

CHAPTER 2

CAUSAL DEPENDENCE RELATIONSHIPS AMONG THE PRACTICES OF THE RSC

From chapter 1, it is perceived that the RSC is multi-faceted and is characterized by a wide range of characteristics, i.e., anticipation, preparedness, absorptiveness, adaptiveness, resistiveness, responsiveness, learning, innovation, etc. These characteristics altogether lead to the minimization of the risk and uncertainty, mitigation of the disruption impacts, the quick response against the adversities, and recovery to an initial or even better position post disruptions, thus making the SC resilient. Further, considering the similarity and the importance of these characteristics in the different phases of risk and disruption management, they can be clustered into four major groups, i.e., readiness, robustness, rapidity, and recovery & growth. These four capabilities enable the decision-makers to strategically design and diligently control the SC and related activities before and after disruptions.

Moreover, from the literature review, it is evident that these characteristics and capabilities are achieved by incorporating various resilient practices across the SC, making risk and disruption mitigation a common behavior of SCM. These resilient practices include flexibility in various activities and the components of the SC, agility in the SC operations, redundancy of the strategic and critical resources, dynamic pricing, product rollover strategies, etc. Moreover from previous research, it is also evident that many of these practices have high causal dependence relationships such that the successful implementation of one leads to the success of many others (Hohenstein et al., 2015; Jain et al., 2017; Agarwal et al., 2020). However, most of the existing research is qualitative and also lags the holistic view of the RSC. Furthermore, existing research

cannot define the causal dependence relationships among the resilient practices, i.e., how and in what way these practices influence one another. Moreover, considering the limitations of the resource availability and the SC partner's competency, the management and the decision-makers would be interested in implementing the practices that have a higher ability to influence the other practices. Therefore, evaluating the causal dependence relationships among the RSC practices is essential for developing a RSC.

Thus, this chapter aims to identify and define the capabilities and practices of RSCs. And also provide an empirical approach for estimating and classifying the importance of these resilient practices considering their ability to influence one another. A total interpretative structural modeling (TISM) approach accompanied by Matrice d'Impacts Croises-Multiplication Applique and Classment (MICMAC) and the literature support is used to address the objective of this chapter.

In this chapter, the RSC's capabilities and practices are discussed thoroughly with the experts, and their responses are collected for further analysis. For this research, the response from seven industrial experts is collected. The experts are selected solely based on their experience in SC and operations management. The selected number of experts is also supported by the literature, such as Sahu et al. (2017), Liu et al. (2018); Jena et al. (2017), Patel et al. (2018), etc., who have considered the 5, 5, 7 and 2 experts respectively, for their analysis. The expert's response is collected through one-to-one personal interviews in two stages (Liu et al., 2018). In the first stage, the practices identified from the literature review are discussed exhaustively with the experts about their relevancy, adequacy, similarity, and possible relationships. Once all the experts are interviewed, their suggestions are incorporated to finalize the practices (Table 2.1).

While in the second stage, the dependence relationships between the practices are obtained and are agglomerated in Table 2.2. The response received in the second stage is the inputs to the TISM and MICMAC analysis. Any discrepancies present in the author's response regarding the relationships among the practices are resolved by the 70% rule (Singh and Samuel, 2018; Alawamleh and Popplewell, 2011). In the third step, quantification of the expert's response takes place and is analyzed in a number of steps. The TISM approach provides the dependent relationship between the practices, and the MICMAC analysis classifies the practices into driving and dependent groups. The advantage of this approach over other methods is its ability to minimize the system complexity of direct and indirect relationships between the practices and provide a better approach to prioritize the RSC strategies/practices (Ahmad et al., 2019). Further, this approach also enables the quantification of the dependence relationships between the strategies/practices to develop a hierarchical structure comprising of the interpretation of the relationships and also classifies them into four groups, i.e., dependent, independent, autonomous, and linkage (Sushil, 2012; Chauhan et al., 2018).

2.1. Capabilities of the RSC

RSC is characterized by anticipation, absorption, adaptation, rapidity (quickness), preparedness (readiness), resistiveness, responsiveness, recovery, and learning and innovation. Considering the importance and the role they play in the different phases and the scenario of SC risk and disruption management, these characteristics can be further classified broadly into four major capabilities of the RSC, i.e., readiness, robustness, rapidity, and recovery & growth (Chapter 1).

Readiness

It is defined as the ability of the SC to anticipate, identify, and prepare against risk and uncertainty, thus minimizing the probability and impact of the disruptions (Pettit et al., 2010; Fiksel et al., 2015; Ponomarov and Holcomb, 2009). It is characterized by improving and developing new capabilities in anticipation of futuristic challenges. It includes imparting flexibility and agility in the SC operations, practicing standardization of parts and processes, etc. (Juttner and Maklan, 2011). Readiness acts as the threshold for the development of a RSC. It provides the essential support for the success of the other resilient capabilities, i.e., robustness, rapidity, and recovery through allowing the space for re-arrangement of alternative strategies and resources (Sheffi and Rice, 2005; Pettit et al., 2013; Chowdhury and Quaddus, 2016; Manning and Soon, 2016). Hence, it reduces the vulnerabilities and enables quick recovery post disruption. In addition, Landry (2020), Simchi-Levi and Simchi-Levi (2020), and Jain and Leong (2005) consider stress testing as an integral part of readiness, which involves the risk assessment and contingency planning at every level of decision-making along with the evaluation of SC to survive and recover from the disruptions. Similarly, Rajesh (2018) acclaims that implementing the SC event readiness will minimize risks and provide an efficient and effective response to potential disruptions. Readiness in the SC is achieved by imparting flexibility, developing redundancy of resources and facilities, developing collaborative relationships, enabling visibility of position and performance of the entire SC, developing the culture of risk minimization and management, sharing of information, enabling capable warehouse and inventory management, improving the financial strength of each member of the SC, developing a decision support system, etc. (Ponomarov and Holcomb, 2009; Juttner and Maklan, 2011; Jain et al., 2017; Govindan et al., 2020, etc.).

Robustness

Robustness is the ability of the SC to execute its intended functions efficiently and effectively in various business scenarios with impending vulnerabilities. It enables the SC to deal with the risks and uncertainties by deploying the corresponding contingency plans and making the SC less likely to fail (Tukamuhabwa et al., 2015; Radhakrishnan et al., 2018). Tang (2006) states that robustness enables SC to improve performance under normal circumstances and sustain operations in significant disruption situations. Moreover, Tukamuhabwa et al. (2015) consider the robustness of the SC as the capability that minimizes the undesirable risk consequences and leads to a competitive advantage during varying situations by absorbing and adapting the vulnerabilities the variabilities. In comparison, Rajesh (2018) considers robustness as the measure of SC strength against disruption and suggests that the robustness of the SC is determined by its weakest link. It improves business continuity by avoiding or resisting the SC disruptions and their impact. Robustness enables the firm to mitigate the disruption impacts by adapting and utilizing unconventional means of operations without considering the recovery strategies (Biringer et al., 2013). Hence, it can be characterized by the SC's absorptive, resistive, and adaptive ability that enhances the firm's ability to withstand its intended function in the course of a disruptive event. It is achieved by practicing postponement strategy in production and distribution, contract and production flexibility, collaboration among the SC member, developing strategic stock for the critical resources, incorporating dynamic pricing strategies, providing economic supply incentives to the weakest or disrupted links, practicing assortment and silent product rollover strategies, spot marketing, etc. (Tang et al., 2006; Richey and Autry, 2009; Hohenstein et al., 2015; Jain et al., 2017; Rajesh, 2018; Dubey et al., 2019). The

SC readiness avails the risk mitigation strategies, thus acting as the major robustness antecedents.

Rapidity

Rapidity is defined as the ability of the SC to quickly respond to expected and unexpected events by implementing and rearranging the available resources to minimize any adverse impacts and gain a competitive advantage (Mao et al., 2020; Balaei et al., 2020; Mancheri et al., 2018). It enables the SC to quickly transform the market demand into the product and services through synchronization and collaboration of SC partners, thus leading to business profitability and growth (Estampe, 2014; Shin and Park, 2020). It enables the swiftness in mitigation, absorption, and recovery of the SC from the disruptions in a cost-effective manner, such that SC with high rapidity will lead to lessening the disruption impact and recovery time (Shuai et al., 2011; Xiao et al., 2012; Yuang and Xu, 2015). Hosseini et al. (2016) consider suppliers' restoration budget and technical resources restoration in the presence of the rapidity as the two arms of the SC restoration. Moreover, according to Wieland and Wallenburg (2013), Tukamuhabwa et al. (2015), and Mao et al. (2020), effective information sharing and communication, redundancy of the resources, advancement of the resources, quick decision making and its implementation, agility in the production process, etc., act as the primary prerequisite for enabling rapidity in the SC.

Recovery and growth

Recovery and growth ability enables the SC to regain its initial position or to move to a better business position after disruption in the minimum possible time and with minimum impact by reconfiguring the resources (Ponomarov and Holcomb, 2009; Chowdhury and Quaddus, 2016). It is intended that a resilience SC should have the

capability to return to its initial performance level or, preferably, to a better position as quickly as possible (Carvalho et al., 2014; Hohenstein et al., 2015). The success of SC disruption recovery ability largely depends upon the effective implementation of the risk mitigation and contingent strategies before the actual disruptions occur. The preparation against the disruption acts as the first line of defense as it lessens the disruption's probability and the effort required to recover post disruption (Hosseini et al., 2019). It is also defined by the quickness with which a SC adapts to the changing business and technological improvement to achieve a stabilized functionality position post disruption (Longo and Oren, 2008; Shashi et al., 2019). Recovery ability is achieved through agility, collaboration, practicing postponement, improving adaptability and learning ability, improving the visibility of SC operations and related events, implementing silent product rollover strategy, providing economic supply incentive to disrupted link or weak SC partner, restructuring or re-arranging the SC facilities, making the SC agile, etc. (Tang, 2006; Manning and Soon, 2016; Jain et al., 2017). Moreover, the success of the SC recovery depends on the preparedness and rapidity with which the organizations can respond to the disruptions.

Hence from section 2.1.1 to section 2.1.4, it can be concluded that these four capabilities are correlated and, when combined, can lead to the development of the RSC and can be pictorially represented as in Figure 2.1.

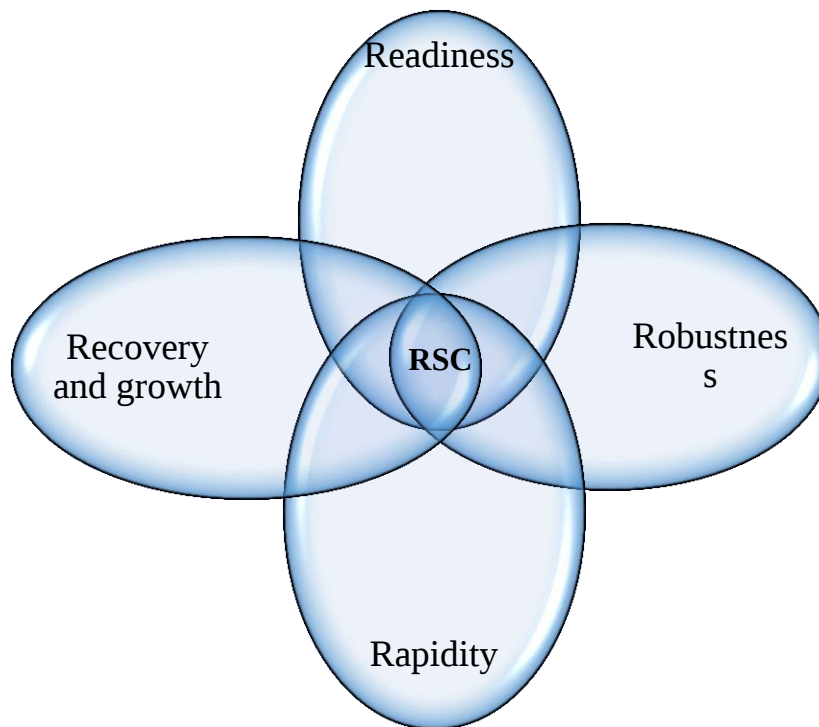


Figure 2.1: Capabilities of the RSC.

Further, seventeen resilient practices are identified, such that most of them contribute to the development of the resilient capabilities of the SCs. These practices are determined considering the different theoretical perspectives like resource base view, organization information processing theory, dynamic capabilities theory, etc., while incorporating the views of the experts from the case organization and literature review provided in Chapter 1. These practices develop the resources enabling the RSC capabilities, like the skilled workforce, redundant facilities, and availability of sufficient raw materials, parts, and components. These practices also enact the dynamic capability into the SC, ensuring sustained innovation and business continuity during uncertain operating conditions. Furthermore, the resilient practices discussed in the following sections also minimize the bullwhip effects, improve trust and loyalty, enable real-time information

sharing, etc. The previous research explaining the role of these resilient practices in enabling resilience capabilities is provided in Table 2.1.

Table 2.1. Resilient practices and their impact on the resilient capabilities of the SC with supporting literature references.

Practices	Capabilities				Literature
	C_1	C_2	C_3	C_4	
P_1	✓	✓	✓	✓	Sheffi and Rice (2005); Juttner and Maklan (2011); Tang and Tomlin (2008); Pettit et al. (2013); Rajesh and Ravi (2015); Chowdhury and Quaddus (2016); Rajesh (2017); Ahmad and Mondal (2019); Shin and Park (2020), Reza et al., (2021)
P_2	✓	✓			Lampel and Mintzberg (1996); Feitzinger and lee (1997); Pagh and Cooper (1998); Christopher and Towill (2002); Yang et al. (2004a); Rajesh and Ravi (2015); Rajesh (2017); Shin and Park, (2020); Reza et al. (2021)
P_3	✓	✓	✓	✓	Saenz and Revilla (2014); Jones et al. (2014); Rajesh and Ravi (2015); Ambulkaret al. (2015); Jain et al. (2017); Shin and Park (2020)
P_4		✓	✓	✓	Christopher and Lee, (2004); Christopher and Peck (2004), Juttner and Maklan, (2011); Sheffi and Rice (2005); Banyai (2016); Rajesh (2017); Jain et al. (2017); Shin and Park, (2020); Reza et al., (2021)
P_5	✓	✓	✓	✓	Christopher and Peck (2004); Ponomarov and Holcomb (2009); Richey and Autry (2009); Prajago et al. (2012); Rajesh (2017); Jain et al. (2017); Shin and Park (2020)
P_6	✓	✓	✓	✓	Jharkharia and Shankar (2006); Nunes et al. (2006); Zhou and Beneton (2007); Zhang et al. (2011); Voss and Williams (2013); Jain et al. (2017); Zhang et al. (2021), Mirzabeiki & Saghiri (2020); Saghiri et al. (2017); Reza et al., (2021)
P_7	✓	✓	✓		Tang (2006); Puga et al. (2009); Rajesh and Ravi (2015); Kumar et al. (2017); Rajesh (2017);

				Hosseini et al., (2019); Kumar and Aouam (2019); Shin and Park (2020)
P_8	✓	✓	✓	Sheffi et al. (2003); Tang (2008); Gustav et al. (2019); Hosseini et al. (2019); Sá et al. (2019); Shin and Park, (2020); Reza et al., (2021)
P_9	✓	✓	✓	Dellena and Hauser (1999); Christopher and Peck (2004); Sheffi and Rice (2005); Blos et al. (2015); Jain et al. (2017); Reza et al., (2021)
P_{10}		✓		Kok et al. (2006); Tang (2006); Mantrala et al. (2009); Rajesh and Ravi (2015); Zhang et al., (2021)
P_{11}		✓	✓	Blackburn and Scudder (2003); Jia and Hu (2011); Rajesh (2017); Jun 2020; Jia and Hu, (2011); Zhang et al., (2020)
P_{12}		✓	✓	Tang (2006); Sodhi and Tang (2012); Rajesh (2017); Barroso et al. (2011); Rajesh (2020); Ye et al. (2020)
P_{13}	✓	✓	✓	Sheffi and Rice (2005); Rice and Caniato (2006); Wu and Pagell (2011); Ambulkar et al. (2015); Alawneh and Zhang, 2018; Shin and Park (2020); Razavian et al. (2021)
P_{14}		✓	✓	Lee (2004); Smit and Wandel (2006); Handfield (2007); Melnyk et al. (2010); Rajesh and Ravi (2015); Jain et al. (2017); Neubauer (2018); Eckstein et al. (2015); Agarwal et al. (2021); Radhakrishnan et al. (2018); Kumar and Anabanandam (2020)
P_{15}		✓	✓	Tang (2008); Blome et al. (2014); Huang et al. (2015); Pakdeechoho and Sukhotu (2017); Jain et al. (2017); Huang et al. (2015); Pakdeechoho and Sukhotu (2018); Agarwal et al. (2021); Reza et al., (2021)
P_{16}	✓	✓	✓	Stemmler (2002); Randall and Farris II (2009); Juttner and Maklan (2011); Blome et al. (2014); Duchek (2018); Agarwal and Seth, (2021)
P_{17}			✓	Croom (2001); Christopher and Peck (2004); Machado et al. (2009); Ponomarov and Holcomb (2009); Jain et al. (2017); Chang et al. (2019); Zhang et al. (2021); Reza et al., (2021)

2.2. Resilient practices of the SC

Flexibility (P_1)

It is the ability of the SC to adjust to the changing business environments and the stakeholders with minimum effort and time (Hosseini et al., 2019; Lahyani et al., 2021). It comprises flexibility in sourcing, production, logistics, human resources availability, etc. (Azevedo et al., 2013; Pettit et al., 2013; Neubauer, 2018; Hosseini et al., 2019), while Christopher (2005) and Maklan (2011) consider redundancy and velocity as a route to flexibility. It safeguards the SC by absorbing the disturbances caused by the undesired events through effective response (Kumar et al., 2008; Skipper and Hanna, 2009). It also enables the organizations to exploit the situation for better results and gain competitiveness. According to Sheffi and Rice (2005) and Wallace and Choi (2011), increasing the level of SC flexibility develops the ability to adapt the changes rapidly and readily in the case of disturbance and improves operational efficiencies during normal working conditions through disruption sensing, event readiness, reorganization of facilities, and disruption absorption. It acts as the prerequisite for many of the other resilient practices such as agility, product rollover, dynamic pricing, etc.

Postponement (P_2)

It is a strategic approach that aims to delay output differentiation as late as possible. It is an intentional attempt that delays the execution of SC activities based on complete and reliable information, which includes delays in sourcing, making, and delivery (Van Hoek, 2001; Yang et al., 2004; Rajesh, 2019). Feitzinger and Lee (1997) and Ashayeri and Selen (2005) consider postponement as a vital means to make mass customization a reality through strategic positioning of the decoupling point of the customer's order. At the same time, Cooper (1993) and Christopher and Towill (2001) believe that

combining postponement and virtual logistics will help in making the SC leagile. Postponement helps in improving agility and flexibility as it helps to develop the product's inventory in semi-finished forms, which further enables it to move the products from surplus to deficit areas (Rajesh, 2019). This enables the handling of supply and demand variability, and also it reduces the inventory cost by keeping undifferentiated inventories along with augmenting the competitive position (Waller et al., 1999; Lohmer et al., 2019; Rajesh, 2020). The first step towards postponement strategy is identifying and defining the activity to be postponed (Beamon 1998) and is achieved by standardization, modular designing, and the commonality of parts (Yang et al., 2004; Yeung et al., 2007). Efficient communication supported by the authority and responsibility distribution among the organizations act as the major enablers for SC Postponement.

Visibility (P_3)

Visibility of the SC enables the firm to realize the position and performance of every activity and stakeholder, that includes marketing, supply conditions, schedule, production process, purchasing, inventory, logistics, competitor, technology advancement, etc. (Longo and Oren, 2008; Jain et al., 2017; Ambulkar et al., 2015). Visibility helps to identify and estimate the impact of a disruptive event well before its actual occurrence, thus allowing the aligning of the capacity and resources to avoid the disruption and its impact (Stecke and Kumar, 2009; Ali et al., 2017). According to Fiksel *et al.* (2015) and Ambulkar *et al.* (2015), visibility comprises the indicator matrix that evaluates the degree of collaboration and information sharing among the SC members. One of the major barriers to SC visibility is the inadequate SC structure and technological capabilities that create functional silos and obstruct the information flow.

Thus the structure of the SC plays an imperative role in improving the visibility across the SC. The modern SC initiatives such as collaborative planning, use of modern information technology tools, continuous replenishment programs, etc., act as the major enablers of SC visibility.

Agility (P_4)

It is the responsive ability of a SC against anticipated and unanticipated events to assure the fulfillment of the customer needs and satisfaction and is achieved by combining the velocity and flexibility characteristics of the SC (Christopher and Peck, 2004; Stevenson and Spring, 2007; Juttner and Maklan, 2011; Rajesh, 2019). Jain et al. (2008) define agility as reacting positively to the changing business environment and converting these changes into opportunities, while Wieland (2013) and Patel et al. (2020) defines agility as the measure of how quickly the SC responds to turbulence in the supply and demand in a cost-efficient and smooth manner. It requires cooperation and information-based integration as an input to promptly fulfill customer demand during the uncertainties in supply and demand (Yusuf et al., 2004; Faisal et al., 2006; Yesim et al., 2020). Monitoring and identifying the weakest signals are the main focus of Sheffi (2005) to develop demand-driven responsive SCs, while Christopher (2004) focuses on visibility and market sensitivity.

According to Banyai (2016), the agile SC is characterized by alertness, accessibility, decisiveness, swiftness, and flexibility. SC collaboration and end-to-end visibility, along with quickness in the flow of material, information, and decisions through an organization, will improve SC agility. It stresses on minimization of the distance between the node, physical coupling of the operations, removal of the non-value adding process, increase in velocity, use of flexible manufacturing and assembly cells, modular

fixturing, minimizing the setup and lead time, etc. thus improving the responsiveness of the SC (Christopher and Lee, 2004; Erol et al., 2010). Dubey et al. (2019) and Hosseini et al. (2019) focus on improving the network structure and operations policy for agility, thus fulfilling dynamic customer requirements.

Collaboration (P_5)

It is the SC members' ability to plan and execute the operations together (Scholten and Schilder, 2015; Hosseini et al., 2019). It involves upstream and downstream SC members in strategic decision-making and planning while sharing resources and responsibilities to achieve the common goal (Christopher and Peck, 2004; Ponomarov and Holcomb, 2009; Hohenstein et al., 2015). Ponomarov and Holcomb (2009) and Blackhurst et al. (2011) consider SC collaboration as a strategic tool to improve SC effectiveness, gain mutual benefits, and mitigate the disruptions and their impacts. According to Prajago et al. (2012) and Day et al. (2014), collaboration with upstream and downstream members improves the SC's responsiveness in the normal situation and during uncertainty in business, social and ecological environments. It is a pervasive concept of SCM that includes risk and reward sharing, trust-based relationships, sharing vision and goals, improving trading partners' capability, collaborative innovation, etc. (Cooper and Elram, 1993; Rajesh, 2017).

Further, supplier involvement during the product design stage minimizes the uncertainty related to lead time and availability of raw materials, parts, and components. The fundamental principle of collaborative working is sharing information and developing intelligence, which improves the capabilities, level of trust, risk and revenue sharing, etc., thus reducing SC uncertainty (Richey and Autry, 2009). The collaborative planning, forecasting, and replenishments (CPFR) is considered to be a strategic tool for

the realization of the SC collaboration, which fosters visibility, responsiveness, uncertainty reduction, financial incentivization, etc. (Rajesh, 2019)

Information sharing (P_6)

It is defined as creating and sharing reliable information (Nunes et al., 2006; Chowdhury and Quaddus, 2016). Li and Lin (2006) characterize the information by timeliness, accuracy, reliability, adequacy, and completeness, while Zhou and Beneton (2007) emphasize the information's frequency, availability, and connectivity. Real-time information sharing helps the members of the SC identify the capability and limitations of each link, thus promoting collaboration and proactive participation in problem-solving (Zhang et al., 2011; Jharkharia and Shankar, 2004). It enables visibility (transparency and tracking), velocity (speedy action), versatility (universality), and flexibility in the SC, thus improving the robustness and recovery ability of the SC (Zhou and Beneton, 2007). Moreover, Soni et al. (2014) acclaim that effective information sharing improves competency, minimizes the risks and vulnerabilities and enables quick recovery post disruptions. Collaboration, information standardization, interoperability, and trust among the members are considered essential elements of information sharing (Rajesh, 2018). However, the content of information always remains a topic of debate in the society of business management as it causes intellectual and property risk (IPR) (Montoya and Ortiz-Vargas, 2014; Drakaki and Tzionas, 2019). Bakshi and Kleindorfer (2009) and Voss and Williams (2013) view that it is desirable to share information beyond the SC boundary, such as governmental and non-governmental bodies involved in policymaking, research, and development disaster management, etc. Neubauer et al. (2018) and Li et al. (2017) consider information sharing to improve SC connectivity and emergency backup planning. Hereafter, information sharing, collaboration, and trust

among the SC members promote risk and reward sharing, financial incentivization, assortment planning, SC restructuring, etc.

Strategic Stock (P_7)

It is defined as developing the inventory of the critical items at a strategic location that is accessible to most SC members (Puga et al., 2009; Jain et al., 2017). According to Tang (2006), in the “pre-JIT” era, the organizations were focusing on having some extra inventory called “just in case inventory” for specific critical components to ensure the smooth functional continuity of the SC in case of disruptions. However, studies prove that it will be more beneficial to have inventories of strategic items at some specified locations called “strategic” sites, such as shared distribution centers, logistics hubs, warehouses, etc., which are accessible to most of the SC members (Zhang 2014; Kumar et al. 2017). These shared inventories provide holding cost benefits and higher customer service in case of demand fluctuations. Funaki (2012) considers strategic stocking a tool to mitigate demand quantity and due date uncertainty, while Kumar and Aouam (2019) consider optimizing production capacity and absorbing the variability in service or lead time. It improves SC responsiveness to counter supply and demand fluctuations through product availability (Rajesh, 2018). It also improves financial rigidity by avoiding the unnecessary stocking of high-risk products. Tang (2006) considered the following example in his work “Robust strategies for the RSC” (a) Car manufacturers like Toyota and Sears used to have inventories at certain strategic locations which are shared by two or more retailers. (b) Center for Disease Control (CDC), the USA used to keep a strategic national stockpile (SNS) at a strategic location, which aims to protect people from a health emergency.

Redundancy (P_8)

It is the development of the excess capacity in the SC that tackles and absorbs the supply and demand variability and disruption impact (Hosseini et al., 2019; Neubauer et al., 2018; Wu et al., 2013; Ali et al., 2017). It enables the SC continuity during uncertainties and improves competency in the normal business environment. Redundancy aims to build excess capacity or back-ups that act as the cushion to the disruption and provide valuable time for the organization to redevelop. Rice and Caniato (2003) consider redundancy in the presence of flexibility as an important characteristic of the SC that enables quick recovery post disruptions. It includes improved supply and procurement strategies, standardization of process and interoperability, multiple logistics facilities, etc. At the same time, Juttner and Maklan (2011) and Park (2011) consider redundancy an enabler to flexibility.

In comparison, Carvalho et al. (2012) focus on improving redundancy through reconfiguring the SC. Ivakou et al. (2007) focus on strategic stocking, excess capacity development, and backup for the facilities through collaboration. Moreover, Sheffi et al. (2003), Tomlin (2006), and Tang (2008) explain redundancy in a SC as the availability of multiple suppliers, added inventory, extra or backup production system, increased production capacity, multi-skilled human resource, alternative facility and components, and strategic stocking. Park (2011) classifies the redundancy into safety stock and slack capacity, where safety stock includes an extra inventory of raw material, parts, semi-finished goods, and finished goods, and slack capacity includes alternative facilities of manufacturing, multiple production lines, multiple sourcing, multi-skilled human resources, extra information technology systems, etc. Sheffi and Rice (2005) insist on fair analysis before going for redundancy as it leads to unutilized capacity. In contrast,

Sá et al. (2019) and Zsidisin et al. (2006) argue that redundancy is the idle capacity usable during disruptions and thus improves the robustness of the SC. Hence, redundancy contributes significantly to the RSC at the cost of some unutilized resources.

Risk Management Culture (P_9)

It represents that every member of the SC embraces the risk minimization approach. It starts with the involvement of the firm's top management to integrate each activity of the SC (Christopher and Peck, 2004; Kamalahmadi and Parast, 2016). It includes the employee's training for risk-sensitive culture and mindset, crisis management, risk and reward sharing, and risk identification and preparedness (Hohenstein et al., 2015; Williams et al., 2009). The continuous strive to reduce the source of risk and its impact while making risk assessment an integral part of planning at each level of decision-making (Christopher and Peck, 2004; Sheffi and Rice, 2005). It is defined as the continuous process of identifying the potential risk, vulnerabilities, disruptions, and corresponding mitigating strategies (Sahu et al., 2017). It includes implementing mitigating strategies through a coordinated approach to mitigate the risk, vulnerabilities, and disruptions. According to Sinclair and Collins (1994), Kanji and Yui (1997), and Dellena and Hauser (1999), the concept of SC resilience is analogous to total quality management and thus needs to be embedded in every action of the SCM.

Moreover, developing a RSC requires initiating the risk reduction and mitigation approach from the original equipment manufacturer (OEM) and follow-up with the involvement of all SC members. It requires top-level management's motivation to create a risk assessment and mitigation planning as an integral part of the planning stages (Christopher and Peck, 2004; Sheffi and Rice, 2005; Agrawal and Seth, 2021).

SCRMC minimizes the risk-causing activity and develops business awareness by sensing and interpreting the events that help understand and plan against the vulnerabilities (Datta et al., 2007; Pettit *et al.*, 2010; Sáenz and Revilla, 2014). When the culture of risk management extends beyond the boundary of organizational risk, it leads to the concept of continuity management in the SC (Blos et al., 2015). It promotes risk and reward sharing, collaborative decision making, information sharing, etc., and leads to the rigidity of the SC structure (Rajesh, 2017; Radhakrishnan et al., 2018).

Assortment planning (P_{10})

It is defined as improving customer service through improvement in product availability (Mantrala et al., 2009; Kok et al., 2006). It seeks to find an optimal set of products the company should offer its customers at each point in time. Mantrala et al. (2009) define the assortment planning at the storage level and provide its three aspects, i.e., variety of products, depth of the products, and the service level or inventory position to be allocated. Bahng and Kincade (2014) define assortment planning as a process of making the quantitative decision for retail buying to fulfill customers' demands. Further, Tang (2006) and Tukamuhabwa et al. (2015) argue that assortment planning absorbs disruptions and enables the firm to gain market share and brand loyalty. It also improves inventory management through substitution and influencing customer preferences (Mahajan and Van Ryzin, 2001). Successful assortment planning requires a proper balance among the variety, depth, and quantity concerning the stock-keeping unit (SKU) (Mantrala et al., 2009) with price sensitivity data, profitability, sales, product correlations, assortment priorities, and more, as the input.

Moreover, demand learning and dynamic decision-making are the essential elements of effective assortment planning (Saure, 2011; Kok et al., 2006). Real-time information

sharing, collaboration, and cooperation among the SC members are the essential enablers to the successful implementation of assortment planning. According to Kok et al. (2006), assortment planning plays a significant role in uplifting the performance of the business. In contrast, Sauré and Zeevi (2013) and Rajesh (2017) consider it has the capability to combat the vulnerability of demand through SC visibility, responsiveness, and integration.

Dynamic pricing (P_{11})

It is the demand-based pricing strategy for the product for a specified period of time to maximize the revenue, manage the demand, and gain a competitive advantage (Blackburn and Scudder, 2003; Jun, 2020). Moreover, it also mitigates the product vulnerability whose demand depends upon time and price and has varying product development and holding cost. In the presence of other resilient strategies, the dynamic pricing strategy serves as the superior strategy in case of uncertainty and fierce competition (Jia and Hu, 2011; Xu and Zhu, 2011; Zhang et al., 2020). According to Bhattacharjee and Ramesh (2000), effective implementation of a dynamic pricing strategy leads to higher profit in the case of uncertain market conditions whereas, according to Blackburn and Scudder (2003), dynamic pricing not only maximizes the profits but also optimizes the operations performed with the available stock. Moreover, Li and Chen (2003) state that dynamic pricing maximizes the profit in the case of shorter product life, varying holding and development cost, and uncertainty in supply and demand. It plays a significant role in managing the inventory level of products that are replaceable and whose demand is price-dependent. Information sharing and visibility are the primary requisites for dynamic pricing success, followed by warehouse

and inventory management, product rollover, postponement, etc. It improves the flexibility of the SC to absorb the sudden changes in supply and demand.

Silent product rollover (P_{12})

Tang (2006) defines the silent product rollover strategy as “the launching of the new products slowly into the market without any formal announcement.” Sodhi and Tang (2012) consider both introductions and withdrawal of products silently to gain more control over product exposures, thus improving SC’s ability to manage demand and other product-related vulnerabilities. Hence, it can be defined as the withdrawal, introduction, or substitution of the existing product into the market without any formal announcement to control the product exposure and the supply and demand variability (Rajesh, 2020; Barroso et al., 2011). Silent product rollover works on the philosophy that customers will accept the available products as substitutes for the unavailable product. The success of the silent product rollover broadly depends upon the SC visibility, integration, and risk and reward sharing. It manages the stock-outs without harming the firm goodwill in the customers and the stakeholders’ eyes and provides a competitive advantage (Ye et al., 2020). It improves the SC adaptability to mitigate vulnerability and disruptions, thus enabling the robustness and recovery ability of the SC.

Warehouse and Inventory Management (P_{13})

Warehouse and inventory management covers all the activities involved in storing goods in a logical and orderly manner at the selected location such that items are accessible when expected (Ambulkar et al., 2015; Hohenstein et al., 2015). It deals with the four key activities, i.e., receipt, storage, picking, and dispatch. It is considered to be the most vital link of the SC that not only improves the competency by supplying the

right quality, at the right place, in the right quantity, and at the right time, but also absorbs the vulnerabilities associated with the supply and demand. It governs all inventory spreads across the SC, constituting raw materials and components supplied by the supplier, work in process at the original equipment manufacturer (OEM), finished goods at upstream members, etc. Inventory holds more than half of the cost and also has an enormous impact on the responsiveness of any SC. It is achieved by developing the infrastructure that facilitates information sharing and control over the lead time and other facilities (Razavian et al., 2021). It enables a competitive advantage during adversities by absorbing the variability in supply and demand (Ambulkar et al., 2015; Alawneh and Zhang, 2018). The modern business practice requires warehouse and inventory management should extend to strategic decision positions. The careful use of standby capacity and resources, e.g., spare stocks, extra facilities, etc., helps to manage the more minor disruptions such as variability in supply, demand, price, and production, as well as it also delays the impact of more significant disruptions to the SC (Rice and Caniato, 2003; Sheffi and Rice, 2005; Saenz and Revilla, 2014).

Adaptive capability (P_{14})

According to Coutu (2002) and Lee (2004), the adaptive capability enables the SC to adapt to the changing condition by self-organizing, emerging, and reconfiguring the structure and behavior. Dovers and Handmer (1992) and Smit and Wandel (2006) define adaptive capability as accepting the changing business environment and learning and evolving to adapt to the new conditions and imperatives. It includes reconfiguring the facilities, capacities, and operations. It involves a dynamic interaction between sustainability and development with the change that accrued anticipation of change, innovation, multi-skilled human resources, continuous improvement program,

coordination, and cooperation (Handfield, 2007; Sheffi and Rice, 2005; Halkos et al., 2018). Melnyk et al. (2010) state that adaptability helps quickly and effectively recover from the disturbance caused by social unrest, epidemics, economic recession, natural calamity, employee disputes, etc. It shows the learning aspect of system behavior in response to any disturbance, recovery after disruption, and getting back to or improving its original state (Stacey 1994 and Jackson 2003). Moreover, adaptive capability enables the absorption of stochastic vulnerabilities and improves the firm's operational and financial performances while enabling flexibility (Dubey et al., 2015; Eckstein et al., 2015; Agarwal et al., 2021). The success of adaptability depends upon the information shared, support and collaboration, quickness in SC re-configuration, etc., and is derived from the decisions made during normal and stressful situations (Neubauer, 2018; Radhakrishnan et al., 2018; Kumar and Anabanandam, 2020). Successful implementation of adaptive capability enables the flexible SC that quickly responds to the disruptions and leads to competitive gain post disruptions.

Supply Economic Incentives (P_{15})

It is defined as the strategically sharing of the resources and monetary benefits with the members of the SC to encourage voluntary participation in risk mitigation, capability development, and recovery from disruptions (Tang, 2008; Hasrulnizzam Wan Mahmood et al., 2011; Blome et al., 2014). It is the process of implementing sustainability across the SC that goes beyond the regulatory requirements (Pakdeechoho and Sukhotu, 2017). There are two types of incentives: internal incentives (incentives provided by internal members of the SC) and external incentives (incentives provided by non-members, e.g., government, research centers, etc.). The down-stream customers play the role of internal stakeholders that provide incentives in terms of sharing benefits

and knowledge and long-term contracts with the upstream members that enhance their capabilities, reduce the uncertainty associated with demand and supply, infrastructure development, etc., thus ensuring the continuity of the SC (Pagell and Wu, 2009; Faisal 2010; Huang et al., 2015). The government plays the role of an external stakeholder that directly provide financial or non-financial (subsidies, certification, credits, tax-exemptions, expert support, technical assistance, etc.) incentive to the most critical member of the SC (Clemens, 2006; Lee, 2008; Sarkis et al., 2010; Sheu and Chen, 2012). Hence, SC incentive helps in collaboration between SC members and helps to overcome the barriers and promote resilience practices in firms. Jain et al. (2017) and Soni et al. (2014) consider it as the prerequisite for the risk-sharing among the SC members, while Narayan and Raman (2004) consider it as the SC capacity improvement tool. Moreover, Pakdeechoho and Sukhotu (2018) and Agarwal et al. (2021) consider it the first step towards sustainability into the SC that brings financial strength and operational capability.

Improving financial strength (P_{16})

It is the ability of the firm to hold sufficient financial reserves and liquidity to mitigate and absorb the financial or non-financial disruption events (Radhakrishnan et al., 2017). Neubauer (2018) considers financial strength as a cushion to absorb the cash flow variability, while Chowdhury and Quaddus (2017) and Hosseini et al. (2019) consider it as the enabler of the SC's dynamic capability. The strategic financial management of a SC leads to the smooth running of the business and develops confidence among the members regarding the continuity of the business (Liu, 2010; Duchek, 2018; Agarwal and Seth, 2021). According to Juttner and Maklan (2011), financial failure leads to closing down several entities, and in some cases, it leads to shutting down the SC.

According to Penrose (1959) and Garnesy (1998), developing new SC capability is easy if the organization has sufficient financial resources. It can be achieved by buying insurance, seeking government support, entering the new market, selling or replacing unwanted assets, using budgetary and improved marketing strategies, registering a security interest for products, etc. (Stemmler, 2002; Randall and Farris, 2009).

SC restructuring (P_{17})

It is defined as the rethinking and redesigning the business system to improve performance, minimize the complexities, and develop new capabilities (Chang et al., 2019; Christopher and Peck, 2004). It includes re-positioning of the facilities and capabilities, such as production unit (number and location), supply condition (single sourcing/multiple sourcing), distribution centers (location and number), mode of information sharing, the transportation system (multiple and multi-mode), business processes, adopting the new technology, choosing the new supplier, distribution centers, logistics, etc. (Ponomarov and Holcomb, 2009; Croom, 2001). According to Machado et al. (2009), selecting the right structure is the first step toward a RSC. The adequately structured SCs have risk mitigation and contingency policies that make the SC less vulnerable to disruptions. According to Petit et al. (2010), the SC vulnerabilities are the function of individual organization vulnerability. Thus, to minimize the vulnerabilities, strategic SC structuring is required. There are two approaches for restructuring an existing SC, proactive and reactive. Proactive restructuring is done based on long-term planning to anticipate future requirements, whereas reactive restructuring is done to balance the situation. Restructuring the SC improves flexibility, coordination, and responsiveness, resulting in reduced cost and an improved decisional approach (Abrahamsson and Brege, 1997; Croom, 2001). Ponomarov and Holcomb (2009)

suggested that planned restructuring of the SC ensures event preparedness and an efficient and effective response system capable of recovering from the disruptions to the initial or more desirable state.

2.3. Methodology: Total interpretive structural modeling (TISM) and MICMAC analysis

Interpretative structural modeling (ISM) transforms vague and poorly expressed qualitative systems models into visible and well-defined useful models using iterative graph theory (Warfield, 1974; Sushil, 2012). It was proposed by John Nelson Warfield in 1974 and is focused on identifying the most influential practices or characteristics that enable the system's success. It presumes that most of the practices or characteristics of a system are related to each other, mostly in terms of causal and dependence relationships. Such that successful implementation or presence of one practice enables the realization of another. The findings of the ISM are pictorially presented in the form hierarchical structure comprising the causal dependence relationships between the practices and levels in the hierarchy of their influencing ability. Based on the available literature, it can be concluded that ISM is used with the practices of the system that are similar in characteristics and have an approach for achieving a common goal.

Moreover, the outputs or hierarchical structure obtained only provide the hierarchy and causal dependence relationships between the practices. However, they lag the interpretation of these relationships. So, the total interpretative structural modeling (TISM) was proposed (Sushil, 2012). TISM constitutes all the ISM characteristics and explains each link of the hierarchical structure. Further, most of the time MICMAC analysis is considered to be the integrated part of the ISM and TISM, which cluster the practices into four groups, i.e., autonomous, linkage, driving, and dependent. Thus, the

TISM approach is advantageous over many other multi-attribute decision-making (MADM) approaches in terms of its ability to prioritize, cluster, and define the causal dependence relationships among the various attributes of the system. Considering this novelty of TISM coupled with MICMAC analysis, it is the most suitable approach to our research objective-identifying and classifying the SC practices that enable the resilient capabilities of the SC. Though there are many other formats for the ISM, the conceptual presentation of Prasad and Suri (2011) and Sushil (2012) is used here.

The steps involved in TISM and MICMAC analysis are pictorially portrayed in Figure 2.2 and are briefly discussed below.

2.3.1. Identification of the resilient practices

In this chapter, the focus is on identifying the practices of the RSC from the literature review that enables resilient capabilities. Further, these practices are discussed with the industry experts to judge the implications and importance of these practices in enabling resilient capabilities to the iron and steel manufacturing SC. Seventeen resilient practices are finalized, which are briefly discussed in section 2.2 and provided in Table 2.1.

2.3.2: Defining the contextual relationship and developing a structural self-interaction matrix (SSIM)

In this step, first, the intent relationships among the RSC practice practices are identified considering the goal of developing a RSC and are also thoroughly discussed with the experts. Further, based on the expert's opinion, the relationships between the practices are rectified to develop contextual relationships corresponding to the SC under consideration. These contextual relationships are tabulated to obtain the SSIM (Table

2.2) by transforming the relations using the symbols Y (Yes) and N (No). Where ‘Y’ signifies that SC practice i influences or leads to achieving practices j , and ‘N’ represents that practice i does not have any influencing relationships over practice j (Prasad and Suri, 2011; Sushil, 2012). E.g., the influencing ability of flexibility over postponement, visibility, agility, etc., are N, N, and Y, respectively.

Table 2.2: Structural self-interaction matrix (SSIM)

i,j	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}
P_1	1	N	N	Y	N	N	N	N	N	Y	N	Y	N	Y	N	N	N
P_2	Y	1	N	Y	N	N	N	N	N	Y	Y	Y	N	Y	N	N	N
P_3	N	N	1	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	N	N	Y
P_4	N	N	N	1	N	N	N	N	N	Y	Y	Y	Y	Y	N	N	N
P_5	Y	Y	N	Y	1	Y	N	N	N	N	N	Y	Y	Y	Y	N	N
P_6	N	N	Y	Y	Y	1	Y	N	N	Y	Y	Y	Y	Y	N	N	Y
P_7	Y	N	N	Y	N	N	1	Y	N	N	Y	N	Y	N	N	N	N
P_8	Y	N	N	Y	N	N	Y	1	N	N	N	Y	N	N	N	N	N
P_9	N	Y	N	N	Y	Y	Y	Y	1	N	Y	Y	Y	Y	Y	Y	N
P_{10}	N	N	N	N	N	N	N	N	N	1	N	N	Y	Y	N	Y	N
P_{11}	N	N	N	N	N	N	N	N	N	Y	1	N	Y	Y	N	Y	N
P_{12}	Y	N	N	Y	N	N	N	N	N	Y	Y	1	N	Y	Y	Y	Y
P_{13}	Y	N	N	Y	N	N	Y	Y	N	Y	N	Y	1	Y	N	Y	N
P_{14}	Y	N	N	N	N	N	N	N	N	N	N	N	N	1	N	Y	N
P_{15}	Y	N	N	Y	N	N	N	N	N	N	N	Y	N	Y	1	N	Y
P_{16}	N	N	N	N	N	N	N	Y	N	N	N	Y	N	Y	N	1	Y
P_{17}	Y	N	Y	Y	N	Y	Y	N	N	N	N	Y	N	Y	N	N	1

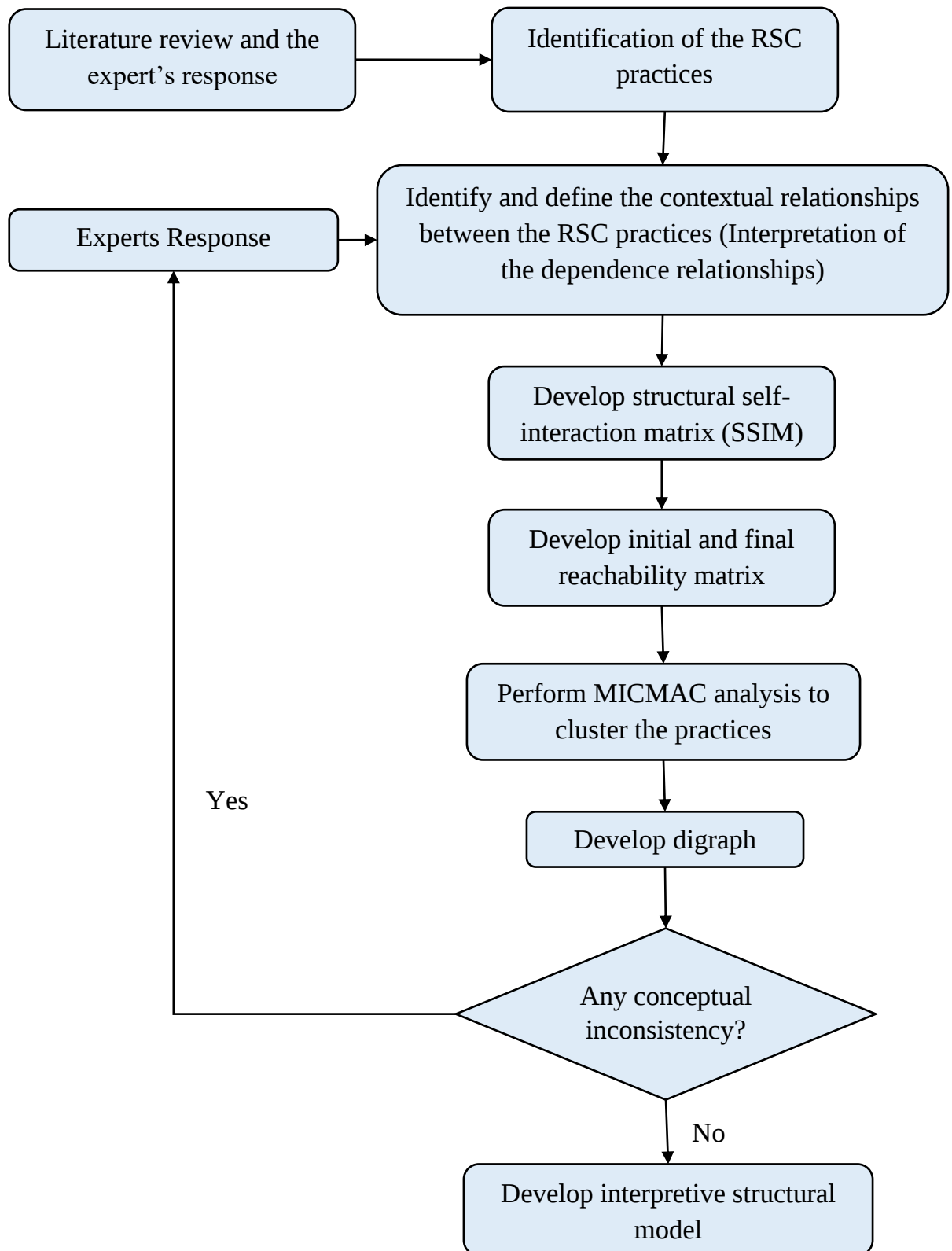


Figure 2.2: Flowchart for TISM and MICMAC

Table 2.3: Initial reachability matrix

i,j	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}
P_1	1	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0
P_2	1	1	0	1	0	0	0	0	0	1	1	1	0	1	0	0	0
P_3	0	0	1	1	0	0	1	1	0	1	1	0	1	1	0	0	1
P_4	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0	0
P_5	1	1	0	1	1	1	0	0	0	0	0	1	1	1	1	0	0
P_6	0	0	1	1	1	1	1	0	0	1	1	1	1	1	0	0	1
P_7	1	0	0	1	0	0	1	1	0	0	1	0	1	0	0	0	0
P_8	1	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0
P_9	0	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	0
P_{10}	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0
P_{11}	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0
P_{12}	1	0	0	1	0	0	0	0	0	1	1	1	0	1	1	1	1
P_{13}	1	0	0	1	0	0	1	1	0	1	0	1	1	1	0	1	0
P_{14}	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
P_{15}	1	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1
P_{16}	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	1
P_{17}	1	0	1	1	0	1	1	0	0	0	0	1	0	1	0	0	1

2.3.3: Interpretation of dependence relationships

In this step, the experts provide the interpretation/logic of the relationship between the practices, i.e., how a practice influences the other practice, and each pair (i, j) is provided with a unique interpretation. This additional step of interpreting the relationships between the practices converts the ISM to the TISM (Sushil, 2012). Moreover, this interpretation is provided in the tabular form as well as pictorial form

(Figure 2.5). E.g., the relation between flexibility and agility is interpreted as “flexibility provides the space for quickly reorganizing the dedicated capacity, thus improving or influencing agility.”

2.3.4: Development of the reachability matrix

The reachability matrix is the numerical presentation of the SSIM and is achieved by quantifying the relationships between the practices under consideration. In ISM or TISM reachability matrix is divided into two, i.e., the initial reachability matrix and the final reachability matrix. Where Initial reachability matrix represents the direct relationships between the practices and is obtained by quantifying the SSIM with 0 and 1 corresponding to Y and N as provided in Table 2.3. For, e.g., Row 1 and column 2, 3, 4, and 5 of Table 2.3 have values 0, 0, 1, and 0 respectively. And final reachability matrix is obtained by quantifying the indirect relationships between the practices. These indirect relationships are obtained by checking the transitivity of the initial reachability matrix. A relation between practice i and practice k is said to be transitive if practice i is related to practice j , and practice j is related to practice k . the transitive relationships are presented by 1* in the final reachability matrix (Table 2.4). E.g., elements corresponding to row 1 and columns 11, 12, and 13 of Table 2.4 are 1*, 1, and 1*, respectively, representing the transitive and direct relations between the resilient practices of the SC.

2.3.5: MICMAC analysis

According to Chandramowli et al. (2011), Michel Godget and Francois Bourse gave the concept of the MICMAC analysis and are used to cluster the practices of a system into dependent, independent, autonomous, and linkage group practices based on their

interdependence relationships. Table 2.5 provides the interdependence relationship between the practices in the form of driving and dependence power.

Table 2.4: Final reachability matrix.

i, j	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}
P_1	1	0	0	1	0	0	0	0	0	1	1*	1	1*	1	1*	1*	1*
P_2	1	1	0	1	0	0	0	0	0	1	1	1	1*	1	1*	1*	1*
P_3	1*	0	1	1	0	1*	1	1	0	1	1	1*	1	1	1*	1*	1*
P_4	1*	0	0	1	0	0	1*	1*	0	1	1	1	1	1	1*	1*	1*
P_5	1	1	1*	1	1	1	1*	1*	0	1*	1*	1	1	1	1	1*	1*
P_6	1*	1*	1	1	1	1	1	1*	0	1	1	1	1	1	1*	1*	1*
P_7	1	0	1*	1	0	1*	1	1	0	1*	1	1*	1	1*	1*	1*	1*
P_8	1	0	0	1	0	0	1	1	0	1*	1*	1	1*	1*	1*	1*	1*
P_9	1*	1	1*	1*	1	1	1	1	1	1*	1	1	1	1	1	1	1*
P_{10}	1*	0	0	1*	0	0	1*	1*	0	1	0	1*	1	1	0	1	1*
P_{11}	1*	0	0	1*	0	0	1*	1*	0	1	1	1*	1	1	0	1	0
P_{12}	1	0	1*	1	0	0	0	1*	0	1	1	1	1*	1	1	1	1
P_{13}	1	0	0	1	0	0	1	1	0	1	1*	1	1	1	1*	1	1*
P_{14}	1	0	0	1*	0	0	0	0	0	1*	0	1*	0	1	0	1	0
P_{15}	1	0	1*	1	0	1*	1*	0	0	1*	1*	1	1*	1	1	1*	1
P_{16}	1*	0	1*	1*	0	1*	1*	1	0	1*	1*	1	0	1	1*	1	1
P_{17}	1	0	1	1	1*	1	1	1*	0	1*	1*	1	1*	1	1*	1*	1

The driving power denotes the number of practices (including itself) influenced by it and is achieved by summing the row elements corresponding to the practice under consideration. In comparison, dependence power represents the number of practices affecting it and is obtained by adding the corresponding column elements. Based on

these driving and dependence power, the resilient practices are clustered into four groups, i.e., dependent, driving, autonomous, and linkage group practices. Where (i) Dependent practices have weak driving power and high dependence over the other practices. These practices are achieved by enabling the driving group practices' success, thus giving comparatively lesser attention than the driving practices. (ii) Driving or independent practices have high driving power and low dependence power. These practices are given maximum attention to improving the system's overall performance or gaining organizational objectives. (iii) Autonomous practices have low driving and dependence power and are given the least importance in resource constraints. These practices must be governed separately compared to driving and dependent practices. (iv) Linkage practices have high driving as well as dependence power. These practices are considered sensitive because a slight change in any one practice will significantly influence the other practices and the system (Shibin et al., 2017). The practices are pictorially presented with their respective clusters in Figure 2.3.

2.3.6. Level partition of the RSC practices

The level partitioning is an iterative procedure that requires comparing the reachability and antecedents set (e.g., Table 2.6). The reachability set consists of the practices itself and all other practices influenced by it, and the antecedents set consists of the practice itself and all other practices affecting it. Further to label, the practices, their corresponding reachability and antecedent's sets are compared. And the practices for which the reachability set is equivalent to the intersection set are named level I. Once the practices got leveled, it is removed from the further iterations. And this step is repeated until all the practices get leveled. For e.g., the reachability set and antecedent set for flexibility are 1, 4, 10-17, and 1-17, and the intersection set is obtained to be 1, 4,

10-17, which is equivalent to the reachability set. Thus ranked as level I. The various iterations involved in the leveling of the resilient practices are provided in Table 2.6 to Table 2.11. Practices with their corresponding levels are provided in Table 2.12.

Table 2.5: Driving and dependence power of the practices

Practices	Dependence power (D_p)	Driving power (D_r)
P_1	17	10
P_2	4	11
P_3	8	14
P_4	17	12
P_5	4	16
P_6	8	16
P_7	13	14
P_8	13	12
P_9	1	17
P_{10}	17	10
P_{11}	15	10
P_{12}	17	12
P_{13}	15	12
P_{14}	17	6
P_{15}	14	13
P_{16}	17	13
P_{17}	15	15

2.3.7: Developing digraph

The digraph is the pictorial representation of resilient practices and their causal dependence relationships. It is developed by arranging the practices in their levels and representing the relationships with the directed arrow. Such that the dotted or broken line represents the transitive or indirect relationships between the practices, whereas the solid arrow line signifies the direct relationships. Such that point of origination of arrow is the influencing practice, and the practice to which arrow head is connecting is the practice which is getting influence.

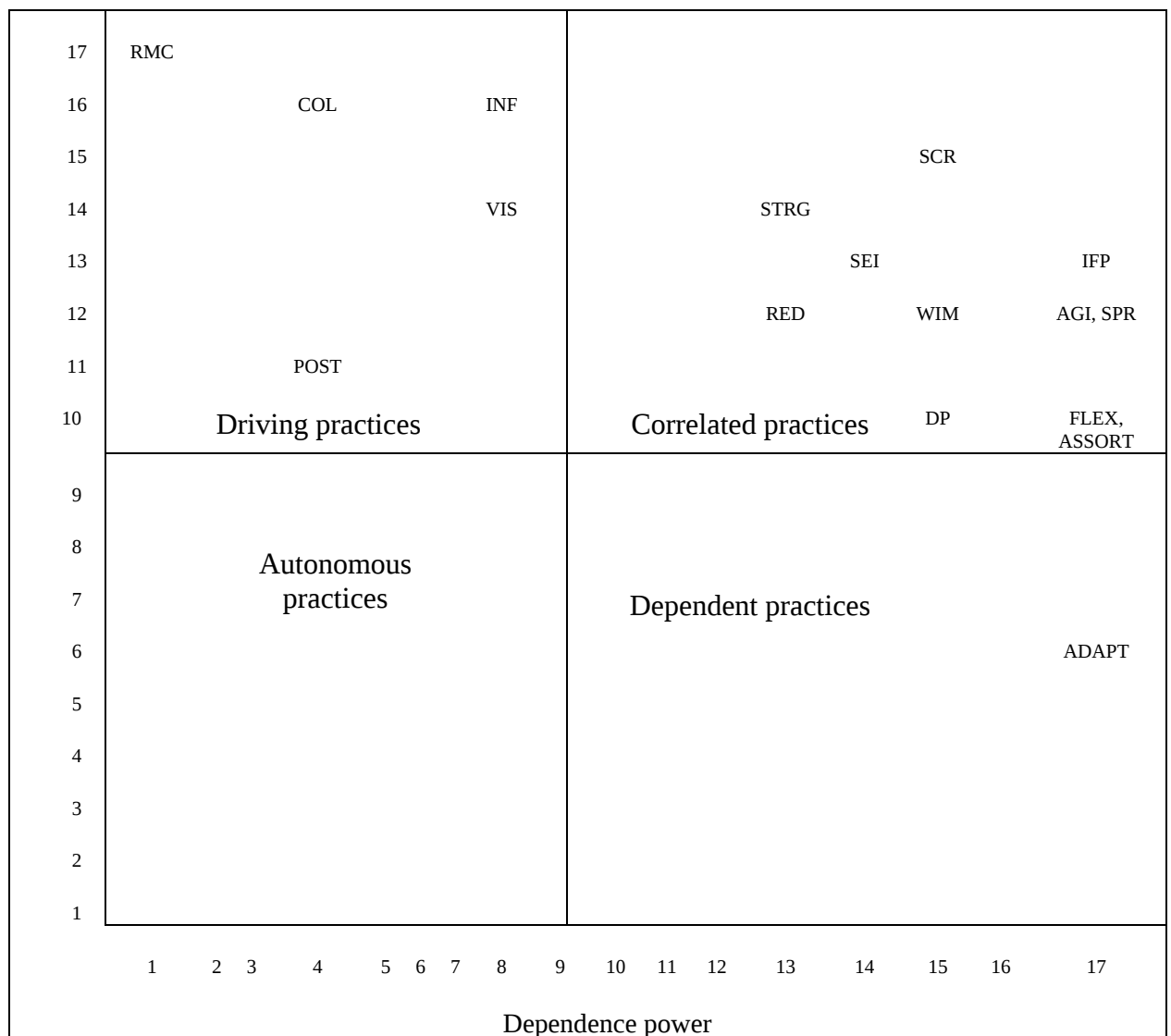


Figure 2.3: Clustering of the practices of a RSC

Table 2.6: Iteration I

RSC practices	Reachability set	Antecedent set	Intersection set	Level
P_1	1,4,10-17	1-17	1,4,10-17	I
P_2	1,2,4,10-17	2,5,6,9	2	
P_3	1,3,4,6-8,10-14,16, 17	3,6,12,15-17	3,6,7,12,16,17	
P_4	1,4,7,8,10-17	1-17	1,4,7,8,10-17	I
P_5	1,2,4-8,10-17	5,6,9,17	5,6,17	
P_6	1-8,10-17	3,5,6,7,9,15-17	3,5,6,7,15-17	
P_7	1,4,7,8,10-14,16	3-13,15-17	4,7,8,10-13,16	
P_8	1,4,7,8,10-17	3-14,16,17	4,7,8,10-14,16,17	
P_9	1-17	9	9	
P_{10}	1,4,7,8,10,12,13, 14,16,17	1-17	1,4,7,8,10,12,13, 14,16,17	I
P_{11}	1,4,7,8,10-14,16,17	1-9,11-13,15-17	1,4,7,8,11-13,16,17	
P_{12}	1,3,4,6,7,8,10-17	1-17	1,3,4,6,7,8,10-17	I
P_{13}	1,4,7,8,10-17	1-13,15-17	1,4,7,8,10-13,15-17	
P_{14}	1,4,8,10,12,14,16,17	1-17	1,4,8,10,12,14,16,17	I
P_{15}	1,3,4,6,7,10-17	1,2,4,5,6,8,9,12,13,15,16,17	1,4,6,12,13,15,16,17	
P_{16}	1,3,4,6,7,8,10,11,12,14-17	1-17	1,3,4,6,7,8,10,11,12,14-17	I
P_{17}	1,3,4,5,6,7,8,10-17	1-6,8-17	1,3-6,8,10-17	

For e.g., the level I practices, i.e., flexibility, agility, assortment planning, silent product rollover strategy, adaptability, and improving financial position, lies at the top position of the digraph (level I), followed by level II practices constituting strategic stocking, dynamic pricing, and warehouse and inventory management. The direct relation between strategic stocking and agility is shown by a continuous arrow, whereas a discontinuous arrow represents the indirect relationship between strategic stocking and assortment planning.

Table 2.7: Iteration II

RSC practices	Reachability set	Antecedent set	Intersection set	Level
P_2	2,11,13,15,17	2,5,6,9	2	
P_3	3,6-8,11,13,17	3,6,15,17	3,6,17	
P_5	2,5-8,11,13,15,17	5,6,9,17	5,6,17	
P_6	2,3,5-8,11,13,15,17	3,5,6,9,15,17	3,5,6,15,17	
P_7	7,8,11,13	3,5-9,11,13,15,17	7,8,11,13	II
P_8	7,8,11,13,15,17	3,5-9, 11,13,17	7,8,11,13,17	
P_9	2,5-9,11,13,15,17	9	9	
P_{11}	7,8,11,13,17	2,3,5-9,11,13,15,17	7,8,11,13,17	II
P_{13}	7,8,11,13,15,17	2,3,5-9,11,13,15,17	7,8,11,13,15,17	II
P_{15}	3,6,7,11,13,15,17	2,3,5-9,13,15,17	3,6,7,13,15,17	
P_{17}	3,5-8,11,13,15,17	2,3,5,6,8,9,11,13,15,17	3,5,6,8,11,13,15,17	

by level II, III, etc. Level VI is provided at the bottom of the digraph, representing the most influencing resilient practices. The digraph is presented in Figure 2.4. However, in this figure, some links are intentionally omitted to minimize the clumsiness of the digraph. The resilient practices lying at a higher level represent their ability to influence a higher number of practices and vice-versa. Level I practices are presented at the top, followed by levels II, III, and so on.

Table 2.8: Iteration III

RSC practices	Reachability set	Antecedent set	Intersection set	Level
P_2	2,15,17	2,5,6,9	2	
P_3	3,6,8,17	3,6,15,17	3,6,17	
P_5	2,5,6,8,15,17	5,6,9,17	5,6,17	
P_6	2,3,5,6,8,15,17	3,5,6,9,15,17	3,5,6,15,17	
P_8	8,15,17	3,5,6,8,9,17	8,17	
P_9	2,5,6,8,9,15,17	9	9	
P_{15}	3,6,15,17	2,3,5,6,8,9,15,17	3,6,15,17	III
P_{17}	3,5,6,8,15,17	2,3,5,6,8,9,15,17	3,5,6,8,15,17	III

Table 2.9: Iteration IV

RSC practices	Reachability set	Antecedent set	Intersection set	Level
P_2	2	2,5,6,9	2	IV
P_3	3,6,8	3,6	3,6	
P_5	2,5,6,8	5,6,9	5,6	
P_6	2,3,5,6,8	3,5,6,9	3,5,6	
P_8	8	3,5,6,8,9	8	IV
P_9	2,5,6,8,9	9	9	

Table 2.10: Iteration V

RSC practices	Reachability set	Antecedent set	Intersection set	Level
P_3	3,6	3,6	3,6	V
P_5	5,6	5,6,9	5,6	V
P_6	3,5,6	3,5,6,9	3,5,6	V
P_9	5,6,9	9	9	

Table 2.11: Iteration VI

RSC practices	Reachability set	Antecedent set	Intersection set	Level
P_9	5,6,9	9	9	VI

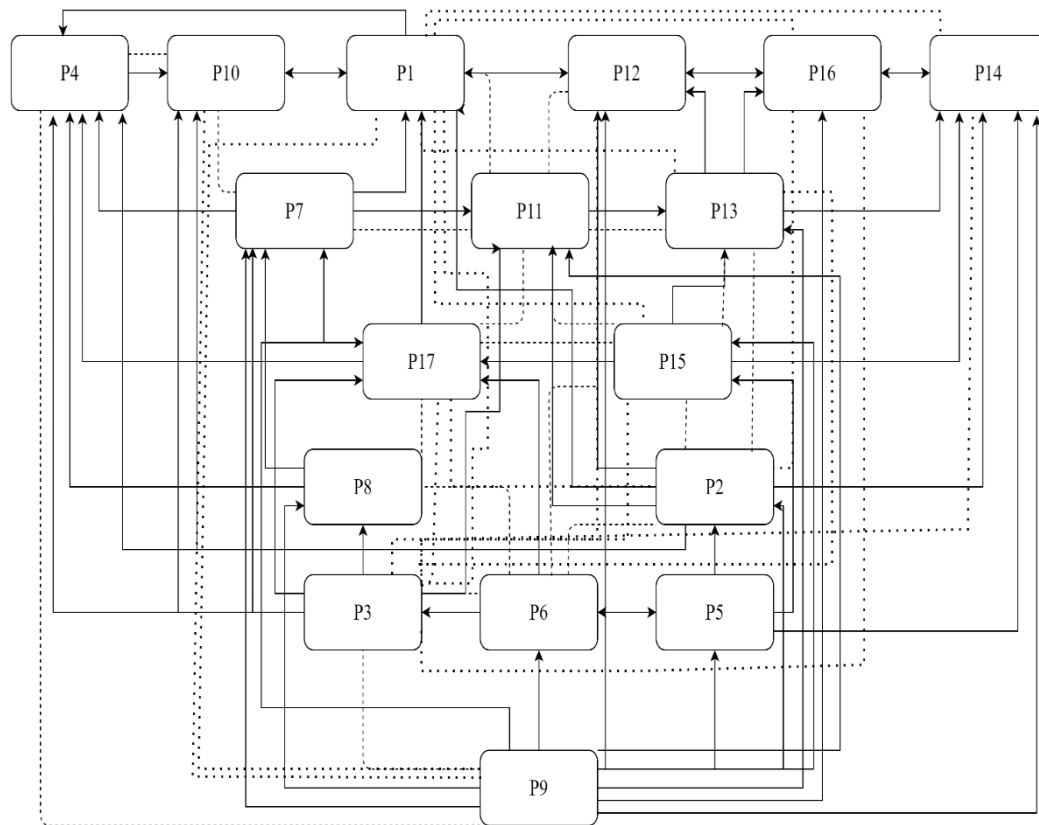


Figure 2.4: Digraph representing the dependence relationships between the practices of a RSC.

2.3.8: Development of an interaction matrix and total interpretive structural model

To develop the interaction matrix (Table 2.13), the unimportant transitive relationships are removed from the digraph and are translated with the binary number (0, 1) (Sushil, 2012). Thus using this interaction matrix, the TISM model is developed (Figure 2.5), consisting of interpreted nodes and links.

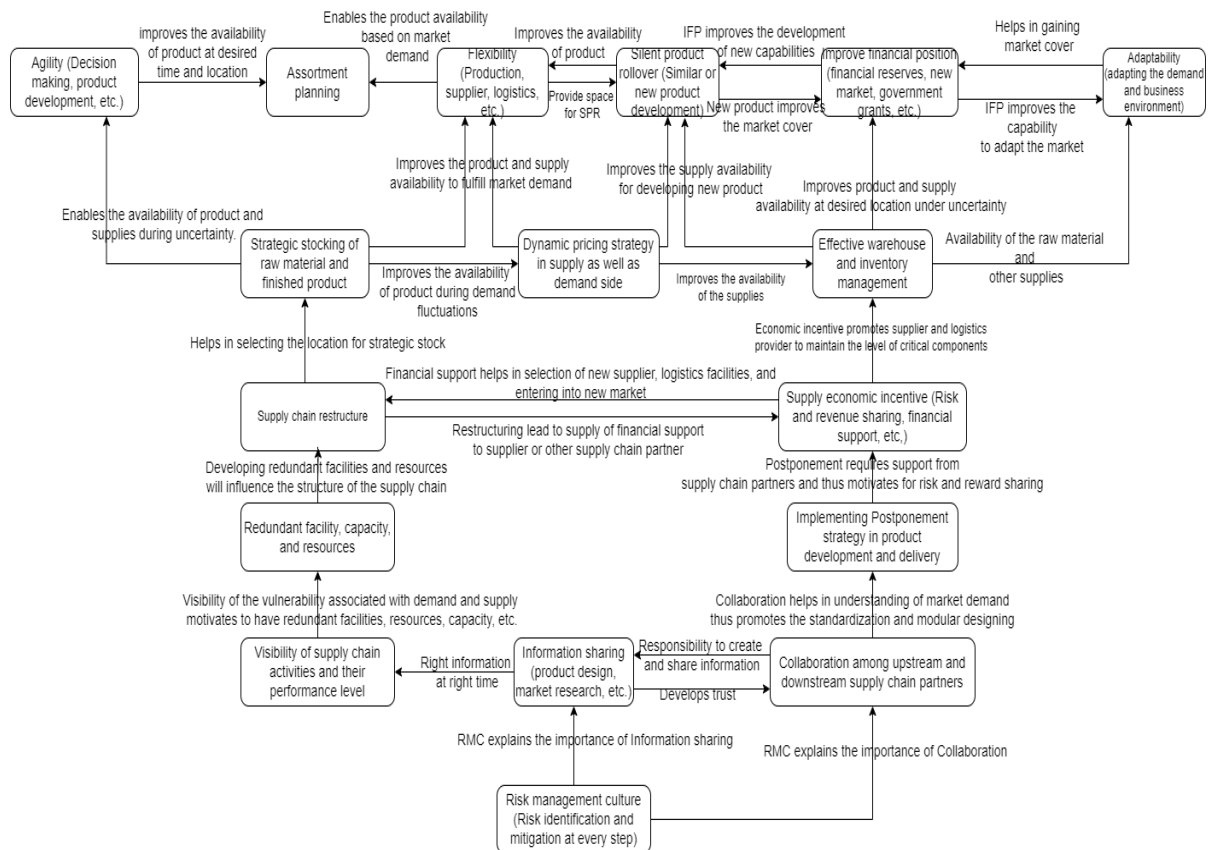


Figure 2.5: Total interpretive structural model for the RSC

Table 2.13: Interaction matrix

i,j	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}
P_1	-									1		1					
P_2		-													1*		
P_3			-	1				1									
P_4				-						1							
P_5		1			-	1									1		
P_6			1		1	-		1									
P_7	1			1			-			1*	1						
P_8		1*		1				-									1*
P_9			1*		1	1			-								
P_{10}										-							
P_{11}	1*										-	1*	1				
P_{12}	1											-				1	
P_{13}												1	-	1	1		
P_{14}														-		1	
P_{15}													1	1	-	1	
P_{16}												1		1		-	
P_{17}				1			1								1		-

Table 2.12: Level partitioning of practices

Sr. No.	Level	Practices
1	I	Agility Assortment planning Flexibility Silent product rollover Improve the financial position

		Adaptability
2	II	Strategic stock
		Dynamic pricing
		Warehouse and inventory management
3	III	SC restructuring
		Supply economic incentive
4	IV	Redundancy of facility and resources
		Postponement
5	V	Information sharing
		Collaboration
		Visibility
6	VI	Risk management culture

Table 2.14: Interpretation of relationships among the RSC practices

RSC Practice ‘i’	RSC Practice ‘j’	Description of how RSC Practice ‘i’ will help to achieve/influence RSC Practice ‘j’.
Flexibility: Ability to absorb the variability in supply and demand, such as Supplier flexibility, in-house production flexibility, logistics flexibility, redundancy, inventory holding capability, etc.	Agility	It provides space for quickly reorganizing the dedicated capacity.
	Collaboration	It enables business continuity during variability in supply, demand, product design, etc.
	Assortment planning	It enables the availability of a more extensive range and variety of products.
	Dynamic pricing	It enables the availability of the same or similar products.
	Silent product rollover	It allows reorganizing the resources and facilities to develop a similar or new product.
	Warehouse and inventory	It improves the availability of resources and products.

	management	
	Adaptability	It allows the re-organization of the available capacity and facilities.
Postponement: Intentional delaying of production and distribution-related activities through standardization, modular designing, the commonality of parts, etc.	Flexibility	It allows for easy product reconfiguration.
	Agility	It improves quickness in the development of a new or similar product.
	Assortment planning	It improves the availability of a variety of products.
	Dynamic pricing	It improves the availability of the products during adversities.
	Silent product rollover	It improves the product compatibility with supplies of different suppliers and also enhances the availability of raw material/ semi-finished products/ parts/components.
	Adaptability	It improves the quick reconfiguration of products with changing demand.
	Improve the financial position	It improves customer satisfaction and also maintains business continuity during variability in supply and demands.
Visibility: Ability to realize the position and performance of the entire SC, such as supply, demand, inventory, production, competitor, innovation, changing market, etc.	Agility	Transitive relationship
	Strategic stock	It helps to select the location and size of the strategic stock.
	Redundancy	It anticipates the possible risk and uncertainty.
	Assortment planning	It tracks product availability, market demand, competitor performance, etc.
	Dynamic pricing	It tracks product availability, market demand, competitor performance, etc.
	Warehouse and inventory management.	It tracks and traces the supply, demand, quality, lead time, etc.
	Adaptability	It tracks the strength, weakness, performance, market trend,

		availability of resources and facilities, etc.
	Restructure SC	It provides information on the weak link, opportunities, technology up-gradation, etc.
Agility: Ability to respond quickly to expected or unexpected events through alertness, accessibility, decisiveness, swiftness, and flexibility.	Assortment planning	It improves the availability of resources/products at the desired location and time.
	Dynamic pricing strategy	It improves the availability of resources, products, supplies, etc.
	Silent product rollover strategy	It reduces product development time.
	Warehouse and inventory management	It enables quick decision-making and implementation and also reduces the production and distribution time.
	Adaptability	It enables the quick reconfiguration of production and other facilities.
Collaboration: Involving the upstream and downstream SC members in strategic decision-making and planning while sharing resources and responsibilities to achieve a common goal.	Flexibility	Through sharing of knowledge and capacity thus develops the capability to accommodate the changes in the supply, demand, product configuration, etc.
	Postponement	Through standardization, modular designing, collaborative planning, and sharing of facilities such as warehousing and logistics.
	Visibility	Transitive relationship
	Agility	Through sharing of facilities, knowledge, cooperating in supplies, etc.
	Information sharing	Through trust, common goal, collaborative planning, etc.
	Silent product rollover	Through quick supplies, adopting and adjusting the changes in product configuration and supplies, etc.
	Warehouse and inventory management	Cooperating through supply quantity, lead time, supply configuration, logistics, etc.

	Adaptability	Cooperating with variability in supply quantity and configuration, lead time, logistics, etc.
	Supply of economic incentives	Cooperating through risk and rewards sharing, technical and managerial support, prepayment, etc.
Information sharing: Creation and sharing of the right information to the right place at the right time.	Visibility	Through the right information at the right time to every member of the SC.
	Agility	Transitive relationship
	Collaboration	It develops trust and commitment.
	Strategic stocking	Through information regarding the variability in supply and demand, anticipation of the risk performance level of the partners, criticality of the supply, location and level of the stocking.
	Assortment planning	Through information regarding market demand, competitor performance, supplier performance, inventory position, etc.
	Dynamic pricing	Through information regarding inventory position, market demand, competitor performance, supplier performance, etc.
	Silent product rollover	Through information about disruption points, availability of resources, market demand, reconfigurability of the capacities, substitutes, etc.
	Warehouse and inventory management	Through information about inventory position and consumption rate at each level of the SC.
	Adaptability	Through information about the vulnerability, uncertainty, capability, changing market trend, availability of technological, etc.
	Restructuring of the SC	Through identification and estimation of disturbances, weak link, available alternatives, market trend, changing technology, etc.

Strategic stock: Developing the inventory of the critical items at a strategic location to deal with unforeseen events and is accessible to most of the SC members during need.	Flexibility	It enables the availability of raw materials, components, products, etc., during the adversities.
	Agility	It enables the quick availability of the material, resources, products, etc.
	Redundancy	It acts as the buffer against the variability of supply and demand.
	Assortment planning	Transitive relationship
	Dynamic pricing strategy	Through the availability of the product.
Redundancy: The creation of excess capacity and back-ups in the SC, such as multiple suppliers, backup production system, multi-skilled human resources, etc.	Warehouse and inventory management	It acts as the buffer against the variability of supply and demand.
	Flexibility	It enables the availability of resources and reconfigurability of the facilities.
	Agility	It allows parallel operations, reconfigurability of the facilities, quick resource availability, etc.
	Strategic stock	It enables the availability of resources and products.
	Silent product rollover	It allows parallel operations, reconfigurability of the facilities, improves resource availability, etc.
Risk management culture: The continuous strive to reduce the source of risk and its impact while making risk assessment an integral part of planning at each decision-making level.	Postponement strategy	Through standardization, parts commonality, modular designing, etc.
	Visibility	Transitive relationship
	Collaboration	Through shared vision and goals and promoting cooperation, coordination, and creativity.
	Information sharing	It provides the importance of generating and sharing the data among the SC members.
	Strategic stocking	It provides information about the resources of strategic importance and their vulnerability.

	Redundancy	It identifies the weaker nodes of the SC and makes the arrangement to combat them, e.g., excess inventory, multiple suppliers, excess capacity, multiskilling of human resources, etc.
	Dynamic pricing	Through sharing the supply and demand data and also enabling the availability of products.
	Silent product rollover	Through continuous strive to improve the capacity, performance, product quality, resource availability, etc., and sharing real-time data of supply, demand, opportunities, and alternatives.
	Adaptability	Through continuous strive to improve the capacity, performance, product quality, resource availability, etc., and sharing real-time data of supply, demand, opportunities, and alternatives.
	Supply of economic incentives	By identifying the critical, disrupted, and weak links that require support and special attention.
	Improve the financial position	By minimizing the disruption, sharing risk and rewards, guaranteeing minimum purchase, sharing facilities, insuring vulnerable processes and capacities, etc.
Assortment planning: Availing the range and variety of products available to the customer based on the market demand, in-stock availability, competitor position, integrated planning, etc.	Warehouse and inventory management	It influences customer preference by offering them various products and thus controls the supply and demand.
	Adaptability	It influences customer preference by availing them a variety of products and thus provides valuable time to develop new capabilities.
	Improves financial position	Through high customer satisfaction and market cover.
Dynamic pricing: Pricing of the products based on availability and demand.	Postponement strategy	Transitive relationship
	Assortment planning	It improves product availability.

Silent product rollover	Transitive relationship	
	Warehouse and inventory management	It controls the supply and demand.
	Adaptability	Controls the supply and demand (and provides time to improve or develop the capacity).
	Financial strength	Improves sales and revenue.
Silent product rollover: Introductions or withdrawal of a product into/from the market without any formal announcement based on the availability and demand.	Flexibility	It improves product (similar/substitutable) availability.
	Agility	It enables product and facility reconfigurability and also improves product availability.
	Assortment planning	It improves the availability of new or similar products.
	Dynamic pricing	It improves the availability of substitute products.
	Adaptability	It enables product and facility reconfigurability and also improves product availability.
	Supply of economic incentives	To get the desired raw material, components, parts, etc.
	Financial strength	Gaining market cover with the new products and enabling substitute products during supply breakdown of the existing product.
	Restructuring of the SC	To develop new capabilities and adapt and gain from the changing business condition.
Warehouse and inventory management: Maintaining the desired level of stocks in a logical and orderly manner at the selected location.	Flexibility	It improves the availability of products and supplies.
	Agility	It improves the availability of products and supplies.
	Strategic stock	Through classification and identification of critical supplies, and

			the importance of its stocking.
	Assortment planning		By enabling the availability of the product.
	Adaptability		By enabling the quick availability of desired supplies.
	Silent product rollover.		By enabling the quick availability of desired supplies.
	Improves the financial position		Through quantity discount, high customer satisfaction, business continuity, etc.
Adaptability: The ability to adapt to the changing condition by self-organizing, emerging, and reconfiguring the structure and behavior.	Flexibility		Through quick changeover capability, accommodating the supplies from different sources, availability of resources, etc.
	Improves financial position		Developing new capabilities, quick reaction to changing market conditions, evolving after the business and ecological turbulence, etc.
Supply of economic incentives: Providing financial support along with the resources, capabilities, and benefits to improve the capability, minimize the risks, and to recover from the disruptions.	Flexibility		Through the development of new capabilities and facilities along with the availability of the resources.
	Agility		Through the development of new capabilities and facilities along with the availability of the resources..
	Silent product rollover		Through the development of new capabilities and facilities along with the availability of the resources.
	Adaptability		Through the development of new capabilities and facilities along with the availability of the resources.
	SC restructure		Through monetary support, technical and managerial knowledge, sharing market research and opportunities, etc.
Improved financial position: Strengthening the financial health, i.e., buying insurance, looking for government supports, entering the	Redundancy		Through investment in development of redundant facilities.
	Silent product rollover		Investing in facility and capability improvement, developing new capabilities, creating new suppliers, etc.

market, selling unwanted assets, using budgetary and improved marketing strategy, etc.	Adaptability	Investing in facility and capability improvement, developing new capabilities, creating new suppliers, etc.
	Restructuring of the SC	Removing financial constraints in the development of new capacity.
SC restructure: The re-positioning of the facilities and capabilities, such as production unit (number and location), supply condition (single sourcing/multiple sourcing), distribution centers (location and number), mode of information sharing, the transportation system (multiple and multi-mode), etc.	Flexibility	Through new or improved capabilities, resources, facilities, supplier, etc.
	Visibility	Removing or rearranging SC links that hinders transparency.
	Agility	Replacing the weak link (supplier, production system, transportation system, etc.) with the swift and agile link.
	Information sharing	Through improved transparency and using modern information-sharing technology
	Strategic stocking	Developing a new stocking location accessible to many of the SC partners.
	Silent product rollover	New supplier, production system up-gradation, quick transportation, outsourcing, etc.
	Adaptability	New supplier, production system up gradation, quick transportation, outsourcing, etc.

2.4. Result

This chapter uses the mixed-method research approach to explore the RSC's characteristics, capabilities, and practices. Section 2.1 shows that the resilient characteristics of the SC enable the four major capabilities, i.e., readiness, robustness, rapidity, and recovery. These capabilities are very much interrelated and altogether lead to the development of the RSC, as shown in Figure 2.1. Further, to enable these four capabilities, seventeen resilient practices are identified, such that most of these practices

influence these resilient capabilities, as shown in Table 2.1. Further, to assess the importance of these practices in enabling resilient capabilities to the SC, the integrated TISM and MICMAC analysis is used. In this approach, the resilient practices are evaluated based on their contextual relationships, thus absorbing the basic assumptions of a system, i.e., the deciding practices of a system are correlated.

The TISM approach models the practices into a hierarchical structure consisting of nodes and links called digraphs (Figure 2.4), where nodes represent the practices. The connecting link (dotted/continuous) shows the dependent relationships among the practices. The SSIM matrix supports our scope of research for identifying the causal dependence relationships as most of the matrix elements are Y. Thus, based on these causal dependence relationships, the TISM models the resilient practices into six different levels (Figure 2.4). Practices lying at the higher-level influence those at a level lower than it. For example, the practice at level VI (risk management culture) is the most influencing and will impact the practices lying at lower levels, i.e., levels V, IV, III, II, and I. The resilient practices and their corresponding levels are provided in Table 2.12, with risk management culture at level VI as the most influencing, followed by level V which comprises visibility, collaboration, and information sharing in the SC. Level IV comprises postponement strategy and development of redundant resources, and level III comprises the supply of economic and financial incentives and restructuring of the SC to improve the overall capability of the SC. Level II consists of stocking the resources at a strategic location, practicing price variability to govern the supply and demand, and efficiently and effectively controlling and managing the warehouse inventory positions. The last level of resilient practices is leveled as I. These practices have very low influencing ability and are influenced by most of the other practices lying at higher levels. It includes flexibility, agility, assortment planning,

product rollover strategy, adaptability, and improving the financial position through various means. Moreover, these resilient practices, their levels, and their corresponding causal dependence relationships are pictorially presented as the TISM model in Figure 2.5. Where the directed arrow is provided with the interpretation of how one resilient practice will help to achieve the goal or success of the other practices, furthermore, all the direct or indirect relationship are interpreted by the experts and is provided in Table 2.14. For e.g., SC restructuring will lead to flexibility, visibility, agility, information sharing, strategic stocking, product rollover, and adaptability through developing new or improved capabilities, removing the financial and hindrances and technological barriers, improving SC transparency, developing new warehousing positions, selecting new or enhanced logistics facilities, etc.

Further, the MICMAC analysis clusters the resilient practices into three groups. The first is the driving group that comprises risk management culture, collaboration among the SC members, improved information sharing, practicing the postponement strategy in product development and distribution, and enabling visibility across the SC. The second group is dependent practices, which comprises adaptability. The third group is the linkage group practices which comprises flexibility of the SC, agility to respond quickly to anticipate and unanticipated events, strategic stocking of the critical resources, redundancy of the capacities, practicing the product assortment, enabling dynamic pricing, incentivizing the SC partners, practicing the product rollover strategy, efficient and effective management of the warehouses and the inventory position, improving financial strength, and restructuring the SC. From Figure 2.3, it is also evident that no resilient practice belongs to the autonomous group, thus justifying the relevance and importance of these resilient practices for enabling the RSC, and also the classification suggests that most of these practices can be enabled by enabling the influencing

practices (Shibin et al., 2017). Moreover, the linkage group practices are considered critical and require very close control because of their high interdependence and impact on the dependent group's resilient practices. Thus, the success of the RSC is dependent on and very sensitive to these practices. Further, the next important group of practices is the driving group practices in terms of control they require but are given higher priority in terms of their implementation because of their higher ability to influence a number of practices than it is influenced by. However, only one resilient practice, i.e., adaptability, belongs to the dependent group, suggesting that considered resilient practices are highly correlated. And to enable adaptability, resilient practices like flexibility, agility, assortment planning, etc., must be implemented first.

From the above discussion, it is evident that the TISM and MICMAC approach outcomes are consistent to a large extent and hence self-validating as per Chauhan et al., 2018. Further, based on the above results, 'risk management culture' is obtained to be the most influencing among the practices of the RSC. That suggests that the continuous strive for reducing the risk and developing resilient capability through business awareness, learning, and making risk assessment an integral part of the planning at each level of decision-making should be the first step towards developing a RSC, which is also in accordance with the findings of Bevilacqua et al. (2019). Further, visibility, collaboration, and information sharing in the SC are the next important practices that improve the preparedness against the vulnerabilities and enable the organizations to combat the disruptions and their impact. All these influencing practices develop the trust and cooperation among the SC partners that enable them to support one another, share risks and rewards, and provide the path for successful implementation of the strategies at lower levels (Sa et al., 2019; Jain et al., 2017). However, the practices lying at the lower levels and also having the lower driving ability may not have the ability to

improve or enable the successful implementation of the high driving ability practices, but they enable the resilient capabilities into the SC and act as the cushion against the variability's, vulnerabilities, and the disruptions.

Managerial implications

This chapter brings theoretical and practical insights into the RSC's capabilities and practices that enable the SC experts to make their SC resilient against vulnerabilities and disruptions. The proposed framework suggests that the risk management culture, information sharing, collaboration among the SC members, and visibility in the SC are the key enablers of the RSC. Moreover, by analyzing these key enablers, it can be assured that managerial commitment and trust can cultivate the development of the RSC among the SC members. The resource availability and technical capabilities are the second stages of RSC development. The highest ranking to risk management culture implies that management should prioritize it, as it obliges every stakeholder of the SC towards risk management. Moreover, this research will also help the decision-makers build the policies and allocate the resources to develop the SC capabilities that minimize the uncertainty and enhance its ability to recover from disruptions. Moreover, the above hierarchy model can also be used as a checklist by the experts to analyze the resilient capabilities of the organizations, which may further help in strategic decision-making and choosing a resilient for smooth SC operations.

2.5. Conclusion

In this chapter, the four capabilities and the seventeen resilient practices are that discussed that enable the resilient behavior of the SC that not only minimizes the risk and impact of disruption but also helps to recover swiftly from the disruption to maintain the business continuity and reach a new or better business position. The four

capabilities are readiness, robustness, rapidity, and recovery & growth, and the resilient practices are agility, assortment planning, flexibility, silent product rollover, improving the financial position, adaptability, strategic stocking, dynamic pricing, warehouse and inventory management, SC restructuring, supply economic incentive, redundancy of facility and resources, postponement, information sharing, collaboration, visibility, and risk management culture. From the final reachability matrix, it is evident that all these resilient practices are essential for developing a RSC. However, their implementation varies based on the influencing ability of the individual practices. Moreover, the hierarchical structural model and the practice clustering explain the relationships between the practices and the priority of their implementation. Further, the results suggest that the first step towards the development of a resilient supply is free and achieved through behavioral management, i.e., determination, trust, and mutual understanding among the SC members. And also, the TISM model explains the nodes and links that provide a better understanding of the dependence relationship among the practices, thus their role in enabling one another. Hence, this chapter contributes significantly to the RSC literature and helps the managers work upon the resilient practices and come up with some significant changes in their policymaking and policies to deal with the uncertainties and disruptions of the SC.

Limitations and future scope

In this chapter, the capabilities of the RSC and the practices enabling these capabilities are discussed and analyzed. However, there exist many hindrances in the successful execution of resilient practices, which need to be identified and evaluated. Moreover, the findings of this chapter can also be extended by evaluating the importance of these resilient practices in enabling resilient capabilities for the SC.

