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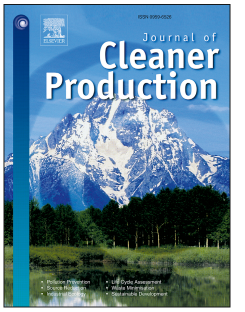

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Dynamic Capabilities for Meeting Stakeholders' Sustainability Requirements in Supply Chain

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Table 3: Participants Description

Participant	Position	Type of the company	Company size (no of employees)	Age of the company
D1	General Manager	Garment manufacturer	2000-3000	20-25 years
D2	Manager Merchandising	Accessory supplier	200- 300	Less than 5 years
D3	Supply chain manager	Garment manufacturer	4000- 5000	5-10 years
D4	Deputy General manager	Accessory supplier	300-400	15-20 years
D5	Deputy General manager	Garment manufacturer	1000- 2000	10-15 years
D6	Manager Merchandising	Garment manufacturer	3000-4000	20-25 years
D7	Supply chain manager	Garment manufacturer	10000-15000	20-25 years
D8	Manager	Accessory supplier	200- 300	5-10 years
D9	Supply chain manager	Garment manufacturer	15000- 20000	15-20 years
D10	Manager Merchandising	Garment manufacturer	2000-3000	10-20 years
D11	Manager	Garment manufacturer	1000-2000	10-15 years
D12	Manager	Accessory supplier	100-200	5-10 years
D13	Supply chain manager	Garment manufacturer	20000-25000	20-25 years

Table 4: Summary of Sustainability requirements and the Strategies

	Sustainability requirements (SR)	**Companies**								
Social		1	2	3	4	5	6	7	8	9
	Ensuring fair payments (SR1)	y	y		y		y	y	y	y
	Ensuring benefits (SR2)	y	y	y	y		y			y
	Ensuring health and Safety factors (SR3)	y	y	y	y	y		y	y	y
	Restricting child labour in organisation (SR4)	y	y	y	y	y	y	y	y	y
	Restricting force labour and harassment (SR5)	y		y		y		y		
Environmental	Environment and health hazard free ingredient in product (SR6)	y	y	y	y	y	y	y	y	y
	Reducing environmental impact and improving efficiency (SR7)	y		y	y		y	y	y	
Operational	Quality (SR8)	y	y		y	y	y			
	Lead time (SR9)	y	y	y	y	y	y	y	y	y

Economic	Cost/competitive price (SR10)	y	y	y	y	y	y	y	y	y
	Sustainability Strategies (ST)									
	Improving human resource (HR) policy regarding workers benefits (leave benefit, medical benefit, child care facility, transportation facility) (ST1)	y		y	y	y		y	y	y
	Undertaking sustainability awareness programs (promoting and communicating sustainability to all employees, training, counselling and workshop on sustainability issues) (ST2)	y	y		y		y			y
	Developing health and safety by improving the existing condition of number of exit door, fire equipment, clean drinking water, adequate toilet. (ST3)	y	y	y		y		y	y	y
	Preparing social and environmental audit report (conducting both internal and external audit) (ST4)	y	y	y	y	y		y	y	
	Supplier evaluation, training and development (ST5)		y		y	y	y			y
	Reducing defection rate, quality control and lab testing during receiving material and shipment of products (ST6)	y		y	y		y	y	y	
	Training and development (skill development programs) (ST7)	y	y		y		y	y	y	y
	Installing efficient machinery and technology (ST8)	y		y		y			y	y
	Recycling, reusing and treatment of wastes (ST9)	y	y	y	y	y		y		y

Appendix 2: Linguistics expression of correlation between the sustainability requirements (WHATs) and the strategies (HOWs)

	ST1			ST2			ST3			ST4			ST5		
SR1	H	H	VH	M	M	H	H	H	VH	M	M	H	L	L	M
SR2	H	VH	VH	M	M	H	M	M	H	M	M	H	L	L	M
SR3	M	M	H	M	H	H	H	VH	VH	M	M	H	M	M	H
SR4	H	VH	VH	H	H	VH	H	VH	VH	H	H	VH	M	H	H
SR5	M	H	H	M	M	H	M	H	H	L	M	M	L	L	M
SR6	L	L	M	L	M	M	M	H	H	M	M	H	M	H	H

SR7	VL	L	L	M	M	H	M	M	H	H	H	VH	M	M	H	V
SR8	M	M	H	L	L	M	VL	L	L	VL	VL	L	M	M	H	I
SR9	M	H	H	VL	L	L	VL	VL	L	VL	VL	L	L	L	M	V
SR10	VL	VL	L	L	M	M	VL	VL	L	VL	VL	L	L	L	M	I

Appendix 3: Correlation between the sustainability requirements (WHATs) and the strategies (HOWs)

WHATs	Weight	(ST1)				(ST2)				(ST3)				(ST4)				(ST5)				(ST6)				(ST7)				ST8				ST9			
	of WHAT	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value
SR1	8.33	6.67	7.67	8.67	7.67	4.67	5.67	6.67	5.67	6.67	7.67	8.67	7.67	4.67	5.67	6.67	5.67	2.67	3.67	4.67	3.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR2	7.67	6.33	8.33	9.33	8.33	4.67	5.67	6.67	5.67	4.67	5.67	6.67	5.67	4.67	5.67	6.67	5.67	2.67	3.67	4.67	3.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR3	8.33	4.67	5.67	6.67	5.67	5.33	6.33	7.33	6.33	7.33	8.33	9.33	8.33	5.33	6.33	7.33	6.33	4.67	5.67	6.67	5.67	2.67	3.67	4.67	3.67	6.67	7.67	8.67	7.67	3.33	4.33	5.33	4.33	0	0	0	0
SR4	9	7.33	8.33	9.33	8.33	6.67	7.67	8.67	7.67	7.33	8.33	9.33	8.33	6.67	7.67	8.67	7.67	5.33	6.33	7.33	6.33	0	0	0	0	0	0	0	0	0	0	0	0	1.33	2.33	3.33	2.33
SR5	7.67	5.33	6.33	7.33	6.33	4.67	5.67	6.67	5.67	5.33	6.33	7.33	6.33	3.33	4.33	5.33	4.33	2.67	3.67	4.67	3.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR6	9	2.67	3.67	4.67	3.67	3.33	4.33	5.33	4.33	5.33	6.33	7.33	6.33	4.67	5.67	6.67	5.67	5.33	6.33	7.33	6.33	7.33	8.33	9.33	8.33	5.33	6.33	7.33	6.33	4.67	5.67	6.67	5.67	0	0	0	0
SR7	7.67	1.33	2.33	3.33	2.33	4.67	5.67	6.67	5.67	4.67	5.67	6.67	5.67	6.67	7.67	8.67	7.67	4.67	5.67	6.67	5.67	1.33	2.33	3.33	2.33	4.67	5.67	6.67	5.67	5.33	6.33	7.33	6.33	7.33	8.33	9.33	8.33
SR8	9	4.67	5.67	6.67	5.67	2.67	3.67	4.67	3.67	1.33	2.33	3.33	2.33	0	0	0	0	4.67	5.67	6.67	5.67	7.33	8.33	9.33	8.33	7.33	8.33	9.33	8.33	7.33	8.33	9.33	8.33	1.67	2.67	0.67	2.67
SR9	8.33	5.33	6.33	7.33	6.33	0	0	0	0	1.33	2.33	3.33	2.33	0	0	0	0	2.67	3.67	4.67	3.67	0	0	0	0	5.33	6.33	7.33	6.33	5.33	6.33	7.33	6.33	0	0	0	0
SR10	7.67	0	0	0	0	3.33	4.33	5.33	4.33	0.67	1.67	2.67	1.67	0	0	0	0	2.67	3.67	4.67	3.67	2.67	3.67	4.67	3.67	7.33	8.33	9.33	8.33	5.33	6.33	7.33	6.33	2.67	3.67	4.67	3.67
AI		44.33	54.33	63.33		40.01	49.01	58.01		44.66	54.66	64.66		36.01	43.01	50.01		38.02	48.02	58.02		21.33	26.33	31.33		36.66	42.66	48.66		31.32	37.32	43.32		13	17	18	
Crisp value			55.41				53.34				54				48.02				48.02				38.51				50				44				24.5		
RI			0.133				0.128				0.129				0.115				0.115				0.093				0.12				0.106				0.059		
Cost		16	18	20	18	3	4	5	4	8	10	12	10	3	4	5	4	3	4	5	4	5	6	7	6	3	4	5	4	7	8	9	8	7	8	9	8

Dynamic Capabilities for Meeting Stakeholders' Sustainability Requirements in Supply Chain

Abstract

In todays' dynamically changing environment and competitive landscape, organisations are adopting sustainable practices for attaining long-term economic viability. However, there is a misalignment between sustainable practices and organisations' strategies and capabilities, especially when sustainability requirements of the stakeholders changes over time. Grounded in dynamic capability view (DCV), this paper addresses the changes in supply chain sustainability requirements of stakeholders in the context of sourcing products from apparel manufacturers in a low cost country Bangladesh. To this end, this study develops a decision support (DS) framework for supply chain sustainability (SCS) that identifies and prioritises optimal strategies for SCS in a dynamic environment. This study adopts a mixed method approach, with the qualitative approach being a field study, and the quantitative approach using fuzzy Quality Function Deployment (QFD) integrated optimization technique. Our DS framework addresses the stakeholders' sustainability requirements over time in the context of a case company. The findings show that concomitant with the changes in the stakeholders' priorities of the sustainability requirements, the organizational sustainability practices, strategies and capabilities also change over time. The SCS DS framework brings a richer conceptual understanding of the dynamic changes in stakeholder requirements and allow managers to choose and select optimal strategies and make astute decisions whilst balancing the economic, social and environmental viability simultaneously.

Key words: Supply chain sustainability, Decision support framework, Stakeholder requirements, Dynamic capability view.

1. Introduction

> *The global textile and apparel industry is at a crossroads. It is a three trillion dollar industry … The flipside of this growth ….has been a broadening and deepening track record of poor working conditions and heavy pollution. The collapse of the Rana Plaza factory in April 2013 in Dhaka, Bangladesh jolted to life widespread and increasingly prolonged scrutiny of the industry. This incident has brought longstanding questions to the forefront over how to bridge the gap between economic viability and social and environmental performance.* (Martin 2013; p. 2).

Clearly, the issues highlighted by Martin (2013) prevail in both a quintessential global industry and one that is inescapably labour intensive (such as the apparel industry) (Islam and Deegan 2008, Ahmed and Peerlings 2009). These issues are heightened in low-cost developing economies who not only face the difficult task of complying with stakeholder requirements but also face the balancing act of economic, social and environmental issues (Pagell and Wu 2009). Compliance of such issues is even more difficult for low-cost country manufacturers noting that shortage of resource is one of the prime constraints in implementing supply chain sustainability (SCS) strategies (Ageron et al. 2012; Muduli and Barve 2012; Welford and Frost 2006). Hence, to remain competitive, organisations in such low-cost countries need to establish contextualised strategies to enhance SCS performance (Plambeck and Taylor 2015).

Organisations need continuous adaptation of sustainable practices to align effectively with their strategies and capabilities (Amui et al. 2017). For example, after the collapse of Rana Plaza building and the factory fire in "Tazreen Fashion" ensuring workers' safety has become an utmost priority for the stakeholders (Human Rights Watch report 2015). It was revealed that in a dynamic environment where priorities of stakeholders were continuously changing, organisations need to mobilise and reconfigure portfolio of capabilities to respond to the changing stakeholder sustainability requirements. However, executing an end-to-end strategy is a daunting task and requires a decision support (DS) framework to address changes in priority of the stakeholders' sustainability requirements.

Literature suggests that it is extremely difficult, if not impossible, to reconcile stakeholders' concerns especially when ambiguity, vagueness, and pressure groups are key elements of stakeholder management (Fassin 2009). This is more so when an industry has myriad of secondary stakeholders (e.g., various lobby groups, environmental activists, media etc.). Hall and Vredenburg (2005 p.11) report that 'stakeholder ambiguity' is difficult to manage as "it is idiosyncratic and context-specific". Recent studies suggest that the requirements of sustainability follow a logic of 'materiality' and 'adaptability' (Lyndenberg 2012; Reeves et al. 2012; Hsu et al. 2013). In the same vein, Reeves et al. (2012) argue that sustainability should be regarded as an 'adaptive advantage' whilst Teece et al. (1997) regard such adaptive capability as a "dynamic capability" of an organisation. Beske (2012) identifies that implementing supply chain sustainability strategies to satisfy the stakeholders' requirements is also a dynamic capability. Henceforth, aligned with Beske (2012), we argue that translating the dynamic nature of the stakeholders' sustainability requirements to appropriate strategies is a dynamic capability of organisations.

Synthesizing the extant literature we identify the following research gaps. Ahmed and Sundaram (2012) suggest a need for DS framework for sustainable business but it falls short of addressing stakeholder ambiguity and adaptability concepts. Empirical studies integrating social, environmental and economic dimensions of sustainability are also lacking (Ahmed and Sundaram 2012; Seuring 2013). Further, a DS framework to select an optimal mix of strategy based on dynamic changes in stakeholders' requirements over time is scarce. Thus, primary motivation of this study is to translate stakeholders' changing sustainability requirements into meaningful and practical strategies using dynamic capabilities view (DCV) (Teece 2007; Teece 2017) through a SCS DS framework. More specifically, this study offers a more nuanced view on the effect of dynamic capabilities on sustainability, and investigates (i) the SCS requirements (economic, social and environmental) of the stakeholders and corresponding strategies to meet those requirements, (ii) prioritize the SCS requirements in (i) and (iii) determine the optimal mix of strategies considering the dynamic nature of stakeholders' sustainability requirements over time.

This study adopts a fuzzy QFD based non-linear optimization technique that translates the dynamic nature of stakeholders' sustainability requirements to most efficient strategies. Such a DS framework will also extend the scope of DCV (Teece 2017). The decision makers will be able to mobilise, manoeuvre and transform optimal portfolio of strategies as stakeholders' sustainability requirements change across both the temporal and contextual spaces. Further, cross linking SCS strategies and practices with stakeholder requirements support the process of adaptation reflected through innovative and sustainable practices (Amui et al. 2017).

This study makes three significant contributions. First, we develop a DS framework which operationalises dynamic capabilities (organizational sustainability strategies) which are interlinked, interdependent and result in saving cost when executed simultaneously. Methodologically this DS framework is based on fuzzy QFD based non-linear optimization technique. This technique is generic in nature as it can be used for any strategy optimization with respect to customer requirements. However it has been customized in our specific application which shows the process of customization thus contributing to the extant literature. Second, this study uses extant literature and field study to come up with various sustainability requirements and corresponding strategies for apparel manufacturing industry. Many of this can be generalized for other similar apparel manufacturing elsewhere. Finally, this study uses apparel manufacturing in Bangladesh as a specific case study. Bangladesh is now 2nd largest apparel manufacturer in the world (https://www.thedailystar.net/business/export/bangladesh-remains-the-second-biggest-apparel-exporter-1614856; accessed on November 25, 2018). This study thus makes significant contribution to the domain of apparel manufacturing industry in the context of supply chain sustainability requirements.

The paper is organised as follows. Section 2 presents the literature review, Section 3 describes the research methodology, Section 4 describes the results, Section 5 focuses on discussions where theoretical and managerial implications are presented, and lastly Section 6 where conclusions are presented.

2. Literature review

2.1 Supply chain sustainability

Issues pertaining to sustainability in supply chain have been researched in recent years from various perspectives. Seuring and Muller's (2008) highlight that in order to achieve SCS organizations need to deal with various sustainability requirements of the stakeholders. Therefore, focal firms in supply chains shall be held accountable for the economic, environmental and social performance of supply chain stakeholders. SCS has been recognized as a strategic weapon for organisations and their supply chain members as it has a pulling effect in the market driven by customer demand (von Geibler et al. 2006). As such, organisations need to maintain a balance among social, environmental and economic goals to satisfy stakeholders' requirements (Carter and Rogers 2008; Carter and Easton 2011; Reefke and Sundaram 2017). In a related study, Pagell and Gobeli (2009, p. 278) have shown that social, environmental and operational performance "do interact in a significant way". Parmigiani et al. (2011) study the dilemma of efficiency and accountability and propose that stakeholders' exposure plays a significant role in SCS outcomes, hence, operations managers should outline various operations to achieve SCS outcomes. Literature also suggests that SCS is now a salient requirement of customers, government and stakeholders (Seuring and Muller 2008) and that organisations and their supply chains are integrating sustainability in their strategic plans.

Previous studies from extant literature (see Table 1) have identified various sustainability issues to meet the buyers' and other stakeholders' requirements. Though stakeholders' sustainability requirements have been investigated by many studies, research on prioritizing the multi-dimensional sustainability requirements and designing optimal strategies to address the important requirements is scarce.

{Insert table 1}

The multi-dimensional sustainability requirements (Table 1) correspond to the earlier discussions on the stakeholder ambiguity and materiality/adaptability sustainability concepts.

2.2 Supply chain sustainability and dynamic capability view

Based on the extant literature, dynamic capability view (DCV) is defined as the organisational capability to successfully identify opportunities, followed by executing necessary actions to reconfigure organisational assets and operational capabilities to address the rapidly changing external environment (Teece et al. 1997; Teece 2009). DCV addresses the context insensitivity of traditional resource-based and fits with the idiosyncracy of market requirements and their changes. In addition, DCV emphasizes on clarifying the processes, resources and strategies through which companies can achieve competitive advantage in a dynamic market environment (Teece et al. 1997; Eisenhardt and Martin 2000). Furthermore, standard-setting bodies, regulatory authorities, the judiciary system, education and research organisations are included in the community of organisation that may have a potential impact on the focal organisation's strategic intent (Teece 2009).

Importantly, Teece (2009 p.1319) defines the micro foundations of dynamic capabilities as "distinct skills, processes, procedures, organisational structures, decision rules, and disciplines—which undergird enterprise-level sensing, seizing, and reconfiguring capacities are difficult to develop and deploy".

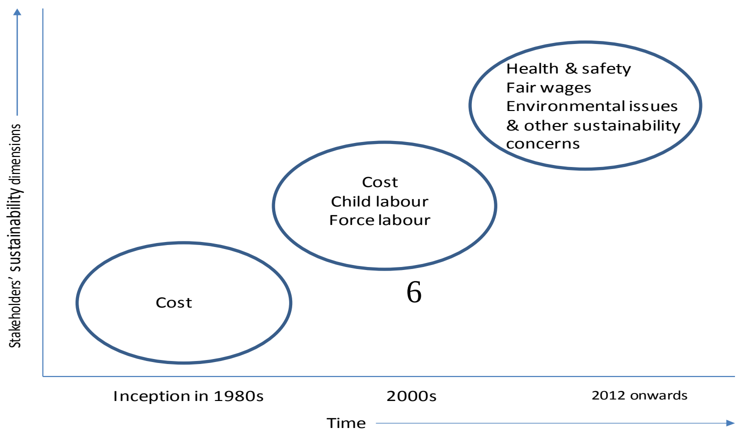


Figure 1: Shift in stakeholders focus over time

Under this premise, we posit that not only do the micro foundations of enterprises change over time in response to external stimuli, the stakeholders' SCS requirements are also changing in line with the market conditions - making it even more difficult to execute (see Figure 1).

The dynamic nature of the market environment (e.g. intensive pressure of stakeholders along with the fierce competition of the competitors, health and safety requirements etc.) is compelling the managers to implement appropriate sustainability strategies through collaboration in supply chains. Therefore, marketers need to translate the sustainability requirements of the diversified stakeholders in devising appropriate strategies to co-exist in a dynamic market environment. Amui et al. (2017) in their recent research study identify the gap that exists between an organisations sustainable practices and the alignment between organisations strategies and capabilities. Commensurate with this, we suggest that organisations need to arrange and remobilise their resources and capabilities to implement sustainability strategies as per stakeholder requirements.

2.3 Process of meeting sustainability requirements

Adherence to and compliance with sustainability requirements is critical when competing in volatile markets. In the context of Bangladesh, a study by Chowdhury et al. (2015) report that lack of regulatory framework and sustainability policy, lack of awareness and sustainable education (among others) are the main barriers to sustainability. Mitigation of these problems is essential in fulfilling the sustainability requirements of the buyers and their stakeholders. Researchers argued that sustainability policy can help an organisation move towards sustainable business practices (e.g., Aragón-Correa and Sharma 2003; Kuasirikun 2005; and others). Regulations in most countries require some social and environmental aspects of business activities by managers who frequently address wider sustainability issues (Schaltegger and Burritt 2005). Plambeck and Taylor (2015) suggest that buying firms in the apparel industry need to apply obvious approaches such as auditing and publicizing negative audit reports, as well as less obvious approaches such as reducing the supplier's margin to motivate suppliers to comply with sustainability standards.

Organisations are increasingly evaluating their social and environmental performance through the achievement of certificates including ISO 14001, United Nations global compact membership from standard setting bodies and more (Adams and Narayanan 2007) whilst ensuring sustainable working conditions including occupational health, safety and hygienic factors for meeting the requirements of customers (Islam and Deegan 2008). Chowdhury et al. (2015) argued that awareness creation and continuous training of employees, management and other stakeholders may help the companies achieve their sustainability objectives. To meet the sustainability standards, technological advancement (in particular the efficiency of technology) is an extremely important aspect of success. Awaysheh and Klassen (2010) reported that supply chain structure (in terms of dependency, transparency and distance) also play an important role in ensuring supplier socially responsible practices. Considering the review of existing literature Table 2 summarizes the processes of meeting sustainability standard in a concise way.

{Insert table 2}

Based on the gaps in the literature and grounded in dynamic capability views we develop a SCS conceptual framework (see Figure 2). In line with the model this study investigates the optimal portfolio of strategies required to meet the SCS requirements of apparel industry stakeholders in Bangladesh using QFD based optimization method. In the next section, we discuss the research methodology.

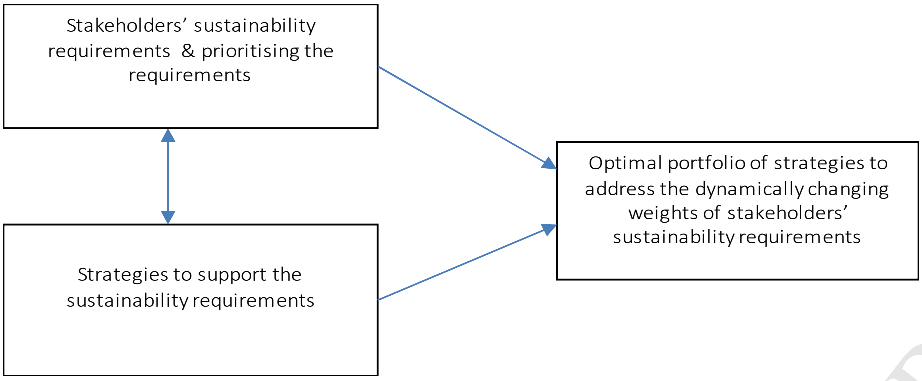


Figure 2: Supply Chain Sustainability (SCS) conceptual framework

3. Research methodology

We use both qualitative and quantitative research methods to assist in increasing the quality, accuracy, validity and reliability of data collected for this research (Creswell 2003). Figure 3 provides a summary of the research design method, the sampling frame and data collected for the research framework proposed in Figure 2. There are three phases underpinning the SCS research framework which are discussed next.

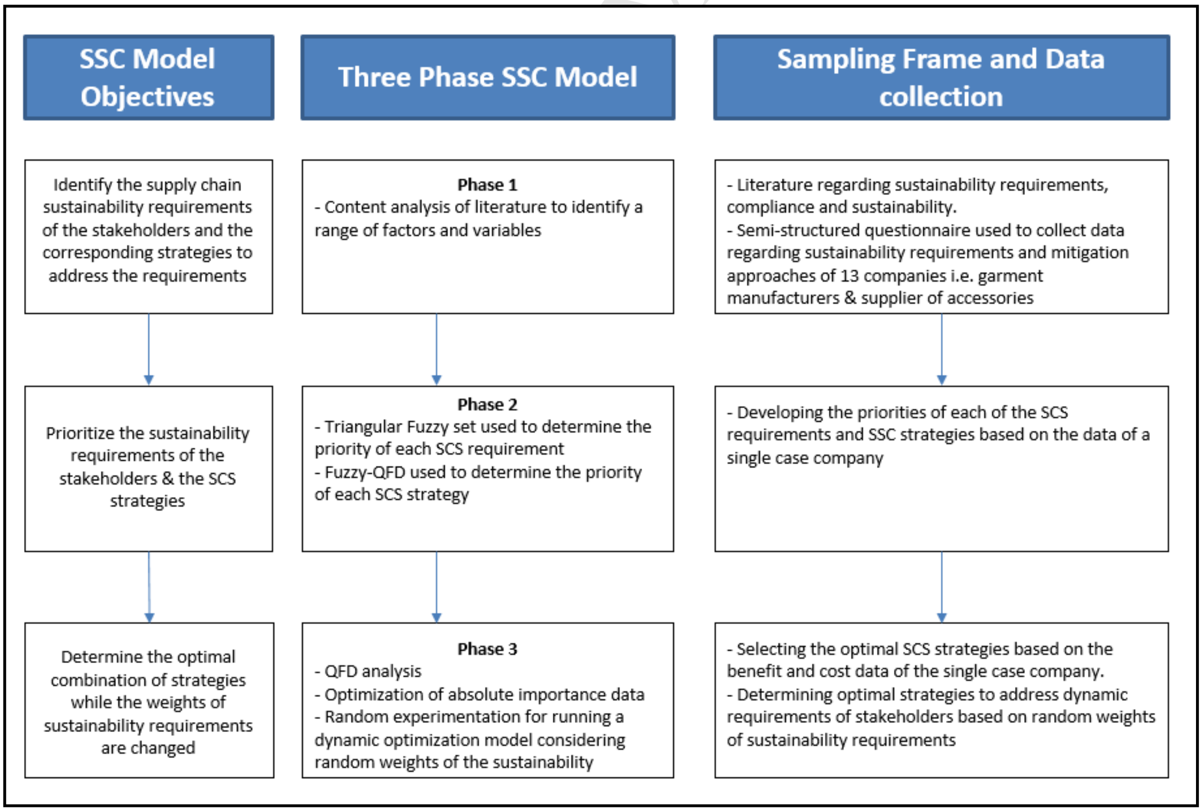


Figure 3: Summary of research design method

3.1 Phase 1

Using a qualitative approach grounded in an extensive literature review followed by interviews, Phase 1 identifies sustainability requirements and associated strategies. Findings from the literature were contextualised adopting a field study approach where we used semi-structured questions (detailed in Figure 3 above).

Data were collected from thirteen apparel manufacturers and their suppliers. Data analysis revealed that convergence occurred after nine interviews, the results for which have been reported in the qualitative phase. Table 3 shows the profile of the interview participants. The supply chain decision making managers of each company was interviewed for approximately 50-60 minutes. During interviews we asked the interviewees about the sustainability requirements in apparel supply chain and the strategies adopted by the firms to meet those sustainability requirements.

{Insert table 3}

3.2 Phase 2

Phase 2 describes the quantitative approach adopted to determine the priority of each SCS requirement identified in phase 1 based on the importance weighting derived from the decision makers' opinion using a triangular fuzzy membership function in line with the previous literature (Bevilacqua et al. 2006) to quantify the linguistic data in our application. The fuzzy membership function is as follows:

$$\mu_x(x) = \left\{ \begin{array}{ll} \frac{x}{x^{\beta}-x^{\alpha}} - \frac{x^{L}}{x^{\beta}-x^{\alpha}}, & x \epsilon\ (x^{\alpha}, x^{\beta}) \\ \frac{x}{x^{\beta}-x^{\gamma}} - \frac{x^{\gamma}}{x^{\beta}-x^{\gamma}}, & x \epsilon\ (x^{\gamma}, x^{\beta}) \\ 0, & \text{otherwise.} \end{array} \right\}$$

To assess a group of attributes we used the linguistic set U= (VL, L, M, H, VH), where, VL = very low, L = low, M = medium, H = high, VH = very high (Bevilacqua et al. 2006). The corresponding triangular fuzzy membership function is shown in Figure 4 where VL= (0,1,2); L= (2,3,4); M= (4,5,6); H= (6,7,8) and VH= (8,9,10) (Bevilacqua et al. 2006). As an example, the linguistic variable H varies from 6 to 8, 7 being most likely with the maximum degree of membership of 1.

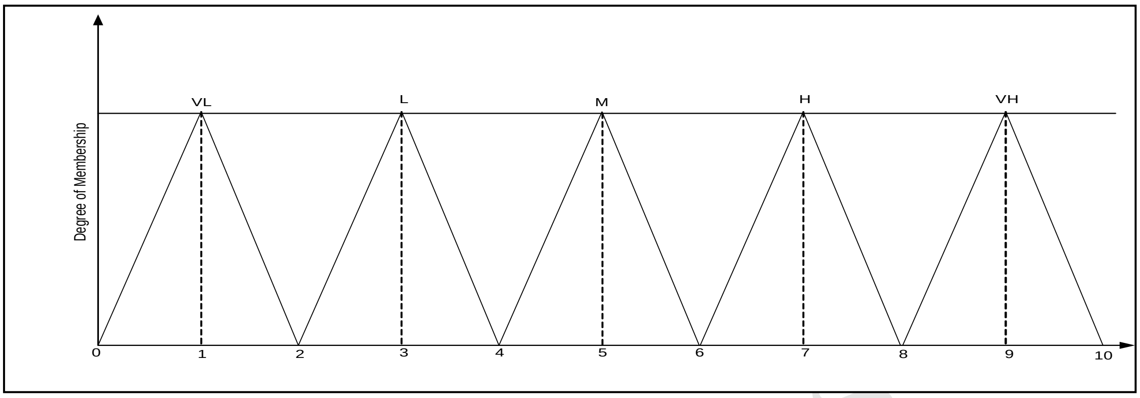


Figure 4. Triangular fuzzy membership function of the importance rating (Bevilacqua et al. 2006)

Next, the crisp values from the triangular fuzzy numbers are used to determine the importance weighting of sustainability requirements. The following equation is used to determine the importance of weight (Facchinetti et al. 1998):

$$AI_{crisp} = (AI_{lower\ value} + 2AI_{most\ likely} + AI_{upper\ value})/4$$

Fuzzy-QFD is then used to determine the relationship between sustainability requirements and the strategies adopted (as identified in phase 1) to meet stakeholder requirements. Figure 5 shows a generic QFD model wherein the 'WHATs' are the stakeholders' sustainability requirements (customer requirements) of apparel supply chain. The 'HOWs' are the design requirements (strategies) to support the sustainability requirements.

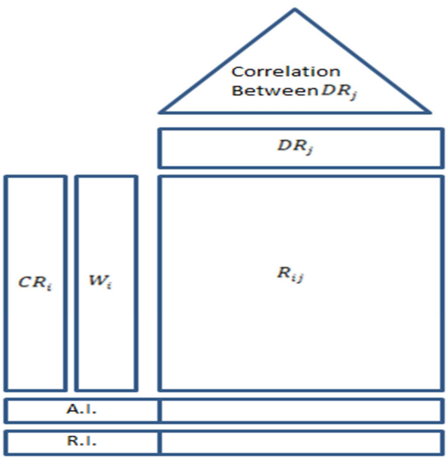


Figure 5. QFD model

Note: CR_i = Customer requirements; W_i = Degree of importance of CR_i's; DR_j = Design Requirements(strategies); R_{ij} = Relationship Matrix (i.e. degree to which CR_i is met by DR_j) A.I.= Absolute importance of DR_j's ; R.I.= Relative importance of DR_j's(strategies).

The "absolute importance and relative importance values" in Figure 5 are the importance weighting of the' HOWs', which can be determined from the relationship between the 'WHATs' and the 'HOWs', i.e., to what extent the 'WHATs' (the sustainability requirements (SRs)) are realized by the 'HOWs '(the strategies (STs)).

To find the absolute importance (AI) and relative importance (RI) of the strategies 'HOWs' equations (i) and (ii) are used.

$$AI_j = \sum_{i=1}^{n} W_i R_{ij} \qquad \forall j\ ,\ \ j = 1, \dots \dots, m \qquad \text{..............} \ \text{(i)}$$

$$RI_j = \frac{AI_j}{\sum_{k=1}^{n} AI_k} \qquad \text{........................} \ \text{(ii)}$$

Where,

AI_j = Absolute importance/sustainability score of the jth strategy (ST or HOWs), (j = 1 to 9 in our case)

W_i = Weight of the ***i***th sustainability requirements (SR or WHATs), (i = 1 to 10 in our case, obtained from table 5).

R_{ij} = Relationship value between the ***i***th WHATs and ***j***th HOWs. (obtained from Figure 5).

The fuzzy triplets of AI values of the strategies (shown in the row of "AI of HOWs" in Figure 5) are de-fuzzified before finding the relative importance (RI) of the strategies. The roof of the QFD model shows the relationship between the 'HOWs', i.e. the extent of overlaps in the strategies. We populate Figure 5 and display its context specific detailed version of the "SCS Model" in Figure 6 which is discussed later.

3.3 Phase 3

Phase 3 develops an optimization model which helps to identify the optimal strategies that address the dynamic changes in stakeholders' sustainability requirements over time. Our optimisation model extends Park and Kims' (1998) model as it incorporates the dynamic process of strategy (HOWs) selection based on the changing focus/weights of (WHATs) stakeholders' sustainability requirements over time. For optimisation modelling the QFD group members provide the necessary information.

As we are considering dynamic changes in sustainability requirements over time, the experiment is run from the time frame t=1 to n. The optimisation problem is formulated as follows:

$$Max\int(x) = \sum_{j=1}^{n} AI_{jt}x_{jt}$$

S.t. $\sum_{j=1}^{n} c_j x_{jt} - \sum_{i=1}^{n}\sum_{j=i}^{n} s_{ijt}x_{it}x_{jt} \leq$ B

x_j = 0, 1, t= 1 to n period.

Where, *AIjt* is the absolute importance of strategy *xj* at time *t*, *cj* is the expected cost of implementing strategy *xj*; *sijt* is the savings from simultaneous implementation of strategy *xi* and *xj* at time t; B is the available budget.

The optimisation model uses random weights of the sustainability requirements at different time frame (t= 1 to n period) to address the dynamic changes in stakeholders' sustainability requirements. Corresponding to changes in the weight of stakeholders' sustainability requirements organisational strategy will change accordingly in line with the theme of DCV (Teece 2007; Teece 2017).

To testify this, a random optimisation experiment is conducted using randomly generated data based on the following seven steps:

Step 1: Generate random number for each sustainability requirement weight for time t=1

Step 2: Determine importance of each strategy corresponding to the sustainability requirements

Step 3: Determine AI/sustainability score of each strategy

Step 3: Solve the model

Step 4: Determine Optimal AI

Step 5: Repeat steps 1 to 4 for t=100 times

Step 6: Record and analyse the results

Step 7: End

4. Application of the SCS Decision Support Framework to Apparel industry in Bangladesh

We apply the SCS framework developed in Figure 2 and validate the dynamic nature of stakeholders' sustainability requirements in the context of a very large company in the apparel industry in Bangladesh. Henceforth, the next section discusses the results for each of the 3 phases described earlier in section 3.

4.1 Phase 1 Results

Table 4 summarises the sustainability requirements and associated strategies into four categories: social, environmental, operational and economic. Correspondingly nine strategies were identified from the data collected. Most of the sustainability requirements and strategies shown in Table 4 are consistent with the factors and strategies identified from the literature review (Tables 1 and 2) and have been derived without any trade-offs.

{Insert table 4}

4.2 Phase 2 Results

Phase 2 uses a quantitative approach to determine the weighting of sustainability requirements and the importance of strategies for meeting various sustainability requirements by adopting fuzzy QFD method on a single case company (one of the nine case companies selected for field study in phase 1). The case company is one of the largest apparel manufacturing companies in Bangladesh. Three decision makers (DMs) were involved from the case company to overcome any bias in decision making (Lee and Kim 2000) i.e. the supply chain manager, merchandising manager, and the production manager.

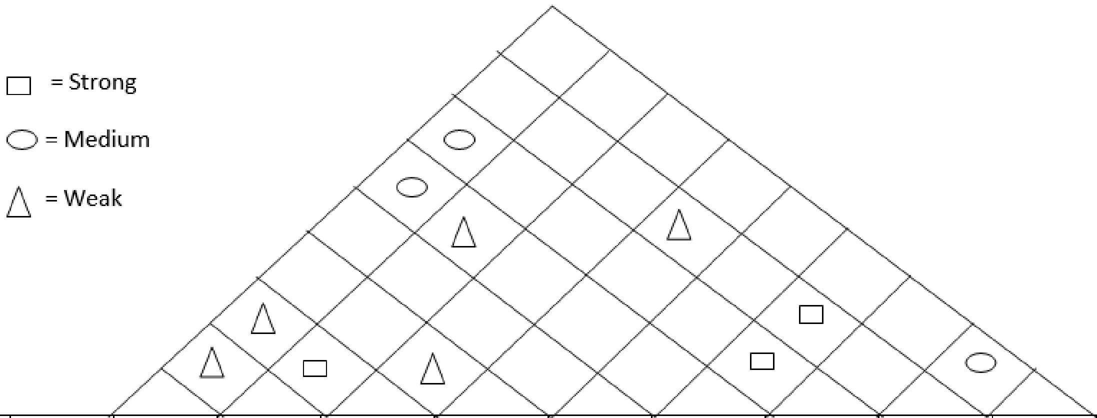
Determining weights of the sustainability requirements

To assess the importance ratings of the sustainability requirements (WHATs) we asked each decision maker (DM) of the case company to provide verbal (linguistic) responses using the linguistic set U= (VL, L, M, H, VH) (appendix 1) and the responses from three DMs were then aggregated using the average operator. Table 5 shows the aggregated importance ratings (W_i, *i* = 1 to 10) in fuzzy triplets.

{Insert table 5}

Determining weights of strategies to meet sustainability requirements

To determine the importance of strategies to meet sustainability requirements we identified the relationship between the sustainability requirements (WHATs) and the strategies (HOWs). This step required extensive interactions with the three decision makers (DMs) of the company. Each DM was asked: 'to what extent the strategies (HOWs) support the sustainability requirements (WHATs)", i.e., the relationship between the WHATs and the HOWs using the linguistic variables as shown in appendix 2 in the form of a correlation matrix. Through aggregation of the three DM's responses the main WHAT-HOW correlation matrix showing the correlation between WHATs and HOWs is determined: R_{ij} in fuzzy triplets in terms of $x^{\propto}$ (lower value), x^{β} (most likely value) and x^{γ} (upper value), where *i* = 1 to 10 are the WHATs and j = 1 to 9 are the HOWs as shown in appendix 3.



HOWs	Weight	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9
SR1	8.33	63.8911	47.2311	63.8911	47.2311	30.5711	0	0	0	0
SR2	7.67	63.8911	43.4889	43.4889	43.4889	28.1489	0	0	0	0
SR3	8.33	47.2311	52.7289	69.3889	52.7289	47.2311	30.5711	63.8911	36.0689	0
SR4	9	74.97	69.03	74.97	69.03	56.97	0	0	0	20.97
SR5	7.67	48.5511	43.4889	48.5511	33.2111	28.1489	0	0	0	0
SR6	9	33.03	38.97	56.97	51.03	56.97	74.97	56.97	51.03	0
SR7	7.67	17.8711	43.4889	43.4889	58.8289	43.4889	17.8711	43.4889	48.5511	63.8911
SR8	9	51.03	33.03	20.97	0	51.03	74.97	74.97	74.97	24.03
SR9	8.33	52.7289	0	19.4089	0	30.5711	0	52.7289	52.7289	0
SR10	7.67	0	33.2111	12.8089	0	28.1489	28.1489	63.8911	48.5511	28.1489
AI		453.194	404.668	453.937	355.549	401.279	226.531	355.94	311.9	137.04
RI		3.30702	2.95292	3.31244	2.59449	2.92819	1.65303	2.59734	2.27598	1
Cost		18	4	10	4	4	6	4	8	8

Figure 6: Supply Chain Sustainability (SCS) Framework

Figure 6 above shows the crisp values of the weighted score of R_{ij} values which is the result of multiplication of weights of WHATs (crisp value) and the crisp values of R_{ij} values. For example, the value 63.89 in R_{11} cell of Figure 6 is the product of 8.33 (crisp value of WHAT 1 in Table 5) and crisp value of R_{11} 7.67 (shown in Appendix 3). From the WHAT-HOW correlation matrix we determine the absolute importance (AI) and relative importance (RI) values of each strategy. Figure 6 shows the crisp values of the AI scores of the strategies. It is noted that these crisp values of AIs constitute the sustainability scores of strategies. It is observed from Figure 6 that the AI crisp values range from a low of 137.04 (for ST9: recycling, reusing and treatment of wastes) to a maximum of 453 (for ST1: improving HR policy regarding worker's benefits and ST3: Developing health and safety by improving the existing condition of number of exit doors, fire equipment, clean drinking water, adequate toilets).

In this phase the interrelationships among the HOWs by interacting with the DMs of the case company in a group environment is established. Results of this group deliberation are shown in the roof of Figure 6. For example, SR2 and SR3 have a very strong relationship. Thus, substantial savings can be achieved if these strategies are implemented jointly. On the other hand, SR1 and SR2 have weak relationship. We also obtained the estimated cost savings, S_{ij} of implementing strategy *i* and *j* together, from the DMs in Bangladeshi Taka (USD). These are as follows: $S_{1,6}$ = 4 million USD, $S_{1,7}$ = 2 million USD, $S_{2,3}$ = 2.5 million USD, $S_{6,7}$ = 3.5 million USD, $S_{6,8}$ = 4 million USD and $S_{8,9}$ = 3 million USD.

4.3 Phase 3 Results

QFD phase 3 determines the optimal strategies (HOWs) to meet the stakeholders' sustainability requirements. The objective function refers to maximizing AI/sustainability score of each strategy. To calculate the cost of implementing these strategies the fuzzy triplets of cost of each strategy in terms of pessimistic, optimistic and most likely values by interacting with the DMs is obtained (in a group environment). After collecting relevant data for optimisation, we attempt to find optimal strategy through solving the optimisation problem. The optimisation problem is formulated as follows:

Max $f(x) = \sum_{j=1}^{n} AI_{jt}x_{jt}$

Subject to: $c_1x_{1t}+c_2x_{2t}+c_3x_{3t}+c_4x_{4t}+c_5x_{5t}+c_6x_{6t}+c_7x_{7t}+c_8x_{8t}+c_9x_{9t}$ -

$S_{1,6}x_{1t}x_{6t-}\ S_{1,7}x_{1t}x_{7t-}S_{2,3}x_{2t}x_{3t-}S_{6,7}x_{6t}x_{7t-}S_{6,8}x_{6t}x_{8t-}S_{8,9}x_{8t}x_{9t} \leq 25$

x_j = 0, 1, t= 1 to n.

The $AI_{j,}$ and c_j are available from Figure 6. The value for s_{ij} has been found earlier in the section (refer to equation or parameter). The available budget B is 25 million USD (obtained from the case company). The result of optimisation is presented in Table 6 along with sensitivity analysis. In a real-life scenario, the weight of sustainability requirement of stakeholders' changes from period to period. For this reason, we ran a dynamic optimisation model considering random weights of the sustainability requirements of the stakeholders and generated 100 random instances (changing the criteria weight). For sample presentation we have shown ten instances in Table 7.

{Insert table 6}

{Insert table 7}

The results from the random experiments show that over time companies can change the optimal portfolio of strategies to keep pace with the dynamic changes in the environment and stakeholders' sustainability requirements ensuring all stakeholders requirements are met jointly. For example, instances two, three, five, eight and ten have different strategic portfolios even at the same budget.

5. Discussions and Implications

5.1 Outcome Phase 1

Table 4 shows ten sustainability requirements (WHATs) that are multi-dimensional in nature and consistent with previous literature presented in Table 1. Five sustainability requirements are under 'social', two requirements are under 'environmental', two are under 'operational' and one under 'economic' sustainability requirements. These findings show that apparel chain stakeholders in Bangladesh are highly concerned with the social aspects of the sustainability requirements which is in line with the existing literature (Martin 2013; Naeem and Welford 2009; Islam and Deegan 2008 and Ahmed and Peerlings 2009). Corresponding to the ten sustainability requirements, nine Strategies (HOWs) have been identified from the nine case companies. It is observed that four strategies (ST1, ST2, ST3, and ST7) have been identified to deal with the employees, while the remaining five strategies (ST4, ST5, ST6, and ST8, and ST9) address the operational aspects of the companies. This is an interesting finding as it shows that the companies are taking a nuanced and balanced approach in selecting strategies to support the sustainability requirements despite the fact that most of their concerns belong to the 'social' category.

5.2 Outcome Phase 2

Phase 2 of our analysis produced the importance ratings (weights) of the sustainability requirements (WHATs) and the absolute and relative importance of the strategies adopted by organisations

(HOWs) by using fuzzy-QFD approach. These results are summarized in Figure 6 which we classify as a SCS DS framework. As per the absolute importance (AI) values, it is observed that all the strategies related to employees are highly ranked (ST1, ST2, ST3 and ST7) compared to the company related strategies (ST4, ST6, and ST8, and ST9) except ST5. In fact, ST6 (environment and health hazard free ingredient in products), ST8 (efficient machinery) and ST9 (recycling) are ranked very low.

Clearly, the case company is dedicated to resolve the employee related (social) concerns with the highest priority. Though the organisational HR policy for making payments and managing benefits of the workers, including hazard and safety factors that have a high cost of implementation do make a significant contribution to sustainability requirements. Therefore, highlighting the importance of implementation of these factors for continued buyer trust else resulting in adverse impact on firm performance. These findings are crucial and an eye opener for the company in terms of their priorities of strategic actions and demonstrates how DCV and its values are embedded in this SCS DS framework.

It is to be noted that relationships between the STs were evaluated in terms of overlaps between the strategies. The roof of Figure 6 shows the positive relationship among the strategies. For example, strategy 6 (Reducing defection rate) and strategy 7 (Training and skill development programs) has a high positive correlation (Figure 6 - Roof matrix) as training will help in reducing defects. However, in theory it is possible to have negatively overlapped strategies, i.e., implementation of a strategy can diminish the effect of another strategy (Pagell and Gobeli 2009; Wu and Pagell 2011). The roof matrix in Figure 6 also adds valuable input to DCV (Teece 2007) as it shows how the sustainability strategies and dynamic capabilities are linked to each other and how jointly help reduce implementation and development cost of the dynamic capabilities.

5.3 Outcome Phase 3

Phase 3 of analyses produced optimal strategies to meet the dynamic nature of stakeholders' sustainability requirements. The optimisation results are shown in Table 6 along with associated sensitivity analysis and also showing that with the budget of 25 million USD the strategies ST2, ST4, ST5, ST6, ST7 and ST8 are selected. However, if the company spends 50 million USD it can implement all strategies. Having said this, stakeholders' focus on sustainability requirements is dynamic in nature because of the changing environment and as a result the weighting of sustainability requirements are also subject to change. The uniqueness of The SCS DS framework lies in the ability to select different portfolio of strategies to reflect changes in weights of stakeholders' sustainability requirements which is highly relevant to the theme of DCV that organizations need to change strategies to respond to environmental changes. Therefore, our optimisation model considering random weights of the sustainability requirements of the stakeholders is suitable to design appropriate organisational strategies for meeting dynamically changing stakeholders' sustainability requirements. The findings of random experiments (Table 7) show that companies need to change the optimal portfolio of strategies to keep pace with dynamic changes in the environment. Therefore, we see a different portfolio of strategies based on the changing weight of sustainability requirements.

From the above discussions it can be concluded that by adopting the SCS DS framework organisations are able to prioritize and implement optimal strategies to ensure implementation of the dynamic nature of SCS stakeholders' requirements effectively and efficiently underpinned by DCV. Organisations and their supply chains can also implement specific strategies/policies under specific circumstances, and they should try to increase their budgets to improve the overall sustainability performance.

5.4 Theoretical implications

Theoretical implications of this study span across the DCV literature. Relying on dynamic capability view (Teece 2007), this paper is instrumental in presenting a SCS DS framework in the context of low cost country sourcing operating under constrained resources - bringing forward a unique contribution in supply chain sustainability literature. Additionally, this research contributes to DCV strategic management by:

(i) developing a SCS DS framework using fuzzy QFD modelling approach using non-linear dynamic modelling,
(ii) cross linking SCS strategies and practices with stakeholder requirements noting the dynamic nature of stakeholders' sustainability requirements.
(iii) extending dynamic capability theory through SCS DS framework enabling organisations to find the optimal portfolio of strategies based on the changing requirements of the stakeholders' requirements.
(iv) investigating how decision makers inculcate dynamic capabilities required and upskill themselves and address the stakeholder ambiguity and materiality/adaptability concept of sustainability requirements,
(v) exploring how dynamic capabilities are interlinked and how simultaneous development and implementation of dynamic capabilities saves costs for the firms.

In summing up, we contribute to the DCV (Teece 2007; Teece 2017) and sustainability literature by offering a more nuanced view on the effect of dynamic capabilities in sustainability by investigating and prioritising specific dynamic capabilities and how they relate to the dynamic changes in supply chain sustainability (economic, social and environmental) as well as operational requirements of the stakeholders in low cost countries. Additionally, where the current literature on sustainability often ignores the place of astute decision makers, we argued that leaders in these organisations drive alignment of SCS requirements to business strategies as they change over time.

5.2 Managerial implications

In terms of the managerial implications, the SCS framework will assist the supply chain managers in identifying the important sustainability requirements of the stakeholders and aligning them with corresponding strategies for ensuring sustainability in the apparel industry of low cost countries. This SCS DS framework can be adapted in other contexts and by other industry supply chain managers to address the dynamic nature of stakeholders' requirements collaboratively whilst strengthening their own capabilities aligned with the strategic intent. Further, the apparel managers, government and other stakeholders will benefit from jointly identifying the prioritized sustainability requirements of the stakeholders in line with adopted strategies, as well as prioritise and implement relevant strategies and practices to meet the sustainability requirements in the apparel industry. When resources are scarce, it is ultra-critical for the decision makers to take optimal decisions and consider viability and feasibility of various scenarios ensuring all stakeholders win. In addition, it allows the apparel supply chain executives to make astute decisions and opt for different combinations of optimal strategies revealing potentially unique differentiation opportunities. This SCS DS framework will help managers and executives decide and implement the best sustainability practices and foster dynamic capabilities aligned with strategies within the limited budgets.

6. Conclusions

This research has several important contributions. Firstly, it identifies and priorities the sustainability requirements of the apparel industry stakeholders and provides a SCS DS framework to align them to corresponding strategies and to identify capability requirements. Secondly, it identifies the optimal strategies under a budget constraint based on resources and sustainability requirements. Thirdly, it conducts a sensitivity analysis to explain the ramifications as the costs and resources are dynamically changed. Finally, drawing on dynamic capability view, the SCS decision support framework is unique in its application in the context of low cost country sourcing as it identifies the sustainability requirements of the stakeholders and arms managers with an instrument that facilitates in selecting and prioritising optimal strategies.

This study has some limitations which opens up opportunities for further research. The quantitative case study is conducted with a single company (albeit being a very large company). A replication of the study in another contrasting company will be ideal. Further research is warranted to identify conflicting SCS strategies to support the sustainability requirements which may result in negative complementariness during strategic implementation. Our immediate future research is in progress and intends to address some of these issues.

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Table 1: Sustainability standards and requirements

Standards and requirements	References
Wages and benefits	Islam and Deegan, 2008; Emmelhainz, 1999.
Hazard and safety	Islam and Deegan, 2008; Emmelhainz, 1999.
Health and sanitation	Islam and Deegan, 2008; Emmelhainz, 1999.
Human rights	Islam and Deegan 2008; Knutsen 2004.
Restricting child labour and force labour	Islam and Deegan, 2008; Emmelhainz, 1999.
Water pollution	Knutsen 2004; Gripsrud, et al. 2006; Epstein and Wisner, 2001
Air pollution	GRI; Epstein and Wisner, 2001
Soil pollution	GRI
Recycling wastes	Epstein and Wisner, 2001
Product safety and restricting the use of Hazardous material	Islam and Deegan, 2008; Gripsrud, Jahre et al. 2006.
Complying environmental legislation	GRI
Sales and business volume	GRI
Cost	GRI
Profit/net income	GRI
Sales growth	Epstein and Wisner, 2001
Delivery lead time	Bateman and David, 2002; Hadjikhani, 2005.
Quality	Bateman and David, 2002; Epstein and Wisner, 2001
Meeting quality, cost and other specification	Chowdhury and Quaddus 2017.
Efficient and Updated Machinery and technology	Drake and Spinler, 2013; Aragón-Correa and Sharma, 2003
Monitoring the social performance of suppliers	Knutsen, 2004; Epstein and Wisner, 2001
Social and Environmental certification and audit	Emmelhainz, 1999.

Table 2: Processes of meeting sustainability requirements

Processes of meeting sustainability	Literature
Enhancing regulatory framework	Belal and Cooper, 2011; Imam, 2000.
Creating awareness and knowledge regarding sustainability	Belal and Cooper, 2011.
Developing written policy	Nayeem and Welford, 2008.
Setting sustainability strategy	Nayeem and Welford, 2008; Brito et al., 2008.
Need for investment and resources	Hahn and Scheermesser, 2006.
Training and development	Hossan et al. 2012; Abdullah, 2005.
Participative management system	Hossan et al. 2012.
Monitoring and auditing	Emmelhainz, 1999.
Social and environmental reporting	Belal and Cooper, 2011.
Environmental certification of suppliers	Caniato et al., 2012.
Supplier evaluation and selection	Caniato et al., 2012

Table 3: Participants Description

Participant	Position	Type of the company	Company size (no of employees)	Age of the company
D1	General Manager	Garment manufacturer	2000-3000	20-25 years
D2	Manager Merchandising	Accessory supplier	200- 300	Less than 5 years
D3	Supply chain manager	Garment manufacturer	4000- 5000	5-10 years
D4	Deputy General manager	Accessory supplier	300-400	15-20 years
D5	Deputy General manager	Garment manufacturer	1000- 2000	10-15 years
D6	Manager Merchandising	Garment manufacturer	3000-4000	20-25 years
D7	Supply chain manager	Garment manufacturer	10000-15000	20-25 years
D8	Manager	Accessory supplier	200- 300	5-10 years
D9	Supply chain manager	Garment manufacturer	15000- 20000	15-20 years
D10	Manager Merchandising	Garment manufacturer	2000-3000	10-20 years
D11	Manager	Garment manufacturer	1000-2000	10-15 years
D12	Manager	Accessory supplier	100-200	5-10 years
D13	Supply chain manager	Garment manufacturer	20000-25000	20-25 years

Table 4: Summary of Sustainability requirements and the Strategies

	Sustainability requirements (SR)	Companies								
Social		1	2	3	4	5	6	7	8	9
	Ensuring fair payments (SR1)	y	y		y		y	y	y	y
	Ensuring benefits (SR2)	y	y	y	y		y			y
	Ensuring health and Safety factors (SR3)	y	y	y	y	y		y	y	y
	Restricting child labour in organisation (SR4)	y	y	y	y	y	y	y	y	y
	Restricting force labour and harassment (SR5)	y		y		y		y		
Environmental	Environment and health hazard free ingredient in product (SR6)	y	y	y	y	y	y	y	y	y
	Reducing environmental impact and improving efficiency (SR7)	y		y	y		y	y	y	
Operational	Quality (SR8)	y	y		y	y	y			
	Lead time (SR9)	y	y	y	y	y	y	y	y	y
Economic	Cost/competitive price (SR10)	y	y	y	y	y	y	y	y	y

	Sustainability Strategies (ST)									
	Improving human resource (HR) policy regarding workers benefits (leave benefit, medical benefit, child care facility, transportation facility) (ST1)	y		y	y	y		y	y	y
	Undertaking sustainability awareness programs (promoting and communicating sustainability to all employees, training, counselling and workshop on sustainability issues) (ST2)	y	y		y		y			y
	Developing health and safety by improving the existing condition of number of exit door, fire equipment, clean drinking water, adequate toilet. (ST3)	y	y	y		y		y	y	y
	Preparing social and environmental audit report (conducting both internal and external audit) (ST4)	y	y	y	y	y		y	y	
	Supplier evaluation, training and development (ST5)		y		y	y	y			y
	Reducing defection rate, quality control and lab testing during receiving material and shipment of products (ST6)	y		y	y		y	y	y	
	Training and development (skill development programs) (ST7)	y	y		y		y	y	y	y
	Installing efficient machinery and technology (ST8)	y		y		y			y	y
	Recycling, reusing and treatment of wastes (ST9)	y	y	y	y	y		y		y

Table 5: Importance ratings of sustainability requirements (WHATs)

WHATs	xα	xβ	xϒ	Crisp value
SR1 (Ensuring fair payments)	7.33	8.33	9.33	8.33
SR2 (Ensuring benefits)	6.67	7.67	8.67	7.67
SR3 (Ensuring health and Safety factors)	7.33	8.33	9.33	8.33
SR4 (Restricting child labour in organisation)	8	9	10	9
SR5 (Restricting force labour and harassment)	6.67	7.67	8.67	7.67
SR6 (Environment and health hazard free ingredient in product)	8	9	10	9
SR7 (Reducing environmental impact and improving efficiency)	6.67	7.67	8.67	7.67
SR8 (Quality)	8	9	10	9
SR9 (Lead Time)	7.33	8.33	9.33	8.33
SR10 (Cost competitiveness)	6.67	7.67	8.67	7.67

Table 6: Optimisation results with sensitivity analysis on Budget (weight of sustainability requirements are fixed)

x1	x2	x3	x4	x5	x6	x7	x8	x9	Budget
0	1	0	1	1	1	1	0	0	20
0	1	0	1	1	1	1	1	0	25
0	1	1	1	1	1	1	1	0	30
0	1	1	1	1	1	1	1	1	35
0	1	1	1	1	1	1	1	1	40
1	1	1	1	1	1	1	1	0	45
1	1	1	1	1	1	1	1	1	50

Table 7: Random experiment result with changing weights of sustainability requirements over time

Instances	AI/sustainability score	St1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9
1	1158.4	0	1	0	1	1	1	1	1	0
2	988.4	0	1	0	1	1	1	1	1	0
3	1134.5	0	1	1	0	1	1	1	0	0
4	1132.6	0	1	0	1	1	1	1	1	0
5	1233.5	0	1	1	1	1	0	1	0	0
6	1445.1	0	1	0	1	1	1	1	1	0
7	1416.4	0	1	0	1	1	1	1	1	0
8	932.1	0	1	1	1	1	0	1	0	0
9	1663.4	0	1	0	1	1	1	1	1	0
10	966.3	0	1	1	1	1	0	1	0	0

Appendix 1: Linguistic expression of importance ratings of sustainability requirements (WHATs)

Sustainability Requirements (SR)/WHATs	DM1	DM2	DM3
SR1 (Ensuring fair payments)	VH	VH	H
SR2 (Ensuring benefits)	H	VH	H
SR3 (Ensuring health and Safety factors)	VH	VH	H
SR4 (Restricting child labour in organization)	VH	VH	VH
SR5 (Restricting force labour and harassment)	H	H	VH
SR6 (Environment and health hazard free ingredient in product)	VH	VH	VH
SR7 (Reducing environmental impact and improving efficiency)	H	VH	H
SR8 (Quality)	VH	VH	VH
SR9 (Lead Time)	VH	VH	H
SR10 (Cost competitiveness)	H	H	VH

Appendix 2: Linguistics expression of correlation between the sustainability requirements (WHATs) and the strategies (HOWs)

	ST1			ST2			ST3			ST4			ST5			ST6			ST7			ST8			ST9		
SR1	H	H	VH	M	M	H	H	H	VH	M	M	H	L	L	M	VL	VL	L	VL	L	L	VL	VL	L	VL	VL	L
SR2	H	VH	VH	M	M	H	M	M	H	M	M	H	L	L	M	VL	VL	L	VL	VL	L	VL	VL	L	VL	VL	L
SR3	M	M	H	M	H	H	H	VH	VH	M	M	H	M	M	H	L	L	M	H	H	VH	L	L	M	VL	VL	L
SR4	H	VH	VH	H	H	VH	H	VH	VH	H	H	VH	M	H	H	VL	VL	L	VL	VL	L	VL	VL	L	VL	VL	L
SR5	M	H	H	M	M	H	M	H	H	L	M	M	L	L	M	VL	VL	L	VL	VL	L	VL	VL	L	VL	VL	L
SR6	L	L	M	L	M	M	M	H	H	M	M	H	M	H	H	H	VH	VH	M	H	H	M	M	H	VL	VL	L
SR7	VL	L	L	M	M	H	M	M	H	H	H	VH	M	M	H	VL	L	L	M	M	H	M	H	H	H	VH	VH
SR8	M	M	H	L	L	M	VL	L	L	VL	VL	L	M	M	H	H	VH	VH	H	VH	VH	H	VH	VH	L	VL	VL
SR9	M	H	H	VL	L	L	VL	VL	L	VL	VL	L	L	L	M	VL	VL	L	M	H	H	M	H	H	L	VL	VL
SR10	VL	VL	L	L	M	M	VL	VL	L	VL	VL	L	L	L	M	L	L	M	H	VH	VH	M	H	H	L	L	M

Appendix 3: Correlation between the sustainability requirements (WHATs) and the strategies (HOWs)

WHATs	Weight	(ST1)				(ST2)				(ST3)				(ST4)				(ST5)				(ST6)				(ST7)				ST8				ST9			
	of WHAT	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value	α	β	ϒ	Crisp value
SR1	8.33	6.67	7.67	8.67	7.67	4.67	5.67	6.67	5.67	6.67	7.67	8.67	7.67	4.67	5.67	6.67	5.67	2.67	3.67	4.67	3.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR2	7.67	6.33	8.33	9.33	8.33	4.67	5.67	6.67	5.67	4.67	5.67	6.67	5.67	4.67	5.67	6.67	5.67	2.67	3.67	4.67	3.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR3	8.33	4.67	5.67	6.67	5.67	5.33	6.33	7.33	6.33	7.33	8.33	9.33	8.33	5.33	6.33	7.33	6.33	4.67	5.67	6.67	5.67	2.67	3.67	4.67	3.67	6.67	7.67	8.67	7.67	3.33	4.33	5.33	4.33	0	0	0	0
SR4	9	7.33	8.33	9.33	8.33	6.67	7.67	8.67	7.67	7.33	8.33	9.33	8.33	6.67	7.67	8.67	7.67	5.33	6.33	7.33	6.33	0	0	0	0	0	0	0	0	0	0	0	0	1.33	2.33	3.33	2.33
SR5	7.67	5.33	6.33	7.33	6.33	4.67	5.67	6.67	5.67	5.33	6.33	7.33	6.33	3.33	4.33	5.33	4.33	2.67	3.67	4.67	3.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR6	9	2.67	3.67	4.67	3.67	3.33	4.33	5.33	4.33	5.33	6.33	7.33	6.33	4.67	5.67	6.67	5.67	5.33	6.33	7.33	6.33	7.33	8.33	9.33	8.33	5.33	6.33	7.33	6.33	4.67	5.67	6.67	5.67	0	0	0	0
SR7	7.67	1.33	2.33	3.33	2.33	4.67	5.67	6.67	5.67	4.67	5.67	6.67	5.67	6.67	7.67	8.67	7.67	4.67	5.67	6.67	5.67	1.33	2.33	3.33	2.33	4.67	5.67	6.67	5.67	5.33	6.33	7.33	6.33	7.33	8.33	9.33	8.33
SR8	9	4.67	5.67	6.67	5.67	2.67	3.67	4.67	3.67	1.33	2.33	3.33	2.33	0	0	0	0	4.67	5.67	6.67	5.67	7.33	8.33	9.33	8.33	7.33	8.33	9.33	8.33	7.33	8.33	9.33	8.33	1.67	2.67	0.67	2.67
SR9	8.33	5.33	6.33	7.33	6.33	0	0	0	0	1.33	2.33	3.33	2.33	0	0	0	0	2.67	3.67	4.67	3.67	0	0	0	0	5.33	6.33	7.33	6.33	5.33	6.33	7.33	6.33	0	0	0	0
SR10	7.67	0	0	0	0	3.33	4.33	5.33	4.33	0.67	1.67	2.67	1.67	0	0	0	0	2.67	3.67	4.67	3.67	2.67	3.67	4.67	3.67	7.33	8.33	9.33	8.33	5.33	6.33	7.33	6.33	2.67	3.67	4.67	3.67
AI		**44.33**	**54.33**	**63.33**		**40.01**	**49.01**	**58.01**		**44.66**	**54.66**	**64.66**		**36.01**	**43.01**	**50.01**		**38.02**	**48.02**	**58.02**		**21.33**	**26.33**	**31.33**		**36.66**	**42.66**	**48.66**		**31.32**	**37.32**	**43.32**		**13**	**17**	**18**	
Crisp value			55.41				53.34				54				48.02				**48.02**				**38.51**				**50**				**44**				**24.5**		
RI			0.133				0.128				0.129				0.115				**0.115**				**0.093**				**0.12**				**0.106**				**0.059**		
Cost		16	18	20	18	3	4	5	4	8	10	12	10	3	4	5	4	3	4	5	4	5	6	7	6	3	4	5	4	7	8	9	8	7	8	9	8