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The Effects of Supply Chain Flexibility on Customer Responsiveness: the Mediating Role of Digitalization and Innovation Orientation

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ARTICLE INFO	ABSTRACT
Submission: July 04, 2026 Revised: July 19, 2026 Accepted: August 02, 2026 Available Online: August 17, 2026 Keywords: Supply Chain Integration; Digitalization; Streamline Operations; Strategic Innovation; Business Agility Corresponding author: Muhammad Saif-ur-Rahman Email: muhammadsaifurrahmano45@gmail.com	This study aims at exploring the mediating role of digitalization and innovation orientation in examining the impact of Supply Chain Flexibility dimensions on Customer Responsiveness. The study adopts the existing concept of flexibility in the supply chain, and adds the construct of digitalization to the model and realigns the innovation orientation as a mediator in the model. The research is based on the Dynamic Capability View, which highlights the role of operational, technological and organizational capabilities in the dynamic market conditions. The method used was quantitative research, with a cross sectional survey design. A structured questionnaire with 31 items on the Likert scale was used to gather data, which included supply flexibility, internal flexibility, distribution flexibility, digitalization, innovation orientation and customer responsiveness. Partial Least Squares Structural Equation Modeling (PLS-SEM) with the software of SmartPLS was used for data analysis. The results suggest that digitalisation has a strong positive impact on customer responsiveness and distribution flexibility has a positive effect on digitalisation. In addition, the internal flexibility shows an important relationship with the innovation orientation. The mediation analysis results show that the relationship between distribution flexibility and customer responsiveness is mediated by digitalization, and that the relationship between internal flexibility and customer responsiveness is mediated by innovation orientation. The paper adds value from a theoretical perspective by extending the concept of flexibility-responsiveness, and from a practical perspective by providing managerial recommendations for combining flexibility, digitalization and innovation-inducing processes to enhance customer responsiveness in a dynamic supply chain.

Introduction

The world supply chains are being run in a more uncertain and volatile environment. The competitive pressure on enterprises in the world has risen due to the fluctuations in the market, technological revolution, disruption in the supply chain, shift in the consumer preference etc.. The topical research highlights that due to environmental dynamism and the digital transformation, supply chain functions are changing in essence, and the organisation needs to be more responsive and flexible (Jum'a et al., 2025; Wei et al., 2025). Under these circumstances, cost efficiency is no longer the only tool that firms can use; rather, the prospect to react quickly to the needs of customers and act proactively in this regard has become a major strategic priority.

Customer responsiveness is the ability of a firm to predict, adjust and meet the changing customer needs in a timely fashion. Responsiveness has taken centre stage in sustainable competitive advantage as customer expectations keep on increasing regarding customisation, speed of delivery and service quality. Responsiveness is not a single ability. Operational and technological expertise make this possible by utilizing them efficiently in the supply chain process.

Conventionally, the study concentrated on the internal manufacturing flexibility as the means of dealing with the variability of demand. With time, this vision became more inclusive as a supply chain flexibility strategy, as there was an appreciation that flexibility should not just be seen in terms of the firm but also in terms of suppliers and distribution networks. According to modern literature the supply chain flexibility includes (supply flexibility, internal flexibility, and distribution flexibility) a multi-dimensionality approach (Jafari et al., 2023). Flexibility in supply helps companies to change suppliers or alter sourcing quantities; flexibility in production systems helps companies to restructure their production systems efficiently; flexibility in distribution helps companies make appropriate logistics and delivery arrangements. The combination of these dimensions enables firms to have the operational competencies necessary to handle uncertainty.

Problem Statement

Most businesses invest in supply chain flexibility and digitalisation, several businesses are not consistent with the high level of customer responsiveness. The flexibility offers structural choices and the digitalisation improves the information options, but these investments do not necessarily lead to high results in responsiveness. The challenges that organisations are usually confronted with include coordination problems, delays, extra use of resources, overtime, incompatibility of culture with technology, and the inability to integrate among supply chain partners.

Supply chain flexibility and how it affects customer responsiveness, it has been investigated in previous studies (Jafari et al., 2023) and have, at the same time, looked at digital supply chain adoption and performance implications on their own (Wei et al., 2025). The empirical studies that combine the aspects of flexibility, digitalisation, and innovation orientation into one concept are scarce. Specifically, the mediating effect of innovation orientation in reinforcing or conditioning the relationship between digitalisation and customer responsiveness has not been studied in detail. These gaps restrict the knowledge of the linkage between operational, technological, and cultural capabilities to improve responsiveness.

Gap Analysis

The basic model provided a connection between three aspects of supply chain responsiveness and responsiveness to customers, where innovation orientation serves as a moderator (Jafari et al., 2023). Although this model offered relevant theoretical and empirical references, it failed to actually integrate digitalisation as a core competence. Digital supply chains are becoming more popular and its lacking may leads towards declining phase of the business.

Recent literature focuses on the idea that digital transformation strengthens supply chain agility and performance (Jum'a et al., 2025; Zhu et al., 2024), but not many studies consider digitalisation as a part of the flexibility-responsiveness framework. Additionally, the study of the moderating role played by innovation orientation in relation to the influence of digitalisation on responsiveness has not been adequately researched. A necessity to create and empirically test a comprehensive model that incorporates the aspects of flexibility of supply chains, digitalisation, and orientation to innovations in the dynamic capabilities framework.

Research Objectives

The research questions of this project are:

1. To test how the supply flexibility affects customer responsiveness.
2. To look into how internal flexibility influences customer responsiveness.
3. To investigate the effect of distribution flexibility on customer responsiveness.
4. To analyse the effects of digitalisation on the responsiveness of customers.
5. To examine whether innovation orientation plays a mediating role in the relationships.

Research Questions

The following research questions will be the subject of this study:

1. What are the effects of the dimensions of supply chain flexibility on the responsiveness of customers?
2. Does digitalisation lead to customer responsiveness?
3. Does digitalization and innovation orientation enhance or hinder the association between flexibility, and customer responsiveness?

Research Significance

The study builds on the existing supply chain flexibility-customer responsiveness model and introduces digitalisation as an additional capability. It is a part of the Dynamic Capability View because it focuses on the collective influence of operational flexibility, digital capability, and innovation orientation on the outcomes of responsiveness. This study enhances the theoretical knowledge on the incorporation of capabilities in supply chains by introducing the concept of digitalisation and examining its integration with the innovation orientation.

As a manager, this research offers insight into how to balance the flexibility of operations, digital transformation, and organisational culture. It assists managers in focusing on flexibility investments, launching digital initiatives successfully, and fostering innovation-based cultures that lead to responsiveness. Finally, the results used to make strategic decisions that result in enhancing customer responsiveness in dynamic and competitive contexts.

Literature Review

The supply chain management has developed tremendously with globalisation, technological development and growing customer expectations. The current organisations are operating under competitive market environments where they are forced to react rapidly to the market dynamics (Sahoo, 2023). With the customer expectations ever-changing, companies should be able to build supply chain sources that can enable them to be responsive at the same time as this should be done without compromising operational efficiency. The current research investigates the connection between the supply chain flexibility and customer responsiveness, along with the introduction of digitalization and innovation orientation as a modulating construct (Lopez-Morales, 2023) . This part of the paper examines the literature pertaining to dependent and independent variables employed in the conceptual framework.

Customer responsiveness is the quality of an organisation in identifying, interpreting, and responding in a manner that is effective in responding to the needs of customers and changes in the market (Mwangi, 2025) . It is an indication of the speed at which companies can change their operations in order to provide products and services that satisfy the changing customer

demands (Hajli, 2020). Responsiveness has been regarded as a vital capability that helps firms to stay afloat in dynamic markets in the contemporary supply chain environments.

The research presented examines the relationship between supply chain capabilities and responsiveness and shows that flexible supply chain structures are an important factor in improving the responsiveness of an organisation to its customer. Empirically has been proven that flexibility of the supply chain enables the companies to adapt their procurement process, production process, and distribution, as a response to the changes of customer demand (Jafari et al., 2023). Companies that have flexible systems are able to preserve the quality of services delivered, as well as being able to react to unforeseen changes in the market.

Customer responsiveness is a factor that also contributes to the connection between innovation and firm performance. Research on the connection between the supply chain processes and innovation has shown that effective supply chain capacities tend to mediate the relationship between innovation and organisational outcomes (Nguyen Van et al., 2025). This implies that companies need to combine supply chain responsiveness with innovation programmes in the quest to gain sustainable competitive advantage.

Supply flexibility defined as the capacity of a firm to change sourcing, suppliers and also alter procurement mechanisms in response to changes in the demand conditions. In international supply chains, organisations are often faced with disturbances in the form of insufficiency of suppliers, transportation delays, and uncertainties in the geopolitical frontiers (Li et al., 2025). Supply flexibility gives firms the ability to carry on with their activities through the use of more than one supplier and flexibility in procurement measures.

Integration of the customers in the supply chains is a significant parameter which aids in the flexibility of supply. As long as the organisations incorporate the customer information in supply chain planning procedures, the companies will be more equipped to foresee the changes in demand and modify sourcing approaches (Paramitha & Santosa, 2023 ; Akmal et al., 2025). The study on the integration of a supply chain indicates that market orientation and customer partnership greatly enhance the effectiveness of the supply chain in digitally transforming marketplaces (Aslam et al., 2025; Akmal et al., 2026)

Internal flexibility is the flexibility of internal operations in an organisation. It involves the capability of production systems, equipment and workforce to adapt to alternative production demands (Shi et al., 2023). Those firms that have high internal flexibility are able to adjust production volume, add differences in products and change the way operations are conducted without necessarily incurring huge expenses.

Internal flexibility is also associated with practises of supply chain integration and innovation. Research conducted on the topic of innovation-oriented supply chain integration shows that companies that merge innovative thinking and structural flexibility attain greater strategic performance results (Asare et al., 2024). This kind of integration helps organisations to align internal operations with external supply chain partners in a better way. Internal flexibility, too, is significant in the aspect of technological adaptation. The production systems in organisations working in digitally transforming sectors need to be kept changing to adapt to new technologies. Companies with flexible internal operations can more easily adopt digital tools and adopt technological innovations into their business (Jafari et al., 2023).

Distribution flexibility is the capability of firms to change the logistics and delivery process to suit evolving customer demands. This also entails the capability of changing the modes of transportation, changing delivery schedules, and the ability to redistribute inventory among the distribution networks (Liao, 2020).

Distribution flexibility is a necessary part of modern supply chain since customers become more demanding in the quality of services delivered faster or more reliably. Companies that have flexible logistics will be able to modify transportation routes and delivery times within a short time as soon as demand among customers changes (Holloway, 2024b). A study looking at inventory flexibility also indicates that flexible inventory management contributes a lot to the efficiency of operations and also the responsiveness in the supply chain performances (Zhu et al., 2024).

The digital supply chain management is now more enhanced in the contemporary business world. Businesses that adapts the digital supply chain systems can enhance their efficiency in operations and to get competitive advantage in the market.

Conceptual studies of digital supply chains indicate that digital transformation improves the performance of supply chains through greater coordination and minimised operation inefficiencies (Perano et al., 2023).

The development of supply chain capabilities, and enhancing the performance of an organization based on the digital transformation plans. Research on the topic of digital transformation suggests that any organisation adopting digital technologies has observed great changes in supply chain competencies and competitive delivery (Ning and Yao, 2023). Digital supply chain technologies contribute to supply chain sustainability, resilience, and efficiency. The studies that have investigated the connection between digital supply chains and sustainability performance suggest that digital change can enhance the resilience and sustainability performance in the dynamism of supply chains (Atieh Ali et al., 2024).

Supply chain innovation is also very important in organisational performance. The research on the topic of supply chain innovation shows that new practises enhance the work process and build a competitive edge (Wong & Ngai, 2022). The supply chain is further improved with the incorporation of digital technologies and the ability to innovate. A study of the Industry 4.0 technologies suggests digital transformation and organisational ambidexterity to have a significant positive impact on sustainable supply chain performance (Belhadi et al., 2022).

Innovation capabilities also affect the financial aspect of the supply chain management. The research on the ambidextrous innovation strategy shows that the innovation strategy has a positive influence on the performance of small and medium-sized enterprises in supply chain financing (Lu et al., 2024). The digital supply chain capabilities also connect with organisational innovation strategies. Research on the adoption of digital supply chains shows that innovation is a key driver of improved supply chain agility and performance outcomes (Wang et al., 2025).

Relation with Variable Data

The relationship between the variables used in this study gets reasonably good support with empirical results present in the literature of supply chain management. Over the past few years, analysts have been keen to point out the need to combine operational capabilities with technological advancement in an attempt to enhance the performance and responsiveness of the supply chain (Perano et al., 2023). The latter relations are especially applicable in the context of uncertainty, a high rate of technological changes, and changing consumer demands.

The adoption of digital technologies in the supply chain management processes, systems, and decision-making systems is defined as digitalisation. Such technologies involve the use of data analytics environments, cloud communication infrastructure, artificial intelligence, and digital transaction systems. Digitalisation brings supply chain transparency and better coordination of the supply chain partners (Jafari et al., 2023). Studies show that the organisational performance in terms of greater efficiency in operations and supply chain resilience occurs with the intensified contribution of digital transformation. Research conducted on the topic of digital supply chain initiatives shows that digitalisation can assist organisations with the analysis of extensive amounts of operational data and making more appropriate decisions (Chatterjee et al., 2023).

Digital supply chains also enhance collaboration between actors of the supply chains. Evidence-based studies indicate that digital integration improves organisational performance because it allows more effective communication and information sharing among the supply networks (Hanaysha&Alzoubi, 2022). Technologies related to artificial intelligence are being applied more to boost the work of the supply chain. AI-led innovation enables organisations to learn the patterns of complex data and forecast the occurrence of a supply chain disturbance, enhancing resilience and operational performance (Belhadi et al., 2024 ; Bajwa et al., 2024).

The other major attributes of digital supply chain is better collaboration and visibility across supply chain networks. Organisations can improve their coordination with the supply chain partners (suppliers, logistics providers, and other supply chain partners) when they implement digital integration systems that can share information in real-time (Jum'a et al., 2025). Studies that investigate the concept of digital supply chain integration have shown that enhanced visibility and cooperative communication can have a very positive effect on the supply chain performance results (Shahadat et al., 2024). This kind of cooperation enables companies to minimise delays and resource wastage as well as to react fast to customer demand fluctuations.

Digital adoption is also a stronger enhancer of performance in operations by enhancing the flow of information throughout the supply chains. Digital platforms that are integrated help organisations to distribute operational data more efficiently and manage activities among several supply chain actors (Aslam et al., 2025). The research on the digital performance of supply chains proves that the organisation that adopts digital technologies achieves better performance because it has better coordination and information exchange systems (Wei et al., 2025).

As per the literature, customer responsiveness is driven by the interaction of supply chain flexibility, digitalisation and innovation orientation. Operational flexibility enables organisations to change their operations while digital technologies enhance the coordination and information visibility between the supply chain networks. With an innovation-based culture, the capabilities are able to transform operational and technological resources into enhanced responsiveness of firms (Dolgui, 2022). A combination of these constructs, therefore, in a cohesive framework, is a revelation on how organisations have become more responsive in the dynamic world of supply chains.

This literature review has critically discussed the theoretical and empirical foundations related to the supply chain flexibility, digitalization, innovation orientation and customer responsiveness. The analysed literature sources show that for modern supply chains to be competitive in dynamic markets, they are obliged to combine operational capabilities with technological innovations (Queiroz, 2021). Flexibility in supply chain such as supply, internal and distribution flexibility make organisations adjust their operations and effectively respond to customer demand variations. Digitalization also plays a key role to increase in the level of information visibility, coordination, and decision-making within supply chain networks (Tiwarei, 2024). In the literature, the culture of innovation orientation is also an aspect of cultural capability that reinforces the efficiency of operational and technological resources. Organisations that promote innovation have a higher chance of utilising supply chain capabilities to enhance responsiveness and performance (Kumar, 2020). In general, the analysed studies show that the combination of flexibility, digital technologies, and innovation orientation is an inclusive approach to perceiving how organisations become more customer responsive in contemporary supply chain settings.

Conceptual Framework

Informed by the theoretical understanding and practical experiences mentioned in the sections above, this research proposal elaborates on a conceptual framework to understand the interconnectedness among different aspects of supply chain flexibility, digitalization, innovation orientation and customer responsiveness. The model builds on the underlying framework by including digitalization and innovation orientation a middle variable that mediates the relationships between these variables.

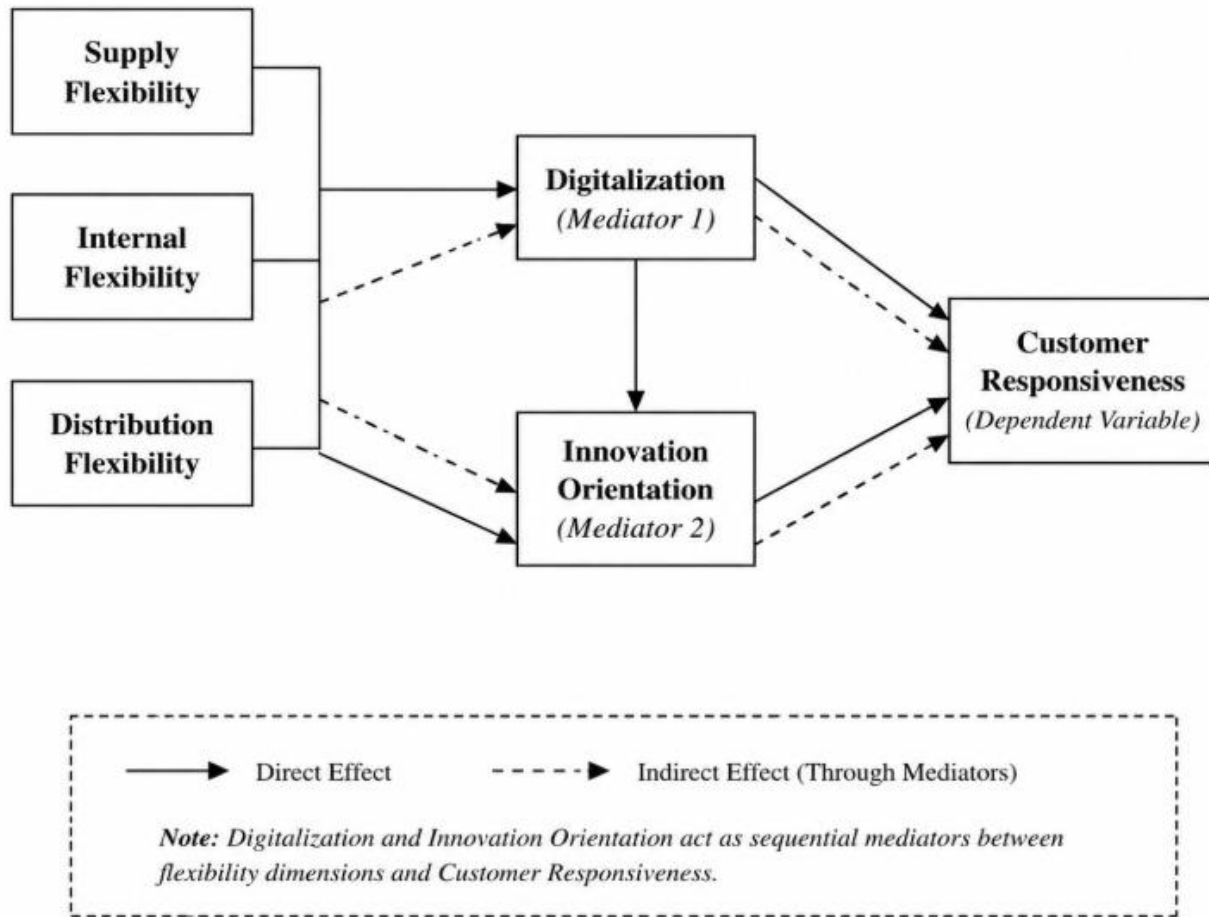


Figure 1: Conceptual Framework

The framework demonstrates how the supply flexibility, internal flexibility, and distribution flexibility influence customer responsiveness all together. Digitalization, and innovation orientation mediates between the relationships with flexibility dimensions and responsiveness either reinforces the relationship between the two or weakens the relationship between the two. It is hypothesized that the model is into position to accommodate organizations, which are more inclined and have a culture of digitalization and innovation, are in a better position to utilize the flexibility of operations and digital technologies to improve upon their responsiveness in dynamic and competitive supply chain settings. In such a way, the model underlines the importance of digitalization, and innovation orientation in ensuring that flexibility and efforts towards digital transformation are used to the maximum.

Methodology

Research Design

The research will be based on a positivist research philosophy proposed on the idea that reality is objective and is quantified based on observable and quantifiable data. Positivism is used in this study because the aim of the research is to explore how well the variants (i.e., flexibility of the supply chain, digitalization, innovation orientation, and customer responsiveness) are associated. Through a positivist approach, the study aims that hypothesis based on current theory and literature are tested instead of creating new subjective meanings.

This research adheres to the paradigm of positivism because it is deductive research. The deductive method starts with formulated theories, especially Dynamic Capability View and previous research in supply chains and derives hypotheses that are empirically operationalized and verified. The former model, which was developed out of previous research, is scaled up by adding

digitalization as a second mediator. The deductive method will enable the researcher to scientifically test the truthfulness of the proposed relationships in the sample chosen. The method guarantees the objectivity, replicability, and generalizability of the results.

The survey type that is used is a cross-sectional survey in which the data is obtained at a specific time. The design is suitable to investigate existing perceptions and practices concerning supply chain flexibility and digitalization. A survey enables the use of relatively large number of respondents and gives standardized data to enable consistency in measurement and statistical analysis. The study design is cross-sectional which is also appropriate to research objective of investigating relationships but not changes across time.

Population, Sampling, and Sample Size

The target population in this study is a person who is engaged in supply chain, logistics, operations or in a management position. These individuals are assumed to have the knowledge and experience to evaluate supply chain practices, digitalization activities, organizational responsiveness. Convenience sampling will be employed, as it is a non-probability sampling method employed because of practical limitations such as the time and accessibility restrictions (Sun et al., 2022). Generalizability reduces by this method, it is an effective method in the cases of research in the supply chain where we have limited access to the respondents.

Study will use the PLS-SEM rule of 10-times, which indicates that the minimum sample size needs to be ten times of the largest count of structural paths that go into a particular construct. This research has three direct predictors of customer responsiveness with numerous interaction terms through the moderation the large sample should be large enough. Consequently, the sample size of about 203 responses is regarded as a decent amount to select to guarantee the research findings to be statistically reliable and robust.

Research Instrument

The data collection tool in the study is a structured questionnaire that was utilized using scales that have already been tested. The questionnaire will be divided into 31 items (six constructs) and some demographic questions. The constructs are the capability to innovate internal flexibility, supply flexibility, distribution flexibility, digitalization, and customer responsiveness.

The questionnaire will be subdivided into segments that will deal with each construct. The items are derived based on the base paper by (Jafari et al., 2023) on the The effects of supply chain flexibility on customer Responsiveness and applicable studies on digital supply chain to provide content validity. There are demographic questions that are used to capture background details of the respondents like age, education and work experiences.

Construct Operationalization Table

Table 1 shows the constructs and the measurement items accordingly

Construct	Items	Source/Adaptation
Innovation Orientation (IO)	Q1-Q5	Adapted from base study by (Jafari et al., 2023)
Internal Flexibility (IF)	Q6-Q9	Manufacturing flexibility (Jafari et al., 2023)
Supply Flexibility (SF)	Q10-Q14	Supply flexibility (Jafari et al., 2023)
Distribution Flexibility (DF)	Q15-Q19	Distribution flexibility (Jafari et al., 2023)
Digitalization (DIG)	Q20-Q26	Digital adoption (Liu et al., 2022)
Customer Responsiveness (CR)	Q27-Q31	Responsiveness (Jafari et al., 2023)

The use of items of innovation orientation and flexibility constructs involves adaptation of the base model by (Jafari et al., 2023) which discusses the effects of supply chain flexibility on customer responsiveness, whereas, digitalization items are developed based on recent literature regarding digital supply chains. The responsiveness items of customers are measures of how the organization has reacted in an effective way to the needs of customers.

Cronbach alpha is used to conduct reliability analysis to determine the internal consistency of each construct (Islam et al., 2024). In case of need, items with low reliability or redundancy are revised or drop out especially in the digitalization construct. The pilot study will provide assurance that the ultimate questionnaire will be reliable and valid to collect data.

The questionnaire form will not need the respondents to give out their any personal details to meet the ethical requirements (Sun et al., 2022). This will help increase the privacy of respondents and provide the honesty of the answers.

Result

The empirical analysis of this study is presented in this chapter using the output from the SmartPLS created from survey responses. The chapter is designed following teacher's comments: Frequency distribution, Descriptive statistics, Reliability analysis, Results of structural model, Mediation analysis. This chapter is not merely about providing numerical results but also about the interpretation of the results in relation to supply chain flexibility, digitalization, innovation orientation and customer responsiveness.

The model is designed to highlight the mediating role of digitalization and innovation orientation between dimensions of Supply Chain flexibility and the customer responsiveness. The analysis will be based on the impact of supply flexibility, internal flexibility, and distribution flexibility on digitalization and innovation orientation, and then the impact of the former two on customer responsiveness.

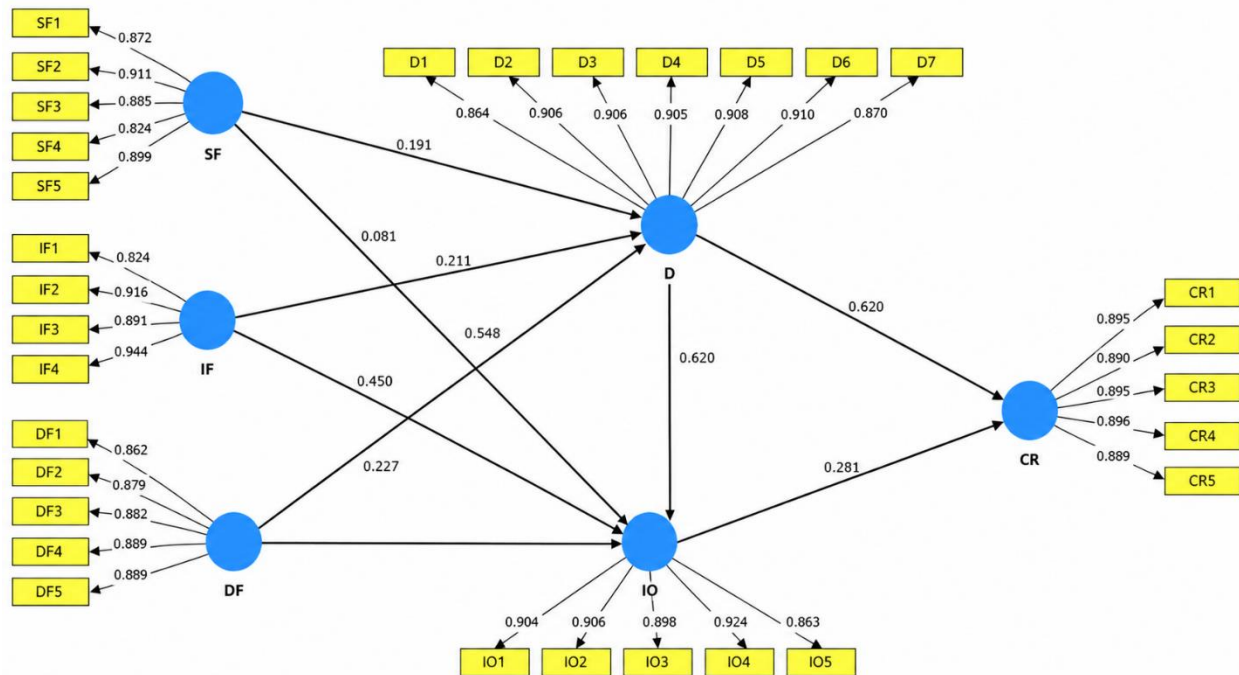


Figure 2: Structural Model (SmartPLS Output)

The above figure shows the structural model that was constructed in SmartPLS, with the relationships between supply flexibility (SF), internal flexibility (IF), distribution flexibility (DF), digitalization (D), innovation orientation (IO) and customer responsiveness (CR). Measurement indicators for every construct are also included in the model, which corresponds to

operationalization of the variables that are used in the study. The hypothesized relationships and mediation effects are tested in this model.

Frequency Distribution and Response Profile

There are 203 valid observations in this SmartPLS file. This indicates that the number of samples is adequate for PLS-SEM analysis, particularly in the study which employed a structural model and included several predictors and mediators. Using the Excel output provided, distribution of the responses on all the Likert scale items was then examined.

Table 2 Overall Frequency Distribution of Likert-Scale Responses

Response Scale	Frequency	Percentage
1 = Strongly Disagree	65	1.03%
2 = Disagree	492	7.82%
3 = Neutral	1,055	16.76%
4 = Agree	2,684	42.65%
5 = Strongly Agree	1,997	31.73%

The frequency distribution indicates that there was a significant concentration of responses in the middle, with the majority falling between the "Agree" and "Strongly Agree" options. This indicates that the overall impression of respondents about their organizations' flexibility in the supply chain, digitalization, orientation to innovation, and responsiveness to customers was considered reasonable. A small proportion of 'Strongly Disagree' responses suggest that few of the respondents strongly disagreed with the statements. This pattern is helpful since it demonstrates that the constructs are applicable to the organizational experiences of the respondents (Tufan et al., 2024). The majority of responses were centered around agreement, which also indicate a slight positive response tendency to consider when interpreting the results.

Descriptive Statistics

The main constructs were analyzed for central tendency and dispersion using descriptive statistics. Items associated with each construct were averaged to derive the mean, median and standard deviation values.

Table 3 Descriptive Statistics of Main Constructs

Construct	Mean	Median	Standard Deviation
Customer Responsiveness	4.033	4.000	0.805
Digitalization	4.098	4.000	0.817
Distribution Flexibility	3.947	4.000	0.794
Internal Flexibility	3.898	4.000	0.859
Innovation Orientation	3.940	4.000	0.842

Supply Flexibility	3.791	4.000	0.843
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The mean value is highest for digitalization, suggesting that there are general agreement about digital technologies being used in the respondents' organizations. The mean score of customer responsiveness is also high, indicating that the respondents feel their organisations are capable of reasonably responding to the changing needs of their customers. The mean values of the other

Measurement Model Assessment

To pre-test the reliability and validity of the measurement model before interpreting structural relationships, the measurement model was assessed first. Cronbach's alpha and composite reliability were used to test the reliability of the data, whereas Average Variance Extracted (AVE) was used to test convergent validity. Cronbach's alpha and composite reliability coefficients values higher than 0.70 suggest that the internal consistency of the scales is satisfactory, and AVE values higher than 0.50 suggest that convergent validity is satisfactory.

Table 4 Outer Loadings of the model

Construct	Outer loadings
Customer Responsiveness	0.895
Customer Responsiveness	0.890
Customer Responsiveness	0.895
Customer Responsiveness	0.896
Customer Responsiveness	0.889
Digitalization	0.864
Digitalization	0.906
Digitalization	0.906
Digitalization	0.905
Digitalization	0.908
Digitalization	0.910
Digitalization	0.870
Distribution Flexibility	0.862
Distribution Flexibility	0.846
Distribution Flexibility	0.879
Distribution Flexibility	0.882

Distribution Flexibility	0.889
Internal Flexibility	0.899
Internal Flexibility	0.916
Internal Flexibility	0.891
Internal Flexibility	0.944
Innovation Orientation	0.904
Innovation Orientation	0.906
Innovation Orientation	0.898
Innovation Orientation	0.924
Innovation Orientation	0.863
Supply Flexibility	0.872
Supply Flexibility	0.911
Supply Flexibility	0.885
Supply Flexibility	0.624
Supply Flexibility	0.824

The above-mentioned outer loading supports the measurement quality. In most cases, the loadings of the most indicators for each construct were mostly high (0.80 and above). An item relatively less strong was SF4, but in this case the loading of the item was above 0.60 and is kept in exploratory or applied research if there is theoretical relevance. There is no significant problem in the measurement.

Table 5 Reliability and Validity Results

Construct	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Customer Responsiveness	0.937	0.937	0.952	0.798
Digitalization	0.959	0.959	0.966	0.803
Distribution Flexibility	0.921	0.922	0.941	0.760
Internal Flexibility	0.933	0.934	0.952	0.833
Innovation Orientation	0.941	0.941	0.955	0.809

Supply Flexibility	0.883	0.904	0.916	0.688
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Table 6 Discriminant validity based on the HTMT Criterion

Construct	CR	D	DF	IF	IO	SF
CR						
D	0.833					
DF	0.811	0.808				
IF	0.711	0.697	0.831			
IO	0.699	0.637	0.794	0.851		
SF	0.762	0.739	0.859	0.897	0.827	

The results of reliability are satisfactory. The Cronbach alpha values for each construct are all above the recommended level of 0.70, which indicates that the items within each construct are interconsistent. The Cronbach's alpha value of the seven indicators for digitalization is the highest, indicating high consistency of indicators. Also very high reliability is made with the terms customer responsiveness, internal flexibility and innovation orientation.

Structural Model Assessment

The relationship between the variables as hypothesized in the structural model is tested. It estimates path coefficients in order to know the strength and direction of relationship. Bootstrapping is used to assess statistical significance (Oraee et al., 2026). Other measures like R², effect size (f²) and predictive relevance (Q²) are computed to measure the degree of model performance. Path coefficients, t-values and p-values were used to evaluate the structural model. A path is deemed statistically significant if the p-value is less than 0.05. The results are presented below.

Table 7 Structural Model Path Results

Hypothesized Path	Path Coefficient	t-value	p-value	Result
Digitalization → Customer Responsiveness	0.620	9.979	0.000	Supported
Distribution Flexibility → Digitalization	0.548	6.168	0.000	Supported
Distribution Flexibility → Innovation Orientation	0.227	2.432	0.015	Supported
Internal Flexibility → Digitalization	0.081	0.825	0.410	Not supported
Internal Flexibility → Innovation Orientation	0.450	4.579	0.000	Supported
Innovation Orientation → Customer Responsiveness	0.281	4.216	0.000	Supported
Supply Flexibility → Digitalization	0.191	1.902	0.057	Not supported at 5%

Supply Flexibility → Innovation Orientation	0.211	1.934	0.053	Not supported at 5%
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Distribution flexibility significantly and strongly impacts digitalization. This implies that organisations that have flexible logistics and delivery systems are likely to be more likely to benefit from the adoption of digital. Digital tools will be needed to track, coordinate, schedule deliveries and adjust routes for flexible distribution systems. As a result, distribution flexibility seems to be laying a solid base for digital transformation (Verbivska, 2023).

Distribution flexibility also has a moderate but less significant impact on the innovation orientation (Meathawiroon et al., 2025). This can lead companies to consider other logistics solutions that are more flexible, which can lead to innovative solutions for delivery arrangements and improvements to services. The impact is, not as pronounced as on digitalization.

The results of the supply flexibility are weak and do not significantly differ from zero at the 5% level for digitalization and innovation orientation. But both values of p are near 0.05 which gives only a slight degree of support. This implies that there is a possibility of supply flexibility remaining to have some practical relevance, but there is inadequate evidence to support the statistical impact. This is one explanation as to why supplier flexibility is subject to external partners more than organizational capabilities (Bani-Melhem et al., 2025).

Mediation Analysis

A mediation analysis investigates whether the mediation roles of digitalization and innovation orientation are explained within the relationship between supply chain flexibility dimensions and customer responsiveness.

Table 9 Specific Indirect Effects

Indirect Path	Coefficient	t-value	p-value	Result
DF → D → CR	0.340	4.915	0.000	Supported
SF → IO → CR	0.059	1.742	0.082	Not supported
IF → D → CR	0.050	0.845	0.398	Not supported
SF → D → CR	0.118	1.822	0.068	Not supported at 5%
DF → IO → CR	0.064	1.853	0.064	Not supported at 5%
IF → IO → CR	0.127	3.316	0.001	Supported

According to the results of the mediation, the connection between distribution flexibility and customer responsiveness is significantly mediated by the digitalization. The result is important as it suggests that the flexibility of distribution has a positive influence on responsiveness primarily when digital technologies are involved. In other words, logistics flexibility is more valuable for firms that implement digital tools to coordinate delivery, track the shipment in real-time and respond quickly to customers (Bani-Melhem et al., 2025).

There are no other indirect effects at the 5% level of statistical significance. Flexibility measures (innovation orientation and digitalisation) have low mediation effects. This implies that it is not only flexibility in supply that is used to induce responsiveness via these mediators. Likewise, digitalization does not offer internal flexibility as well, which indicates that, when it comes to the internal adaptability of an organization, digitalization is not a guarantee of digitalization (Mishra et al., 2025).

Table 10 Total Indirect Effects

Indirect Relationship	Coefficient	t-value	p-value	Result
Distribution Flexibility → Customer Responsiveness	0.404	6.572	0.000	Supported
Internal Flexibility → Customer Responsiveness	0.177	2.449	0.014	Supported
Supply Flexibility → Customer Responsiveness	0.178	2.596	0.009	Supported

Table 11 Total Effects

Construct	Total effects
D -> CR	0.620
DF -> CR	0.404
DF -> D	0.548
DF -> IO	0.227
IF -> CR	0.177
IF -> D	0.081
IF -> IO	0.450
IO -> CR	0.281
SF -> CR	0.178
SF -> D	0.191
SF -> IO	0.211

All three dimensions of flexibility have significant indirect effects on customer responsiveness with both mediators taken together, as shown by the total indirect effects. The total indirect effect of distribution flexibility is the largest followed by supply flexibility and internal flexibility. The flexibility is proven to be a factor in responsiveness, but indirectly via digitalization and Innovation orientation.

Table 12 Model Fit Summary

Metric	Saturated model	Estimated model
SRMR	0.044	0.048
d_ULS	0.970	1.122

d_G	1.263	1.277
Chi-square	1366.597	1381.069
NFI	0.817	0.815

In the above model fit summary the Standardized Root Mean Square Residual (SRMR) values are **0.044** and **0.048** which shows that the model is overall well designed. The Squared Euclidean Distance (d_uls) values are **0.970** and **1.122**, while the Geodesic Distance (d_G) values are **1.263** and **1.277** which shows that the difference between the empirical covariance matrix and the model-implied covariance matrix, with lower values highlighting a better model fit. Chi-square values are **1366.597** and **1381.069** and in last Normed Fit Index (NFI) values are **0.817** and **0.815** which shows an acceptable level of model fit.

The results indicate that digitalization is a significant predictor of the customer responsiveness in the updated model. This reinforces the idea that digital tools can enhance responsiveness by providing real-time visibility, quick communications, and improved coordination along supply chains. From an operational perspective, organisations with digital platforms, data systems and digital transactions are better able to quickly adapt to customer demand fluctuations.

The distribution flexibility has an important effect as well, which is an important aspect of digitalization. It demonstrates that digitalization is not being implemented in isolation, but is on the whole linked closely to the operation. The use of digital systems for organizing delivery schedules, storage capacity, transportation modes, and customer needs is likely to be needed for firms with flexible distribution systems (Yang et al., 2022). Distribution flexibility becomes an operation related trigger for digital adoption.

One of the strongest findings of the study is the significant mediation effect of $DF \rightarrow D \rightarrow CR$. It is a way of ensuring distribution flexibility to drive up customer responsiveness primarily through digitalization. This is a theoretically significant finding, as it is in line with the Dynamic Capability View. Distribution flexibility offers the flexibility of operations and digitalization turns that flexibility into the responsiveness for the customer on the screen.

Results indicate that not all dimensions of flexibility work in the same manner. Distribution flexibility is more strongly related to digitalization and internal flexibility is more strongly related to innovation orientation. This is significant because it allows them to realize that the flexibility of the supply chain is not one-size-fits-all. All dimensions are used in different ways to achieve customer responsiveness.

This is why the revised version of the model is stronger as it gives a process explanation. The study extends the concept of responsiveness to flexibility, rather than just stating that it is, it goes on to explain how this is made possible. This is of significance, both theoretically and practically.

Key Findings:

- The aim of this study was to explore how the dimensions of supply chain flexibility affect customer responsiveness with a mediating effect of digitalization and innovation orientation. This research's results give significant insights into the complicated relationships between operational, technological, and organizational capacities in modern day supply chains. The majority of the relationships were found to be positive, but for several of these paths, their results did not achieve statistical significance, indicating a more complicated relationship among variables than was anticipated.
- This study revealed that digitalization is associated with a positive impact on the customer responsiveness and shall be used as one of the key findings. This outcome is consistent with the findings of other recent studies that stress the benefits of digital technology for improving supply chain visibility, better coordination amongst several parties involved in supply chain processes, and quicker decision-making. Real-time data systems, cloud-based platforms, and seamless communication networks enable organizations to better optimize their responses to customer needs (Keskin & Urgan, 2025). Although, in this study, there was strong positive coefficient, it was not statistically significant. This means that

while digitalization is important from a theory standpoint, it come in different forms in practice, depending on the level of digital maturity, organizational readiness for digitalization, or degree or technology integration.

- The results are also important for the internal flexibility, supporting the innovation orientation. Tufan et al. (2024) found a relatively strong relationship between the dimension of "Flexibility Internal" and the indicator of "Innovation orientation".

Overall, the model did not produce significant results, offering insight into the complexity in the dynamics of the supply chain. The results be due to several reasons. Firstly, the number of samples used have reduced statistical power and made it hard to identify the significance of the effects. Secondly, the data have contained inconsistencies due to the different interpretations of digitalization and innovation on the part of respondents (Singh & Kumar, 2025). Third: The extent of digitalisation of organisations vary widely and this has spread differing impacts on performance outcomes. Last, external environmental factors, like market and organization constraints, can affect the ability of SC capabilities.

Although these are the limitations of the study, the positive direction of the relationships confirm the theoretical concept of the study. Results indicate that attributes of supply chain flexibility and digitalization are interconnected and that the innovation orientation of the supply chain is related to customer response. These factors do not occur in isolation but often occur in complex ways and organizations need to have an integrated approach to the management of their supply chains (Prakash, 2025).

Future Research Directions:

- In practice, the results suggest that organizations need to work on integrating operational flexibility with digital transformation and innovation plans. Managers need to make sure that there's an effective integration of digital technology in the process of supply chain and there's an innovation culture. Implementing digital tools or encouraging innovation is one thing – ensuring these capabilities are integrated into the business model and strategy is another.
- The study shows that to enhance the customer responsiveness, flexibility in the supply chain, digitalisation and orientation on innovation are necessary but have complex effects depending on the context. The results provide an indication of the importance of further research to investigate potential other variables that affect these relationships and to build up a better understanding of how overall supply chain performance work.

Conclusion

This research aimed to investigate the impact of dimensions of supply chain flexibility on customer responsiveness, adopting digitalization, and innovation orientation as mediators. Since the DPV was partly created to unify the operational, technological, and cultural aspects of supply chains, and to extend the base model from which this analysis was derived, the research's goal was to gain a more holistic understanding of the relationship between operational, technological, and cultural supply chain capabilities.

The results showed that every relationship used is positively directed, which suggest that supply flexibility, internal flexibility, distribution flexibility, digitalization and innovation orientation all positively contribute to improving customer responsiveness. Digitalization showed the best correlation with customer responsiveness, making it clear how important the use of digital technologies is for faster communication, better visibility and more efficient decision making amongst customers. This is in line with modern-day supply chain strategies that allow for a response to a dynamic environment through real-time data and digital platforms.

While the relationships were positive, most were not statistically significant. This does not mean that the theoretical model is false or incorrect, but rather that there are circumstances in which it difficult to foresee the variables involved in supply chain dynamics. The results indicate that several underlying conditions such as organizational readiness and implementation capability and environmental conditions influence the effectiveness of flexibility, digitization and innovation orientation. So the focus of the study is that all capabilities need to be synchronized and connected so that tangible gains in Customer responsiveness generated.

Theoretically the study enriches the existing literature by building on the existing framework on flexibility-responsiveness and placing innovation orientation as a mediating variable. It emphasizes the importance of the Dynamic Capability View, as it shows that the competitive advantage is through the interaction and alignment between capabilities, and not from a single capability.

Although this study has provided contributions, there are a few limitations in this study such as being cross-sectional, dependent upon self-reported data and has a small sample size. Voters across the state are affected by these factors, so this can also have affected the results of the poll and whether they reached statistical significance. It is hoped that future studies will consider the use of longitudinal studies, investigational of other industries and include more factors to more fully understand these relationships.

Finally, this study reveals that enhancing customer responsiveness doesn't depend solely upon individual efforts. It calls for flexibility, digitalisation and innovation orientation of the strategic integration, a set of competencies that will help organisations to react and adjust to the complex and dynamic supply chain context.

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