

**A Conceptual Framework for Building Resilience in
Supply Chain: A Case of Indian Iron and Steel
Manufacturing Sector**



Thesis submitted towards the partial fulfillment

for the Award of Degree

Doctor of Philosophy

by

AJEET KUMAR YADAV

**DEPARTMENT OF MECHANICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY
(Banaras Hindu University)
VARANASI – 221 005**

CHAPTER 6

CONCLUSIONS

This chapter concludes the entire research work and discusses the major contributions, inherent limitations, and the scope for future research.

6.1. Conclusions

The literature suggests that the 21st-century global business has been very competitive and derived from the complex set of connected and inter-dependent organizations called SC. These SCs are intended to enhance customer value, minimize cost, and optimize the organization's financial benefits. However, the success of the SCs is subjective to the success of each of its entities which is subjected to risks, uncertainties, and disruptive events. The impacts of the SC failure are very pronounced, and if not addressed rightly, it may lead to the complete loss of the business. Therefore, for the survival and growth of the business in the propensity of the adversities, the SC needs to be incorporated with the capabilities that enable them to counter and capitalize on the events that could potentially harm and questions its survival. Hence the resilient concept of the SC gains its importance, which not only enables the SC entities to prepare for the expected challenges and respond effectively to the adversities but also enables quick and efficient recovery post disruptions.

This study reviewed the extant literature on the functions, characteristics, and behavior of the RSC and provided the four important capabilities of the RSC. These capabilities are readiness, robustness, rapidity, and recovery & growth. Further, the literature suggests that much research has been carried out explaining the importance of resilient practices for enabling the resilient characteristics of the SCs. However, very few

attempts to identify and explain their interdependence relationships. And evaluating the resilience score of a SC while considering the resilient practices and their corresponding attributes is even rare. Further, very little research has been carried out for the exploration and analysis of the factors inhibiting the successful implementation of the resilient practices of the SC, which ultimately hinders the attainment of the definitely resilient position of the SC. The literature also suggests that research study focusing on enabling the resilient behavior of Indian manufacturing SC is rare. However, there is a complete absence of any comprehensive study done with respect to Indian iron and steel manufacturing SC.

The objectives of this research are carried out in chapters 2 to 4 while considering the case of an Indian iron and steel manufacturing SC.

1. Chapter 2 identifies the resilient practices of the SC and interprets their causal dependence relationships.
2. Chapter 3 estimates the utility of the resilient practices for enabling the resilient capabilities of the SC.
3. Chapter 4 evaluates the resilience level of the case organization SC.
4. Chapter 5 identifies the factors hindering the implementation of resilient practices in the SC and prioritizes them considering their influencing relationships.

Causal dependence relationships among the practices of the RSC

This chapter explains the four capabilities of the resilient SC (readiness, robustness, rapidity, recovery & growth) and identifies the practices required to achieve them. These practices cover the broader aspect of the SC, including structure, financial health, cooperation, use of modern tools and technology, etc. Moreover, the findings reveal that

these resilient practices complement one another, with the highest driving power to the risk management culture across the SC, followed by collaboration, information sharing, visibility, etc. These high driving ability practices provide the basis for the development of the RSC. Here, the lesser driving power of the resilient practices does not signify their inferiority in the development of the RSC. Instead, it only provides information regarding their priority for the implementation by the SC entities. Further, the clusters of practices, i.e., driving, linkage, and dependence obtained from the MICMAC analysis, justify their close adherence and belongingness to the RSC. And also, the findings of this chapter suggest that the first step towards the building of RSC is the practice of the behavioral strategy in the SC, i.e., risk sensing culture, determination, trust, and mutual understanding among the SC members.

Estimating the utility of the resilient practice for the building of RSC

This chapter provides a novel approach to quantifying the importance ranking of resilient capabilities and the contribution of the resilient practices in enabling the resilient capabilities to the SC. The findings reveal that all four capabilities are essential for enabling RSC, among which the disruption recovery and post-disruption growth gain slightly more importance, followed by the ability to absorb the variabilities, preparedness, and quick response to the uncertainties and disruptions. Moreover, the importance weight or utility of the resilient practices for enabling the resilient capabilities to the SC is obtained very close to one another, thus proving their significance for the RSC, with high weightage to the practices enabling the recovery & growth of the SC post disruptions. These high utility score practices include the silent product rollover, collaboration among the SC members, SC adaptability, improving SC's financial position, etc.

Evaluating the resilience level of an Indian manufacturing supply chain

This chapter identifies the attributes of the resilient practices enabling the resilient capabilities to the SCs. Also, it provides a systematic fuzzy logic approach to quantify the resilience score of an Indian iron and steel manufacturing SC. The resilience score is evaluated based on the implementation level of the resilience attributes by the case organization SC. The findings suggest that the case organization SC is intensely resilient and thus can combat most of the internal and external uncertainties making the SC vulnerable. However, the next possible resilience position of the case organization SC is found to be “very resilient,” followed by the “definitely resilient” position. Hence, this suggests that the case organization SC lags far behind the “definitely resilience” position. Moreover, the fuzzy performance index (FPI) suggests that the case organization SC is performing extremely well for the attributes like the multi-mode and multi-carrier transportation system, collaborative decision making, multi-skilled human resources, postponement of product differentiation, the flexibility of the production system, and providing financial aid to weak link of the SC. It also suggests that the case organization SC needs to improve its information sharing and communication system, risk assessment and mitigation planning, logistics facilities, procurement of supplies, etc. Further, the gap between the actual resilience level and the “definitely resilient” position signifies the presence of the factors that inhibits the successful implementation of resilient practices and their corresponding attributes.

Analyzing the factors opposing the resilient behavior of the RSC

This chapter identifies and analyzes the factors opposing the attainment of the definitely resilient level of the SC, also called the barriers to the RSC. The causal-dependence relationships suggest that most of these barriers are influencing one another, such that

the lack of managerial commitment, poor risk awareness, poor information sharing, mistrust among the SC members, the poor financial health of the organizations, and poor judgment and inaccurate forecast are obtained to be the most impactful barriers. Thus, to minimize the obstruction in achieving the definitely resilient level of the SC, the most influencing barriers need to be mitigated first, followed by the influenced barriers. And also, for attaining the true RSC, the practitioners need to effectively implement resilient practices and develop a strategy to mitigate the factors inhibiting its successful implementation.

6.1.1. Theoretical contribution

This research provides a thorough background of the RSC, including the concepts like SC, SCM, risks, uncertainty, vulnerability, disruptions, and SCRM. Further, it explores the RSC by explaining its capabilities, practices enabling the resilient capabilities, attributes of the resilient practices, and the barriers opposing the successful implementation of the resilient practices. It clustered the RSC abilities and characteristics into four capabilities, i.e., readiness, robustness, rapidity, and recovery & growth. And also identifies the nineteen practices which when implemented successfully, lead to the truly RSC. The empirical analysis carried out for the analysis of the causal dependence relationships among the resilient practices and also the utility of individual practices for enabling the resilient capabilities suggest that they are closely associated with each other, and their effect should always be seen in their combined form only. However, the hierarchical structure provides information about the priority and the sequence of their implementation when there are resource constraints.

Further, seventy-six attributes of the resilient practices are identified, which enables the successful implementation of the resilience concept at the root level of the SC.

Similarly, the high causal dependence relationships between the barriers to the RSC suggest that if all the barriers are present together, then their combined effect would be detrimental and may cause the complete breakdown of the SC. Thus suggesting that the RSC is the result of the resilient practices and the barriers. The approach discussed for the assessment of the resilient score of the SC can be implemented in the assessment of the other functionality of the SC. Moreover, the approach used for prioritizing the RSC factors and also measuring the resilience performance fills the void presented in most of the RSC studies, such as Rajesh (2020), Singh and Singh (2019), Ruiz-Benítez et al. (2018), etc. Moreover, this research is carried out for an Indian iron and steel manufacturing supply chain; however, the conceptual framework so developed may be equally applicable to most of the other manufacturing SCs. In addition, this research provides a broader perspective of the RSC concept to the academicians and the researchers, which further paves the way to carry out research in this field and allows the researchers to add more insights into the RSC phenomenon.

6.1.2. Managerial contribution

This study explores the SC activities, risks, and vulnerabilities associated with these activities and the impact of their disruptions on business continuity. It also explores the sources of various uncertainties of the SC, i.e., internal or external to the organization, business-related or ecological disturbances, societal or stringent regulations, etc. The various examples in this research will help the experts anticipate the RVDs to which their organizations are subjected. This understanding of RVDs will further enable the practitioners to understand the controllable and uncontrollable risk-causing activities and the sources of the major disruptions. It also supports the practitioners to know and prioritize their functions, responsibility, and contributions in efficient SC operations and

mitigating the RVDs. And also, the three phases of the RSC management, i.e., pre-disruptions, during disruptions, and post-disruptions, provide the benchmark strategies to counteract the RVDs associated with the SC.

The four resilient capabilities (readiness, robustness, rapidity, and recovery) and their characteristics discussed in the research will provide the guiding principles to the SC managers to efficiently manage the RVDs in the three phases of the RSC, thus creating value for all its stakeholders. These capabilities enable business continuity during uncertainties and have proven to be the most spectacular agent in making the organization a front-runner in the business. Readiness focuses on the development and alignment of the resources that eradicate or minimize the sources of the risk and develops the buffer that activates during the disruptions to absorb its impacts. This research suggests that readiness provides the base for developing resilience capacities in the SCs and is widely incorporated into the business during the planning stage. Thus to have readiness, research suggests that the top management should develop a culture of SC stress testing and contingency planning as an integral part of each decision-making in their organization.

Further, this research will help the practitioners by explaining the strategies enabling the readiness attribute to the RSC, such as imparting flexibility, developing redundancy of resources and facilities, developing collaborative relationships, promoting the 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. Similarly, the next RSC capability provided in this research is robustness, which provides the guidelines to SC managers to sustain

their business performances at the intended level irrespective of the variability in their business operation scenarios. This research suggests the incorporation of the SC practices like postponement 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., for enabling the SC robustness.

Further, this research suggests strategies for incorporating the quickness by which the organization transforms the market demand into the product and services through synchronization and collaboration of SC partners, thus leading to business profitability and growth. These strategies include suppliers' restoration budget, effective information sharing and communication, redundancy of the resources, advancement of the resources, quick decision-making and implementation, agility in the production process, etc. Moreover, this research discussed the strategies that enable organizations to quickly recover from disruptions and guide them to attain a better position than the competitor working in the same environment. These strategies include 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.

Further, to smoothen the SC expert's efforts for developing a RSC, the strategies responsible for enabling the 4R capability to the SC are defined in the form of sixteen practices of the RSC. Risk management culture is found to be the most influencing, followed by visibility, information sharing, collaboration, and so on. The risk

management culture is analogous to the quality culture of total quality management, which needs to be imparted to the SC from the top management and involves every stakeholder of the business for avoiding, mitigating, and controlling the risk-causing events, vulnerability reduction, and disruption management with the least impact over the business outcomes. It suggests to the practitioners that mitigating RVDs is everyone's responsibility, and it should be inherited in each business activity. Similarly, the high driving power of the collaboration suggests the importance of the core SC partners in gaining competitive advantage and mitigating RVDs, thus signifying the vital involvement of the SC partners in strategic decision-making.

Further, the high driving power of information sharing suggests the importance of real-time information availability across the SC. This availability of information eradicates most of the loopholes in the SC and enables timely responses to uncertain events and disruptions. Thus, minimizing the disruption's impacts and time to recover from it. Moreover, this research will also help the decision-makers build the policies and allocate the resources to develop the SC capabilities that minimize uncertainty and enhance its ability to recover from disruptions. The hierarchy model presented in Figure 2.5 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 smooth SC operations. In addition, the implication procedure of all the nineteen resilient practices and their contributions to the RSC development provided in the research will help the SC experts in various phases of the SCM, which results in the making up of a RSC.

The seventy-six attributes provided in the research act as the ladder steps for the implementation of the nineteen resilient practices of the RSC. These attributes will help the practitioners to strategize and prioritize the resources and activities to attain the

'definitely resilient' position of the SC. Further, the methodology discussed in chapter 4 will enable SC experts to quantify an SC's resilience position, comparing the SC's resilient performance of the SCs, identifying the benchmarked RSC of the industry, etc. In addition, it provides information about the attributes that minimally contribute to the resilience score, thus leading to the identification of the areas that make the SC vulnerable. In addition, an elaborate list of barriers and their causal dependence relationship is provided in the research that will help the practitioners eliminate the sources causing the SC vulnerability and inhibit the successful implementation of resilient practices. And also, specific measures can be taken against these barriers to eradicate them or nullify their impact, thus making the RSC a reality. It also paves the way toward more sophisticated research by industry experts focusing on improving the resilient ability at each node point of the SC.

6.1.3. Limitations and the future research

Despite providing the elaborated concept of the RSC and the significance of this research in real-case scenarios, this research has some limitations. The first limitation lies in the generalization of the findings for the global SC because the respondents belong to an individual manufacturing SC only, and the inputs provided by them are subjective to their knowledge and understanding regarding RSC and firm operations. And also, irrespective of all possible efforts that have been made to minimize the biasness present in the expert's response, its presence cannot be neglected. The second limitation lies in the analysis of the SC functions, i.e., in this research, a broader picture of the SC is considered while giving lesser importance to the production process and raw material characteristics. And also, because of the presence of the inhibiting factors to the implementation of resilient practices, the resilience score of the case organization

SC is found to be lagging behind the “definitely resilient” position. Therefore, this research can be extended in the following ways. (1) By employing more experts from different sections and the different SCs to minimize or eradicate any input biases. (2) The combined effect of the resilient practices and the barriers inhibiting its implementation can be evaluated to obtain the exact resilience score of the SC. (3) Some recent advancements in SC management like blockchain technology, big data analytics, the internet of things, outsourcing knowledge, objective-oriented collaboration, improved infrastructure for information sharing, *etc.*, have gained much attention in the recent literature. And also, these advancements are expected to counter many of the barriers explained in this thesis and can convert the pseudo-RSC to a truly or definitely RSC. Thus, our research can also be elaborated while considering these advancements.

