.90 (Hair et al., 2006)	0.939
AGFI	≥ 0.90 (Hair et al., 2006)	0.924
NFI	≥ 0.90 (Arbuckle, 1995)	0.926
CFI	≥ 0.90 (Hair et al., 2006)	0.984
TLI	≥ 0.90 (Hair et al., 2006)	0.982
RMSEA	< 0.05 (Browne & Cudeck, 1993)	0.025
Model summary		**Acceptable Model Fit**

Remark: CMIN/DF = ratio of the chi-square value to degree of freedom, GFI = goodness-of-fit index, AGFI = adjusted goodness-of-fit index, NFI = normalized fit index, CFI = comparative fit index, TLI = Tucker-Lewis index, and RMSEA = root mean square error of approximation.

4.3. Structural Equation Model (SEM)

The measurement model demonstrates an acceptable fit based on the model fit indices. The CMIN/DF value of 1.251 is well below the threshold of 3.00 (Hair et al., 2006), indicating a good model fit. Additionally, all other fit indices exceed the recommended values, including the GFI (0.939), AGFI (0.924), NFI (0.926), CFI (0.984), and TLI (0.982), all of which are greater than 0.90 (Arbuckle, 1995; Hair et al., 2006). Furthermore, the RMSEA value of 0.025 is well below the cutoff of 0.05 (Browne & Cudeck, 1993), further confirming a good fit. Overall, these results suggest that the measurement model is robust and well-suited for the data analysis, as resulted in Table 6.

Table 6: Goodness of Fit of Structural Model

Index	Acceptable Values	Structural Model
		Statistical Values
CMIN/DF	< 3.00 (Hair et al., 2006)	462.738/292 = 1.585
GFI	≥ 0.90 (Hair et al., 2006)	0.920
AGFI	≥ 0.90 (Hair et al., 2006)	0.904
NFI	≥ 0.90 (Arbuckle, 1995)	0.904
CFI	≥ 0.90 (Hair et al., 2006)	0.962
TLI	≥ 0.90 (Hair et al., 2006)	0.958
RMSEA	< 0.05 (Browne & Cudeck, 1993)	0.038
Model summary		**Acceptable Model Fit**

Remark: CMIN/DF = ratio of the chi-square value to degree of freedom, GFI = goodness-of-fit index, AGFI = adjusted goodness-of-fit index, NFI = normalized fit index, CFI = comparative fit index, TLI = Tucker-Lewis index, and RMSEA = root mean square error of approximation.

4.4. Research Hypothesis Testing Result

The research hypothesis testing results are measured from the standardized coefficients (β) with t-values, which provide insights into the relationships between digital transformation, flow integration, supply chain resilience, and operational performance, as shown in Table 7 and Figure 2.

Table 7: Hypothesis Result of the Structural Model

H	Paths	Standardized Path Coefficients (β)	S.E.	T-Value	Tests Result
H1	IFI←DT	0.291	0.068	4.701*	Supported
H2	PFI←DT	0.639	0.071	8.690*	Supported
H3	FFI←DT	0.656	0.083	10.454*	Supported
H4	SCR←IFI	0.043	0.048	0.859	Not Supported
H5	SCR←PFI	0.384	0.071	5.952*	Supported
H6	SCR←FFI	0.402	0.047	6.857*	Supported
H7	OP←SCR	0.327	0.069	5.551*	Supported

Note: *p<0.05

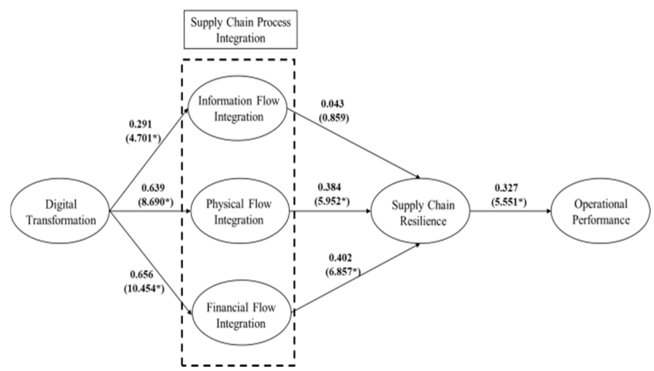

Figure 2: The Results of Structural Model

Remark: Dashed lines, not significant; solid lines, significant.
*$p<0.05$

The results of the structural model hypotheses provide valuable insights into the relationships between digital transformation, flow integration, supply chain resilience, and operational performance, as shown in Table 7 and Figure 2.

The research hypothesis testing results are measured from the standardized coefficients (β) with t-values, which help assess the strength and significance of the relationships between digital transformation, flow integration, supply chain resilience, and operational performance. According to the findings, Hypotheses H1, H2, and H3 are all supported, indicating that digital transformation significantly influences various aspects of flow integration in the supply chain. Digital transformation has a significant positive effect on information flow integration (β=0.291, t=4.701), physical flow integration (β=0.639, t=8.690), and financial flow integration (β=0.656, t=10.454), all with t-values greater than the critical value of 1.96 ($p<0.05$). These results align with previous research by El Baz and Soudani (2020), which suggests that digital transformation improves the efficiency and integration of various flow processes, facilitating seamless communication and data exchange in supply chain operations. Additionally, the findings from this study support the work of Camarinha-Matos et al. (2019), who highlighted the importance of digital tools in enhancing both physical and financial flow integration.

In contrast, H4, which hypothesizes a significant effect of information flow integration on supply chain resilience, is not supported (β=0.043, t=0.859). This finding suggests that while information flow integration is crucial for optimizing supply chain processes, it may not directly contribute to supply chain resilience, which may be influenced by other factors. This aligns with the observations made by Sheffi and Rice (2005), who noted that resilience is influenced by a more complex set of factors, including but not limited to information flow.

However, H5 and H6 are supported, showing that both physical and financial flow integration have a significant positive effect on supply chain resilience. The results reveal that physical flow integration (β=0.384, t=5.952) and financial flow integration (β=0.402, t=6.857) significantly contribute to enhancing supply chain resilience, as confirmed by studies such as those by Christopher and Peck (2004) and Simchi-Levi et al. (2000), who argued that efficient flow integration helps organizations better respond to disruptions and ensures more robust supply chains. The positive impact of financial flow integration on resilience also aligns with the work of Goh et al. (2017), who emphasized the role of financial integration in building agility and responsiveness in supply chains.

Finally, H7 is supported, with the results indicating that supply chain resilience significantly affects operational performance (β=0.327, t=5.551). This suggests that organizations with resilient supply chains are better equipped to handle disruptions and maintain operational performance. This finding is consistent with studies by Hohenstein et al. (2015), and Vongurai (2022) who found that supply chain resilience enhances operational performance by enabling firms to adapt to unexpected challenges and maintain continuity in their operations. In conclusion, these findings highlight the importance of digital transformation and flow integration in strengthening supply chain resilience, which, in turn, contributes to improved operational performance.

5. Conclusions and Recommendation

5.1. Conclusion and Discussion

The results provide strong support that firms with valuable, rare, and inimitable resources, such as digital technologies, can achieve competitive advantages. Our findings suggest that digital transformation, which serves as a resource for enhancing supply chain integration, directly impacts key dimensions of integration and resilience. Specifically, the significant positive effects of digital transformation on physical and financial flow integrations align with previous studies, which have argued that digital technologies enable firms to synchronize and optimize the flow of physical goods and financial transactions (Camarinha-Matos et al., 2019; Sheffi & Rice, 2005).

From the perspective of dynamic capabilities, this study supports the notion that digital transformation enhances an organization's ability to adapt to changes and uncertainties, thereby improving supply chain resilience. This is consistent with the work of Christopher and Peck (2004), who emphasize the importance of building a resilient supply chain through flexibility, collaboration, and the integration of new technologies. Additionally, the positive relationship between supply chain resilience and operational performance is in line with previous literature suggesting that resilient supply chains can absorb disruptions and sustain or even improve performance in the face of challenges (Hohenstein et al., 2015; Vongurai, 2022).

The insignificant impact of information flow integration on supply chain resilience may stem from several factors. While digital transformation enhances information sharing, resilience depends on how effectively firms act on it. Excessive or fragmented data can lead to decision paralysis, and delays in response time may reduce its immediate benefits. Additionally, resilience often relies on external partners, whose inefficiencies can limit the effectiveness of shared information. Unlike physical and financial flow integration, which directly influence tangible adjustments, information flow alone may not enhance resilience without real-time decision-making and agile responses. Organizational factors such as leadership, analytical capabilities, and strategic execution may also mediate this relationship, highlighting the need for further research on leveraging information flow for resilience.

This study contributes to the literature by extending the application of digital transformation and supply chain integration theories within the context of supply chain resilience and operational performance. The findings underscore the importance of digital transformation in enhancing physical and financial flow integrations, which are key drivers of resilience. Additionally, this study highlights the limited role of information flow integration in directly influencing resilience, suggesting that future research might consider other factors, such as organizational culture, flexibility, or external environmental factors, that may mediate the relationship between information flow integration and resilience.

Furthermore, by linking supply chain resilience to operational performance, this study offers empirical support for the dynamic capability's perspective, particularly the ability of firms to leverage digital transformation to respond to disruptions and achieve sustained performance. This provides valuable theoretical insight into the role of digital transformation in improving not only operational efficiency but also the strategic adaptability of supply chains.

In conclusion, this research contributes to the growing body of knowledge on the digital transformation of supply chains and provides practical insights for managers and policymakers seeking to enhance supply chain resilience and performance. The study emphasizes the need for a holistic approach to digital transformation, considering the interdependencies between different types of integration and the critical role of resilience in achieving long-term operational success.

5.2. Recommendation

Based on the findings from this study, several recommendations can be made for both academics and practitioners in the field of supply chain management.

The significant impact of digital transformation (DT) on physical, information, and financial flow integrations highlights the importance of continued investment in technology. Supply chain managers should prioritize digital tools and platforms that streamline operations, improve real-time data sharing, and enable better decision-making. Implementing advanced technologies, such as blockchain and cloud-based systems, can further enhance supply chain integration and resilience.

Given the positive effects of physical and financial flow integration on supply chain resilience, businesses should focus on improving the alignment between logistics operations and financial management. This can be achieved through technologies that support better inventory tracking, financial data integration, and optimized cash flow management. Firms should look to integrate physical and financial systems more tightly to create a more resilient and adaptive supply chain.

The study confirms that supply chain resilience significantly impacts operational performance. Therefore, organizations should continue to build resilience through diversified sourcing strategies, agile supply chain models, and proactive risk management plans. Investments in training and scenario planning will help firms become more adaptable in the face of disruptions.

While information flow integration showed no direct impact on supply chain resilience in this study, future research could explore additional factors or contextual variables that may influence its effectiveness. Researchers should investigate how different types of information technologies or organizational culture could enhance the role of information flow in improving resilience.

This study contributes to the theoretical understanding of supply chain integration, digital transformation, and resilience. The findings validate previous research on the importance of digital tools for integrating different supply chain flows and the connection between resilience and performance. Future theoretical advancements should build on this by exploring the long-term impacts of digital transformation on different supply chain variables, with an emphasis on emerging technologies like AI and machine learning.

By following these recommendations, organizations can drive improvements in their supply chain performance and resilience while contributing to the growing body of research in supply chain management.

5.3. Limitation and Further Study

A key limitation is the lack of consideration for external uncertainties like regulations, geopolitical risks, and economic instability, which can moderate the impact of digital transformation on resilience. In volatile environments, even well-integrated supply chains may struggle to adapt due to factors beyond their control. Future research should examine how these external forces influence resilience strategies to provide a more comprehensive understanding.

In addition, a potential limitation is sampling bias due to the exclusion of non-digitally transformed firms. By focusing only on companies already adopting digital technologies, the study overlooks organizations that have yet to undergo digital transformation. This may limit the generalizability of the findings, as the impact of digital integration on resilience could differ for firms at varying stages of technological adoption. Future research should consider a broader sample to capture diverse digital maturity levels.

A limitation of this study is the lack of industry-specific analysis, despite including firms from FMCG, electronics, and apparel sectors. Digital transformation may impact supply chain resilience differently across industries due to variations in operational complexity, demand volatility, and technology adoption. Future research should explore these sectoral differences to provide more tailored insights.

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