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***Abstract* -** During COVID-19, supply chain (SC) mapping has appeared as one of the critical supply chain capabilities that could make a striking difference in organizations' supply chain performance. Despite its crucial role in responding to SC disruptions, there is a void in the literature on this topic. In this context, the prime objective of the current study is to introduce a comprehensive measure of SC mapping accounting for its various dimensions. A review of the literature is conducted to identify the relevant dimensions and sub-dimensions of SC mapping. Next, two rounds of focused group discussions are conducted in order to refine the identified dimensions and to add any relevant dimensions of SC mapping. Third, we employ exploratory factor analysis to develop the construct of SC mapping. The findings reveal that SC mapping has three major dimensions, namely upstream mapping, downstream mapping, and midstream mapping, with a total 25 items. The developed construct can be used to operationalize the SC mapping and to examine its antecedents and precedents.

***Keywords*:** Supply chain mapping; upstream; downstream; midstream; exploratory factor analysis

1. Introduction

Owing to the innate complex nature of supply chains involving various geographically dispersed organizations, it becomes highly challenging for companies to maintain visibility over the topology of their supply network. According to Achlies (2013), *"40% of companies who sourced only in the UK, and almost 20% who sourced globally, had no supply chain information beyond their direct suppliers."* The invisibility of supply networks is a serious threat to organizations. Supply chain (SC) invisibility not only hampers an organization's capacity to respond to any sudden SC disruption but can also create issues related to the sustainability of SC operations. Researchers (e.g. Choi et al., 2020; Mubarik et al., 2021) consider the lack of SC visibility as one of the profound reasons that firms' SC departments struggle to cope with SC disruption due to COVID-19.

Firms are struggling hard to cope with the COVID-19 effects and putting in their best efforts to secure the supplies of components and raw materials to keep their supply chains afloat. However, the unavailability or inaccessibility to critical information is creating hurdles in responding to the disruption caused by COVID-19. It is leading to a reactive, unorganized, and subtle response to unprecedented disruptions, thus compromising the SC performance to a greater extent. On the other hand, according to Choi et al. (2020), a few companies have handled SC disruption extremely proactively and agilely. The prime reason behind proactive and proficient response was their SC mapping—*the ability of an organization to keep track of their upstream, downstream, and process value chains through the latest digital technologies* (Mubarik et al., 2021). Such organizations had comprehensively mapped their SC processes, which kept them fully informed about their supplier's strength, the flow of material, and geographical locations. Further, SC mapping also enables a firm to track the tier 2 suppliers and even tier 2 customers, thus making the whole SC visible to the company. Once all SC processes are visible to the organization, it becomes easier to pre-empt SC disruption and also equip the firm form an appropriate strategy for encountering SC disruptions (Srai et al., 2008; Eckstein et al., 2015; Oliveira and Handfield 2019; Ivanov and Dolgui 2020)

Despite the importance of SC mapping, the scholastic work in this area is minimal. A handful of articles have been published on this topic, a majority of which vaguely define SC mapping and its dimensions. Recently, Choi et al. (2020) strongly emphasized the need to look into SC mapping for fighting against the negative impacts of COVID-19 and recommended SC mapping as a remedial action to cope with SC disruptions. Fabbe-Costes et al. (2020, p. 1–2) opine that “companies, professors and consulting firms make various supply chain maps [SC mapping], but few studies question the role of these maps, their use or value for supply chain practitioners or how they might relate to the central concepts in SC mapping theory and practice.” Most importantly, studies have not addressed the question of measuring SC mapping. Unless SC mapping is measurable, it is difficult to examine its impact on any performance indicator (Melnyk et al., 2009). In order to analyze the impacts of SC mapping on SC resilience, integration, and performance, it is essential to have a comprehensive construct of SC mapping. The literature on SC mapping does not offer any such measure that can operationalize the SC mapping capability of a firm, thus making it challenging to examine the association of SC mapping with any performance criteria. This research gap leads us to draw the key objective of this research, i.e., to develop a comprehensive construct of SC mapping accounting for its various dimensions.

The study adopts a threefold approach. In the first step, the available literature on SC mapping is reviewed to find out its various dimensions and subdimensions. In the second step, two rounds of focus group discussion are conducted in order to refine and identify any new dimensions of SC mapping. In the third step, we employ exploratory factor analysis (EFA) on 391 observations collected from SC experts to develop the construct of SC mapping. In doing so, the study offers a valid construct of SC mapping, encapsulating its various possible dimensions. To the best of our knowledge, this is the first study of its kind.

2. Literature Review

We posit that in the context of external SC linkages, certain organizational resources and capabilities enable information to be shared within the linkages, which leads to improved visibility and subsequently improved performance. For the resources to be capable of providing a sustainable competitive advantage, an organization must be capable have distinctive visibility—an ability to visualize the distinctive information. In line with resource-based theory (Wernerfelt 1984), we argue that SC mapping is the distinctive visibility of an organization, which has the potential of providing a SC linkage with a sustainable competitive advantage. How to measure such distinctive information capability is the main objective of our research. In doing so, the following section has been dedicated to comprehensively review the literature on the SC mapping and its objectives.

2.1 Supply Chain Mapping: Views and Dimensions

We reviewed the literature on SC mapping from 1980 to 2020. The review reveals that SC mapping could be traced back to the late 80s (Stevens 1989; Star and Griesemer, 1989), and since then, it has been used as an essential organizational strategy for increasing the SC performance. Most studies on SC mapping identify one map of a SC as a common reference point for all actors concerned. "As such, a supply chain map, like a geographical map, is supposed to represent the supply chain territory," according to Fabbe-Costes et al. (2020, p.2). This echoes that SC mapping is a stand-in for the actual SC environment, which simplifies the complex relationships to a greater degree, yet captures the essence of the environment. SC mapping allows for a macrographic representation of the current state of SC.

SC mapping has been defined as linking of activities, actors, resources, and geography in order to ensure that the flow of products and information is visible across all three streams—*upstream, midstream,* and *downstream*—and SC networks are visible as a whole (e.g., Fabbe-Costes et al., 2020; Mubarik et al., 2021b). Upstream SC represents the network of a firm's suppliers and sub-suppliers (teir 2 supplier). Midstream SC refers to all activities and processes which are performed within the company to convert the raw material to a value-added product. Whereas downstream SC refers to the coordination of the flow of information and goods with clients and customers.

This reveals five important views of SC mapping i) relational view (Dyer and Singh, 1998), ii) supply chain practice view (Carter et al. 2017), iii) the SCM view (Hine and Rich 1997; Gardner and Cooper 2003; Lambert et al., 2008; Eriksson 2003), iv) the network view (Henneberg et al., 2006; Geiger and Finch 2010; Meyer et al., 2013) and v) the boundary objects view (Star and Griesemer 1989; Henderson 1991; Carlile 2004; Star 2010; Zeiss and Groenewegen 2009). These views negate the notion of some researcher who, according to Cox (1999), consider supply chain being a theoretical. Before explaining the view adopted by this study, we briefly delineate each of them below.

2.1.1 Relational View

Traditionally, resource-based view is considered as the foundation stone for explaining the impact of supply chain on performance and competitive advantage. Highlighting the limitations of RBV and Porter's industry structure theory for competitive advantage, Dyer and Singh (1998, p.1) argued that, "these two perspectives have contributed greatly to our understanding of how firms achieve above-normal returns, they overlook the important fact that the (dis)advantages of an individual firm are often linked to the (dis)advantages of the network of relationships in which the firm is embedded." They argued that the main focus of the RBV is the attainment of the competitive advantage by maneuvering the resources a firm owns, thus completely ignoring the external resources like network relationships. They argue, ". *idiosyncratic interfirm linkages* may be a source of relational rents and competitive advantage". They *showed a direct relationship of investment in inter-firm collaborations for knowledge sharing with the performance.* Dyer and Singh (1998) argue that capitalization of the relationship requires deliberate efforts and investment of a firm. It implies that a firm must take some unique and specific action for developing relationships. Supply chain mapping in this context is such a deliberate effort that uplifts the inter-firms' relationship.

2.1.2 Supply Chain Practice View

Contrary to RBV, supply chain practice view (SCPV), an extension of practice-based view (PBV) (Bromiley and Rau 2014), consider imitable and transferable practices also a significant source of performance. Carter et al. (2017) assert that beside inimitable practices the one which are imitable can also be a significant source of performance differences. The same has also been revealed by SCM researchers where popular practices like strategic sourcing, vendor quality management could explain the differences in the organization's performance. PBV focuses on the intra-organizational practices and activities. SCPV extending PBV, focuses on the inter-organizational practices and extent of their adoption as the source of performance. According to Craig et al. (2017), "*an inter-organizational SCM practice as a specific activity or a set of activities that spans different formal organizations and that other supply chain dyads or networks can imitate. Inter-organizational SCM practices conceptually differ from intra-organizational SCM practices in that they require mutual efforts from two or more organizations to be effective. Examples of inter-organizational SCM practices include knowledge sharing with suppliers and customers, electronic data interchange, supplier development for sustainability, joint product development with a key customer, and product returns processing".* Supply chain mapping can be a such significant practices which not only better integrate a firm with its tier 1 and tier 2 suppliers but also help to build better relationship with upstream supply chain partners

2.1.3 Boundary Objects View

According to Fabbe-Costes et al. (2020, p.4), "*The concept of boundary objects was developed in science and technology studies but was subsequently adopted by organization scholars.*" Notably, Carlile (2002, 2004) considers the boundary objects view as an essential view in tasks where coordination across various organizational boundaries is indispensable. For the boundary view, objects like maps, drawings, or models permit intra- and inter-organization communication and coordination. For example, a model initially developed by a design engineer to elaborate the functioning of a product may be used by a production engineer to explain the production process. The ergonomic industrial designer may also use the same model for delineating the aesthetic aspects. This example explains that various departments or organizations can communicate with each other and can benefit from a common design without knowing the technical aspects of other departments or organizations. Maps are one of the important boundary objects, according to Carlile (2002), which can be used to communicate across departments and organizations without requiring the knowledge of other specialist areas. In the early year of SC mapping, Star and Griesemer (1989), in their seminal work, mention that boundary objects can be used by a group sharing a goal to develop a standard understating of everyone's task and responsibilities, despite having significant differences in knowledge and language.

Nevertheless, to function effectively, boundary objects need to be robust and flexible (Star and Griesemer, 1989), allowing different groups to use them in their social worlds. Further, Star (2010, p. 602) explaining the importance of boundary objects says, "*Boundary objects* are physical or other forms of the entity that allow different groups to work together without consensus." In short, boundary objects take SC map as an object which can be understood and used across various departments and organizations according to their specific understating and requirement.

2.1.4 Supply Chain View

SC view assumes the SC as a linear representation of functions. It maps the SC activities by taking the firm's SC as a "chain of various interconnected activities." The earlier work in this regard was focused on the linear presentation of the internal function of a SC. Work of Stevens (1989), among others, is greatly applauded in this regard. The literature representation of internal function was only focused on the organizational SC processes, while it ignored the upstream and downstream SCs. In the early 90s, SC mapping was expanded, and linear representation was extended and elaborated by the work of Mentzer et al. (2001). Lambert et al. (1998) developed a comprehensive SC mapping, taking into account all three dimensions of the SC. This paved the way for the modern value stream mapping (Slack et al., 2016), and most of the work on SC mapping followed the footsteps of Lambert et al. (1998). The work of Lambert et al. (1998) focused on linking three elements, activity, actors, and resources through SC mapping. Farris (2010) included the geography and magnitude to the work of Lambert and developed the contemporary information technology (IT) mapping and Neuro Linguistics Program (NLP) mapping.

2.1.5 Network View

The literature on industrial marketing and purchasing (IMP) takes networks as the core concept while making relevant decisions. Drawing on this tradition of IMP scholars and recognizing the inherent complexities of an actual SC, a large group of SC researchers (Choi et al., 2001; Carter et al., 2015; Septiani et al., 2016; Fabbe-Costes et al., 2020; Van et al., 2020) have substituted the concept of chain with networks. In contrast to the dialogic literature, the network literature focuses on the processes of graphical representations and mapping for monitoring efficiency and detecting issues in supply networks. This research primarily focuses on the graphical representation, process visualization, coordination, and integration as the overarching capabilities of a SC network.

In the context of SC mapping, it is essential to discuss its contribution in increasing the performance of an SC. The prime focus of a SC, according to Fabbe-Costes et al., (2020), is integration. A lack of integration among SC players can create a catastrophic situation for business. The solution to this problem, according to Houlian (1983, p. 4), is "The total supply chain – from purchased material to delivery to the customer – is treated as a single entity.... The approach to direct and indirect logistics functions is to integrate them horizontally – along the supply chain."

Although Houlian (1983) focused on internal SC functions integration through SC mapping, this concept soon was extended to downstream and upstream SCs, taking inter-organizational integration into account. Researchers (e.g., Frohlich and Westbrook, 2001) started discussing SC mapping as a fundamental solution to increase firms' visibility and improve network integration. Since a number of firms are part of a SC network, working for a common goal, with each firm having differentiated tasks, integration becomes a major concern. Especially in the context of SC management, "it takes a particular form, being concerned with the boundaries arising from the differentiation between various organizations, departments and individuals concerned with the sequence of activities required to source, produces and deliver products to end customers and, if needed, manage their return" (Fabbe-Costes et al., 2020, p. 4). Conclusively, the network literature emphasizes mapping of the SC network in order to improve integration and overcome other critical issues.

Since the network concept of SC is more realistic, a majority of SC researchers have adopted this concept. According to Fabbe-costes et al. (2020*),* "*acknowledging the great complexity of real SCs, many SC mapping researchers have also adopted the concept of the network rather than chain*." Further the five views of supply chain are linked with each other in a way that flaws of the one view have been covered by the others. Hence taking a hybrid approach by adopting the essential point of each view can better help to define the supply chain mapping and its role. In this context, present study adopts a hybrid approach and take SCPV, SC view and the network view as the basis to explain the objective and measurement of SC mapping.

2.2 Objectives of SC Mapping

The key aim of SC mapping is visualization of interconnected organizations in SC networks involved in the ultimate provision of product and service packages required by the end customers (Song et al., 2018; Saberi et al., 2019). SC mapping focuses on inter-organization connectivity and integration. While relationships are the building blocks of chains and networks, two links do not make a chain. The next level of the system to be considered here is the inter-business chain. It allows for local coordination, across inter-functional and inter-organizational boundaries, in a fluid and uncertain world.

Researchers argue that SC mapping enhances SC visibility, improves SC integration, and facilitates SC monitoring. Further, it also helps to understand channel dynamics and provides a shared perspective on diverse stakeholders (Melnyk et al., 2009; Wakolbinger and Cruz 2011; Wichmann et al., 2020). According to Choi et al. (2020), a well-mapped SC can enhance SC visibility and offers a consolidated basis for SC analysis. It also plays an instrumental role in linking the SC strategy with corporate strategy. According to Gardner and Cooper (2003, p. 39)*,* "a well-constructed supply chain map with the right information, easily displayed and understood, should enhance the environmental scanning process of strategic planning." They further maintain that SC mapping plays an essential role in cataloging and distributing the information, which is essential for surviving in a dynamic and turbulent environment. The most critical role of SC mapping is to enable a firm's proactive SC management by alerting to the SC planners and managers about possible hurdles, issues, or bottlenecks in the SC. There are many examples when due to SC mapping companies could find the questionable position of their critical component or raw material supplier, like improper dumping of toxic waste, corruption in the business processes (Cooper et al., 1997; Fine 1998). Timely identification of such critical information about suppliers' supplier (that is, tier-II suppliers), can significantly help to avoid any SC disruption. In addition, a well-mapped SC enables a firm to visualize all three streams of the SC (upstream, midstream, and downstream) and highlights the inefficiencies in the SC processes. A SC map can also play an instrumental role in tracking the flow of material, components, and products in the SC. SC mapping can also be vital in guiding quantum changes in the SC, according to Farris (2010).

The overarching object of SC mapping is to permit a firm to visualize the flow of products, information, and finance both upstream and downstream (Nag et al., 2014). Gardner and Cooper (2003) argue that the major objective of SC mapping is to acquire an in-depth understanding of a SC. Likewise, Farris (2010) says that the prime purpose of SC mapping is to offer a comprehensive framework that visualizes the business processes, practices, and technologies. This framework helps to improve the efficiency and effectiveness of the SC management of a firm. Additionally, SC mapping also illustrates the geographical relationships and allows spatial visualization. Mubarik et al. (2020) mention that a good SC mapping should capture and provide real-time information of products, sourced materials, their costs, prices, quantities, lead time, etc. Likewise, there is consensus among scholars on the fact that SC mapping should be a simplified illustration of upstream, midstream, and downstream SC processes, relationships, and technologies; however, it must capture the essence of the environment in which the SC operates (Farris , 2010).

Table 1 exhibits various aspects of SC mapping of each stream, identified through the review of literature. These aspects serve as the basis to develop the construct of SC mapping.

Table 1: Dimensions of Supply Chain Mapping

S#	Indicators	Source(s)
A. Upstream mapping		
1	Information about the supplier of critical components	Stevens (1989); Gardener and Cooper (2003); Bagdia (2005); Farris (2010); Fearne et al. (2012); Faisal et al. (2016); Fabbe-Costes et al. (2020)

2	Information about the financial stability of suppliers	Gardener and Cooper (2003); Taylor (2005); Fearne et al. (2012); Faisal et al. (2016); Wichmann et al. (2018); Wichmann et al. (2018); Fabbe-Costes et al. (2020)
3	Visualization of upstream supply chain processes	Choi et al. (2001); Gardener and Cooper (2003); Bagdia (2005); Farris (2010); Carvalho et al. (2012); Knoll et al. (2017); Wichmann et al. (2018); Fabbe-Costes et al. (2020)
4	Geographical representations of suppliers	Choi et al. (2001); Gardener and Cooper (2003); Singer and Donoso (2008); Farris (2010); Choi et al. (2020); Fearne et al. (2012); Wichmann et al. (2018); Anastasiadis et al. (2020)
5	Visualization of key information	Choi et al. (2020); Gardener and Cooper (2003); Bagdia (2005); Mason et al. (2008); Farris (2010); Fearne et al. (2012); Fabbe-Costes et al. (2020)
6	Real time information sharing with suppliers	Choi et al. (2001); Gardener and Cooper (2003); Singer and Donoso (2008); Farris (2010); Fearne et al. (2012); Fabbe-Costes et al. (2020)
7	Real time information about the geographical locations of suppliers	Choi et al. (2020); Gardener and Cooper (2003); Mason et al. (2008); Farris (2010); Fearne et al. (2012); Faisal et al. (2016)
8	Have real time information of Sub-supplier	Bagdia (2005); Carvalho et al. (2012); Farris (2010); Fearne et al. (2012); Choi et al. (2020)
9	Understanding of the tier 2 suppliers technology	Choi et al. (2001); Gardener and Cooper (2003); Busse et al. (2017); Wichmann et al. (2018)
10	Visual documentation of the processes dealing with suppliers	Gardener and Cooper (2003); Bagdia (2005); Barroso et al. (2011); Carvalho et al. (2012); Anastasiadis et al. (2020)
11	Real time visualization of the flow of material from key suppliers	Choi et al. (2020); Gardener and Cooper (2003); Singer and Donoso (2008); Busse et al. (2017); Anastasiadis et al. (2020)
12	Digitalized processes	Gardener and Cooper (2003); Mason et al. (2008); Singer and Donoso (2008); Farris (2010); Barroso et al. (2011); Anastasiadis et al. (2020)
13	Sharing of real time information with suppliers	Harland (1996); Mason et al. (2008); Farris (2010); Fearne et al. (2012); Anastasiadis et al. (2020)
14	Visualization of flow of materials across the value chain	Harland (1996); Mason et al. (2008); Singer and Donoso (2008); Farris (2010); Busse et al. (2017)
15	Visualization of material coming from tier 2 supplier to tier1 supplier	Choi et al. (2020); Mason et al. (2008); Farris (2010); Barroso et al. (2011); Busse et al. (2017); Fabbe-Costes et al. (2020)
B. Midstream mapping		

1	Value stream mapping	Bagdia (2005); Jones and Womack (2002); Barroso et al. (2011); Carvalho et al. (2012); Wichmann et al. (2018)
2	Tracking of the goods with the company	Gardener and Cooper (2003); Farris (2010); Barroso et al. (2011); Carvalho et al. (2012); Miyake et al. (2010)
3	Real time sharing of information across the departments	Jones and Womack (2002); Gardener and Cooper (2003); Farris (2010); Barroso et al. (2011); Faisal et al. (2016); Anastasiadis et al. (2020)
4	Identification of process inefficiencies	Gardener and Cooper (2003); Bagdia (2005); Carvalho et al. (2012); Faisal et al. (2016); Fabbe-Costes et al. (2020)
5	Visualization of the supply chain processes	Bagdia (2005); Singer and Donoso (2008); Farris (2010); Barroso et al. (2011); Busse et al. (2017);
6	Monitoring of supply chain strategy	Gardener and Cooper (2003); Singer and Donoso (2008); Farris (2010); Faisal et al. (2016); Wichmann et al. (2018)
7	Cataloguing and distribution of key information with the help of mapping	Gardener and Cooper (2003); Taylor (2005); Taylor (2009); Farris (2010); Carvalho et al. (2012); Fabbe-Costes et al. (2020)
8	SC alertness	Jones and Womack (2002); Gardener and Cooper (2003); Mason et al. (2008); Carvalho et al. (2012); Faisal et al. (2016)
9	Visualization of end-to-end supply chain	Gardener and Cooper (2003); Taylor (2005); Mason et al. (2008); Carvalho et al. (2012); Faisal et al. (2016)
10	Identification of areas of improvement through mapping	Harland (1996); Fine (1998); Jones and Womack (2002); Taylor (2005); Taylor (2009); Carvalho et al. (2012); Fabbe-Costes et al. (2020)
11	Mapping guides about quantum changes	Jones and Womack (2002); Gardener and Cooper (2003); Taylor (2009); Farris (2010); Fabbe-Costes et al. (2020)
12	Simplified representation of supply chain	Gardener and Cooper (2003); Taylor (2005); Singer and Donoso (2008); Farris (2010); Barroso et al. (2011);
13	Visualization of information, products and finances	Gardener and Cooper (2003); Bagdia (2005); Mason et al. (2008); Taylor (2009); Barroso et al. (2011); Carvalho et al. (2012); Faisal et al. (2016); Anastasiadis et al. (2020)

C. Downstream Mapping

1	Real-time information about the customers network	Choi et al. (2001); Gardener and Cooper (2003); Farris (2010); Knoll et al. (2017)
2	System of obtaining real-time information from customers	Choi et al. (2020); Gardener and Cooper (2003); Barroso et al. (2011); Knoll et al. (2017)
3	Mapping flow of information from tier 1 supplier	Choi et al. (2020); Mason et al. (2008); Farris (2010); Wichmann et al. (2018)
4	Mapping flow of product from tier 1 supplier	Choi et al. (2020); Gardener and Cooper (2003); Barroso et al. (2011); Faisal et al. (2016)

5	Linkage with tier 2 customers	Choi et al. (2020); Gardener and Cooper (2003); Faisal et al. (2016)
6	Information sharing with tier 2 customers	Gardener and Cooper (2003); Taylor (2009); Farris (2010); Barroso et al. (2011); Faisal et al. (2016)
7	Can track the geographical dispersed tier 2 customers	Choi et al. (2020); Gardener and Cooper (2003); Fearne et al. (2012); Wichmann et al. (2018)
8	System of getting real-time information from customers	Choi et al. (2020); Gardener and Cooper (2003); Farris (2010); Barroso et al. (2011); Busse et al. (2016)
9	Sharing of information to customers	Gardener and Cooper (2003); Singer and Donoso (2008); Farris (2010); Barroso et al. (2011); Fearne et al. (2012); Knoll et al. (2017)
10	Visualization of flow of goods going out from company	Harland (1996); Gardener and Cooper (2003); Taylor (2009); Fearne et al. (2012); Busse et al. (2017); Fabbe-Costes et al. (2020)
11	Visualization of outbound logistics	Harland (1996); Gardener and Cooper (2003); Singer and Donoso (2008); Barroso et al. (2011); Knoll et al. (2017); Anastasiadis et al. (2020)

3. Methodology

Simms (2008, p. 414) says, "The apparent simplicity and efficiency of the [survey] method can be illusionary, as much time and consideration are needed to develop measures that allow us to make reliable and valid inferences about people." The applicability and durability of a construct can well encounter statistical and methodological challenges if it has been developed by adopting multiple methods. With this in mind, we adopted a threefold approach to ensure the long-term relevance durability, reliability, and validity of SC mapping construct. Figure 1 below illustrates a graphical view of methodology.

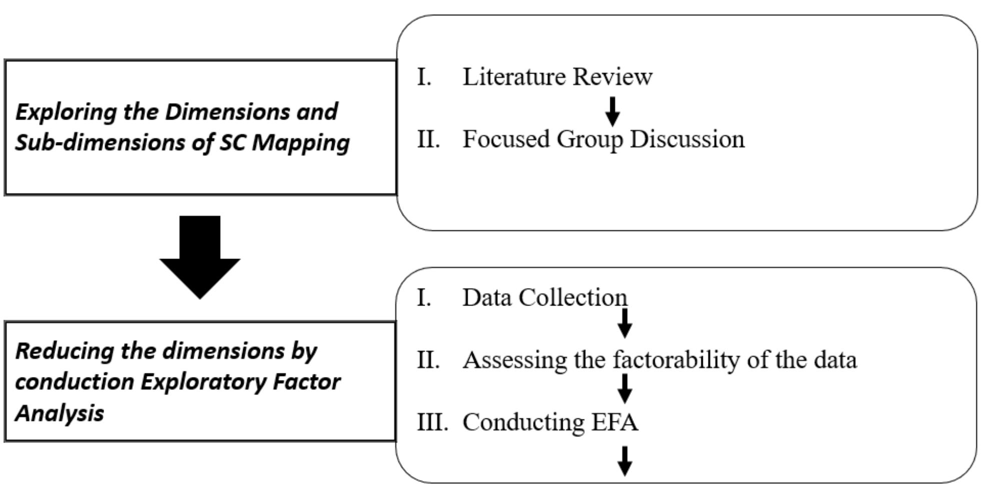

Figure 1: Flow of Methodology

3.1 Exploring the Dimensions and Sub-dimensions of SC Mapping

This step consisted of two phases. In the first phase, we reviewed the literature to identify the empirical dimensions of a SC that denote the abstract construct of SC mapping. In the second phase, we conducted three rounds of focused group discussion to generate additional items and to check the relevance of the identified items.

3.1.1 Literature Review

We rely on the relevant literature to identify the empirical dimensions that denote the abstract construct of SC mapping. In the first phase, we thoroughly reviewed the literature from 1980 to 2020 on SC mapping and value chain mapping. A total of 39 dimensions of SC mapping—15 upstream, 13 midstream, and 11 downstream—were identified through the review of literature as exhibited in Table 1. Based on this, we pre-specify the dimensions and meanings of a construct. We generate an item against each identified dimension of SC mapping as exhibited in Table 2.

Table 2: Item(s) Generation

S#	Indicators	Item(s)	Code(s)
A. Upstream Supply Chain			
1	Information about the supplier of critical components	Our company is aware of the critical component and raw material suppliers.	USM1
2	Information about the financial stability of suppliers	Our company is aware of the financial stability of your key suppliers.	USM2
3	Visualization of upstream supply chain processes	We are able to visualize our upstream supply chain processes, activities and resources with the help of SC mapping process	USM3
4	Geographical representations of suppliers	The mapping of our supply chain depicts geographical relationships, allowing spatial visualization.	USM4
5	Visualization of key information	Our firm is able to capture the key information, such as products and materials sourced, costs and prices, quantities, and replenishment lead time.	USM5
6	Real time information sharing with suppliers	SC mapping provides real time information sharing of suppliers	USM6
7	Real time information about the geographical locations of suppliers	We have mapped the geographical location of our critical supplier.	USM7
8	Have real time information of tier 2 supplier	We are aware of the tier 2 suppliers of the critical component and raw material.	USM8
9	Understanding of the tier 2 suppliers technology	We are aware of the technology of tier 2 suppliers.	USM9
10	Visual documentation of the processes dealing with suppliers	We have documented processes for dealing with suppliers.	USM10
11	Real time visualization of the flow of material from key suppliers	We have mapped processes showing the flow of material coming from suppliers.	USM11
12	Digitalized processes	We have digitalized processes showing real time flow of material from the suppliers.	USM12
13	Sharing of real time information with suppliers	We have a system for sharing real time information with suppliers.	USM13
14	Visualization of flow of materials across the value chain	We can visualize the flow goods from your supplier to your company.	USM14
15	Visualization of material coming from tier 2 supplier to tier1 supplier	We can track the material flows coming from tier 2 supplier to tier 1 supplier.	USM15
B. Midstream mapping			
1	Value stream mapping	We have mapped processes showing the flow of material within the company.	MSM1

2	Tracking of the goods with the company	We can real time track the flow of goods within your company from one department to other.	MSM2
3	Real time sharing of information across the departments	We have system of sharing real time information within the company, across several departments.	MSM3
4	Identification of process inefficiencies	We can identify the supply chain processes inefficiencies in real time	MSM4
5	Visualization of the supply chain processes	We can visualize the sustainability of the supply chain processes	MSM5
6	Monitoring of supply chain strategy	Monitoring of supply chain strategy	MSM6
7	Cataloguing and distribution of key information with the help of mapping	The mapping of our supply chain helps to catalog and distribute key information for survival in a dynamic environment.	MSM7
8	SC alertness	Our SC mapping alerts our concerned managers to possible constraints in the system.	MSM8
9	Visualization of end-to-end supply chain	The mapping of our supply chain processes allows us to visualize end-to-end supply chain.	MSM9
10	Identification of areas of improvement through mapping	The mapping of our supply chain processes permits our company to identify areas for further analysis.	MSM10
11	Mapping guides about quantum changes	The mapping of our supply chain plays an essential role in providing guidance in the quantum changes in the supply chain.	MSM11
12	Simplified representation of supply chain	Our SC mapping provides us a simplified representation of our supply chain system by capturing the essence of the environment in which the supply chain operates	MSM12
13	Visualization of information, products and finances	Supply chain mapping allows our company to visualize how products, information, and finances flow in both the upstream and downstream directions and through a firm.	MSM13
C. Downstream-mapping			
1	Real-time information about the customers network	We have mapped the geographical dispersion of your customers.	DSM1
2	System of obtaining real-time information from customers	We receive real time information for your immediate customers.	DSM2
3	Mapping flow of information from tier 1 customers	We have mapped the flow of information from tier 1 supplier	DSM3
4	Mapping flow of product from tier 1 customers	We have mapped the flow of product from tier 1 supplier	DSM4
5	Linkage with tier 2 customers	We are connected with our tier 2 customers.	DSM5
6	Information sharing with tier 2 customers	We have mapped the flow of information from tier 2 customers.	DSM6
7	Can track the geographical dispersed tier 2 customers	We have mapped the geographical dispersion of our tier 2 customers.	DSM7

8	System of getting real-time information from customers	We get information from the customers about their demand.	DSM8
9	Sharing of information to customers	We have system of sharing real time information with customers.	DSM9
10	Visualization of flow of goods going out from company	We can visualize the flow of goods from our company to customers.	DSM10
11	Visualization of outbound logistics	We can visualize the flow of goods from your company to customers' customers	DSM11

3.1.2 Focus Group Discussion

In the second phase, we carried out focus group discussions (FGDs) to get the expert opinion about the items identified in the literature review and to explore new items for SC mapping. In order to ensure the effectiveness of the FGDs, we selected eight participants from eight different industries namely textile, pharmaceutical, automobile, leather, electronics, food, chemical, and engineering equipment. All the participants were from the large firms, firms having employment size more than 250. According to Fabbe-Costes and Roussat (2013) eight is the suitable size for focused group. The participants were from diverse functions of a SC like procurement, sourcing, planning, inventory management, distribution, logistics operations, and information technology. Demography of the respondents is exhibited in Table 3. The author conducted the session along with one research assistant. The first session was conducted in January 2020 and was three hours long. The second session was conducted in the second week of February 2020 and lasted for two and a half hours.

Table 3: Experts Demography

Respondent	Department	Experience	Education	Designation
A	Procurement	10 years	BE (Industrial Engineering)	Manager
B	Sourcing and Supplier	14 years	MBA (Supply chain Management)	Asst Manager
C	Vendor Management	12 years	MSC (Logistics)	Dy Manager
D	Planning department	18 years	BE (Mechanical)	Senior Manager
E	Inventory Management	13 years	Master in SCM	Manager
F	Logistics operations	11 years	MBA (Supply chain Management)	Manager
G	Distribution	16 years	BS(CS), MBA (Digital supply chain), CSCP	Dy Manager
I	Information Technology	9 years	BS (CS), MS(CS)	Asst Manager

The first session was divided into three parts. In the first half, after a short briefing, participants were handed SC mapping dimensions and the items generated therefrom in hard copies and were requested first to read them and then note down their observations. The participants were also asked about their interpretation of the SC mapping construct. In the second half, the discussion was initiated by asking each respondent to highlight any dimension(s), which was redundant and then to suggest any other dimension, which should be included in the construct. This was followed by questions related to the participants' interpretations of each dimension found in the literature review, including to what degree they agreed with each dimension. The researcher probed the participants for possible scale items, including the wording of items representing each dimension.

The researcher also took notes of the discussion and, where necessary, presented a question to stimulate the discussion. The discussion was recorded and transcribed with the permission of participants and was coded in two steps: first, participants' opinion about the existing dimensions and subdimensions of SC mapping were elicited and then if any item could be added to the constructs of SC mapping was discussed. Findings of the FGDs revealed that 11 items (*USM1, USM2, USM7, USM9, MSM5, SM9, MSM11, DSM2, DSM3, DSM4, DSM5)* were not related to SC mapping. Five items (*USM3, USM4, USM4, MSM2, and MSM13)* were modified as advised by the experts. The FGDs also suggested addition of four items, namely *USM16, USM17, DSM12, and DSM13*, two in upstream SC mapping and two in downstream SC mappings. We included the suggested items and removed the items that were considered redundant or irrelevant by the participants. The updated document was then shared with the participants in the second round of FGD, sessions of which lasted only for an hour and all the participants broadly agreed to retain the revised 33 items in the construct.

3.1.3 Content Adequacy Assessment

Pretesting: We developed the questionnaire based on the 33 items, finalized in a focused group discussion on the Likert scale ranging from 1 to 5. The pre-test was conducted to identify any measurement error in the constructs, which can occur due to several reasons like long sentences or language, vagueness in questions, double-barreled questions, or biased questions etc. According to Carpenter (2018, p.34), "pre-test sample sizes can range from 5–100 people depending upon the diversity of target subpopulations." For pre-testing, the updated questionnaire was sent to 11 academic and domain experts, five of whom were participants in the FGD and who had consented to participate in the pre-test as well. In addition to it, we sent the questionnaire to the six academic experts the content adequacy and refinement. The experts provided some minor changes in the language of the items, which were incorporated into the questionnaire.

Table 4: Finalized items after Focused Group

Code(s)	Item(s)
A. Upstream Supply Chain	
USM3	We are able to visualize our upstream supply chain processes, and activities.
USM4	The mapping of our supply chain processes depicts geographical relationships with supplier, allowing spatial visualization.
USM5	Our firm is able to capture the real time information about the products and materials sourced, their quantities, and replenishment lead time.

USM6	SC mapping provides real time information sharing of suppliers
USM8	We are aware of the tier 2 suppliers of the critical components and raw material.
USM10	We have documented processes for dealing with suppliers.
USM11	We have mapped our supply chain processes showing the flow of material coming from suppliers.
USM12	We are able to visualize the real time flow of material from the suppliers.
USM13	We have a system for sharing real time information with suppliers.
USM14	We can visualize the flow of goods from our supplier to our company.
USM15	We can track the material flows coming from tier 2 supplier to tier 1 supplier.
USM16	Our SC mapping provides us a simplified representation of our upstream supply chain by capturing the essence of the environment in which the supply chain operates
USM17	We have mapped the flow of products, and information in the upstream supply chain.
B. Midstream mapping	
MSM1	We have mapped processes showing the flow of material within the company.
MSM2	We can real time track the flow of goods within our company from one department to other.
MSM3	We have system of sharing real time information within the company, across several departments.
MSM4	We can identify the supply chain processes inefficiencies in real time
MSM6	Due to the mapping of mid-stream processes, we can monitor the effectiveness of our supply chain strategy
MSM7	The mapping of our supply chain helps to catalog and distribute key information for survival in a dynamic environment.
MSM8	Our SC mapping alerts our concerned managers to possible constraints in the system.
MSM10	The mapping of our supply chain processes permits our company to identify areas for further analysis.
MSM12	Our SC mapping provides us a simplified representation of our supply chain system by capturing the essence of the environment in which the supply chain operates
MSM13	We have mapped the flow of products, and information in the mid-stream supply chain.
C. Downstream-mapping	
DSM1	We have mapped the geographical dispersion of our customers.
DSM6	We have mapped the flow of information from company to tier 2 customers.
DSM7	We have mapped the geographical dispersion of our tier 2 customers.
DSM8	We get real time information from the customers about their demand.
DSM9	We have system of sharing real time information with customers.
DSM10	We can visualize the flow of goods from our company to customers.
DSM11	We can visualize the flow of goods from our company to customers' customers
DSM 12	The mapping of our downstream processes plays an essential role in providing guidance in the quantum changes in the downstream supply chain.
DSM13	We have mapped the flow of products, and information, in the downstream supply chain.

DSM 14	The mapping of our downstream supply chain processes permits our company to identify areas for further analysis.

Note*:*
a) Items USM1, USM2, USM7, USM9, MSM5, SM9, MSM11, DSM2, DSM3, DSM4, DSM5 have been removed on the advice of experts
b) Items USM3, USM4, USM4, MSM2 and MSM13 have been modified according to the advice of the experts
c) Items USM16, USM17, DSM12 and DSM13 have been added by the expert in construct

Pilot test. A pilot test is a rehearsal of the actual survey in actual field conditions. In order to conduct EFA, according to Carpenter (2018, p.34), "the pilot test sample size should range from 50–100 participants." Therefore, a pilot test, followed by a pretest, was conducted to evaluate how suitable is the data in determining whether items should be added or deleted. We developed the questionnaire based on the 33 items, finalized in an FGD, with a Likert scale ranging from 1 to 5, which was administered to 95 individuals who had worked in the SC department as assistant manager or above for more than four years. A total of 67 responses were received, out of which three responses were excluded due to incompleteness. Thus, the data from 64 respondents was processed for the pilot EFA. In order to keep the paper short, the results of the pilot EFA are not reported. However, the results, by and large, were encouraging, thus permitting us to proceed for a full-blown survey.

3.3 *Exploratory Factor Analysis*

After pilot test, study employed exploratory factor analysis (EFA) in three steps. In first steps, data was collected using purposive sampling approach. In the second step, factorability of the data was ascertained using Kaiser-Meyer-Olkin (KMO) and Barlett's test of sphericity. In the third step using the procedure exhibited by Carpenter et al. (2018) and Khan and Mubarik (2020), main EFA was run. Following section explain the findings of EFA.

4. Findings of Exploratory Factor Analysis

4.1 Sampling and Data Collection

Owing to the nature and content of SC mapping, the target population for this survey was experts working in the SC department. Following the expert sampling approach, which is a subcase of purposive sampling, we kept the minimum experience (four years of experience working in the SC or a related department) and designation (assistant manager or above) as two criteria for selection. Although the ideal sample size for EFA varies from 50 (Barrett and Kline, 1981) to 400 (Aleamoni, 1976), 300 observations are considered adequate by a majority of the scholars (Worthington & Whittaker, 2006). The study targeted a minimum of 450 sample size of SC experts and questionnaire was sent electronically to 800 SC professionals during March 2020 to May 2020. The business research unit of Muhammad Ali Jinnah University, Karachi, assisted in data collection. Owing to COVID-19, it was highly challenging to meet the targeted number of respondents. After various rounds of calls and follow-ups, we could obtain data from 405 respondents, with a response rate of almost 50%. Among the 405 responses, 14 were eliminated due to issues like unengaged responses, high missing values, etc. Hence 391 observations were processed for the EFA.

4.2 Factorability of the Data

The first step in EFA is to ensure the factorability of the data. We employed correlation matrix, Bartlett's sphericity test, and Kaiser-Meyer-Olkin (KMO) test to test the factorability of the data. The correlation results showed that all inter-item correlation ranges between 0.30 to 0.84, which is well within the specified upper (0.90) and lower (0.30) limits. Likewise, the p-value of Bartlett's chi-square (p-value = 0.000) was significant, whereas the value of KMO (0.75) was higher than the threshold value of 0.60 (Tabachnick and Fidell, 2007), ensuring that data can be processed for factor analysis (Table 5).

Table 5: Factorability of the Data

Construct	**KMO Test**	**Bartlett's Test of Sphericity**	
		Chi-Square	**p-value**
Supply Chain Mapping	0.75	1091.48	0.000

** KMO stands for Kaiser Meyer Olkin, it measures the sampling adequacy*

4.3 Factor Analysis

We employed principal component analysis (PCA) for factor extraction. In PCA, the first step is to identify the number of factors. There are three approaches, i.e., *Kaiser's criteria (eigenvalue approach), scree plot,* and *parallel analysis,* which are as alternatives for factor extraction. Kaiser's criteria widely appear in the literature to determine the number of factors. The fundamental rule is that factors with an eigenvalue greater than one should be retained (Ford et al., 1986; Henson and Roberts, 2006; Morrison, 2009; Russell, 2002). A higher eigenvalue shows the greater variance explained by a factor (Kaiser 1960). Table 6 exhibits the results of factor extraction using Kaiser's criteria and confirms that a total of four components can be retained, which cumulatively explain 72.06% of the variance and have the eigenvalue higher than 1.

Table 6: Kaiser Criteria of Factor Extraction

Component	Total	%of variance	Cumulative %
1	5.95	30.68	30.68
2	3.55	19.57	50.25
3	1.87	13.57	63.82
4	1.05	8.24	72.06
5	0.91	5.83	77.89
6	0.82	4.95	82.84
7	0.72	4.15	86.99

Further, we use scree plot in order to confirm the findings of Kaiser's criteria. The scree plot illustrates *factors* on the x-axis and their *eigenvalues* on the y-axis (See figure 2). The point where the curve levels off is considered the optimal number of factors to be generated. The scree plot in Figure 1 shows that the curve is leveling off at the fourth factor, indicating that four factors should be retained for further analysis. Although Kaiser's criteria and scree plots are widely used in SC and management literature, researchers consider the claim that both approaches can recommend a higher number of factors than required. In such a case, majority parallel analysis (PA) is the most recommended approach for deciding the number of factors to be retained. PA compares the resultant values to a randomly ordered set of data. The results of PA have been exhibited in Table 7, comparing the actual eigenvalues of data with the criterion values from PA.

In order to retain a factor, the eigenvalue must be higher than the criterion values from PA. It is clear from the results that the first three factors have eigenvalues higher than PA values, recommending only three factors to be retained for further analysis. Since the results of PA are considered more robust, we compute the rotated matrix using three factors.

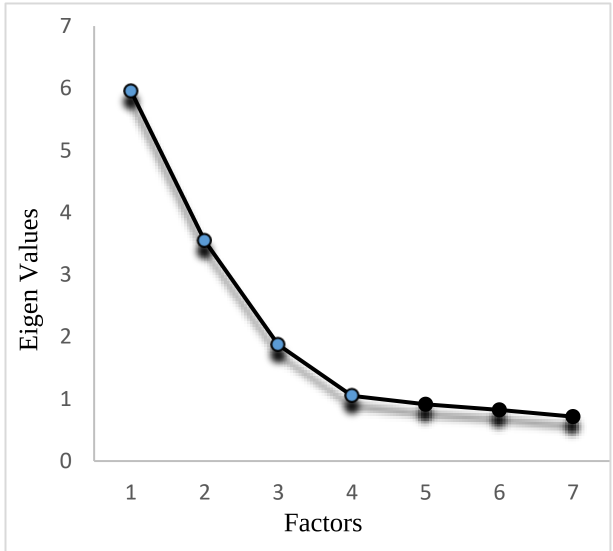

Figure 2: Scree Plot

Table 7: Parallel Analysis

Factor	Actual Eigen values from	Criterion Values from Parallel Analysis
1	*5.954**	*1.599*
2	*3.546**	*1.515*
3	*1.872**	*1.456*
4	1.051	1.408
5	0.912	1.361
6	0.823	1.319
7	0.715	1.280

In the second step, the component matrix was computed in order to decide the retention and deletion of items. The results are exhibited in Table 8. According to Carpenter (2017), the items with factor loading less than 0.32 should be removed because such items do not adequately represent their respective constructs. We removed eight items *DSM6, DSM8, DSM10, MSM10, MSM12, USM11, USM14,* and *USM15*, having factor loadings less than 0.32. It reduced our scale to a total of 25 items.

Table 8: Component Matrix

Items	USM	MSM	DSM
USM3	*0.75*		
USM4	*0.73*		
USM5	*0.66*		
USM6	*0.68*		
USM8	*0.78*	0.39	
USM10	*0.81*		
USM12	*0.68*		
USM13	*0.72*		
USM16	*0.76*		
USM17	*0.83*		
MSM1		*0.67*	
MSM2	0.41	*0.72*	
MSM3		*0.69*	
MSM4		*0.72*	
MSM6	0.43	*0.75*	
MSM7		*0.87*	
MSM8		*0.71*	
MSM13		*0.74*	
DSM1			*0.78*
DSM7			*0.82*
DSM9		0.38	*0.84*
DSM11			*0.71*
DSM 12			*0.82*
DSM13			*0.75*
DSM 14			*0.68*

Note: DSM6, DSM8, DSM10, MSM10, MSM12, USM11, USM14, and USM15 have been removed because of low loading (less than 0.32)

4.4 Rotated Factors

Factor rotation is conducted in order to identify the items of each factor clearly. Varimax, an orthogonal rotation, was performed to analyze factor rotations and to aid in the interpretation of these three factors. Since the correlations of factors were low, not exceeding the Tabachnick and Fiddell threshold value, we of employed the Orthogonal rotation. The rotated solution revealed presence of a simple structure, with all three components showing a number of strong loadings and all variables loading substantially on only one component. The three-factor solution explained a total of 63.82% of the variance, with factor 1 contributing 30.68%, factor 2 contributing 19.57%, and factor 3 contributing 13.57%. The finalized construct of SC mapping after performing EFA is exhibited in Table 9.

Table 9: Finalized Construct after EFA

Codes	Item(s)
	Upstream Supply Chain
USM3	We are able to visualize our upstream SC processes, and activities.
USM4	The mapping of our SC processes depicts geographical relationships with supplier, allowing spatial visualization.
USM5	Our firm is able to capture the real time information about the products and materials sourced, their quantities, and replenishment lead time.
USM6	SC mapping provides real time information sharing of suppliers.
USM8	We are aware of the tier-2 suppliers of the critical components and raw material.
USM10	We have documented processes for dealing with suppliers.
USM12	We are able to visualize the real time flow of material from the suppliers.
USM13	We have a system for real time sharing of information with suppliers.
USM16	Our SC mapping provides us a simplified representation of our upstream SC by capturing the essence of the environment in which the SC operates.
USM17	We have mapped the flow of products, and information in the upstream SC.
	Midstream mapping
MSM1	We have mapped processes showing the flow of material within the company.
MSM2	We can track the flow of goods within our company in real time from one department to other.
MSM3	We have a system of real time sharing of information within the company, across several departments.
MSM4	We can identify the SC processes inefficiencies in real time.
MSM6	Due to the mapping of midstream processes, we can monitor the effectiveness of our SC strategy.
MSM7	The mapping of our SC helps to catalog and distribute key information for survival in a dynamic environment.
MSM8	Our SC mapping alerts our concerned managers to possible constraints in the system.
MSM13	We have mapped the flow of products and information in the midstream SC.
	Downstream mapping
DSM1	We have mapped the geographical dispersion of our customers.
DSM7	We have mapped the geographical dispersion of our tier-2 customers.
DSM9	We have a system of real time sharing of information with customers.
DSM11	We can visualize the flow of goods from our company to customers' customers.
DSM12	The mapping of our downstream processes plays an essential role in providing guidance in the quantum changes in the downstream SC.
DSM13	We have mapped the flow of products and information in the downstream SC.
DSM14	The mapping of our downstream SC processes permits our company to identify areas for further analysis.

EFA does not compute model fitness of the resulting factors (Long, 1983), which is its major limitation. There is a high probability that "an indicator that meets the criteria of exploratory factor analysis may not fit into the measurement model due to a lack of external consistency" (Gerbing and Anderson, 1988, p. 75). In order to overcome this limitation, we performed a confirmatory factor analysis (CFA) using AMOS. The next section has been devoted to discussing the results of CFA.

4.5 Confirmatory Factor Analysis

The results of the CFA are exhibited in Table 10.

Table 10: Model Fitness, Reliability, and Validity Tests

Construct	**Items**	**Loadings**	**AVE**	**CR**	**CB Alpha**	**Fitness Indices**
Upstream mapping	USM3	0.68	0.59	0.93	0.83	*Chi-square/df=2.481*
	USM4	0.81				*RMESA=0.06*
	USM5	0.73				*GFI=0.94*
	USM6	0.72				*PGFI=0.58*
	USM8	0.79				*CFI=0.92*
	USM10	0.85				
	USM12	0.82				
	USM13	0.68				
	USM16	0.74				
	USM17	0.82				
Midstream Mapping	MSM1	0.68	0.56	0.91	0.81	*Chi-square/df=1.98*
	MSM2	0.76				*RMSEA=0.08*
	MSM3	0.72				*GFI=0.90*
	MSM4	0.81				*PGFI=0.51*
	MSM6	0.71				*CFI=0.88*
	MSM7	0.66				
	MSM8	0.84				
	MSM13	0.77				
Downstream Mapping	DSM1	0.84	0.63	0.921	0.84	*Chi-square/df=2.95*
	DSM7	0.78				*RMSEA=0.05*
	DSM9	0.71				*GFI=0.91*
	DSM11	0.75				*PGFI=0.48*
	DSM 12	0.82				*CFI=0.93*
	DSM13	0.88				
	DSM 14	0.75				

4.5.1 Model Fitness

Three-dimensional model fitness, i.e., absolute, incremental, and parsimonious, has been ascertained. The results exhibited in Table 10 show the values of absolute fitness indices (i.e., chi-square/df, RMSEA, GFI), incremental fitness indices (i.e., CFI), and parsimonious fitness indices (i.e., PGFI). The values of GFI and CFI are well above the threshold value of 0.90. Likewise, the values of chi-square/df and RMSEA are well below the recommended upper values of 5 and 0.10, respectively. Values of PNFI are too within the recommended range of 0 to −2.

4.5.2 Internal Consistency and Reliability

The internal consistency and reliability of the construct were evaluated by computing the values of Cronbach's alpha, factor loading, and composite reliability. Cronbach's alpha and composite reliability values were well above the threshold values of 0.70. Likewise, values of factor loading range from 0.66 to 0.89, showing that all items load well on their respective sub-construct.

4.5.3 Construct Validity

Both convergent and discriminant validities of the construct were checked. The values of average various extracted (AVE) of all three sub-constructs are above 0.50, which confirms the convergent validity of the construct. For discriminant validity, we employed the Fornell-Larcker criteria. The result reproduced in Table 11 shows that square rooted values of AVE are higher than correlations among three sub-constructs.

Altogether, the results of the CFA confirm model fitness, reliability, and validity of the SC mapping construct.

Table 11: Fornell Larcker Criteria

	USM	MSM	DSM
USM	***0.768***		
MSM	0.74	***0.748***	
DSM	0.69	0.73	***0.794***

Note: The diagonal values are square rooted AVEs

5. Discussion and implications

5.1 Discussion of Findings

The results of the EFA clearly confirms that items can be grouped into three distinct groups namely upstream mapping, midstream mapping and downstream mapping. These results echo the findings of the Mubarik et al. (2021) and Fabbe-Costes et al. (2020). Further, diving into the nature and objective of each items of the three streams, it can be observed that a majority of the retained items have focus on the linkage, integration and connectivity with tier 1 and tier 2 suppliers and customers. The need for linking to the tier 2 suppliers in order to have the supply chain visibility is not knew and heap of studies have stressed its importance. For example, Burt, Dobler, and Starling (2003) mention the need for channel integration for supply chain visibility and supply chain integration. They explained channel integration as the integration and sharing of the information with suppliers and suppliers' supplier and customers and customers' customers. The same was recently reinforced by Khan et al. (2021) explaining the need of supply chain visualization by linking to the tier 2 suppliers. Our results on the items related to the downstream integration are not only unique but also provide a new way of looking at customers integration. Items of sub-construct "downstream mapping" exposes the significance of linking with tier 2 customers by improving the information sharing. Previously, a majority of the studies talk about customers integration but they do not go beyond the tier 1 customer. Our results reveal the importance of integration beyond tier 1 customer. Putting together our results extend the findings of the other studies confirming the existence of supply chain practice view of supply chain mapping

5.2 Managerial Implications

Our study has profound managerial implications. First and foremost is the use of SC mapping scale to test the relationship of SC mapping with other related variables like SC integration, performance, and visibility. The developed construct can also be used to gauge the level of SC mapping in a firm. From the practitioners' point of view, the items of SC mapping construct can act as the building block to map supply chain of a firm. It will also help to boost the future work in the area of SC mapping. In doing so, this study can lay the foundations for developing SC resilience with the help of proactive SC management. By evaluating their firm's SC mapping capability, managers can explore the underlying weaknesses in their SC management and develop the right action plan to overcome these weaknesses.

6. Conclusion

6.1 Summary

The overarching objective of this study was to develop and validate SC mapping construct to assess the SC mapping capability of a firm. We used a multi-stage approach in order to develop the construct and to confirm its fitness, reliability, and validity. The study included a review of SC mapping literature, conducting focus group analysis, and application of CFA and EFA. The findings accrued 25 items construct with three sub-construct tapings into interrelated dimensions of SC mapping. The construct has sufficient model fitness and is highly reliable and valid. The results of CFA showed that all the newly generated items have high factor loadings on their respective sub-constructs. The results of the qualitative study, EFA, and CFA establish the significance of the newly developed constructs in precisely operationalizing SC mapping. There is a void in the literature on SC mapping instrumentation issue.

6.2 Limitations and Future Research Directions

The study has some limitations. First, to confirm the generalizability of this construct, a study is required with a new sample. Although we have adopted a multi-tiered approach, we could only confirm the statistical generalizability within the scope of our sample. Since all experts were from the manufacturing sector, the generalizability of this instrument may not be suitable in the service sector. Therefore, future studies can replicate this study, but focus on SC mapping construct in the service sector. The results can then be compared with the findings of this study to check similarities and differences. This may lead to the generalization of some of the constructs.

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