Unravelling the critical success factors for resilient supply chains – insights from the textile industry of Pakistan

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ABSTRACT – REZUMAT

Unravelling the critical success factors for resilient supply chains – insights from the textile industry of Pakistan

This study focuses on developing a theoretical framework for the Resilient Supply Chain for analysing the various types of resilience and the role-play of different managerial levels in developing them effectively. Data is collected from the textile sector of Pakistan with the aid of semi-structured interviews, which were done with employees from different managerial levels. Analytical Hierarchy Process (AHP) was used to define the importance of the multiple Critical Success Factors (CSFs) which were derived from an extensive literature review. The identified CSFs are categorized into Ecological, Engineering, Evolutionary, and Technological resilience. The weight of each criterion and their cause-effect relationships are determined. The findings reveal that the Use of Modern Technology holds the highest weightage at 24.1%, followed by the Development of Effective SCM Strategy (14.6%) and Reliable Supplier Development (9.6%). Additionally, the study establishes connections between the CSFs and different managerial levels (Tactical, Strategic, and Operational), facilitating employee understanding of their roles in mitigating disruptions and fostering resilient supply chains. Overall, this research offers a comprehensive framework for enhancing Textile Supply Chain resilience, providing practical insights for improving operational performance and addressing industry challenges.

Keywords: *supply chain resilience, Critical Success Factors, textile industry, Analytical Hierarchical Process (AHP)*

Evidenţierea factorilor critici de succes pentru lanţurile de aprovizionare reziliente – informații din industria textilă din Pakistan

Acest studiu se concentrează pe dezvoltarea unui cadru teoretic al lanțului de aprovizionare rezilient pentru analiza diferitelor tipuri de reziliență și jocul de rol al diferitelor niveluri manageriale, cu privire la modul de dezvoltare eficientă a acestora. Datele sunt colectate din sectorul textil din Pakistan cu ajutorul interviurilor semi-structurate, care au fost realizate cu angajați de la diferite niveluri manageriale. Procesul de Ierarhie Analitică (AHP) a fost folosit pentru a defini importanța multiplilor Factori Critici de Succes (CSF) care au fost derivați dintr-o analiză extinsă a literaturii. CSF-urile identificate sunt clasificate în Reziliență ecologică, de inginerie, evolutivă și tehnologică. Se determină ponderea fiecărui criteriu și relațiile lor cauză-efect. Concluziile arată că utilizarea tehnologiei moderne deține cea mai mare pondere, cu 24,1%, urmată de dezvoltarea unei strategii eficiente SCM (14,6%) și dezvoltarea de încredere a furnizorilor (9,6%). În plus, studiul stabilește conexiuni între CSF-uri și diferite niveluri manageriale (tactic, strategic și operațional), facilitând înțelegerea angajaților cu privire la rolurile lor în atenuarea perturbărilor și încurajarea lanțurilor de aprovizionare reziliente. În general, acest studiu oferă un cadru cuprinzător pentru îmbunătățirea rezilienței lanțului de aprovizionare textil, oferind perspective practice pentru îmbunătățirea performanței operaționale și abordarea provocărilor din industrie.

Cuvinte-cheie*: reziliența lanțului de aprovizionare, Factori Critici de Succes, industria textilă, Proces Ierarhic Analitic (AHP)*

INTRODUCTION

Supply Chains(SC) of today are facing far more challenges of uncertain situations which hinder their performances at various levels [1]. In recent times, there has been considerable attention given to the efficiency of supply chain management (SCM) and the concept of supply chain resilience (SCR) in both academic research and the manufacturing sector. Wieland [2] stresses the need for more adaptable frameworks in the domain of resilient supply chains is apparent, Singh et al. [3] their study discussed how during the COVID-19, the Public Distribution System (PSD) was disturbed and the supply of essential items was halted thus showing the need for research for a resilient supply chain for disaster management. Remko [4] has pointed out that a strong need for empirical analysis is needed which can aid industries in making their SCs more resilient. The frequency and severity of unexpected unforeseen events have compelled experts and analysts to shift from conventional techniques of risk management to incorporating resilience in SCs to mitigate disruptions caused by human-made disasters [5, 6].

Disruptive risk is the output of natural disasters such as hurricanes, tremors, and flooding, as well as risks caused by human beings examples being any attacks by terrorists and economic job strikes. Disruptive risks usually refer to those which have a minimum likelihood but may cause significant impact in case of occurrence in short or long-term [7]. The purpose of resilience is to bind all the elements in a system but it needs to be ascertained in what ways each element is contributing to the total system. Vegt et al. [8] emphasized the fact that the element that gives the most strength to a system is its resilience which aids the system in unforeseen times.

Looking from the organization's viewpoint, the core function of an organization is Operations Management (OM) whose sole purpose is to keep a balance between demand and the supply of material whereas Corporate Finance makes sure that money outflow is recovered by the supply distribution [9,10]. SCs face various activities that threaten to disrupt the operating activities of SC and jeopardize productive and successful production in today's globally increasingly chaotic environments. The effect of resilience towards the performance of the supply chain is greatly dependent on the ability of the firm to ascertain vulnerabilities that will happen shortly and use its capacity enhancement budget to bridge that gap.

Research gap

The challenges of developing a reliable and consistent SC is becoming all the more difficult in the wake of multiple disruptive events [11]. Organizations are realizing that the need to make their supply chains resilient is not the only way to prosper but they need to develop a network of resilience for the distributors and suppliers, in short, a global resilient SC. This global SC becomes vital in the wake of Low-frequency high-impact (LFHI) risks like extreme weather due to global warming, terrorist attacks, and safety. Hosseini et al. [7] stated that in the present worldwide and progressively powerful and violent situations, SC had stood up to various occasions that took steps to disturb SC operational exercises and endanger proficient and viable execution.

Morales et al. [12] emphasized that the worldwide economy is described by a dynamic intricacy, vulnerability, and unpredictability, which apply serious weights to associations and go up against them, with expanding recurrence, to troublesome and sudden occasions. In such situations, a few associations built up a flexibility profile to expand the ability to envision, adjust, and recuperate balance or even, increase another preferred position after the interruption. Grenoble [15] and Shahzad and Hadj-Hamou [16] argued that changing business scenarios can leave firms inside a store network exposed to higher inward and outer dangers. This introduction is regularly exacerbated by the hindrances which can be either internal or external or both occurring simultaneously on the SCs [17, 18]. A progressively coordinated inventory chain became more significantly interdepend and is a weakness of the company [19]. Interruption to the progression of material or data brought about by such issues can lessen a firm's budgetary and showcase what is more, operational execution [20].

Background to Critical Success Factors

The main purpose of Critical Success Factors (CSFs) for any organization is to identify major three to six areas of work, which will ultimately decide the success of that organization. By exploring, which particular tasks the company needs to do exceedingly well, the success of the company can be determined [21]. Huma et al. [22] emphasise the fact that the success of any organization is heavily dependent on the success of its SC, The activities such as planning, administration and operations must be aligned with the company`s CSFs so favourable results are generated [23].

Business owners lacking the ability to distinguish and oversee CSFs for developing a resilient SC may result in business failure. An empirical framework, which helps organizations transform their SCs resilient in the wake of risks and uncertainty, is needed as apparent in the literature.

Azam et al. [24] gives a list of 11 vital CSFs derived after a thorough review of the literature. Multiple frameworks were studied and the work of established authors was recorded. The CSFs thus identified were an amalgamation of the literature existing from the year 2000 to 2021. The CSFs thus obtained are depicted in figure 1. The percentage of each CSF depicts the weightage of its presence in the selected literature.

Supply Chain Resilience (SCRES)

Corsini et al. [25] emphasized that during the last 10 years, global organizations have been taking lessons from the studies done on the SCs dynamics so they can react effectively against multiple disruptive events. Eltantawy [26] made an important conceptual advance by identifying two types of resilience:

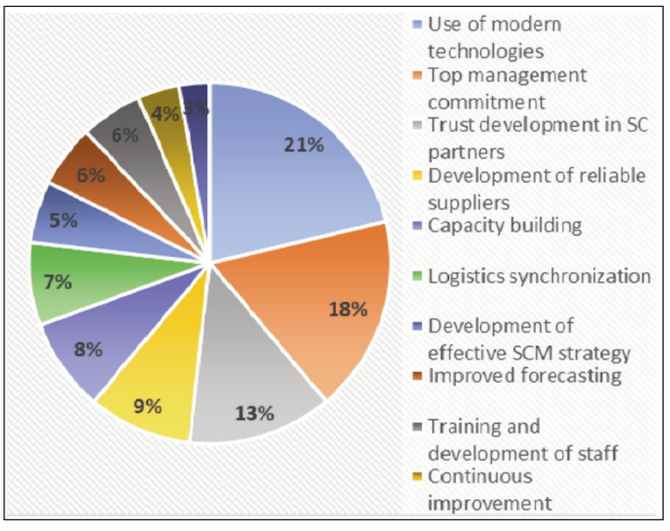

Fig. 1. CSFs identified from the literature

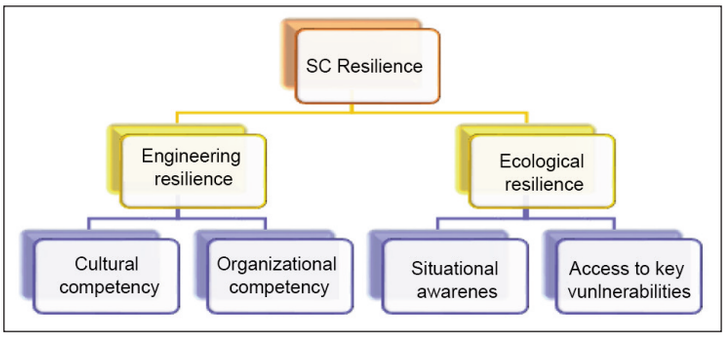

Fig. 2. Framework of Resilient SC [26]

Engineering and Ecological resilience in supply chains. The authors concluded that engineering resilience can be achieved by working towards cultural competency and operational competency whereas Ecological Resilience is an amalgamation of situational awareness and access to the key vulnerabilities of the organization and thus working towards them to mitigate the disruptions. Looking closely engineering resilience focuses on the strengths and weaknesses of the organization whereas the ecological is more about the threats and opportunities present in the VUCA (*volatile, uncertain, complex and ambiguous*) world. The framework given by the authors is depicted in figure 2.

Adobor [27] extended this framework by adding a third form of resilience, evolutionary or socio-ecological resilience. The study discussed how engineering resilience is an efficiency-based approach whereas ecological resilience focuses on the adapting capabilities of the SC. Although both types of resilience are important focusing on these two only will not make the supply chain resilient. Hence another type of resilience is added namely Evolutionary Resilience where the focus is building collaborative capability by developing inter-firm trust, systems thinking visionary leadership etc. The authors conclude that SC managers must concentrate on all three forms of resilience: engineering, ecological, and evolutionary, as the SCs of organizations tend to become more dynamic and evolutionary with each passing day. It is critical to acknowledge that effectiveness; and long-term supply chain performance may require both transformation and adaptability. Because of this realization, businesses must build a variety of skills to manage supply chain risk and lower sensitivity to disruptions (figure 3).

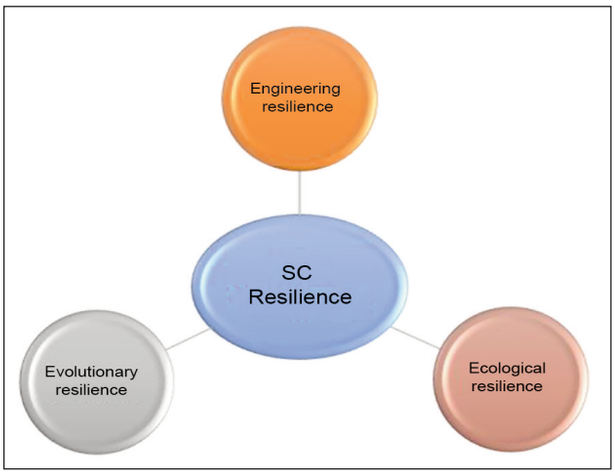

Fig. 3. SC Resilience Framework [27]

METHODOLOGY

Delphi technique

Delphi Technique`s key characteristics, anonymity, use of experts and controlled feedback, are one of the many reasons this technique is in vogue. The method's usefulness in structuring group communication for the discussion of specific issues and as an aid to policymaking are some of its biggest advantages [28]. In Delphi studies, it is done with the utilization of a progressive survey. The respondents have requested data and their viewpoints. It is a technique for putting together individual responses on issues with no or little predefined proof where assessment is critical.

For initial sampling total number of textiles in the selected region is taken into account from state-provided data. Adopting methodological guidelines on participant selection of experts was adopted and the experts were emailed regarding the scope of the study and asked to sign a consent form [29]. Top specialists verified the CSFs identified from the literature and added on any other CSF, which they thought, were important. Data from online meetings and interviews are recorded. Furthermore, structured interviews with key partners to identify all potential CSFs within the local SCs were also done was then utilized in the prioritization of CSFs utilizing MCDM Strategy (figure 4).

The CSFs thus identified are coded as:

- CSF 1 – Top management commitment;
- CSF 2 – Development of an effective SCM strategy;
- CSF 3 – Logistics synchronisation;
- CSF 4 – Use of modern technologies (robust information and communication technology);
- CSF 5 – Information sharing with SC members, collaborative partnership;

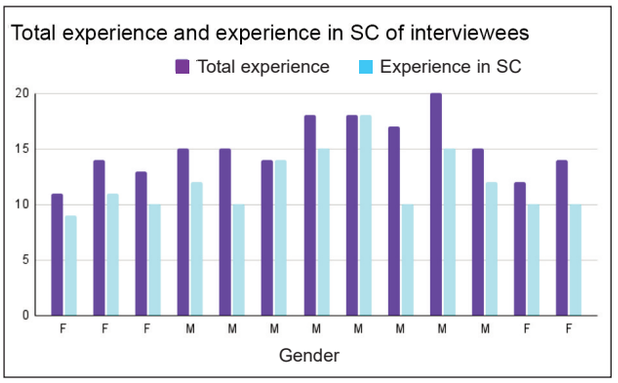

Fig. 4. Demographics of respondents

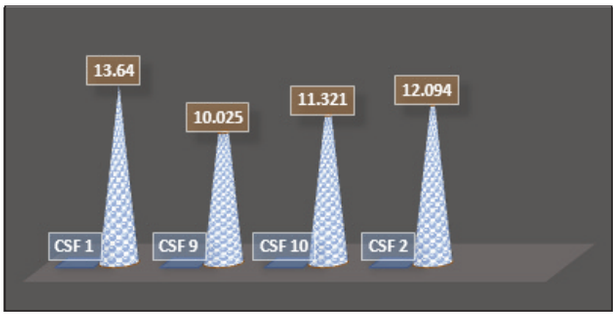

Fig. 5. CSF ranking by experts

- CSF 6 – Improved forecasting;
- CSF 7 – Development of trust in SC partners, collaborative partnership, strategic partnership;
- CSF 8 – Development of reliable suppliers (coordination and collaboration with other organisations)
- CSF 9 – Continuous improvement in the preparedness and response practices (implementing the lesson learned from previous events);
- CSF 10 – Capacity building (mock drill, training, house preparedness, first aid preparedness, etc.);
- CSF 11 – Staff training and development.

The responses received by the experts are summarized in figure 5.

Background of Analytical Hierarchy Process (AHP)

Saaty [30] first introduced the Analytic Hierarchy Process in 1977. For solving problems about elements in a hierarchy, AHP comes in as a useful methodical tool. Hierarchically structured decision-making problems are supported by AHP.

Several MCDM methods applied to logistics research over the past years are presented in table 1.

Table 1 shows that most SCRM research uses MCDM techniques and the most common among them is AHP and Fuzzy AHP. In this research, the AHP technique is used the study explored the 11 CSFs and the relative importance of each CSF. Hence AHP technique is used where each CSF is analysed from the viewpoints given by industrial experts and this weightage for each CSF is calculated. A review of MCDM techniques is performed and multiple techniques are studied to identify which technique will fulfil the research objectives of the study. AHP is a widely used technique because of its ability to solve complex problems. AHP analysis will give relative weightages to each CSF which would help the stakeholders in decision-making. For this study, the textile sector is chosen. Top decision makers and strategy makers are invited for a virtual interview via Google Meet. The research instrument was developed and its content test and validity tests were performed beforehand. The interviews are lined up. This research tool is drafted in such a way that it runs on two scales of 1–9 and 9–1

Table 1

MCDM TECHNIQUES USED BY MULTIPLE AUTHORS IN SCM LITERATURE

Authors	AHP	Fuzzy AHP	Fuzzy TOPSIS
Zaidi and Hasan [31]	X		
Ayyildiz and Taskin Gumus [32]		X	
Gajović et al. [33]	X	X	
Tuammee [34]	X		
Gajović et al. [35]	X	X	
Samvedi et al. [36]		X	X
Gajović et al. [35]	X	X	
Samvedi et al. [36]		X	X

and interviewees can choose according to their preference of the CSF.

DISCUSSION & ANALYSIS

The CSFs of the resilient supply chain are listed and a hierarchy diagram is developed. The purpose of the study is placed on the top level. The second level combines the factors into commonly understood logical groups. The third level then categorizes the second-level codes into large, remarkably differentiated perspectives as elaborated in figure 6. This is an addition to the body of knowledge in the SCRES which will be counted as one of the first after COVID-19. This framework takes into account the havoc global SCs had to go through during this century`s biggest disruption. The interviewees discussed in detail the problems they faced due to the unavailability of a completely resilient supply chain and showed interest great interest in this study as they termed it the need of the hour.

Step 1: The CSFs verified by the industry experts fit in the textile sector. The sub-criteria are well-defined.

Step 2: Main and sub-criteria are identified, and a hierarchy to show the relationship between the main and sub-criteria is developed for simulation analysis as shown in table 2.

Step 3: To get the ranking and importance. weights of main criteria and their associated sub-criteria, con-

Fig. 6. AHP Hierarchy Diagram

sidered case company experts performed pairwise comparison based on Saaty [30] scale.
Following this, the calculation of the weights of every comparison matrix is then carried out, using the value of the Eigenvector equivalent to the value of the Largest Eigen of the matrix that is evaluated:

$$Aw = \lambda \max w \quad (1)$$

where "A" signifies a consistent pairwise comparison matrix along with "w" which signifies the priority vector. Further, the calculation is carried out through the addition of the specific weights for weights of each selection in the hierarchy's bottom.
A validity check is conducted after the calculation to make sure the pairwise comparison matrix decisions are made accurately and completely. A pairwise comparison matrix's consistency ratio (CR) is determined by the equation provided:

$$CR = \frac{\lambda \max w - n/RI}{n - 1} \quad (2)$$

where *RI* is taken from the random inconsistency index. The pairwise comparison matrix's order is shown here by the letter "n". The pairwise comparison matrix falls into a suitable consistency range if *CR* turns out to be less than 0.1; alternatively, the judgements need to be updated. To attain the goal of a perfect order index, AHP is utilized to specify as well as assess the risk elements inside the supply chain.
AHP separates and categorizes complicated issues into hierarchical structures based on priorities, characteristics, and options. Using an integer between 1 and 9 or their reciprocals, the decision-maker determines their priority in the paired co-relational matrix. The numbers 3, represent moderate, 5 represent strong, 7 represent very strong and 9 represent extreme judgements, while the numbers 2, 4, 6, and 8 represent an intermediate option between two odd values of above above-stated representations. If a priority needs to be contrasted to itself, it is labelled as "1." The table below provides a basic explanation of the marking or selecting process:
Step 4**:** Once the pair-wise comparison from experts is done in step 3, Experts Choice® software is used to get the weights of the main criteria and their associated sub-criteria.
It can also be seen in figure 7 that the inconsistency is 0.02 which is < 0.1. Therefore, the judgement is consistent.

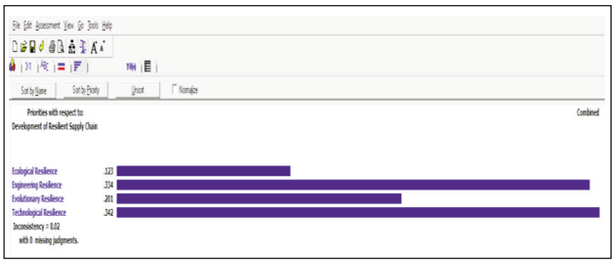

Fig. 7. Priority calculation of major nodes

RESULTS

Figure 8 shows the details of the importance of weights and ranking of sub-criteria. The most effective CSF is Logistics Synchronization which has a score of 18.9% followed by collaborative partnership

Table 2

MAIN AND SUB-CRITERIA			
Criteria	**References**	**Sub-Criteria**	**References**
Evolutionary Resilience	[27]	Top management commitment	[37–39,46–52]
		Development of reliable suppliers (Coordination and collaboration with other organizations	[39,53-60]
		Trust development in SC partners, collaborative partnerships, strategic partnership	[38,41,45–47,49,51,58,61–63]
Ecological Resilience	[26, 27]	Training and development of staff	[38,41,45–47,50,51,64]
		Capacity building (mock drill, training, house preparedness, first aid preparedness, etc.)	[45,58,59,65,66]
Engineering Resilience	[26, 27]	Logistics synchronization	[41,45,47,52,65-67]
		Continuous improvement in the preparedness and response practices (implementing the lessons learnt from previous calamities)	[65,67–69]
		Development of an effective SCM strategy	[39,45,59,60,66,67]
Technological Resilience	Proposed	Use of modern technologies (Robust information and communication technology)	[38–41,43,45–49,51,57,58,61,63,65,67–70]
		Information sharing with SC members, collaborative partnership	[38,40,57]
		Improved forecasting	[45,59–61,65,67]

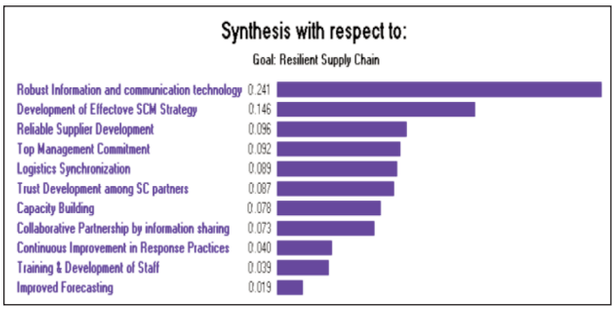

Fig. 8. Priority calculation of each Sub Node by using Expert Choice

by information sharing scoring 17.4% and Top Management Commitment scoring 15.4%. The first two CSF fall under the Technological Resilience domain while the third highest-scoring CSF is from the evolutionary resilience domain.

The below framework depicted in figure 9 is the novel outcome of this study. The top management which is the Tactical level of management will be focusing on four major areas. Their first CSF is a commitment towards the success of the organization. The second area of focus for organizations is their planning for the continuous improvement of the response system. The third area of focus is capacity building which relates to their second focus. Identifying capacity gaps and continuously working on them thus building value of the organization for themselves and all stakeholders involved. The fourth major CSF under their domain is the training and development of staff. Cardoso et al. [71] states that the most important asset a company owns is its people and their training should be taken seriously.

The strategic level focus is on four major CSFs that is development of effective SCM Strategy, logistics synchronization development of reliable suppliers and building trust amongst the SC partners. These four CSFs reinforce the trust among SC partners and help to build co-dependent supply chain teams.

The operational level focuses on three major CSFs and all three are related to the technology. With the advent of the Industrial Internet of Things (IIoT), there have been revolutionary changes in the way business is done. Khan et al. [72] focuses on Blockchain technology and how it revolutionizing sustainable production.

CONCLUSION

The conclusion of this study has several important implications for academia, industries, and policymakers. The adaptable theoretical framework presented in figure 9 offers a valuable reference for researchers exploring SC Resilience across various sectors.

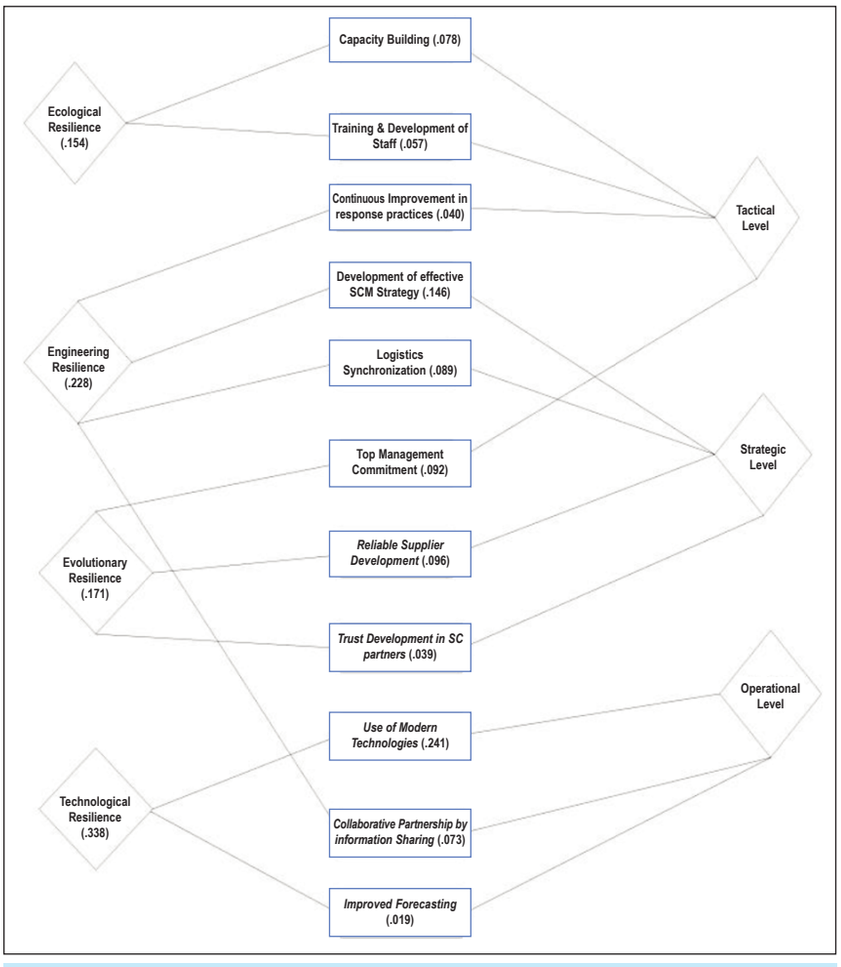

Fig. 9. The theoretical framework of a Resilient Supply Chain

By tailoring Critical Success Factors (CSFs) to specific industry contexts, researchers can gain deeper insights into resilience dynamics in diverse supply chain settings. For industries, the identified CSFs and resilience domains provide practical insights to strengthen their supply chains. Prioritizing investments in areas like Technological and Engineering resilience, such as robust information systems and structural adaptations, can enhance businesses' ability to withstand disruptions and uncertainties.

Implementing effective Supply Chain Management (SCM) Strategies and fostering reliable supplier development are also essential to building resilient supply chains. From a policy perspective, this study underscores the importance of investing in technological advancements and sustainable practices to improve supply chain resilience at national or regional levels. Policymakers can use the findings to design targeted interventions and incentive programs that promote the adoption of

modern technologies and sustainable practices within industries, fostering resilience and contributing to economic stability.

FUTURE RESEARCH

The study's conclusion opens up exciting avenues for future research in the field of supply chain resilience. Researchers could delve into the dynamic aspects of resilience, exploring how disruptive events like pandemics or natural disasters impact the identified CSFs and their interrelationships. Additionally, investigating the role of organizational culture, collaboration among stakeholders, and proactive risk management strategies could provide deeper insights into the factors influencing supply chain resilience. Moreover, the framework's adaptability invites further exploration of its implementation and effectiveness in different industrial sectors. Comparative studies across diverse industries could uncover sector-specific challenges and opportunities for resilience enhancement. Furthermore, longitudinal research tracking the evolution of supply chain resilience over time could shed light on how organizations adapt and respond to changing circumstances. This will ultimately benefit industries and policymakers in building robust and sustainable supply chains.

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