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Adoption of Proactive and Reactive Supply Chain Resilience Strategies: A Comparative Analysis of Apparel and Construction Industries in Sri Lanka

Anuradha Ranawakage
Faculty of Graduate Studies, University of Sri Jayewardenepura, Nugegoda, Sri Lanka
Email: anuradha.ranawakage@gmail.com

Chathurani Silva
Management, Technology and Organisation Department,
Auckland University of Technology, New Zealand
Email: chathurani.silva@aut.ac.nz

ABSTRACT

With the current uncertain globalized supply chain (SC) networks, business organizations face serious resilience challenges during disruptions. To mitigate the effects of these disruptions, organizations adopt variety of resilience strategies. The degree of adoption of resilience strategies may differ across industries based on variances in the business environments and the characteristics of SCs. Considering the significance of exploring the differences, particularly, in the developing economies that have undergone frequent disruptive events due to economic and political reasons, this study assesses the degree of adoption of three proactive and three reactive SC resilience strategies in Sri Lankan apparel and construction industries. The primary data for this study were gathered using an online survey consisting of multi-itemed questions on the six resilience strategies from 162 apparel and 185 construction companies in Sri Lanka. The findings revealed that a significant difference exists between the two industries in terms of the level of implementation of five resilience strategies, namely, proactive collaboration, digital connectivity, integrated SC risk management, inventory and reserve capacity and lifeline maintenance, while reactive collaboration has no significant difference across the two industries in terms of implementation. Further analysis confirmed that the export-oriented apparel industry led in adopting SC resilience strategies, mainly the reactive strategies compared to the construction sector, which has project-based characteristics in SCs. Improving proactive strategies could be a great initiative to higher resilience performance in both apparel and construction sectors, where implementation could be challenging due to high resource and knowledge requirements of strategies including digital connectivity.

Keywords: *apparel, construction, proactive strategies, reactive strategies, supply chain resilience*

1. INTRODUCTION

In today's highly complex and turbulent business environment, business organizations face various types of disruptions. These disruptions frequently affect the entire supply chain (SC) of organizations, since modern SCs are complex with a large number of local and global links (Enayati *et al.,* 2024). Generally, SC disruptions are defined as unexpected and unanticipated incidents that interfere with the regular flow of materials and goods in a SC (Craighead *et al.,* 2007). Disruptions can negatively impact the overall SC performance of a company in terms of loss of revenue, increased downtime, delivery delays (Ivanov *et al.,* 2014), reduced market share, loss of customers and damage to brand reputation (Katsaliaki *et al.,* 2021). Moreover, disruption risks can impact SC sustainability as well (Moktadir *et al.,* 2018).

Although the repercussions of some disruptions are manageable, others may have a far greater influence on the long-term effectiveness of the SC (Baghersad and Zobel, 2021). Hence, it is vital to strengthen the SC with abilities to face these disruptions. However, recent studies have revealed that it is impossible to properly quantify or foresee all hazards associated with a volatile business environment (Scholten *et al.,* 2014). Therefore, the SCs must be designed to deal with the disruptive events and respond quickly and effectively to return to pre-disturbance circumstances or even improve their position by reducing the associated risks (Jafarnejad *et al.,* 2019). The ability of a company to recover from disruptive conditions is known as SC resilience (Abeysekara *et al.,* 2019). Therefore, SC resilience is a popular topic among practitioners and academicians due to the increasing uncertainty in business environments (Durugbo *et al.,* 2020). Researchers have focused on practical ways to enhance resilience in SCs (Naghshineh and Lotfi, 2019) and strategies that can be used to build resilient SCs (Wieland and Wallenburg, 2013; Sahab and Salah, 2025).

Generally, SC resilience strategies can be divided into proactive and reactive depending on whether a strategy is used to prevent a risk or mitigate the effect (Tukamuhabwa *et al.,* 2017). Proactive strategies evaluate SC resilience prospects and create remedies for impending risk events, while reactive strategies are effect-oriented and focus on mitigating the negative effects after a disruption occurs (Kilubi, 2016).

During this decade, various disruptions significantly impacted many industrial sectors in Sri Lanka. The export oriented apparel industry plays a pivotal role in Sri Lanka's economy and is globally recognized for supplying garments to major markets in the United States and Europe (Abeysekara *et al.,* 2019). However, the industry has faced numerous challenges over the past few years due to both natural and man-made disruptions. Natural disasters such as tsunami, recurring floods, and landslides caused delays in fulfilment of international orders. In addition to these environmental disruptions, the inherent challenges in apparel SCs, such as the need for rapid response to shifting consumer demands, frequent order modifications, higher competitiveness (Chowdhury *et al.,* 2019), and short product life cycles (Bruce *et al.,* 2004), further increase its SC vulnerability. As a developing nation, Sri Lanka is highly susceptible to global policy shifts and economic turbulences. One notable example is the suspension of the Generalized System of Preferences Plus (GSP+) in 2010, which had previously enabled Sri Lankan exporters to access the European Union market on a duty free basis for over 7,200 products (Democracy Reporting International, 2016). The removal of this preferential trade status led to the partial or complete closure of numerous apparel manufacturing firms in Sri Lanka (Abeysekara *et al.,* 2019). During this period of adversity, a few large-scale apparel companies that had greater financial and operational capacity relocated their production facilities to African nations such as Kenya and Ethiopia (Deyshappriya and Zylva, 2016). Although Sri Lanka regained the GSP+ concessions in 2017, many firms that experienced bankruptcy during the earlier withdrawal phase have not yet been able to fully recover (Abeysekara *et al.,* 2019). In addition, Sri Lankan apparel sector is heavily dependent on imported raw material for its production process. Therefore, financial crises in 2022 due to political instability raised concerns that Sri Lankan apparel manufacturers did not have sufficient funds for sourcing orders and buying necessary raw materials. Therefore, several international fashion brands began shifting from Sri Lankan suppliers to other neighbouring countries to avoid high risks.

The construction industry, on the other hand, can be considered as a project-based industry sector (Behera *et al.,* 2015; Loosemore, 2000). A construction SCs contains a number of parties than other manufacturing SCs due to the involvement of project clients, designers, main contractors, subcontractors, specialized contractors, and suppliers of labour, materials, and equipment (O'Brien *et al.,* 2008). Further, construction SCs typically consists of the client and the design team as the downstream linkage, and the principal contractor, subcontractors, and suppliers participating in the tasks leading to the setup of the production on site as the upstream linkage (Akintoye *et al.,* 2000). Due to this reason, the construction industry has temporary SCs with different start and end dates in different phases of construction projects (Abidin and Ingirige, 2018). This makes it difficult for the parties involved in the projects to understand their SC activities and associated threats clearly. Tsunami in 2004, Easter bomb attack in 2019, Covid 19 pandemic and economic crisis due to the political instability in 2022 are the recent examples, which adversely affected the performance of construction industry in Sri Lanka. Out of these disruptions, the economic crisis in 2022 influenced mostly because of the import restrictions on construction related goods due to the dollar deficit. Lack of essential items such as air conditioners, tiles and bathroom items caused permanent shut down of many construction companies and delays in completing the projects. Therefore, improving resilience or capability to recover from unexpected disruptions is very important for both project-based construction industry and export-oriented apparel industry in Sri Lanka.

Due to their specific operational environments and conditions, most of SC risks are specific to industries (Aigbogun *et al.,* 2016). Therefore, different strategies work differently in managing risks in SCs while it has not been explored adequately in prior research. Proactive and reactive resilience strategies offer two distinct approaches to handle SC disruptions. In industries which have predictable nature in the operations and strict delivery deadlines such as export-oriented apparel industry might prioritize proactive resilience strategies to foresee potential disruptions and take remedial actions in advance. In contrast, construction industry, which has project-based SC characteristics that differ from one project to another has unpredictable nature for its operations could tend to depend on reactive resilience strategies that are implemented based on the situation. However, empirical evidence for the level of adoption of resilience strategies across different industrial sectors, particularly from developing countries impacted by frequent disruptions recently, is not available. Therefore, based on the above points highlighting the significance of resilience in apparel and construction SCs, this study sought to answer the following research question: "What is the level of adoption of proactive and reactive resilience strategies in apparel and construction industries in Sri Lanka?"

Three proactive strategies: digital connectivity (adoption of new digital technologies to manage SC processes), integrated SC risk management (cross-company integrations for identifying and minimizing risks affecting the entire SC), proactive collaboration (information and resource sharing mechanisms to mitigate disruption effects) (Belhadi *et al.,* 2020; Bastas and Garza-Reyes, 2022) and three reactive strategies: reactive collaboration (greater levels of information and resource sharing during disruptions), lifeline maintenance (flexible transportation for changed conditions), inventory and reserve capacity (maintaining safety stock for increased responsiveness) (Belhadi *et al.,* 2020; Bastas and Garza-Reyes, 2022) were selected for the study. The rest of this paper is structured as follows: the relevant literature on SC resilience and proactive and reactive resilience strategies is reviewed in Section 2. The research methodology, including the development of

measurement instruments, sample, data collection method, and instrument reliability and validity testing is explained in Section 3. Section 4 presents the results obtained in the data analysis. The last section includes the conclusion, theoretical and managerial implications of the study, limitations, and future research directions.

2. LITERATURE REVIEW

2.1 Supply Chain Resilience

According to Shafi *et al.* (2020), resilience is the capacity of a system to withstand external shocks and quickly return to its initial state. However, different scholars have defined SC resilience in varied ways (Modgil *et al.,* 2021). For example, according to Golan *et al.* (2020), a resilient SC can bounce back from unanticipated setbacks and adjust to unforeseen future developments. The most widely used definition for SC resilience is "the ability of a system to return to its original state or move to a new, more desirable state after being disturbed" (Christopher and Peck, 2004). Resilience enables SC members to lower the likelihood of disruptive events and move the organization toward a stronger and more sustainable state (Chowdhury and Quaddus, 2017). Therefore, organizations use various strategies to maintain the resilience of their SCs (Modgil *et al.,* 2021), and these can be categorized basically as proactive and reactive strategies (Barroso *et al.,* 2010; Tukamuhabwa *et al.,* 2015).

2.2 Proactive Resilience Strategies

Proactive efforts include taking precautions to reduce the chance of occurrence (Thun and Hoenig, 2011), taking steps to lower the intensity of disruptions, and acting before any disruptions occur (Hendry *et al.,* 2019). Accordingly, three resilience strategies, namely, digital connectivity, integrated SC risk management, and proactive collaboration have been identified as proactive strategies in the existing literature (e.g. Belhadi *et al.,* 2020; El Baz and Ruel, 2020; Bastas and Garza-Reyes, 2022; Balakrishnan and Ramanathan, 2021; Lotfi and Larmour, 2022).

2.2.1 Digital Connectivity

According to Ivanov *et al.* (2019), proactive strategies typically concentrate on improving technical infrastructures, such as SC automation and digital connectivity, to avoid future disruptions. Digital SC concerns how various new technologies manage SC processes (Balakrishnan and Ramanathan, 2021). These new technologies include the Internet of Things (IoT), big data, augmented reality, blockchain (Beaulieu and Bentahar, 2021), cloud computing systems, as well as numerous other applications (Lee *et al.,* 2022). Further, these technologies help SC partners to foresee potential disruptions. Hence, businesses can prepare for disruptions before they occur and gain a competitive advantage (Linkov *et al.,* 2020). Compared to traditional SCs, the digitalized SC is more connected, and quick to react (Merlino and Sproġe, 2017). Moreover, digital connectivity helps to exchange information across the SC partners flawlessly (Balakrishnan and Ramanathan, 2021). Therefore, organizations can maintain consistent business relationships in procurement and inventory control by delivering reliable data through the proper application of digital technology (Barua *et al.,* 2004).

Therefore, using digital technologies to share real time data between manufacturers, brands and suppliers in the apparel industry helps them quickly respond to changes in fashion trends, customer demand, and production related issues before a disruption occurs. Similarly, in the construction industry, when all SC partners like architects, engineers, contractors and clients are digitally connected, they can foresee disruptions like material shortages prior to occurrence and can take proactive actions to minimize the impact.

2.2.2 Integrated Supply Chain Risk Management

Unexpected events have always impacted businesses, particularly those operating internationally with complex SCs. These events threaten the viability and survival of the organizations (Can Saglam *et al.,* 2021). 'Risk management' often refers to identifying, evaluating, and controlling hazards (Thun and Hoenig, 2011). The objective of SC risk management is to protect businesses from unfavourable situations and the detrimental effects they can have (Afraz *et al.,* 2021). However, integrated SC risk management is contrary to this traditional risk management process, since it is regarded as a cross-company focus on identifying and minimizing risks that affect the entire SC of the organization. Tang (2006a) defines integrated SC risk management as a collaborative practice in which key parties of a SC work together to ensure their continuity and profitability. Further, SC risk management can lessen vulnerabilities both reactively and proactively (Wieland and Wallenburg, 2012). Moreover, the proactive aspect of SC risk management enables organizations handle disruptions by monitoring the trends of disruptions and assess their associated risk probabilities (Blackhurst *et al.,* 2008).

Therefore, practicing integrated SC risk management strategy is vital for both apparel and construction industries since proactive risk management aids in seeing potential risks and evaluating their likelihood and impact before they happen. The decision-makers can then put plans in place to eliminate the risk or, at the very least, lessen its effects when it does occur.

2.2.3 Proactive Collaboration

SC collaboration consists of seven related components: sharing of information, goal alignment, synchronization of decisions, alignment of incentives, resource sharing, cooperative communication, and shared knowledge creation (Cao *et al.,* 2010). Sharing information among SC partners is mostly important to identify vulnerabilities, prepare for disruptions, and execute effective crisis management (Kleindorfer and Saad, 2005). By facilitating information sharing among SC partners, collaboration helps mitigate disruptions before they occur. Scholten and Schilder (2015), emphasized that information sharing, collaborative communication, and mutual knowledge creation lead to a more resilient SC. Moreover, establishing effective communication channels with SC partners is crucial for building a more efficient SC (Kim and Lee, 2024), and it is vital in a disruptive situation.

Due to strict deadlines, fast-changing customer preferences, and the competitiveness of the apparel industry, effective communication throughout the SC helps minimize future disruptions by enabling relevant proactive measures. It ultimately helps to avoid last-minute delays, and raw material shortages, and gain competitive advantage. Moreover, maintaining effective communication between all

SC members in the construction industry helps to proactively prepare for material shortages due to government policy changes, labour shortages, extreme weather conditions and can adjust project delivery times smoothly without cost overruns.

2.3 Reactive Resilience Strategies

Reactive tactics are typically used when unexpected risks occur (Ivanov *et al.,* 2017). As a result, reactive strategies are totally effect-oriented and act to reduce the negative impacts of a risk factor by understanding how each risk factor would negatively affect a certain situation (Dohale *et al.,* 2021).

Therefore, three resilience strategies, namely, inventory and reserve capacity, lifeline maintenance, and reactive collaboration have been identified as reactive resilience strategies in the existing literature (e.g. Belhadi *et al.,* 2020; Bastas and Garza-Reyes, 2022; Lotfi and Larmour, 2022; Tang, 2006b; Barroso *et al.,* 2010).

2.3.1 Reactive Collaboration

Some resilience strategies can be categorized as proactive or reactive, depending on when and why they are adopted. The best example is collaboration (Tukamuhabwa *et al.,* 2017). According to Scholten *et al.* (2014), collaboration allows SC actors to share resources and provide a coordinated reaction, which can aid post-disruption recovery. Moreover, Ponomarov and Holcomb (2009), explained that the close partnerships among SC partners can help to reduce the risk of interruption by facilitating appropriate information flow between SC partners. During disruptions, greater levels of information sharing among the SC partners may enhance the ability of SC to restore its operations successfully (Mandal and Sarathy, 2018). Without proper collaboration and cooperation among SC partners during a disruption, a SC cannot sustain and safeguard its operations further (Ponomarov, 2012). Hence, collaboration is vital to creating SC resilience during a disruption (Mandal and Sarathy, 2018).

Reactive collaboration is useful for smooth operation of both apparel and construction SCs since it facilitates taking immediate actions to overcome disruption effects through collaborative efforts like sharing of required resources, responsibilities and relevant information among SC members. For the apparel industry, reactive collaboration helps to avoid delivery delays which is crucial for international buyers. In the same manner, construction industry can take benefits of reactive collaboration in situations such as adverse weather conditions, and pandemic outbreaks by making quick adjustments to project plans through collaborations with SC Members (Meng, 2020).

2.3.2 Lifeline Maintenance

For a SC network to continue operations during and after a disruption, it is crucial to comprehend how commodities physically travel between SC nodes (Golan *et al.,* 2020). For a continued flow of materials during a transportation disruption, lifeline maintenance practices should include multi-modal transportation, multi-carrier transportation, and various routes (Tang, 2006b). Organizations must be able to use alternative routes when a particular route has problems (Pujawan, 2004). Some companies use flexible transportation strategies such as multiple modes including trucks, motorcycles, bicycles, and ships (Tang, 2006b). On time transportation is highly important, particularly to continue operations during disruptive situations. For example, during the Covid 19 pandemic, most of the apparel manufacturers in Sri Lanka experienced delivery delays of their finished goods due to border closures and port congestions at supplier and buyer locations. In the same manner, on time transportation of required raw materials and machinery is essential for the construction companies to meet their project schedules, where keeping huge inventories is not practical with the space and resource requirements.

Another specific reason to consider lifeline maintenance as a variable in this study is that there was a major transportation disruption in Sri Lanka during the period of this study. Due to the dollar deficit, and as a solution to stop the flow of foreign currency, Sri Lankan government reduced the import of fuel sufficiently and it created a huge problem in the transportation system in Sri Lanka. However, the government granted a fuel quota for some selected industries to continue their operations during this difficult time. As a result, both construction and apparel companies had to continue their operations with the limited fuel quota, and it disturbed their entire production and supply process. In the construction industry, heavy equipment including metal crushers and concrete mixers required large amounts of fuel, and the projects were delayed due to lack of fuel to operate such machinery. The human transportation also did not happen as usual due to the failures in continuing the public transport system. Therefore, lifeline maintenance was considered as an important reactive strategy that needs to be investigated in this study.

2.3.3 Inventory and Reserve Capacity

Most companies use risk mitigation inventory and reserve capacity to minimize the negative results of SC disruptions (Tomlin, 2006). Risk mitigation inventory is an extra inventory maintained to ensure uninterrupted fulfilment of customer demand during SC disruptions (Simchi-levi *et al.,* 2014). Maintaining safety stock is the most common strategy to increase the flexibility of the SC under a demand and supply uncertainty (Angkiriwang *et al.,* 2014), and it improves the firm's responsiveness as well (van Kampen *et al.,* 2010). Therefore, maintaining safety stock is a reactive measure since it involves responding to uncertainties rather than proactively minimizing them (Angkiriwang *et al.,* 2014).

Reserve capacity means maintaining extra production capacity that can be utilized for production when a supply of inputs is interrupted (Chopra and Sodhi, 2004). To achieve flexibility, most companies use a capacity buffer or set capacity higher than the average demand. Using this method, they can avoid significant shortages at peak times and disruption situations (Angkiriwang *et al.,* 2014). Thus, maintaining inventory and reserve capacity helps to minimize the impacts of SC disruptions, ensuring consistent customer demand fulfilment and maintaining production resources.

Inventory and reserve capacity strategy plays a crucial role in both apparel and construction industries. By having safety stock of high-risk parts, apparel manufacturers can continue their production process in case of raw material import delays, supplier unavailability or demand fluctuations. Similarly, having safety stock for the high-risk materials or parts for the critical construction machinery may prevent project delivery delays in construction industry.

Table 1 Sample Profile (N = 347)

Category	Description	Overall Sample	Apparel Industry	Construction Industry
Industry	Apparel	162 (46.7%)		
	Construction	185 (53.3%)		
Position of respondents	CEO / Managing director		2 (1.2%)	12 (6.5%)
	Supply chain manager		11 (6.8%)	13 (7.0%)
	Operations director/ Manager		2 (1.2%)	14 (7.6%)
	Planning manager		18 (11.1%)	23 (12.4%)
	Sourcing / Warehouse manager		23 (14.2%)	20 (10.8%)
	Other		106 (65.4%)	103 (55.7%)
Experience of respondents	Below 1 year		3 (1.9%)	4 (2.2%)
	1 to 3 years		5 (3.1%)	6 (3.2%)
	4 to 10 years		60 (37.0%)	62 (33.5%)
	More than 10 years		94 (58.0%)	113 (61.1%)

3. RESEARCH METHODOLOGY

3.1 Population, Sample, and Data Collection

The sample selected for this study consists of 347 firms, including 162 apparel companies and 185 construction companies in Sri Lanka. All the apparel companies were export-oriented and registered under the Board of Investment (BOI). All the construction companies were contractor companies registered under the Construction Industry Development Authority (CIDA) in Sri Lanka. The survey method was selected as the best way of collecting data for this research. An online questionnaire (Google form) was used to collect data from apparel and construction companies based in Sri Lanka. The survey included multiple-choice questions on demographic information of the companies and the respondents, and 7-point Likert scale questions on the six proactive and reactive SC resilience strategies (Appendix) identified in the literature review.

Table 1 illustrates the composition of the sample used in this study. As shown in the table, 40% of the survey participants were in managerial roles with a high level of awareness of the operations and SC functions of their respective organizations, while the 'Other' category, which represented the largest proportion of the sample, contained the respondents in executive and assistant manager roles that are closely related to the SC functions. For example, they were assistant managers, senior executives from procurement, purchasing, planning, warehouse, transport, and logistics divisions. In addition, majority of the respondents (58% and 61% from the apparel and construction industries respectively) had more than ten years of professional experience in SC management, with more than 90% having at least four years of experience. Hence, the sample profile guarantees that valuable and reliable data on the adoption of proactive and reactive SC resilience strategies have been gathered in this study.

3.2 Validation of Measurement Instruments

The ability of a scale to measure what it is intended to measure is referred to as the validity of that scale. There are three main types of validity that can be used to evaluate the validity of a questionnaire. Such as face and content validity, criterion-related validity, and construct validity (Saunders *et al.,* 2015). The researchers examined the face validity of each of the six constructs used in the study, and they found it acceptable for the context of the present study. Content validity describes whether the questions adequately cover the subject matter of the investigation. Therefore, to confirm satisfactory level of content validity, a thorough analysis of prior literature on each construct (concept) was carried out when determining the measurement items (the full operationalization of the six research constructs is given in the Appendix). After that, an initial draft of the questionnaire was sent to a few selected industry professionals for a pre-test. They were requested to fill in the initial questionnaire draft and provide additional feedback on the questions, cover page, questionnaire content, layout, and length. Based on their comments, a few minor modifications were made to increase the clarity and readability of the questionnaire.

Finally, SPSS version 26 was used to analyse the collected data in the survey. First, exploratory factor analysis (EFA) was performed to refine the items under each construct, as some adjustments were made to the measurement items adopted from prior literature, and several items were suggested in qualitative research without proper quantitative validation. The convergent and discriminant validity of the identified scales of the six resilience strategies were established using EFA results. Later, Cronbach's alpha (α) values were calculated to examine the internal consistency reliability of each construct. Moreover, descriptive statistical analysis and independent sample t-test were conducted to compare the average levels of adoption of each strategy between the two industries.

4. RESULTS AND DISCUSSION

4.1 Validity and Reliability Results

Cronbach's alpha, a coefficient with a value ranging from 0 to 1 is the most common technique for measuring internal consistency reliability of a measurement scale of a construct (Saunders *et al.,* 2015) where values of 0.7 or above indicate that the questions combined in the scale measure the same thing. It is regarded as the most suitable reliability indicator when employing the Likert-scale (Whitley and Ball, 2002). In this study, Cronbach alpha

Table 2 Validity and Reliability Assessment

Construct	Items	Factor Loadings						AVE	Cronbach's α
		1	2	3	4	5	6		
Integrated SC risk management	ISCRM4	0.673						0.554	0.857
	ISCRM5	0.761							
	ISCRM6	0.852							
	ISCRM7	0.811							
	ISCRM8	0.597							
Inventory and reserve capacity	INVN1		0.706					0.582	0.811
	INVN2		0.963						
	INVN3		0.565						
Lifeline maintenance	LIFE2			0.466				0.540	0.772
	LIFE5			0.885					
	LIFE6			0.788					
Proactive collaboration	PCOL4				0.623			0.535	0.758
	PCOL5				0.912				
	PCOL6				0.620				
Reactive collaboration	RCOL1					0.537		0.528	0.747
	RCOL2					0.925			
	RCOL3					0.664			
Digital connectivity	DC5						1.018	0.658	0.706
	DC6						0.530		

Table 3 Adoption of Resilience Strategies in Apparel and Construction Industries

Resilience Strategy	Apparel		Construction		t-test (p-value/ 2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
Digital connectivity	5.58	0.86	5.34	0.99	0.024
Proactive collaboration	5.46	0.98	4.81	0.99	0.000
Integrated SC risk management	4.98	1.07	4.59	1.01	0.001
Reactive collaboration	5.76	0.80	5.60	0.97	0.107
Inventory and reserve capacity	5.87	0.97	5.41	1.04	0.000
Lifeline maintenance	6.01	0.83	5.20	1.00	0.000

values of all the constructs were greater than 0.7 (Table 2), and it adequately confirmed the consistency reliability of the measurement instrument for the six SC resilience strategies considered.

The EFA was conducted on all items belonged to the six constructs - digital connectivity, proactive SC collaboration, integrated SC risk management, reactive collaboration, inventory and reserve capacity, and lifeline maintenance to assess their unidimensionality and construct validity. The maximum likelihood extraction and Promax rotation were used in the EFA. Several items that exhibited cross-loadings to several factors were removed from each scale. The remaining items were loaded into the respective factors with no indication of significant cross-loadings and factor loadings ranged from 0.5 to 1.0, and thus, discriminant validity has been confirmed. Then the AVE values were calculated using the factor loadings of each construct and all the values were above 0.5 indicating sufficient convergent validity. Table 2 presents all these results corresponding to the final EFA model that yielded a chi-square statistic of 3223.569 ($p < 0.000$) in the Bartlett's test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy of 0.830, which is greater than the threshold of 0.7. Therefore, sufficient correlations among the variables were confirmed for conducting factor analysis.

4.2 Adoption of SC Resilience Strategies in Apparel and Construction Sectors

First, the descriptive statistics (mean and standard deviation) of the factor scores of the six resilience strategies were computed for the apparel and construction sectors separately. Then, an independent sample t-test was performed to test the significance of the differences in the mean adoption levels of each strategy between the apparel and construction industries. The results are shown in Table 3 and Figure 1. In addition, 95% confidence intervals (Figure 2) were obtained to visualize the t-test results more clearly.

According to the independent sample t-test results, the adoption levels of five strategies, namely, digital connectivity, proactive collaboration, integrated SC risk management, inventory and reserve capacity, and lifeline

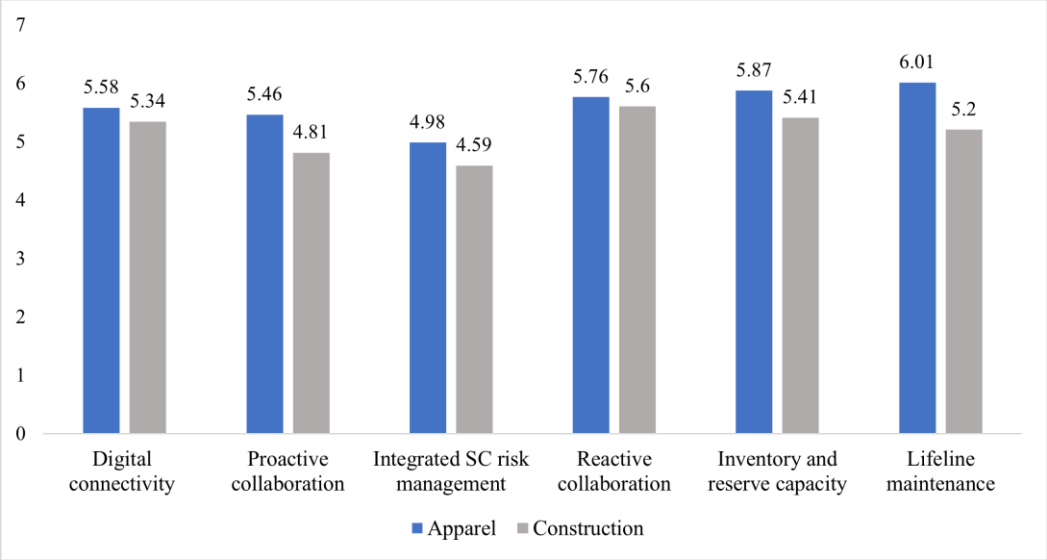

Figure 1 Adoption of Resilience Strategies in Apparel and Construction Industries

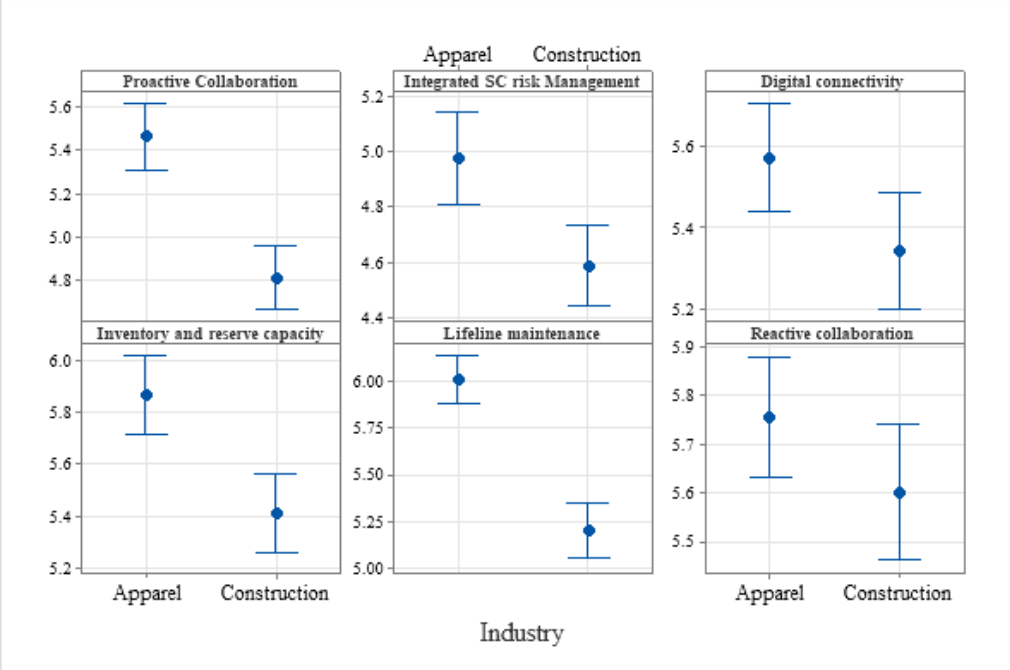

Figure 2 95% Confidence Intervals for the SC Resilience Strategies

maintenance was not equal among the two sectors ($p < 0.05$). However, only reactive collaboration has equal averages across the two industries, and their confidence intervals overlap with each other (Figure 1). Generally, it is impossible to foresee all the disruptions before occurrence. Therefore, reactive strategies come into action to recover from the disruption (Meng, 2020) and in such situations reactive collaboration becomes the key strategy to make communication link between the stakeholders to take relevant remedial actions.

As per the t-test results and the confidence intervals, all the SC resilience strategies except reactive collaboration are practiced in the two industries in significantly varied degrees. As per the mean values shown in Table 3 and Figure 1, all these strategies, namely, digital connectivity, proactive collaboration, integrated SC risk management, inventory and reserve capacity, and lifeline maintenance strategies are mostly adopted by the apparel companies compared to the construction industry. Out of all the strategies, lifeline maintenance, inventory and reserve capacity, and reactive collaboration, have been the most preferred response strategies within the apparel industry to overcome SC disruption effects. This finding is similar to the findings of Bastas and Garza-Reyes (2022), as manufacturing firms largely adopt reactive strategies including inventory and reserve capacity, lifeline maintenance and SC collaboration to minimize the impact of SC disruptions.

On the other hand, reactive collaboration, inventory, and reserve capacity, digital connectivity, and lifeline maintenance have been the most preferred response strategies by the SC practitioners in the construction industry. The observation on digital connectivity, is in line

with the research on the healthcare sector by Rubbio *et al.* (2018), who stated that digital connectivity is crucial to enhance the resilience practices. Digital connectivity helps to exchange real time information among SC partners and due to complex nature of the construction SCs, usage of digital connectivity is essential to improve the SC resilience. Furthermore, this finding proves the study done by Balakrishnan and Ramanathan (2021) that emphasized the fact for the automotive industry in Asia Pacific region. Integration with digital technologies in SCs can improve SC resilience as well as competitive advantage (Kang *et al.,* 2024).

Higher mean values of resilience strategies in the apparel industry compared to the construction industry confirm the existing literature that suggests the specific nature of apparel SCs in terms of demand volatility, just in time production (Bruce *et al.,* 2004) and global sourcing risks necessitating the well-arranged approaches for its SC resilience (Ali *et al.,* 2021). Therefore, export-oriented apparel industry in Sri Lanka tends to use more resilience strategies to face global challenges in maintaining SC resilience capabilities compared to the construction industry, which serves local customers.

Moreover, it was observed that integrated SC risk management is the least practiced strategy in both industries (with means of 4.98 for apparel and 4.59 for construction). However, this is somewhat deviating from existing literature. The reason is that most of the construction firms do an onsite risk management process before the construction project begins, which helps to identify potential risks and vulnerabilities before they occur (Abidin and Ingirige, 2018). In the same manner export-oriented apparel companies should also give relatively high priority to the integrated SC risk management process as it helps to identify disruptions in advance and plan adequate remedial action before it occurs. In general, moving towards higher levels of proactive strategies including proactive collaboration and digital connectivity would be highly important for both industries in improving resilience while implementation of these require more resources and systematic pre-arranged SC mechanisms.

As all the mean values are above the centre of the scale (1-7), it can be concluded that the two industries utilize all the six resilience strategies at least moderately. The reason is that recent disruptions including Covid 19 pandemic have taught important lessons to all the industries how important it is to have a flexible and resilient SCs to quickly adopt to market changes and customer requirements (Nguyen *et al.,* 2024).

5. CONCLUSION

SC resilience has been a trending topic in the SC management discipline during last few years mainly because of its significance highlighted in several recent worldwide disruptions. However, qualitative or quantitative evaluations on adoption of SC resilience strategies in developing economies were very limited in the existing literature. Hence, this study was carried out to assess the extent to which three proactive (digital connectivity, proactive collaboration, integrated SC risk management) and three reactive (reactive collaboration, inventory and reserve capacity, and lifeline maintenance) resilience strategies are practiced in Sri Lankan apparel and construction industries. A descriptive statistical analysis and independent sample t-test were performed using the data collected from 162 apparel and 185 construction companies in Sri Lanka. According to the mean comparison (t-test) results, a significant difference exists in the average levels of implementation of five resilience strategies, namely, proactive collaboration, digital connectivity, integrated SC risk management, inventory and reserve capacity and lifeline maintenance across the two industries. Practicing reactive collaboration is not significantly different between the apparel and the construction industries. Apparel sector leads in maintaining resilience in SCs through the adoption of all types of strategies, and lifeline maintenance has been identified as its most prominent strategy.

5.1 Theoretical Implications

Developing and validating measurement instruments for proactive and reactive strategies for SC resilience is the major theoretical contribution of this study. Comprehensive measurement scales for most of SC resilience strategies were not found in the literature (e.g. lifeline maintenance). Thus, based on the strong theoretical foundations, new measurement models for the six strategies have been developed. A seven-point Likert scale was used to measure the degree of adoption of each strategy in the selected sectors. The measurement model was tested using relevant statistical methodologies including exploratory factor analysis and reliability and validity tests.

5.2 Managerial Implications

Having a clear understanding of the business and current market changes is vital for top and middle level managers in order to establish and build resilient SCs (Kamalahmadi and Parast, 2016). Therefore, they attempt to implement various resilience strategies to face disruptive challenges proactively and reactively. Exploring the degree of adoption of three proactive and three reactive strategies in apparel and construction sectors in Sri Lanka that encountered various economic and pandemic disruptions in the recent past offers vital managerial implication to these industries operated in developing economies.

This research reveals that digital connectivity, integrated SC risk management, inventory and reserve capacity and lifeline maintenance strategies are adopted at significantly different levels in the two industries, whereas the adoption of reactive collaboration strategy does not vary significantly. The apparel industry primarily employs lifeline maintenance, inventory and reserve capacity, reactive collaboration, and proactive collaboration strategies to manage SC disruptions. This implies that Sri Lankan apparel sector that caters primarily to global markets, has selected: maintaining alternative transportation, buffer stocks of material and supplies, and strong collaborative partnerships with suppliers as the key strategies for making their SCs resilient. In contrast, the construction industry that has the project-based product deliveries to local markets mostly employs reactive collaboration, inventory and reserve capacity, digital connectivity and lifeline maintenance strategies, but stays behind the apparel sector in adopting all these strategies except reactive collaboration. Although inventory and reserve capacity is somewhat difficult strategy due to the space requirement of materials and higher

handling costs in the construction sector, improving lifeline maintenance, digital connectivity, and reactive collaboration would provide enhanced capability for them to face disruptions. However, integrated SC risk management remains as the least adopted strategy in both industries. Therefore, considering the recent disruptive effects observed in the apparel and the construction industries in Sri Lanka, it is highly recommended for both sectors to improve collaborations with SC partners for managing SC wide risks for better resilience.

5.3 Limitations and Future Research

This study has some limitations even though it presents some important novel findings on SC resilience strategies used in apparel and construction sectors. Since this research is limited to two industries in Sri Lanka, the findings may not be equally applicable to other industries or countries that have different SC or economic characteristics. Therefore, empirical investigations into other industries and countries are recommended. Furthermore, this research considered only six resilience strategies that are widely observed in proactive and reactive response to SC disruptions. Thus, future research focusing on other resilience strategies, such as virtual markets and business continuity plans (Belhadi *et al.,* 2020), would be valuable. Since this study had limited its scope to assess the level of implementation of SC resilience strategies, evaluating the effectiveness or understanding of the impact of these strategies on useful performance metrics will generate significant results for both SC practitioners and researchers.

CONFLICTS OF INTEREST

The authors have no financial or proprietary interests in any material discussed in this article.

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Anuradha Ranawakage holds a bachelor's degree in Facilities Management from the University of Moratuwa, Sri Lanka, and a master's degree from the University of Sri Jayewardenepura, Sri Lanka, majoring in supply chain management. Her broad areas of research interests are supply chain risk management and resilience, sustainability practices and operations management.

Chathurani Silva is a lecturer in Supply Chain Management at the Management, Technology and Organisation Department, Business School, Auckland University of Technology, New Zealand. She obtained her B.Sc. (Special) degree in Statistics from the University of Sri Jayewardenepura, MBA in Management of Technology from the University of Moratuwa, Sri Lanka, and PhD from Massey University, New Zealand. Her current research interests include supply chain risk management and resilience, adoption of digital technologies in supply chains, circular economy and sustainability practices, and collaborative product development.

APPENDIX

Table 4 Operationalization of Variables

Variables	Item Code	Items	References
Proactive collaboration	PCOL 1	Our firm and supply chain partners collaborate in developing new market and customer response.	(Simatupang and Sridharan, 2008); (Cao and Zhang, 2011); (Kim *et al.,* 2013); (Pettit *et al.,* 2013)
	PCOL 2	Our firm and supply chain partners collaborate in designing their processes/products.	
	PCOL 3	Our firm develops strategic plans in collaboration with our partners.	
	PCOL 4	Collaboration in demand forecasting and planning with our supply chain partners is something we always do in our company.	
	PCOL 5	Our data flow transparently between supply chain members, with full access by all parties to facilitate collaborative forecasting/planning.	
	PCOL 6	We have proactive product life-cycle management programs that strive to reduce both costs and risks in supply chains.	
	PCOL 7	Our firm works closely with the supply chain partners to prevent potential threats in the supply chain.	
Integrated SC risk management	ISCRM 1	We have a department to manage supply chain risks and disruptions.	(Ambulkar *et al.,* 2015); (Liu *et al.,* 2018); (Elbaz and Ruel, 2020)
	ISCRM 2	We have key performance indicators (KPI) and metrics to monitor supply chain risks.	
	ISCRM 3	We have information systems in place to manage supply chain risks and disruptions.	
	ISCRM 4	Our company encourages its employees to share their knowledge about risk management.	
	ISCRM 5	Our company has included the subject of risk management as an important topic in new personnel training.	
	ISCRM 6	We are comprehensively informed about basically possible risks in our supply chain.	
	ISCRM 7	Supply chain risk management is an important activity in our company.	
	ISCRM 8	Our risk management processes are very professionally designed.	
Digital connectivity	DC 1	Internet of Things provides the linkage for all our devices to the internet associated with production processes.	(Bienhaus and Haddud, 2018); (Raman *et al.,* 2018); (Cegielski *et al.,* 2012); (Merlino and Sproǵe, 2017) (Ben-Daya *et al.,* 2017)
	DC 2	Our organization can exchange real-time information with supply chain partners through digital platforms.	
	DC 3	We use advanced information systems to track and/or expedite shipments.	
	DC 4	The digital predictive analysis tools have a high degree of impact on our company's transaction speed.	
	DC 5	Our company is able to achieve information exchange with cloud computing.	
	DC 6	Our company employees have high digital technology capabilities.	
	DC 7	Internet of Things provides a link between our customers and the company.	
	DC 8	A high number of customer transactions in our organization are processed through digital systems.	
Reactive supply chain collaboration	RCOL 1	Our firm works closely with supply chain partners to recover from supply chain disruptions.	(Simatupang and Sridharan, 2008); (Cao and Zhang, 2011); (Kim *et al.,* 2013); (Pettit *et al.,* 2013)
	RCOL 2	Our firm and its supply chain partners help each other in several means at supply chain disruptions.	
	RCOL 3	At disruptive events, we hold meetings with our suppliers to make decisions collectively.	
	RCOL 4	At disruptions, we search for means of recovery not only to our firm but also to all our supply chain partners.	
	RCOL 5	Our customers are willing to delay orders when our production capacity is hampered.	
	RCOL 6	Our firm invests in facilities and equipment at suppliers' plants and is prepared to share risks with both suppliers and customers at disruptions in supply chains.	

Table 4 Operationalization of Variables (cont'd)

Variables	Item Code	Items	References
Inventories and reserve capacity	INVN 1	We have back up capacity for machinery, parts and logistical supports.	(Bastas and Garza-Reyes, 2022); (Chowdhury and Quaddus, 2017); (Angkiriwang *et al.,* 2014); (Manuj and Sahin, 2011); (Pettit *et al.,* 2013)
	INVN 2	We have buffer stocks for raw material.	
	INVN 3	Our company tends to stock high-risk parts and critical spares.	
	INVN 4	Our company sets capacity higher than average demand.	
	INVN 5	Our company prefers to maintain surge capacity in the form of extra assembly lines.	
	INVN 6	We have reliable back-up utilities (electricity, water, communications, etc.)	
	INVN 7	We maintain access to duplicate or redundant facilities and equipment.	
	INVN 8	We have significant excess capacity of materials, equipment, and labour to quickly boost output if needed.	
Lifeline maintenance	LIFE 1	Our company satisfactorily maintains transportation system and lifeline during disruptions.	
	LIFE 2	During disruptions, we were able to transport materials as we needed.	
	LIFE 3	During disruptions, we were able transport our products/semi-finished products as we needed.	
	LIFE 4	During disruptions, our company was able to ensure the availability of sufficient transportation facilities to the staff.	
	LIFE 5	Our company has means to quickly respond to disruptions happened to transportation systems and lifeline.	
	LIFE 6	Our company is able to recover from disruptions happened to transportation systems and lifeline.	
	LIFE 7	We have equipment and tools required to maintain our transportation facilities.	