Supply Chain Flexibility in Modern Markets: The Impact of Technological Integration, Workforce Agility, and Supplier Relationship Management through Operational Responsiveness

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Abstract: - Supply chain flexibility is vital for firms operating in dynamic, technology-driven environments. This study examines how technology integration, workforce agility, supplier relationship management, and operational responsiveness influence flexible supply chains. Grounded in dynamic capabilities theory and adaptive supply chain management, the study develops a framework linking organizational strategy to supply chain agility. Data were collected through a survey of 244 professionals from manufacturing and distribution firms in Bangladesh and analyzed using Partial Least Squares Structural Equation Modeling. Results show that technology integration and supplier relationship management significantly enhance supply chain flexibility, while workforce agility is the strongest predictor of operational responsiveness. However, operational responsiveness does not significantly mediate the relationships between the explanatory variables and supply chain flexibility. The findings suggest that flexibility depends more on strategic managerial capabilities than responsiveness alone. This study contributes by integrating technological, human, and relational capabilities within a predictive model for emerging-market supply chains.

Key-Words: - Technological Integration, Supplier Relationship Management, Workforce Agility, Operational Responsiveness, Supply Chain Flexibility, Modern Markets.

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1 Introduction

The rapid changes that characterize contemporary, globalized markets mean that supply chain flexibility is assuming a central role in the quest for competitive advantage. The responsiveness required in the supply chain is defined by the ability to realign operations as quickly as possible in response to changes in demand, supply, market conditions, and other external disruptions. This realignment is a function to varying degrees of the three core components: technology, workforce, and supplier relationship management (SRM). The supply chain changes that need to be made in real-time are made possible by the use of advanced technology such as AI and data analytics, [1]. The ability to adapt rapidly to change is a function of a skilled and flexible workforce that embraces new technologies. They are the key to creating an environment of operational responsiveness, [2]. Effective practices in SRM engender the cooperation and confidence of parties to control disruptions, [3]. The level of operational responsiveness, in turn, interacts with the factors outlined to determine the flexibility of the supply chain, an essential quality for organizations to maintain resilience in conditions of uncertainty and rapid change.

Given advancements in globalization through technology and shifting consumer patterns, the current state of supply chain management (SCM) necessitates an understanding of the complexities and flexibility of supply chains. The evidence suggests that incorporating technology into the supply chain enables the processing of real-time information, which is valuable to every participant, and facilitates the creation of a supply chain that provides the necessary flexibility, [4]. In addition,

the management of supplier relationships (SRM) has proved to be a significant way of maintaining the needed flexibility and competitiveness within a supply chain, [5]. The formation of these partnerships helps streamline the procurement of needed resources and improves innovative collaboration. Besides the mentioned aspects of technology and relationships, the agility of the workforce also becomes significant within the supply chains, as an adequately trained and agile workforce can respond to a changing market and operational environment. To achieve the necessary flexibility in a supply chain, a synthesis of the above-mentioned components is required, and for that, an adequate operational responsiveness framework must be in place. With technological responsiveness, the right relationships with suppliers, and an agile workforce, a supply chain will have the flexibility needed to survive in any market within a set of given parameters.

However, [6] suggests that several barriers exist to achieving the desired flexibility. These barriers include the pace of change in technology, regulation, and economy, and the complexity of environmental and sustainable issues. For example, technological integration facilitates responsiveness; however, implementation struggles continue to explain the gaps regarding responsiveness and performance, [7]. Furthermore, poor supplier relationships hinder the necessary collaborative efforts required for adaptive supply chain strategies. Ineffective supplier integration leads to poor performance, making it difficult for companies to implement just-in-time manufacturing and respond to demand changes, [8]. The speed of necessary business changes and workforce adaptability are also critical issues, as the rapid pace of technological shifts demands constant and ongoing training, [3]. The combination of these issues creates a situation in which it becomes crucial to develop a risk management system that maintains the flexibility needed for any business to survive and address the problems created by a complex supply chain system, [9].

Multiple important issues require deep exploration when it comes to the issues surrounding the flexibility of a supply chain. First, while the existing literature considers the relationship of system/technology integration, workforce agility, and supplier relationship management individually and their impact on supply chain responsiveness, very few have attempted to study them together and how they impact overall supply chain flexibility, [10]. To our most excellent knowledge, each of the studies in the literature has taken a singular approach in tackling each of the factors, and has thus sought to present a narrow, if not linear, framework that fails to account for the interdependencies and collective influence of other factors on operational efficiency. Moreover, prior studies continue to overlook the impact of managerial and organizational culture on the integration of these variables, [11]. Additionally, most of the literature primarily focuses on the manufacturing and logistics sectors. In contrast, other areas, such as services and the supply chain problems of these industries, remain under-researched. There is also a lack of understanding of the metrics in the variables themselves, as the variables of operational responsiveness and its impact on flexibility are inadequately defined and narrowed, [12]. The rapid changes in the global environment necessitate a new perspective on the role of emerging technologies, such as artificial intelligence and blockchain, in enhancing the flexibility of supply chains. These insights would aid both theorists and practitioners in their quest to build supply chains that are resilient to the uncertainties of the current environment.

This study develops a theoretical and practical understanding of the management supply chain by analyzing the relationship in terms of technology adoption, workforce agility, supplier relationship management, and operational responsiveness, [13]. The study aims to mitigate the challenges in relations with operational responsiveness and supply chains. Overall, the study's findings have the potential to assist professionals in creating and pioneering more adaptive and resilient supply chain strategies, enhancing the agility, flexibility, and operational responsiveness of the supply chain in response to the complexity of the marketplace. The operational frameworks proposed in the study will enhance the responsiveness of the supply chain and strengthen collaborative relationships with supply chain partners, thereby sustaining value within the supply chain ecosystem. A firm that aims to sustain its position within the market is greatly hindered by its limited understanding of the interplay between the mentioned variables. During global disruption crises, rapid market changes sustain the goals of sustainability.

2 Literature Review

2.1. Supply Chain Flexibility

The role of supply chain flexibility in the literature examines the contribution of flexibility in enhancing organizational performance levels, particularly in

highly volatile market conditions. The work of scholars demonstrates that flexibility within the supply chain positively affects the strategic capabilities of competitiveness owing to the responsiveness, flexibility, visibility, and resilience of the supply chain, [14]. Effective supply chain management necessitates the seamless integration of operations and marketing management to enhance customer satisfaction while improving the business's market adaptability. Flexibility and responsiveness are fundamentally interconnected; therefore, for IT and relationship management within core actors to be successful, there must be a seamless integration of technology and strong relationships to respond to or attain flexibility, [8]. The combination of lean and agile to form 'leagile' demonstrates the need for operational strategies to sustain a high level of flexibility, enabling effective management of fluctuating conditions, [15]. The frequent attribution of improvements in supply chain system performance to logistics capabilities suggests that a high level of performance within a supply chain necessitates adopting a systemic view of both internal processes and external suppliers. There are also empirical research studies and conceptual frameworks that detail the interactions between the elements and the sectors, explaining their interconnectedness, particularly in the contextual and methodological aspects of agility, [14].

2.2 Technological Integration

Technological integration challenges have become more prominent in supply chain management (SCM) due to the rapid advancement of communication and information technology. Technologies such as blockchain, artificial intelligence, and data analytics are facilitating the enhancement of traditional supply chain processes, improving efficiency, transparency, and decision-making, [11]. A systematic review that highlights the potential of supply chains to enhance traceability and security, aspects that can strengthen the trust of participants. In addition, the integration of information technologies in agricultural supply chains to enhance performance demonstrates the applicability of these technologies in various fields, [16]. The intersection of knowledge management and information technology has the potential to establish a robust structure for SCM, enabling SCM partners to communicate and coordinate more easily. Moreover, the operationalization of certain sustainability practices in supply chains has been facilitated through the integration of Industry 4.0 technologies. Unfortunately, studies have yet to answer the types of difficulties companies encounter when attempting to adopt these technologies, the kinds of organizational cultures that facilitate their adoption, and the types of organizational cultures that foster their adoption, [17].

2.3 Supplier Relationship Management

Supplier relationship management (SRM) encompasses carefully planned initiatives that enable businesses to enhance the performance of their supply chains, particularly the relationships between the businesses and their suppliers. The literature documents that the effectiveness of an organization's purchasing function can be further improved if it takes the time to strengthen supplier relationships through SRM initiatives. The successful SRM initiatives lead to performance achievements in organizations and their SRM partner organizations through supplier collaboration and relationships based on trust and effective communication, [18]. More collaboration, trust, and communication lead to lower costs and higher-quality products. The significant role that trust and communication play in collaborative relationships among suppliers in the e-commerce space. Moreover, the adoption of advanced technologies, including blockchain and AI, that focus on SRM aims to improve transparency in the systems and enhance their speed. These technologies, when properly implemented, facilitate the development of stronger and more sustainable partnerships with suppliers, which will be necessary to enhance their competitiveness in the market, [19]. Nevertheless, the field has been noted, such as the difference in priorities and the complications caused by globalisation. Despite such impediments, the ability to adapt and maintain the positive outcomes achieved through one’s strategies, goals, and objectives on a macro level is highly intertwined with the effectiveness of SRM. More SRM strategies fuel the preference for further research on addressing these shortcomings to enhance the chain and support the additional goal of sustainable supply chain efforts.

2.4 Workforce Agility

Agility of the workforce has been a positive attribute as a necessary one in the Bid for Change, as well as the Ability to Compete. Recently, it has been determined that the agility of the workforce is the ability to respond to the fluctuations in the demand of the market, as well as to participate in various roles. The workforce enhances operational flexibility and innovation in products and services within the processes, as it draws on the self-determination theory of intrinsic motivation and the

need to have competencies, [20]. Additionally, there are certain parameters recognized by scholars that enhance the agility of the workforce in an organization, such as the fostering of supportive leadership, employee participation in decisions, and the organization of learning activities in an organization. How an organization can enhance the engagement and satisfaction of employees and, in turn, enhance organizational outcomes by fostering an agile workforce through certain HR practices, [21]. Moreover, psychological empowerment, which elaborates on the value of empowering proactive workforce approaches, is crucial, as most organizations need to focus on culture to reap the rewards of agile workforce approaches. The studies that have been conducted on workforce agility have been limited and operational in nature, [22]. The impact of digital transformation on the workforce and the agility of the workforce are two interconnected areas of study that need to be explored. The knowledge gained will lead to the development of organizational structures and HR strategies that support agile workforce innovation and adaptability.

2.5 Operational Responsiveness

The ability of organizations to respond to changes in demand and supply conditions represents their operational responsiveness. Operational responsiveness is now considered one of the most important factors in supply chain performance. Organizations must implement operational responsiveness as a means of maintaining a competitive advantage in current markets. The authors emphasize the need to develop customer-responsive supply chains, considering the complexity in the relationship between operational responsiveness and flexibility, [23]. The authors posit that operational responsiveness has the potential to enhance the strategic design of a supply chain if the two terms, responsiveness and flexibility, are defined and distinguished. The positive correlation between a supply chain's responsiveness to specific demand uncertainty and its financial performance, [24]. The additional findings of the studies indicate that organizations (or firms) can achieve significant operational performance if they utilize responsive supply chains, which can adjust to dynamic changes in the marketplace. Furthermore, operational responsiveness is one of the significant factors affecting supply chain disruptions and the balance between flexibility and responsiveness, [6]. The multidimensional facets of operational responsiveness and its relationships with technology and people remain scant. Building such knowledge is necessary to propose models that enable organizations to be operationally effective and responsive and to enhance their resilience.

2.6 Hypothesis Development

2.6.1 Technological Integration and Operational Responsiveness

Fostering effective technological integration and operational responsiveness is crucial for all organizations seeking to develop their supply chain management capabilities. There is a growing consensus within the literature that effective technological integration leads to enhanced operational responsiveness, resulting from the capabilities that concurrent real-time data sharing, automated decision systems, and process collaborations offer to organizations, [24]. The consistent integration of business and IT resources within a firm is a necessary condition for effective and immediate responsiveness to a firm's external environment. Furthermore, Unified IT systems' operational agility and coordination remove some of the communication boundaries and operational silos, [25]. Such integration leads to systems that, in addition to empowering organizations to adapt rapidly to changing environments, empower users and organizational members to make real-time decisions.

2.6.2 Supplier Relationship Management and Operational Responsiveness

Within the discipline of supply chain management, the connection between supplier relationship management (SRM) and operational responsiveness is crucial for organizations seeking to improve their competitive positioning, [26]. Studies show that SRM fosters trust and collaboration between a company and its suppliers, resulting in enhanced flexibility and responsiveness to marketplace opportunities. The ability to work closely with a supplier and receive their information enables organizations to solve problems quickly and respond to customer needs promptly, [27]. In addition, firms with solid supplier relationship management (SRM) frameworks can eliminate the risks of losing operational flexibility and responsiveness due to supply chain disruptions.

2.6.3 Workforce Agility and Operational Responsiveness

Organizations that wish to understand and respond to rapidly changing market environments need to

understand the connection between agility and operational responsiveness. Workforce agility refers to the ability of employees to rapidly adapt and adjust to changing conditions, enabling proactive responses to customer and operational demands, [28]. A substantial body of work demonstrates that operational responsiveness is most efficient when information flow and collaboration agility are present. The importance of change management strategies to increase workforce agility with the telling example that ‘an organization that fosters adaptability responds to more change in the market, [29]. Additionally, it is demonstrated that innovating and collaborating more rely directly on operational flexibility, increasing in a manner that enhances responsiveness to customer diversity.

2.6.4 Technological Integration and Supply Chain Flexibility

Formulating an initial hypothesis regarding the technological integration and flexibility of the supply chain is necessary to enhance the firm's competitive edge in a volatile industry. Integration of technology refers to the incorporation and synchronization of informational technologies that enable instantaneous engagement and exchange of information among supply chain participants, [30]. Empirical evidence suggests that well-connected tech deployments enhance supply chain flexibility by increasing responsiveness and adaptability, [30]. A function of the fast IT-enabled reengineering of workflows in the business, [31]. The positive relationship between supply chain integration and flexibility is a function of the alignment of information systems and the practices governing supplier management. In addition, authors of the supply chain digitization suggest a positive relationship between systems collaboration and the improved flexibility and responsiveness of the supply chain, [32].

2.6.5 Supplier Relationship Management and Supply Chain Flexibility

There is a unique and important connection between supplier relationship management (SRM) and supply chain flexibility. There is a notable improvement in operational performance during periods of market volatility, [33]. This link is the result of several studies demonstrating how managed supplier relationships impact the level of cooperation, trust, and willingness to work together between companies and suppliers, which ultimately leads to enhanced flexibility in the operational supply chain, [34]. Chen illustrates how trust among supply chain partners contributes to agility and innovativeness. This suggests that SRM practices are crucial in supporting a rapid response to market changes.

2.6.6 Workforce Agility and Supply Chain Flexibility

To achieve global supply chain effectiveness and thrive in the world's dynamic and unpredictable environment, maintaining a strong relationship between the supply chain and workforce agility is essential. Workforce agility is the capacity to adapt to new situations and control varying challenges. Studies demonstrate how a flexible workforce contributes to a firm's supply chain responsiveness; agile and skilled employees who can control various challenges adapt to new disruptions (customer demand) and sustain supply chain responsiveness, [35]. Specifically, high workforce agility means a firm can better synchronize its operational resources with demand (as the market is volatile), thus increasing its supply chain flexibility, [36]. Moreover, fostering agility in employees is critical to achieving total supply chain agility.

2.6.7 Operational Responsiveness and Supply Chain Flexibility

Understanding the relationship between operational responsiveness and supply chain flexibility is crucial for enhancing a firm's competitive market advantage. Operational responsiveness refers to a supply chain's ability to adjust to variations in demand and operational situations quickly. Operational responsiveness is positively correlated with supply chain flexibility, where organizations can modify processes, products, and service delivery to meet customer needs. Supply chain responsiveness enhances firm performance, improving costs, quality, and delivery reliability, which in turn contributes to strengthening a firm's competitiveness, [37]. Contact/disconnect competencies greatly influence supply chain flexibility, which in turn affects operational responsiveness and total supply capacities.

2.8 Theory

2.8.1 Dynamic Capabilities Theory (DCT) Dynamic Capabilities Theory (DCT) focuses on how specific organizations maintain a competitive advantage in their industry by adapting to environmental changes, particularly in the context of supply chain management. According to the theory, organizations need to develop specific

capabilities to identify (sense), pursue (seize), and successfully reconfigure (as per the resource-based theory) their resource base to remain competitive, [38]. Nowadays, pulled from the theory, operational responsiveness, or the ability to be responsive to changes in supply chain and operational, integrated with technological advancement, the development of supplier networks, and workforce or employee agility (all catalysts of operational responsiveness) becomes particularly pertinent, [39].

The ability to form flexible responses to changing conditions in a supply chain has been facilitated by the incorporation of technology. The real-time functionality for monitoring supply chains in support of optimal decision making for the collection of functionalities provided by the contemporary innovations of the comprehensive analytics technologies for big data and artificial intelligence. Supply chain partnerships provide internal functionality, forecasting, and inventory separation, as well as overall flexibility improvements to the supply chains of the particular institutions through increased collaboration, [40]. The operational responsiveness and flexibility of supplier relationships, facilitated by streamlined collaborations and internal communications within the supply chain, are increasing. The impact of facilitating responsive collaborations on supplier relationships to detail the changes and improvements in the supply chain. Collaborations and trust support enhancements of operational responses to market shifts in practices that synchronize with the supplier systems of businesses. The operational shifts, collaborations, and increased synchronization practices with supplier systems within businesses.

Moreover, employee agility is also very pertinent to the dynamic capabilities of modern supply chains. Organizations must have a workforce capable of rapidly acquiring and honing new skill sets to maneuver through volatile ecosystems, [41]. This agility also enables firms to leverage their technological capabilities and deepen their operational and relational competencies with supply chain partners, thereby enhancing overall responsiveness, [42]. DCT legitimizes the need for the synergy of technology integration, relational management of suppliers, and employee agility to facilitate operational responsiveness, a core to sustaining the flexibility of supply chains in today's highly dynamic environment.

2.8.2 Resource-Based View (RBV)

The Resource-Based View (RBV) explains how firms exploit their particular resources and capabilities to achieve and morph a competitive edge. As posited by RBV, resources are supposed to be valuable, rare, inimitable, and non-substitutable for a firm to be successful and efficient, [43]. In supply chain management, RBV recognizes internal strengths, such as technological resources, workforce, and bonds with suppliers, as fundamental in promoting supply chain flexibility and efficiency, [44]. Supply chain capability includes the understanding of technological integration of the system, a concept rooted in the RBV theory. Companies that utilize information technology in their supply chains can enhance organizational performance and create resilient supply chains. Companies that utilize advanced processing technologies and digital platforms can respond to changes in the marketplace and disruptions to their processes, which demonstrates that these companies view advanced technologies as a competitive resource, [45].

Additionally, the RBV emphasizes the importance of strong supplier partnerships as a means of achieving a competitive advantage. The use of shared technology platforms, joint problem-solving, and standardized operational processes fosters an environment that encourages innovation and operational flexibility. These are the elements needed to respond quickly to changes in consumer demand and the uncertainty of supply, [46]. When external suppliers can provide a complement of resources, the firms can achieve synergistic effects within the supply chain. Workforce capability is also crucial for the RBV because skilled workers who can learn and adapt to new conditions enhance the organization's agility and responsiveness, [47]. Among the firm's resources, human capital is particularly significant and least valued because organizations rarely invest in it properly to build and maintain the firm's operational viability in conditions of turbulence and uncertainty in the supply chain.

2.9 Conceptual Framework

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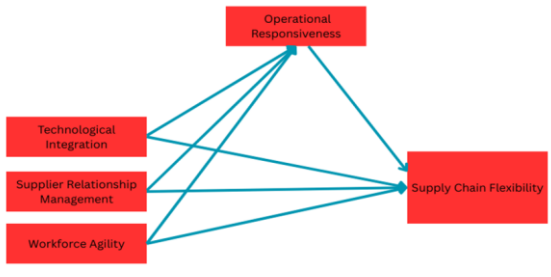

Fig. 1: Framework

Source: Developed by Author

3 Methodology

3.1 Sampling and Data Collection

Because this research aimed to establish connections between various factors, a deductive approach under the positivist paradigm was used. For this research, a quantitative approach was adopted to gather data using a structured questionnaire, which was administered to professionals in the supply chain and operations functions of manufacturing and distribution companies in Dhaka, Bangladesh. The manufacturing and distribution sectors were selected because they form the backbone of urban supply chain activities in Bangladesh and are currently undergoing rapid digital transformation and modernization of their processes. Dhaka was selected for the research as it is the economic and industrial nucleus of Bangladesh and has a significant presence of manufacturing companies, logistics service providers, and supply chain-intensive industries. The Bangladesh Bureau of Statistics (BBS) reports that the majority of industrial units and supply chain-related establishments are located in Dhaka, underscoring the region's significance for research on contemporary supply chain activities. Since there was no complete list of supply chain and operations employees in Dhaka, non-probability sampling, specifically convenience sampling, was the preferred approach. It was determined that employees in the sought-after category were located in multiple firms. Therefore, it would be impossible to obtain a complete list of employees, making this approach the most viable.

A statistical power analysis was conducted prior to data collection to determine the minimum sample size required for a robust structural model (Figure 1). Using G*Power 3.1.9.4 software [48], this analysis determined that, with a medium effect size of 0.15, a significance level of 5% (0.05), and a statistical power of 95%, a minimum of 244 subjects would be necessary. Due to the likely non-response and/or missing data in questionnaires, the researcher retained a sample size that was approximately four times larger, increasing the likelihood of reaching the target number of usable responses. As such, a total of 976 questionnaires were administered through face-to-face surveys and online survey software. Surveys were completed in two months, August and September 2025. Three hundred ten people completed the survey, of which 244 were usable. Scholars utilize SPSS 26 and SmartPLS 4 to analyze data.

Table 1. Demographic profile of the respondents

Variable	Categories	Frequency	Percentage	Mean	Std. Deviation
Gender	Male	182	74.6	1.25	0.436
	Female	62	25.4		
Age	20 to 25 years	24	9.8	2.59	0.794
	26 to 30 years	76	31.1		
	31 to 35 years	121	49.6		
	36 years to above	33	9.4		
Education Level	HSC	20	8.2	2.48	0.682
	Bachelors	92	37.7		
	Masters	126	51.6		
	PhD	6	2.5		
Experience	1-3 years	50	20.5	2.38	1.017
	4-5 years	99	40.6		
	5-7 years	48	19.7		
	7-10 years	47	19.3		
Position	Officer	25	10.2	2.50	0.809
	Executive	96	39.3		
	Manager	99	40.6		
	Top Management	24	9.8		

Source: Outcome from SPSS for descriptive analysis

A total of 244 responses were analyzed, and a demographic profile was created for each. As shown in Table 1, males comprised a higher frequency (74.6%) than women. The most typical age ranges of the respondents were 31-35 (49.6%) and 26-30 (31.1%). Over 80% of the respondents hold advanced degrees, with a majority having a Master's (51.6%), followed by 37.7% with a Bachelor's, and 2.5% with a PhD. For the distribution of work experience, most respondents have 4-5 years (40.6%), and the fewest were in the 1-3 year category. The roles were also imbalanced, with most individuals holding a Manager (40.6%) or Executive (39.3%) position, while fewer held positions in Top Management (9.8%) and Officer (10.2%).

4 Results

This section presents the empirical findings of the study, beginning with the assessment of the measurement model's reliability and validity, followed by the evaluation of model fit and the analysis of direct and indirect relationships among the key constructs.

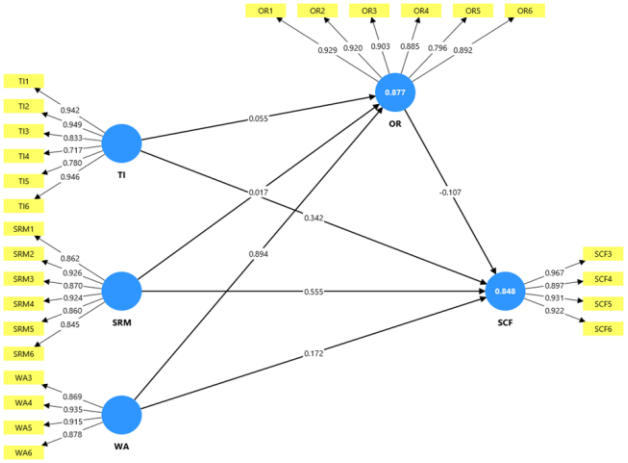

Fig. 2: Cronbach alpha
Source: Outcome from SmartPLS 4

In Table 2, it can be seen that all variables, operational responsiveness (OR), supply chain flexibility (SCF), supplier relationship management (SRM), technological integration (TI), and workforce agility (WA), show very good internal consistency. Figure 2 shows that all Cronbach's alphas and composite reliabilities are well above the threshold value of 0.70. In addition, all the averages of the variance explained (AVE) are above 0.50, confirming that the criteria of the model are valid with regard to convergent validity, [49], [50].

Table 2. Construct reliability and validity

Construct	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
OR	0.946	0.948	0.957	0.790
SCF	0.947	0.951	0.962	0.864
SRM	0.943	0.945	0.954	0.778
TI	0.931	0.946	0.947	0.750
WA	0.921	0.925	0.944	0.809

Source: Outcome from SmartPLS 4

Table 3. Heterotrait-monotrait ratio (HTMT) – Matrix

Construct	OR	SCF	SRM	TI	WA
OR					
SCF	0.573				
SRM	0.548	0.957			
TI	0.631	0.947	0.993		
WA	0.999	0.587	0.538	0.629	

Source: Outcome from SmartPLS 4

Table 3 presents the results of the discriminant validity analysis, which employed the Heterotrait–Monotrait Ratio (HTMT). According to [51], it is suggested that HTMT values in the range of 0.85 (a strict criterion) or 0.90 (a more relaxed criterion) reflect adequate discriminant validity. The results indicate that sufficient discriminant validity exists across constructs, as the majority of the pairs of constructs fall within the accepted range. However, several HTMT values (most of which are in relation to the pairs of Supplier Relationship Management and Technological Integration (0.993), Technological Integration and Supply Chain Flexibility (0.947), and Supplier Relationship Management and Supply Chain Flexibility (0.957)) are above the suggested range, indicating that there is probably some overlap among these constructs. Overall, the HTMT evaluation provides valuable evidence to warrant assessing discrimination among the constructs in the model.

Table 4. Fornell-Larcker criterion

	OR	SCF	SRM	TI	WA
OR	0.889				
SCF	0.545	0.929			
SRM	0.521	0.907	0.882		
TI	0.592	0.900	0.940	0.866	
WA	0.935	0.552	0.506	0.583	0.900

Source: Outcome from SmartPLS 4

Table 4 illustrates the application of the Fornell–Larcker criterion to measure the extent of discriminant validity. [51] argue that the square root of the Average Variance Extracted (AVE) must be above all the other correlations of the constructs. As visible in the table, the diagonals (representing √AVE) of all constructs—Operational Responsiveness (0.889), Supply Chain Flexibility (0.929), Supplier Relationship Management (0.882), Technological Integration (0.866), and Workforce Agility (0.900)—demonstrate greater values than the respective totals from the other cross-correlations of the other constructs. Therefore, it is to be concluded that all constructs explain sufficient discriminant validity in the measurement model, as they all exhibit higher values in shared variance than the other indicators.

Table 5. R-square

	R-square	R-square adjusted
OR	0.877	0.875
SCF	0.848	0.845

Source: Outcome from SmartPLS 4

Table 5 presents the R-squared values for the dependent variables (endogenous constructs) of the structural model. [52] State that R-squared levels of 0.75, 0.50, and 0.25 are considered to be high, moderate, and low, respectively. Therefore, it is without question that Operational Responsiveness has an R-squared value of 0.877 (adjusted = 0.875), where the exogenous variables explain 87.7% of the total variance, and thus meet the requirement for high predictive accuracy. Supply Chain Flexibility, with an R-squared of 0.848 (adjusted = 0.845), holds the same explanation. Therefore, both of the endogenous constructs included in this model are at high predictive accuracy levels. Hence, this model can predict with confidence.

Table 6. Model fit

	Saturated model	Estimated model
SRMR	0.058	0.058
d_ULS	1.174	1.174
d_G	2.232	2.232
Chi-square	2302.429	2302.429
NFI	0.759	0.759

Source: Outcome from SmartPLS 4

Table 6 depicts both the saturated and estimated models. Both models show a Standardized Root Mean Square Residual (SRMR) of 0.058, which is below the cut-off criterion of 0.08, indicating an acceptable model fit, [51]. Furthermore, the model's dULS and dG (1.174 and 2.232, respectively) exhibit lower discrepancies, indicating a good fit. Although having a lower NFI (0.759) indicates a poorer fit, the acceptable threshold value in PLS-SEM, especially in complicated models, is 0.70; hence, the 2302.429 chi-square value and NFI are adequate, [52]. Overall, the indices of model fit provide evidence to conclude that the goodness-of-fit standards for the proposed structural model are acceptable.

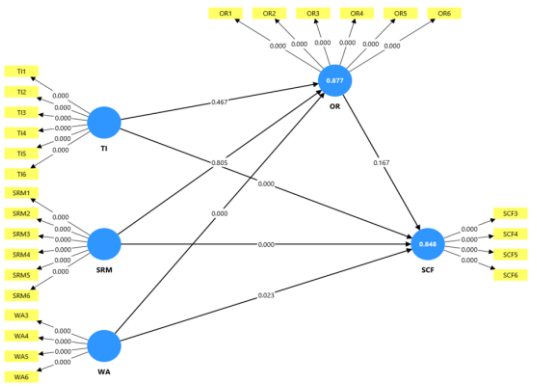

Fig. 3: P value result
Source: Outcome from SmartPLS 4

Table 7. Total effects

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
OR -> SCF	-0.107	-0.113	0.077	1.383	0.167
SRM -> OR	0.017	0.017	0.067	0.247	0.805
SRM -> SCF	0.553	0.558	0.084	6.598	0.000
TI -> OR	0.055	0.054	0.076	0.728	0.467
TI -> SCF	0.336	0.332	0.092	3.639	0.000
WA -> OR	0.894	0.895	0.025	36.384	0.000
WA -> SCF	0.077	0.077	0.034	2.261	0.024

Source: Outcome from SmartPLS 4

The impacts of specific constructs were examined within the context of this study, specifically Technological Integration (TI), Supplier Relationship Management (SRM), Workforce Agility (WA), Operational Responsiveness (OR), and Supply Chain Flexibility (SCF). Figure 3 Operational Responsiveness (OR) did not operationally span the Supply Chain Flexibility (SCF) II (β = -0.107, p = 0.167) through OR, as demonstrated in Table 7. SRM, however, was demonstrated to have II via a direct route to SCF. Thus, his influence on SC OR can be posited as insignificant (β = 0.017, p = 0.805) within Table 7. Thus, TI was found to have a positive and significant influence on SCF (β = 0.336, p < 0.001), albeit to a lesser extent on OR (β = 0.055, p = 0.467). WA demonstrated the most significant influence (β = 0.894, p < 0.001), within Table 7, thus showcasing WA as a principal contributor to OR. SCF was indirectly increased as a result of WA, thus supporting the posited outcomes of direct and indirect pathways.

In direct response to the aforementioned Penalized Value Function, we focus our attention on the specific asymmetric indirect effects that the exogenous variables of the model have on the Operational Responsiveness' effects on the Supply Chain Flexibility in the model presented in Table 8. In this regard, none of the indirect effects within the values of the model can be treated as statistically significantly valid – in the case of Supplier Relationship Management the indirect effect was

found to be weak and statistically insignificant (β = –0.002, t = 0.196, p = 0.845), while for Technological Integration, that same indirect effect was found to be weak, and statistically insignificant as well (β = –0.006, t = 0.535, p = 0.593). Workforce Agility has also shown significant predictive power towards Operational Responsiveness in previous work, but, in this case, has fallen back on this indicator and has shown no indirect effect to be statistically significant towards Supply Chain Flexibility in Operational Responsiveness (β = –0.095, t = 1.364, p = 0.173). This suggests that Operational Responsiveness cannot be classified as a mediator within the model of exogenous variables (SRM, TI, WA) towards the Supply Chain Flexibility.

Table 8. Specific indirect effects

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
SRM -> OR -> SCF	-0.002	-0.002	0.009	0.196	0.845
TI -> OR -> SCF	-0.006	-0.006	0.011	0.535	0.593
WA -> OR -> SCF	-0.095	-0.102	0.070	1.364	0.173

Source: Outcome from SmartPLS 4

5 Discussion

The focus of this study was to find the effect of technological integration, workforce agility, and supplier relationship management on flexibility within the supply chain of manufacturing and distribution enterprises in Dhaka, Bangladesh. The analysis indicated that supply chain flexibility is mostly affected directly by factors internal to the organization, and not indirectly through operational responsiveness. This is consistent with more recent research, which remarks that the factors that influence flexibility within supply chains are modern and primarily concerned with strategy and human capital, as opposed to being operational in nature, [10]. The model has a high predictive power, as shown by the significant R-square of operational responsiveness of 87.7% and supply chain flexibility of 84.8%. This demonstrates that the chosen variables are indeed fundamental drivers of performance of the supply chains in the case of developing markets, [6].

The results show that there is a tendency for workforce flexibility to have the most significant impact on operational responsiveness due to the importance of flexibility within the workforce needed to address turbulent environments. This aligns with other recent work suggesting that a flexible workforce fosters an ability to quickly address disruption, change processes, and operate adaptively through uncertainty, [28]. On the other hand, operational responsiveness is not influenced by the degree of technology integration and management of supplier relationships, as opposed to the prominence given to technology emphasis in the responsiveness of operational frameworks, [10]. This indicates that in the case of Bangladesh, the potential of digital technology and collaboration on the supply side is still limited by inadequate technological advancement, uncoordinated supplier ecosystems, and organizational stagnation.

Moreover, of particular interest are the suggested conclusions of this research, which directly correlate Empirical Mediation with supply chain flexibility, with the integration of supplier relationship management and technological integration. This is congruous with the literature that cites the growing emphasis on flexible supply chain management partnerships and the integration of highly developed digital structures, [16]. The idea that the outside world must be engaged is essential, and that technology, in particular, must be utilized. The lack of mediation shows that responsiveness in and of itself does not translate upwards or downwards without strong supplier relationships and technological underpinning. This is supported or aligned with the contemporary empirical research findings that have suggested supply chain resilience and flexibility stem from the alignment of the multiple organizational dimensions, [53].

5.1 Main Findings

The current research highlights that the proposed model exhibits considerable explanatory power. Exogenous variables explain operational responsiveness (OR) by 87.7% and supply chain flexibility (SCF) by 84.8%. The measurement model illustrates a high degree of internal consistency and convergent validity for each of the constructs. Discriminant validity for each of the constructs is acceptable and is not likely due to overlap among

the constructs of Technological Integration (TI), Supplier Relationship Management (SRM), and SCF. Regarding the structural relationships, workforce agility (WA) is the strongest predictor of OR ($\beta = 0.894$, $p < 0.001$). This confirms that the presence of agile employees is a prerequisite for a responsive operation. WA was also found to have a positive but weak direct influence on SCF ($\beta = 0.077$, $p = 0.024$). The variables TI ($\beta = 0.336$, $p < 0.001$) and SRM ($\beta = 0.553$, $p < 0.001$) are also model predictors and can positively and directly influence SCF, but they do not exert an influence on OR. Importantly, operational responsiveness does not have a substantial impact on supply chain flexibility ($\beta = –0.107$, $p = 0.167$), and there are no statistically significant indirect effects from technology integration, supplier relationship management, and workforce agility. This shows that operational responsiveness does not act as a mediating variable in this framework.

5.3 Contributions: Theoretical and Practical

5.3.1 Contributions Theoretical

This research makes a significant contribution to the field of supply chain flexibility in the context of emerging economies. To begin with, this research develops and tests an integrated model in the field, which, for the first time, examines the interrelationship between technological integration, supplier relationship management, workforce agility, operational responsiveness, and supply chain flexibility within the same empirical framework. In prior research, these constructs have been considered in isolation or in pairs in a linear fashion. This working schema integrates the human (workforce agility), technological (integration), and relational (SRM) dimensions into a single predictive design. This contribution responds to the literature's calls for a better and more comprehensive understanding of the interaction of multiple organizational capabilities to achieve better supply chain outcomes. Your findings refine Dynamic Capabilities Theory (DCT) by demonstrating that not all dynamic capabilities function via operational responsiveness as an intervening mechanism. Contrary to the prevailing assumption that responsiveness is the primary mechanism through which capabilities drive performance, the findings reveal that technological integration and SRM have substantial direct effects on supply chain flexibility. In contrast, operational responsiveness is not a meaningful mediator of these effects. This indicates that in turbulent, resource-constrained environments, flexibility is more attainable through the strategic alignment of technology, relationships, and human capital than through incremental enhancements to response time.

Moreover, the study adds to the Resource-Based View (RBV) by providing empirical confirmation of the vital importance of workforce agility as a rare, inimitable capability underpinning operational responsiveness. Workforce agility stands out as the most significant predictor of operational responsiveness, demonstrating that human capital is not merely a supporting resource but a primary strategic resource necessary to attain adaptive supply chain responsiveness. Simultaneously, the substantial direct impacts of the technological and relational resources on flexibility indicate that the configurations of interdependent resources—rather than a singular resource—are most critical to achieving supply chain flexibility and resilience in emerging economies. Ultimately, this study focuses on manufacturing and distribution companies in an emerging economy, specifically Dhaka, Bangladesh, and aims to evaluate the complexities of digital supply chain theory and its fine-tuning. It shows that the theoretical frameworks of digital supply chains developed in more developed nations and economies are not always applicable in less developed economies, such as Bangladesh, where digital infrastructure gaps, readiness to adopt digital solutions, and relationships with suppliers are still in their early stages. This study offers several contributions to its readers, as discussed in the following sections.

5.3.2 Practical Contributions

From a managerial standpoint, the study provides a roadmap for companies to improve their supply chain, particularly in terms of flexibility and addressing uncertainties and disruptions that may arise. First, the study's findings suggest that agility in the workforce is the most significant driver of operational responsiveness. This therefore supports the notion that organizations should implement people-driven strategies as the foundation of their constructs. Merely training employees continuously, equipping employees with multiple skills, managing the employees, and facilitating organizational empowerment are not just HR techniques. These are strategies that are fundamentally supply chain-oriented, enabling employees to tailor processes, technologies, and relationships as needed. Second, the study's findings indicate a strong, positive relationship, where the significant impact of technological integration has enabled greater flexibility in the supply chain. Therefore, organizations should align their digitalization

initiatives with strategies that improve supply chain flexibility. Managers need to adopt a new design principle that views technology as a collaborative tool for enhancing efficiency. Instead, the dexterous management of technology should enable rapid changes in operations, provide visibility throughout the supply chain, and facilitate agile data management for informed decision-making, especially during disruptions.

The substantial contribution of supplier relationship management suggests that, for flexible supply chains, the quality of collaboration with external stakeholders is of paramount importance. From this, it follows that managers should develop trust-based, collaborative relationships with key suppliers on a relational basis, and where appropriate, align technological systems to enhance information sharing. Such collaboration enhances the network's overall adaptability to demand volatility, supply shocks, and changes in the legal and physical environment. Similarly, the fact that operational responsiveness is not a mediating variable in the relationship between key capabilities (TI, SRM, WA) and supply chain flexibility is of practical significance for managers: it is not sufficient to respond faster. Structural and strategic capabilities, such as agile workforce structures, integrated systems, and collaborative supplier relationships within networks, need to be designed to create flexibility in the supply chain. Thus, the managerial focus moves from short-term responsiveness to long-term capability development. The results for policymakers and industry bodies in emerging markets, such as Bangladesh, indicate the need to focus on digital infrastructure, skill development, and collaborative ecosystems established among manufacturers, distributors, and logistics providers. Stakeholders can enhance the flexibility and resilience of interconnected national and regional supply chains by removing technological barriers, offering supply chain management education, and fostering collaborative frameworks.

5.4 Limitations and Future Research

While this study presents valuable findings on the drivers of supply chain flexibility within the emerging market context, it is not without limitations, which in turn create opportunities for future research. First, the research is based on non-probability convenience sampling involving supply chain and operations professionals in manufacturing and distribution firms in Dhaka, Bangladesh. While this situation is theoretically and practically valuable, it presents challenges for the generalizability of the findings to other regions, industries (e.g., services, retail, healthcare), and countries with different institutional and technological contexts. In future research, it would be beneficial to apply probability sampling, where possible, to broaden the study to multiple cities and sectors, and to incorporate cross-country comparisons (e.g., research in emerging and developed economies) to determine the degree to which the relationships in question remain constant across varying contexts.

The design of the research study is cross-sectional, which limits the generalizability of the findings and the ability to explain the relationships between variables for the study of technology integration, employee adaptive behaviors, supplier collaboration, and operational responsiveness over time. Future studies could incorporate longitudinal studies, repeated measures surveys, or the use of panel data to examine how the flexibility of a supply chain's adaptive capabilities is affected by the diffusion of multiple technologies and disruptions. Additionally, experimental and quasi-experimental designs, along with longitudinal case studies, could clarify with greater precision the mechanisms of causation and the sequence of relationships over time for the variables proposed in the study.

The study utilizes self-report perceptual measures from single representatives per organization, which brings about common method bias and subjective evaluation. The measurement model demonstrates a certain degree of reliability and validity; however, the high HTMTs in Technological Integration, Supplier Relationship Management, and Supply Chain Flexibility indicate a degree of overlap among the constructs. Subsequent studies should aim to refine the theoretical and empirical specification of measurement scales, gather input from multiple informants within the same organization (e.g., supply chain and IT, HR, and finance managers), and utilize additional indicators to measure operational and supply chain performance more effectively. Survey data triangulation with archival or system data (e.g., lead times, service levels, stockouts, or digital logs) would resolve standard method concerns.

Fourth, the focus of the structural model on three specific antecedents (technological integration, SRM, and workforce agility) and one mediator (operational responsiveness) creates a balanced framework, which has an excellent theoretical foundation but lacks cohesion, as other important factors should be included in the form of both mediators and moderators. For example, in future

research, organizational culture, digital maturity, environmental uncertainty, risk management practices, and even types of leadership can be included as moderators that strengthen or weaken the effects and relationships that are presented. Additionally, other mediators can be included, such as supply chain integration, co-innovation, knowledge management, or organizational learning, to provide a clearer understanding of the strategic capabilities and the flexibility they offer.

Lastly, the present research is based on PLS-SEM, which is the best option for prediction and exploration of the structure in question, but further research can test the results obtained to determine the robustness of the model by using covariance-based SEM, or improve the model by incorporating other techniques like multi-group analysis or latent class/segment analysis to identify unobserved heterogeneity within and across firms. Furthermore, exploring curvilinear or even non-linear relationships would deepen theoretical understanding.

6 Conclusion

Using the lens of operational responsiveness, this research aimed to evaluate the impact of combining technological integration, workforce agility, and supplier relationship management on the supply chain flexibility of manufacturing and distribution companies in Dhaka, Bangladesh. Under the Dynamic Capabilities Theory and the Resource-Based View, the proposed model aimed to explain the flexibility in the advanced and ever-changing supply chain by integrating human, technological, and relational attributes into a single predictive model. The research focused on 244 respondents who work in the supply chain and operations domain, and using PLS-SEM, provided a significant contribution to the emerging markets by proving the structural relations of the proposed constructs. The research determined that flexibility in a supply chain is primarily caused by the presence of strategic and structural capabilities, rather than by the operational responsiveness of the supply chain. The relationships within the constructs indicate that the management of supplier relationships and technological integration are key drivers of supply chain flexibility. Therefore, digital connectedness and collaborative relationships are essential for flexible firms to adapt their operations to volatility. The most significant operational agility, as a determinant of operational responsiveness, also affected it in a minor, yet notable, way. This highlights the flexibility of the supply chain and its operational responsiveness.

There is conflicting empirical data in the literature and industry suggesting that operational responsiveness has an impact on flexibility in the supply chain, as well as on technology integration, supplier relationship management, and workforce agility. Each of the proposed indirect paths has little to no impact on operational responsiveness, and the data is statistically insignificant. This operational responsiveness challenges the assumption that responsiveness is the primary constituent of how operational capabilities are converted into flexibility and subsequently into differentiated operational performance. In the context of this study, and perhaps all other contexts in the industry, flexibility is a function of how well companies optimize the configuration and alignment of their technological, human, and relational resources, rather than the ability of companies to respond flexibly to market changes.

By illustrating that dynamic capabilities and strategic resources do not always act on a single, unitary performance driver, such as responsiveness, this study contributes to the theory by showing that effectiveness may also be contextually direct, interdependent, and indirect. In this way, it extends to the emerging market context, where DCT and RBV theories suggest that digital infrastructure, suppliers, ecosystems, and workforce skills are disjointed and developing in a fragmented manner. These findings should inform managers that digital integration, supplier relational investment, and workforce development should be seen as long-term strategic investments as the only way to achieve responsiveness and flexibility in the supply chains and to protect the supply chains from disruption, rather than attaining responsiveness alone, which may be seen as a low-hanging fruit.

This research is one of the first to consider the technological, human, and relational dimensions as one entity in the context of supply chain flexibility in an emerging economy. Demonstrating that operational responsiveness is not a default mediator in the relationship between a firm's capabilities and its flexibility invites both scholars and practitioners to rethink how flexibility is cultivated and maintained in the presence of uncertainty. This study represents the first step toward addressing the gaps in the design and management of sub-supply chains and their supply chain networks within a complex and emerging market economy.

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-`Moniruzzaman: Conceptualization and execution of the research; Methodology; Software; Data curation; Writing of original draft; Literature Review; Conclusion of the study; Discussion; Review and formatting.
-`Junainah Mahdee: Conceptualization, Writing; Supervision; Discussion; Review
-`Nurazlin Binti Mohd Fauzi: Conceptualization; Supervision; Discussion; Review.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest

No potential conflict of interest was reported by the authors.