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ORIGINAL RESEARCH

Performance indicators for supply chain resilience: review and conceptual framework

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Abstract
In the current competitive and dynamic market, customer demands and interests are changing continuously, and hence, risk of disruption in the supply chain is also increasing. To be successful in this scenario, supply chain of a firm should be resilient. Most of the firms realize that with a specific end goal to develop a resilient supply chain, there is a need for assessment of performance. The purpose of this paper is to discuss supply chain resilience and identify indicators which can help in increasing the performance and making a supply chain resilient. Articles published on this issue were collected and classified to draw out some meaningful information. After classification and analyses of the collected literature, seventeen performance indicators for supply chain resilience are found. A supply chain resilience framework is developed using these indicators to assist the supply chain managers to examine and withstand the disruption.

Keywords Supply chain · Resilience · Performance indicators · Literature review · Framework

Introduction

A supply chain can be depicted as a system that connects different specialists from the supplier to the end customer through service and manufacturing with the goal of maintaining the flow of goods and information. This is helpful to adequately figured out how to meet the business necessities (Azevedo et al. 2013). After business became globalized and the company started to follow new strategies such as lean, quick response programs and efficient customer response, the market becomes dynamic and increases the need for changes in supply chain (Rao et al. 2013). These changes are responsible for raising complexity of the supply chain (Carvalho et al. 2012).

In the present scenario, supply chain becomes more unstable and unpredictable due to which it faces different challenges. There are various possible reasons for these disruptions in supply chain described by different researchers and practitioners in the literature. According to Roberta Pereira et al. (2014) and Ghadge et al. (2012), short life cycle of product and high variability in demand due to changing requirements and expectations of the customer are the possible reasons of the changes. PwC/MIT Forum for Supply Chain Innovation conducted Global Supply Chain Risk Management Survey (2013), which revealed business continuity plans, raw material price fluctuation, currency fluctuation and market change as the areas of risk. APICS supply chain council published a report in 2015, mentioning that natural disaster, lack of information sharing and partner underperformance were the major disruption in the supply chain, while BCI supply chain resilience report (2017) suggests that lack of visibility, cyber-attack, IT communications and loss of skills are the main cause of the disruption. If a supply chain faces any disruption, it can have a negative impact on organization's economic performance. To sustain in this changing market scenario, it is necessary for organization that their supply chain should be resilient. According to Peck (2005) and Ji and Zhu (2008), capacity should be build up to respond to an unanticipated unsettling influence and possess the power to return quickly to its original position or shift to another and become profitable after shifting and facing the interruption.

Supply chain resilience is defined by numbers of authors in different ways:

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The ability to respond to an unpredicted interruption, caused by a natural disaster or a terrorist attack, and rapidly come back to its normal operations, Rice and Caniato (2003).
The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function, Ponomarov and Holcomb (2009).
The adaptive capability of system, respond to disruption in a better way or even gain advantage out of this type of events, Brandon-Jones et al. (2014).
The ability to predict the risk, minimize the impact and come back rapidly through survival, evolution, adaptability and growth in the appearance of turbulence alteration Day (2014).

This intrigue speaks to a move in organizations far from customary hazard administration considering, which is lacking in tending to the expanded vulnerabilities, unexpected disturbances looked by complex worldwide supply chains (Kamalahmadi and Parast 2016). By looking at the current state of the research on SCR, it became necessary to build some operational capabilities along with their supply chain partners to cope with predictable or unpredictable disruptions (Raj Sinha et al. 2004; Stevenson and Spring 2007). Although there exist numerous continuous research endeavors on different viewpoints and regions, very little consideration has been given to performance measurement of the supply chain. Supply chain of an organization will not be successful, if they have not been able to increase the supply chain performance measures (Jüttner and Maklan 2011). However, there is lack of insight into the development of performance measure which is needed to obtain a fully integrated supply chain (Poon and Lau 2000). Additionally, such measures and measurements are expected to test and uncover the suitability of techniques without which an unmistakable bearing for development and acknowledgment of objectives would be very complicated (Saleheen et al. 2018).

The performance of a supply chain exposed to danger when it is affected by a disturbance, e.g., losing competitiveness, reduced short-term financial performance (Ji and Zhu 2008). To continue to exist, organizations must develop the ability to react to an unexpected disturbance and to return quickly to their original state or move to a new (Carvalho and Cruz Machado 2007). In recent years, the idea of SCR has received more attention by researchers and practitioners. Fiksel et al. (2015) suggested that resilience is a significant ability that reduces traditional risk in many companies. The concept of SCR appears to offer a way to avoid the limitations of traditional approaches to risk prevention and protection strategies and to deal with the complexities of global supply chains (Pettit et al. 2013; Sheffi 2015).

In this paper, indicators for SCR are found out from the literature and a framework is presented to increase the resilience of supply chain along with findings and recommendations for future research. The purpose of this study is threefold: (1) to identify and propose indicators that make supply chain resilient, (2) to develop a conceptual framework which can help increasing the performance of supply chain and (3) to find current research gaps that future research can concentrate on. To fulfill these objectives, a systematic literature review is done and seventeen performance indicators are extracted from the literature. These indicators are used in construction of the supply chain resilience framework, which will be helpful for increasing the performance of supply chain. This study will be helpful for the supply chain managers of any organization to examine and improve the performance of their supply chain and make it resilient for any kind of disruptions.

The structure of this paper is organized as follows: Sect. 1 contains the introduction and needs of this study; in Sect. 2 the article collection and review methodology is described. Section 3 enlists and explains the SCR indicators. Section 4 proposes and discusses about SCR framework. Finally, Sect. 5 ends with conclusion and future research directions.

Review methodology

To find out the indicators of SCR, articles are collected from various scientific publishing databases. The systematic review methodology of this study is adopted from Badhotiya et al. (2016) and Kamalahmadi and Parast (2016), as shown in Fig. 1. It illustrates the approach for collection of the relevant literature using collection of keywords, i.e., supply chain, resilience, review, performance indicators, in different databases, i.e., Science direct, Springer, Emerald insight, Taylor & Francis, Inderscience and IEEEXplore. In the initial search, 130 articles were collected, which are further screened for subject relevance. After exclusion of irrelevant articles, a total of 55 articles were selected for further analysis. Table 1 shows the journal-wise distribution of these articles.

The time span of the collected articles was set for 2000 and till 2018. Following the view of Ghadge et al. (2012), on the consequences of writing audit ponder on SCR, this study considers it as a basis of article collection and believes that the authors started to examine resilience in supply chain after the year 2003. Their study demonstrated

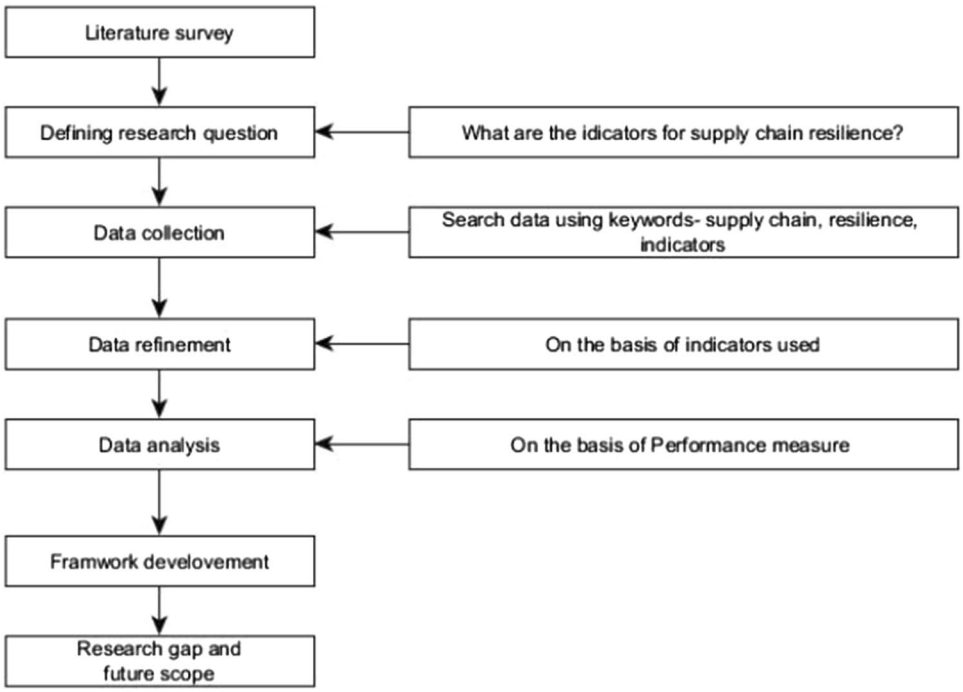

Fig. 1 Review methodology of the current study

Table 1 Indicators for supply chain resilience

S.N	Indicator	Author's name
1	Agility	Kamalahmadi and Parast (2016), Ali et al.(2017),Christopher and Peck (2004), Choi and Hong (2002)
2	Flexibility	Stevenson and Spring (2007), Pettit et al.(2013), Chopra and Sodhi (2004), Sheffi and Rice (2005)
3	Robustness	Wieland and Wallenburg (2013), Ehrenhuber et al. (2015), Sheffi and Rice (2005), Tang (2006)
4	Redundancy	Christopher and Peck (2004), Rice and Caniato (2003), Ehrenhuber et al. (2015), Christopher and Holweg (2011), Ali et al. (2017)
5	Visibility	Jüttner and Maklan (2011), Christopher and peck (2004), Pettit et al. (2010), Tang (2006), Azadeh et al. (2014)
6	IT capability/information sharing	Jain et al. (2017), Nishat Faisal et al. (2006), Setak et al. (2018), Bababeik et al. (2017)
7	Collaboration	Simatupang and Sridharan (2008), Raj Sinha et al. (2004), Barratt (2004), Glenn Richey and Autry (2009), Papadopoulos et al. (2017)
8	Sustainability	Hohenstien et al. (2015), Khorasani and Almasifard (2017), Jain et al. (2017), Hafezalkotob and Zamani (2018), Yang et al. (2018)
9	Awareness/sensitiveness	Jain et al. (2017), Scholten and Schilder (2015), Mandal (2014)
10	Supply chain risk management culture (SCRM) Culture	Christopher and Peck (2004), Choi and Hong (2002), Rao et al. (2013)
11	Velocity	Jüttner and Maklan (2011), Stevenson and Spring (2007), Christopher and peck (2004)
12	Market position	Roberta Pereira (2014), Fiksel et al. (2015), Jüttner and Maklan (2011), Pettit et al.(2010)
13	Risk control/revenue sharing	Jain et al. (2017), Li et al. (2017), Fiksel et al. (2015), Ehrenhuber et al. (2015)
14	Public–private partnership	Li et al. (2017), Jain et al. (2017)
15	Adaptability	Chowdhury and Quaddus (2016), Jain et al. (2017)
16	SC network design	Christopher and Peck (2004), Choi and Hong (2002), Jüttner and Maklan (2011)
17	Security	Rice and Caniato (2003), Glickman and White (2006), Singh Srai and Gregory (2008)

a sudden increment in the quantity of publishing the paper on supply chain resilience after 2004. After collecting the data, data refinement is done on the basis of indicators described by the different authors. Which indicators are increasing performance of the supply chain, on the basis of that, data analysis is done and then the SCR framework is prepared.

Indicators for Supply Chain Resilience

The focus of SCR is to cope with the temporary disruptive events. It is simply described as the capacity to prepare the plan and construct the network of the supply chain that can envision sudden troublesome or negative occasions and will adaptively react to interruptions while keeping up command over the network and structure of supply chain. SCR has the capacity to rise above to an initial position as before the disruption, or preferably to be more improved and more profitable (Ponis and Koronis 2012). In this definition, all the characteristics of SCR are included, i.e., capacity, preparation, adaptive capability well-timed recuperation to the original state, preferably a better state. There are few indicators of SCR, and if a supply chain consists them, it surely indicates that a supply chain is resilience. This study is conducted to identify these indicators which are discussed as follows:

Collaboration

In the supply chain, collaboration is simply means that supply chain operations are planed and executed jointly by two or more autonomous firms for mutual benefits (Simatupang and Sridharan 2008). Collaborative partnership helps to anticipate the disruption and manage risks efficiently (Raj Sinha et al. 2004; Qian et al. 2018). In a situation of disaster, collaboration can keep supply chain organizations together (Barratt 2004; Glenn Richey and Autry 2009). A risk can be mitigating by a high level of collaborative work across supply chains (Hsieh 2018). Incentive alignment and decision synchronization are the two major contributions of supply chain collaboration and critical for successful responses to organization-level disruption (Papadopoulos et al. 2017).

Sustainability

Sustainability is by and large characterized as utilizing the resources that are able to mitigate the present problems without using the resources that should be used by the future ages to mitigate their own problems (Hohenstien et al. 2015; Kusrini and Primadasa 2018). Sustainability procedures make numerous security benefits for both providers and makers (Khorasani and Almasifard 2017). Jain et al. (2017)enhanced comprehension about what sustainability contributes to SCR. It helps for better quality choice and reduction in the wastes and dangers of the whole organizations (Hafezalkotob and Zamani 2018). A plethora of research in SCR has featured that flexibility assumes an essential part in supporting dynamic skills and keeping the crucial connection between sustainable competitive advantage and integrated competences (Yang et al. 2018).

Agility

Supply chain agility can be characterized as the capacity to quickly react to an erratic change in supply and demand (Christopher and peck 2004). An agile supply chain has increased velocity to rapidly adapt to unpredicted changes in demand or supply (Pettit et al. 2010), and acceleration to increase the response time (Choi and Hong 2002). It is seen that flexibility requires agility to react quickly to random occasions and maintain an alternate advantage in an unverifiable and fluffy condition. Supply chains can diminish the risk related to stock by managing a large level responsive supplier (Chopra and Sodhi 2004).

Redundancy

Redundancy includes the vital and serious utilization of extra stock that can be conjured amid an emergency to adapt, e.g., request surges (Aghaei et al. 2017) or with supply deficiencies (Christopher and Peck 2004). It is additionally stated that redundancy includes the duplication of limit with a specific end goal to proceed with operations amid a disappointment (Rice and Caniato 2003) and that it can along these lines likewise be viewed as a course to flexibility (Ehrenhuber et al. 2015).

Further, redundancy is like a buffer stoke; sometimes it can be expensive methods for building resilience because it accounted the holding cost (Esmaeili et al. 2018). Although the firms use a different type of basic ways to cope with the weakness and develop the resilience, some time save limit is required and plays a vital role (Christopher and Holweg 2011). Ali et al. 2017 found that redundancy builds flexibility, which encourages reaction through the versatile organization of assets.

Flexibility

To be resilience, a supply chain should be flexible and it is characterized as the capacity of a supply chain to adjust according to the required necessities of its partners and environmental condition in the smallest amount of time (Stevenson and Spring 2007). The literature uncovers the different types of flexibility hones that can improve SCR, e.g., flexible transportation, flexible work game plans, postponement, flexible supply base and order satisfaction flexibility (Pettit et al. 2013).Chopra and Sodhi (2004)state that flexibility can be apply both to an organization and to the complete supply chain. In this way, flexibility makes supply chain resilience by upgrading brief versatility amid turbulence (Christopher

and Holweg 2011). A flexible supply chain will help to fast reaction and recovery (Sheffi and Rice 2005).

Visibility

Supply chain visibility is defined as the ability of supply chain manager to see from one end to another and can find the place of disruptive event (Christopher and Peck 2004). Visibility is an intercession apparatus that permits managers the opportunity to react rapidly to interruptions or unsettling influences in view of exact, continuous evaluation (Jüttner and Maklan 2011). Visibility portrays the necessity for straightforward structures and procedures to recognize requirements and interruptions rapidly and to have the capacity to actualize changes in a successful way (Pettit et al. 2010). Visibility fills in as a notice procedure that gives valuable time to firms to adjust their capabilities to limit problematic effect (Tang 2006). It additionally gives information about the current status of working resources and environment of the supply chain by utilizing key execution pointer measurements to monitor execution (Azadeh et al. 2014).

IT capability/information sharing

In supply chain, sharing the right information is very desirable and it reduces the risk in the supply chain (Nishat Faisal et al. 2006). In the present dynamic and indeterminate supply chain environment, to minimize the risk in the supply chain, it is essential to form a group of active partners and right information should flow among all partners of that particular group (Setak et al. 2018; Tohidi et al. 2017). Information sharing also plays a vital role in minimizing the bullwhip impact (Jain et al. 2017).

Robustness

Robustness is the capacity of the supply chain to oppose change and involves a proactive expectation of progress before it happens (Wieland and Wallenburg 2013). Building robustness requires the strategic planning to construct supply chain network (Ehrenhuber et al. 2015). For that, it is needed to design a value-creating supply chain network which will able to resist the operation before and after the unwanted event (Izadi and Kimiagari 2014). A robust supply chain can work in spite of a few unsettling influences, as it withstands and adapts to stuns by holding its dependability when changes happen (Tang 2006; Shishebori and Babadi 2018).

Awareness/sensitiveness

Sensitiveness can be defined as anticipating the actual demand. Awareness includes comprehension of supply chain vulnerabilities and making arrangements for such occasions, and it requires capacity to perceive a conceivable disturbance by detecting and translating occasions through early cautioning systems, and congruity arranging (Jain et al. 2017). These practices will help in mapping of the supply chain vulnerabilities in order to stay away from, contain or control chance (Scholten and Schilder 2015). At the same time, these practices require coordination, information sharing and learning between supply chain accomplices to proactively create and increase the level of circumstance awareness in expecting disturbances (Mandal 2014).

Supply chain risk management (SCRM) culture

After the globalization of industry and emergence of numerous values adding processes, various changes are faced by supply chain and this is root cause of vulnerability in the supply chain (Singh Srai and Gregory 2008). Christopher and Peck (2004) state that dynamic supply chain with more complexity is more venerable to disruptions. To make supply chain resilient, one should be initiative and each and every organization should have a member in members of the board that have a proper understanding of the risk, an element of SCR and the structure of the supply chain (Choi and Hong 2002).

Security

Security is a basic piece of SCR that ought to be composed ahead of time instead of looked for after an episode (Rice and Caniato 2003). Building security secures the supply chain against counterfeiting, for example cyber-security and freight security (Glickman and White 2006). In addition, security can be enhanced by making collaborations with supply chain partner and public–private partner (Singh Srai and Gregory 2008).

Velocity

Supply chain velocity is speed of reaction of the supply chain to advertise changes. The capacity to react to showcase changes to a great extent relies upon the effectiveness of data sharing between supply chain individuals (Jüttner and Maklan 2011). It is predominantly worried about the pace of adjustment change (Stevenson and Spring 2007). Nonvaluable time reduction, streamline the process and reduced inbound time are the three basic foundations for improved supply chain (Christopher and Peck 2004).

Adaptability

Adaptive capabilities are characterized as tolerating the certainty of progress and to make a framework that is fit for

adjusting to new conditions and objectives (Jain et al. 2017). If a supply chain has the capability to adapt things easily, then it can get back to its original or enhanced state after disruption. Supply chain resilience focuses on the framework's versatile ability to adapt to transitory problematic occasions (Chowdhury and Quaddus 2016).

Market position

Market position is associated with the financial capability of the organization (Pettit et al. 2010). A strong market position is related to having increased market share and as a result allows investment in SCR, which surely help to maintain the relationship with the customers aftermath the unwanted event (Roberta Pereira 2014; Fiksel et al. 2015). Having a solid market position builds an association's capacity to recuperate from supply chain disturbances because of money-related quality (Jüttner and Maklan 2011).

Risk control/revenue sharing

Revenue sharing encourages sharing the risk among supply chain accomplices (Jain et al. 2017). Sharing profit with the top of the stream and down of stream accomplices to make competitive advantage (Li et al. 2017). If some organization wants to collaborate for mutual benefit, then risk and revenue sharing plays a vital role (Fiksel et al. 2015). Supply chain risk revenue sharing works successfully with different organizations for common advantage in different areas, for example forecasting, delay and risk sharing (Ehrenhuber et al. 2015).

Public–private partnership

Making social capital among supply chain partner and other organizations, e.g., community shareholder, increases the strength of the organization and gives the opportunity to learn from each other. Public–private partnership may help post-disruption in the supply chain because of interpersonal relation and social capability (Li et al. 2017). Such practices can be additionally encouraged by building trust and utilizing co-creation processes (Jain et al. 2017).

Supply chain network design

It seems many times that a supply chain becomes more vulnerable to disruption when it is complex and dynamic (Christopher and Peck 2004). To make supply chain resilient, it is necessary that there should be a proper understanding of supply chain network design (Choi and Hong 2002). Consequently, SCR is enhanced by developing learning administration in the pre-disturbance stage through practices, e.g., instruction and preparing (Jüttner and Maklan 2011).

Result and discussion

To comprehend the multi-perspective views of concept, articles were sorted out from twenty-one different journals. Table 2 enlists the articles published in various journals.

Annual distribution of the number of articles published from 2001 to 2018 is shown in Fig. 2. The figure shows that most of the articles are published in the recent years; 18 papers out of 42 are published till 2012, and rest 24 papers which have been included in this study are published in 2012 and onwards.

Supply chain performance measures

Many organizations has not succeeded in making its supply chain resilient because they have often failed to develop the performance measures needed to maximize the efficiency (Jüttner and Maklan 2011). Table 3 shows different supply chain performance measures identified through the literature. Carvalho et al. (2014) focus on total cost and lead time ratio to increase the firm performance. Betts and Tadisina (2009)point to incomplete performance measures existing among industries for assessment of the entire supply chain and suggest focusing on manufacturing lead time and inventory holding costs. Khan and Pillania (2008) suggest that measurements should be understandable by all supply chain members and should offer minimum opportunity for manipulation.

In order to increase the performance and resiliency of the supply chain, many researchers investigate the supply chain and draw out the indicators; for example, Carvalho et al. (2014) pointed out the redundancy and transport flexibility as the indicators in their study about the Portugal automotive supply chain. While Elleuch et al. (2016) suggested collaboration, flexibility and redundancy are indicators when examined the agri-food industry. Furthermore, Lam and Bai (2016) described visibility as a supply chain resilient indicator in a maritime supply chain. Figure 3 shows the frequency and occurrence of different indicators in the different supply chains and illustrates that collaboration is the most frequent indicators. It is described in most of the examined papers that if an organization is in collaboration with others for the mutual profit, then it makes their supply chain more resilient. After the collaboration, flexibility is most influenced indicator to follow the visibility, agility, SCRM culture and onwards.

Resilience is a dynamic ability of an organization that increases the capability of the organization to react

Table 2 Journal-wise distribution of the paper

S. No.	Name of the journals	No. of papers
1	Supply Chain Management: An International Journal	9
2	International Journal of Supply Chain Management	4
3	International Journal of Operations & Production Management	4
4	Journal of Industrial Engineering International	3
5	The International Journal of Logistic management	3
6	Journal of Enterprise Information Management	2
7	Transportation Research	2
8	International Journal of Logistic Research and applications	2
9	Journal of Cleaner Production	2
10	International Journal of Disaster Resilience in the Built Environment	2
11	International Journal of Supply Chain and Operations Resilience	2
12	International Journal of Physical Distribution& Logistics Management	2
	International Conference IEEE	2
13	International Journal of Production Economics	1
14	Technological Forecasting & Social Change	1
15	Management Decision	1
	IFAC Paper online	1
16	Management Research Review	1
17	Journal of Operations Management	1
18	MIT Sloan management review	1
19	Benchmarking: An International Journal	1
20	Journal of Manufacturing Technology Management	1
21	Journal of Applied Business Research	1
22	Computers & Industrial Engineering	1
23	Business Process Management Journal	1
24	International Journal of Production Research	1
25	Electronic Commerce Research and Applications	1
26	Journal of Business Logistics	1
27	International Journal of Logistics Systems and Management	1
Total		55

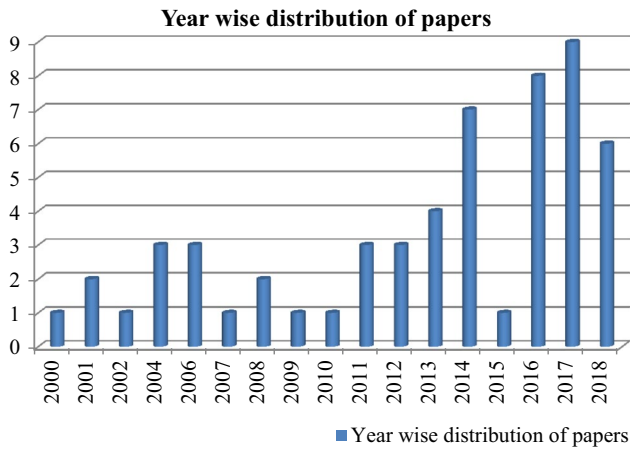

Fig. 2 Year-wise distribution of the papers

according to disruption and it also depends on the individuals, groups and subsystems that constitute a system (Li et al. 2017). Therefore, the company wants to be resilient with individuals, groups and subsystems. The concept of resilience is not limited to few countries. Companies from all over the world are concern about it. Prater et al.(2001) focused on the general electric supply chain that belongs to the USA. An automobile supply chain from Portugal was studied by Azevedo et al. (2013). Figure 4 shows the supply chain from the different regions of the world that were examined in this study and illustrate that 47% of the total supply chain is from India and USA. Rest 53% is from UK, China, France, Portugal, Ireland, Australia, The Netherland, Hong Kong, Singapore, UAE and Germany.

There exist supply chains from different sectors that faced the disruption, i.e., automobile sectors (Carvalho et al. 2014; Azevedo et al. 2013), manufacturing sectors (Rajesh 2016; Sahu et al. 2017), food supply chain (Elleuch et al. 2016; Scholten and Schilder 2015), textile

Table 3 Supply chain performance measure

Authors	Supply chain performance measures
Yang (2013)	Cost efficiency
Carvalho et al.(2014)	Total cost, Lead time ratio
Yusuf et al.(2014)	Cost, Turnover, Net profit, Market share, Customer loyalty
Betts and Tadisina (2009)	Manufacturing Lead time, Product development cycle time, Inventory holding costs, Demand forecasts, On-time delivery
Khan and Pillania (2008)	Setup time, Manufacturing lead time, Order-to-delivery cycle time
Yauch (2011)	Total cost, Manufacturing lead time
Azevedo et al. (2013)	Energy consumption
Kamalahmadi and Parast (2016)	Value (redefine their valuation methods to account for unpriced costs and benefits), Individual investment, Demand Forecast and planning
Elleuch et al. (2016)	Peak demand, Change in production plan, Power cuts (recovery to shutdown)
Ali et al.(2017)	Timely information about the event, Real-time strategic decision, Knowledge of operating assets, Speed of recovery, Loss per unit of time, Culture of quality, Effective communication, Leadership and Innovation
Tang (2006)	Change in the configuration of the new product
Wieland and Wallenburg (2013)	Recovery to shutdown
Jain et al.(2017)	Demand forecasting
Glickman and White (2006)	Real-time assessment, Increased inventory level, Technological threats
Pettit et al.(2010)	Lead time reduction, Fast re-routing of requirements, Alternative technology development, Cyber-security, Access restrictions, Brand equity, Customer loyalty

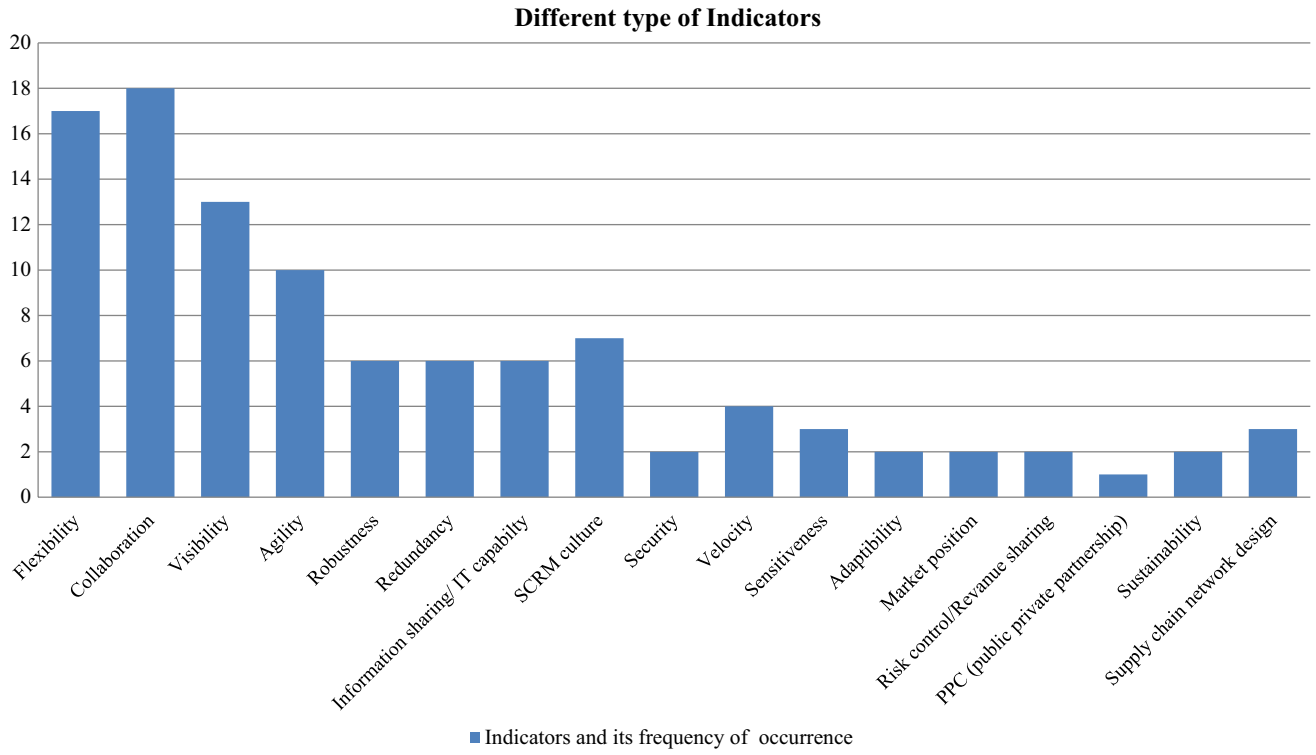

Fig. 3 Different types of indicators

supply chain (Li et al. 2017). Other supply chains belong to energy, IT, electronics and chemical. Figure 5 shows the different supply chains from various sectors and illustrates total supply chain that were examined, out of which 19% supply chain belonged to manufacturing sector, 14% supply chain belonged to automobile sector and rest was belonging to food, chemical, IT, electronics, transport, textile, and marine and energy sector.

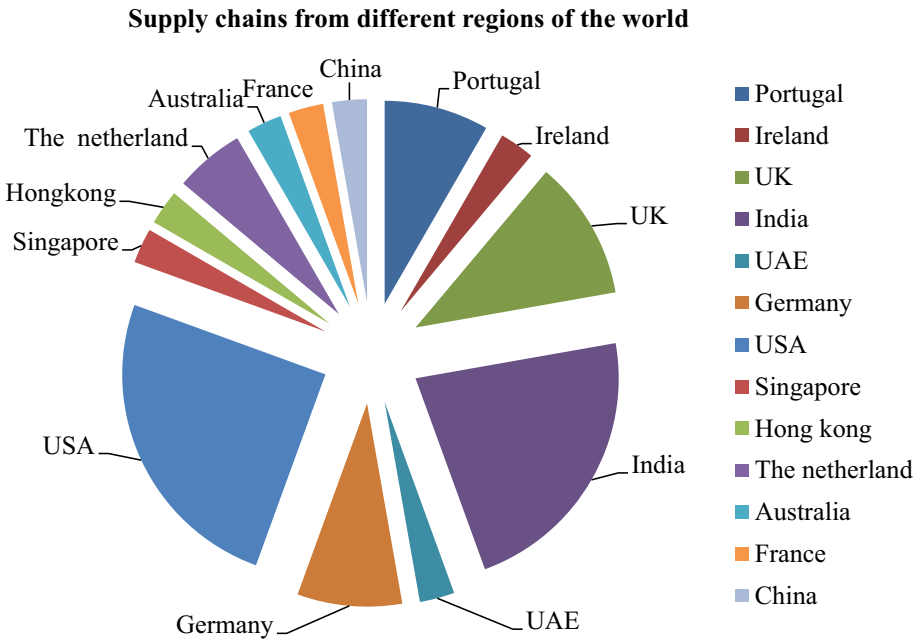

Fig. 4 Supply chains from different regions of the world

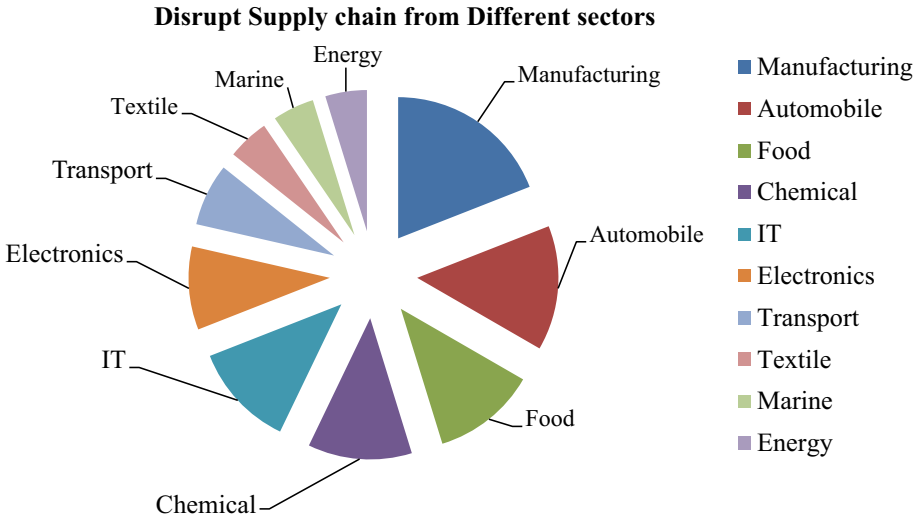

Fig. 5 Disrupt supply chain from different sectors

Supply chain resilience consists of three parts in the definition—anticipation, resistance and recovery and response (Kamalahmadi and Parast 2016; Ali et al. 2017). These states are described here:

a. *Anticipation* For a supply chain manager, it is necessary that he can anticipate the incidence of the disruption and can prepare the supply chain for predicted or unpredicted change in the surroundings. To minimize the probability of occurrence, the disruption and their impact should be totally understood. Anticipation is pre-disruption phase in the supply chain. In this phase awareness, visibility, security, SCRM culture are the essential indicators for supply chain resilience.

b. *Resistance* In few cases, if any foreseen or unforeseen disruption may be detected, then a supply chain should have ability to resist it and disable the negative impact ahead of its presence (Alkaff et al. 2018); this would play a crucial function in continuity of the supply chain. A well-prepared supply chain can resist the effect. This phase is also defined as disruption phase. Flexibility, redundancy, collaboration, robustness are the essential indicators for this phase that make the supply chain resilient.

c. *Recovery and response* Sometimes disruption has potential capability to interrupt the supply chain. To reduce harmful effect of it on the supply chain, it is needed to show instant and useful response according to the

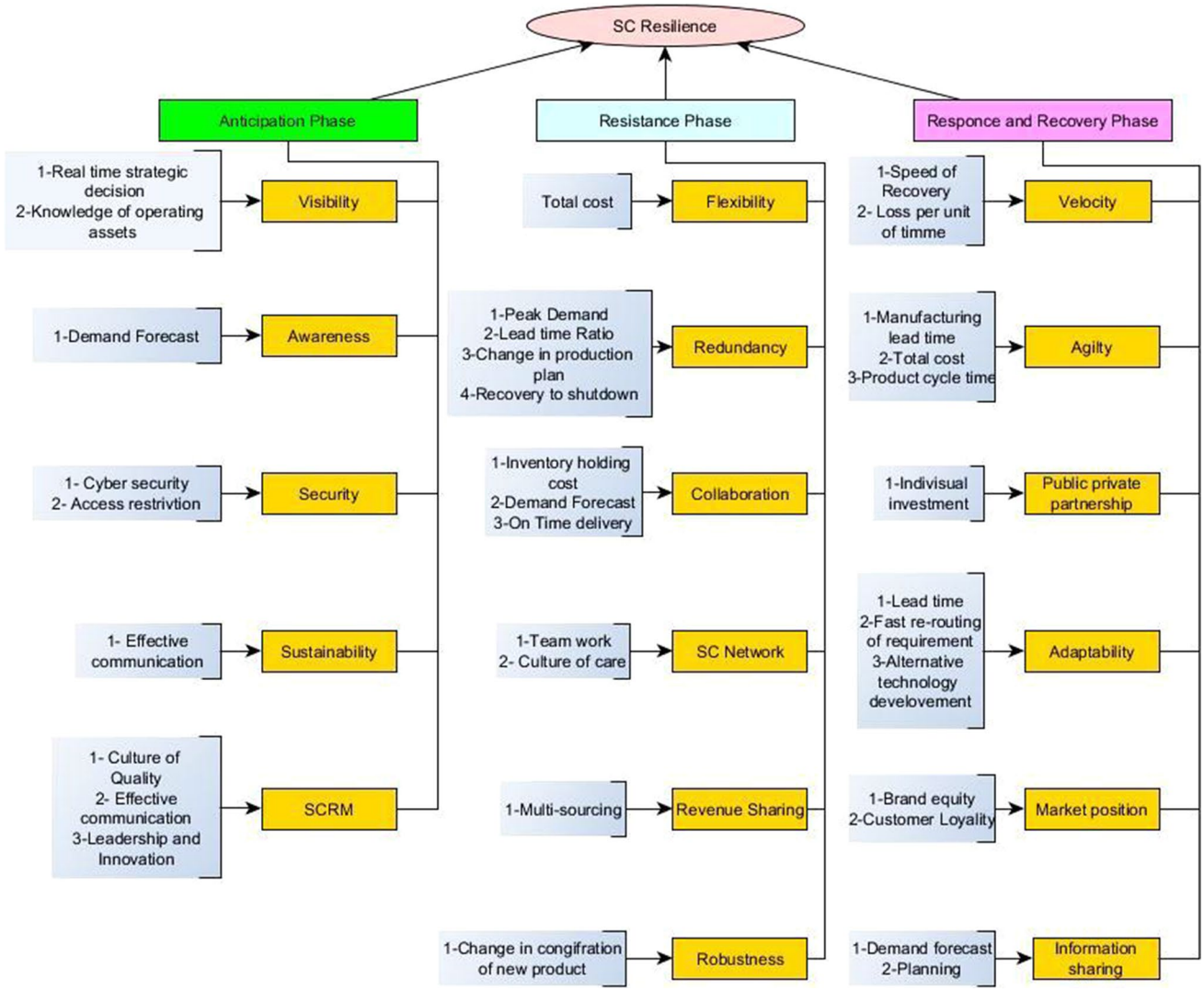

Fig. 6 Supply chain resilience framework

resources (Doussoulin et al. 2018). A well-prepared supply chain not only have the ability to regain the position as before the pre-disruption, but also restore the firms position to the higher level that can lead to competitive advantage. For this phase, strong market position, information sharing, velocity, public–private partnership and agility play crucial role to make supply chain resilient.

Supply chain resilience framework

Few researchers in the literature have given a systematic framework for SCR. Mandal (2014) did a comprehensive review on SCR and proposed a framework that define issues in supply chain resilience and supply chain performance. Christopher and Peck (2004) did an investigation for devolvement in SCR and tried to find out existing state of work. They proposed a framework that tells about the principles and few indicators of SCR. Ali et al. (2017) analyzed the concept of SCR and proposed a framework for the conceptual clarity. Their framework revealed three major constructs used to define SCR; resilience strategies, phase of resilience and capabilities needed to be resilient. The framework defines the concept and tells about elements needed to increase capability of SCR and also gives comprehensive detail of practices needed to take advantage of these capabilities. Pettit et al. (2010) tells about vulnerabilities and capabilities of resilience in their proposed framework. Their framework shows three potential state of resilience: First is unbalance resilience due to high vulnerabilities and low capabilities which result as an excessive result, second is balanced resilience which results as improved performance, and the third one is unbalanced resilience due to low vulnerabilities and high capabilities which results as eroded profitability.

The frameworks proposed in the literature for SCR are not able to provide comprehensive knowledge of indicators of SCR which will be helpful to increase performance of the supply chain. In this study, a conceptual framework is proposed, overcoming the gaps and drawbacks in the literature. As shown in Fig. 6, this framework shows different phases of SCR and categorizes the indicators according to these phases. The framework also depicts different performance measures of supply chain and provides the knowledge of indicators which are helpful to increase performance of the measures.

The proposed framework provides management an insight into linkages between each indicator and a set of performance measures. For example, if a supply chain manager wants to forecast correct demand, awareness and collaboration are the two indicators that will help to make it happen. If there is collaboration between two organizations, then it would help to reduce inventory holding cost and simultaneously increases the responsiveness to customer by doing on-time delivery. Elleuch et al. (2016) explained that if there is redundancy in any supply chain, then it would be helpful during peak demand period and would increase recovery during shutdown, due to circumstances such as power cut, flood and earthquake. If a supply chain is agile, it would reduce manufacturing lead time and total cost. Sometimes supply chain faces disruption due to its data leak by a cyber-attack or by doing access to a restricted area. This problem can be overcome by providing security in any organization.

The proposed framework has huge potential for providing management insight into their strengths, weaknesses and priorities. By identifying highly rated measures, managers will have detailed information on their strengths. Also, the framework can identify weaknesses in supply chain network of enterprises, e.g., if a supply chain has no SCRM culture, there is no effective communication in the organization and there is lack of opportunity of leadership and innovation of new product. At last, the structure provides administrative direction to setting needs to make a methodology for enhancing SCR. This methodology must be founded on appraisal of the association's example of vulnerabilities and its upper hands, weighed against the potential quantifiable profit. In doing as such, corporate system will center asset speculations to fill holes.

Conclusions

The idea of resilience is more extensive in scope than incorporated supply chain management, congruity planning, risk management or combination of these controls. From the analysis of the literature, SCR is divided into three faces, namely anticipation phase, resistance phase and response and recovery phase, which assist supply chain managers to examine the supply chain and withstand disruptions. The outcome of this study reveals that there exists a large number of disrupted supply chains all over the world, so there is a need to concern about SCR. This study tried to unearth various indicators that are helpful to make a supply chain resilient. Thus, contribution of this research is to translate resilience concepts into the supply chain resilience framework, to create a useful managerial tool for improving performance.

There are some limitations of this study. The SCR indicators were categorized into three phases, but there exist others indicators apart from these phases. Future research should be directed toward investigation of these unexplored indicators. The quantitative content analysis sample of this study is limited to forty-two research paper only. Hence, on the basis of this study, results cannot be generalized. A large sample size will ensure generalization of indicators that make supply chain resilient. Finally, most of the indicators which are taken into consideration in this study are from a set of earlier published literature. So, future research should focus on empirical investigation of indicators of supply chain resilience and may explore new indicators.

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