

MITIGATING SUPPLIER VULNERABILITIES TO IMPROVE SUPPLY CHAIN RESILIENCE

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ABSTRACT

Purpose: After the shocks from the coronavirus pandemic were over, supply chain resilience has been proposed by experts to help businesses and their supply chains to better prepare, better respond, and better recover from the next disruptions within short timeframe. All stakeholders along the chain are equally vital to build a resilient supply chain. To the best of the authors' knowledge, however, almost all studies have built the supply chain resilience through the lens of buyers, where numerous vulnerabilities around the buyers including suppliers as sources of supply have been pinpointed. Resilient initiatives have then been strategised for buyers to eliminate vulnerabilities in their networks (e.g. multi-sourcing and diversifying supplier base). Despite the significant improvement on resilience, these initiatives do not create business-friendly environment with suppliers. The aims of the paper are to look into increasing the resilience capability from the perspective of suppliers. Vulnerabilities of suppliers are analysed, identified, and alleviated through the proposed framework. This is to mitigate supply chain risks created by suppliers. This is to ensure building the resilient supply chain while also maintaining the supplier businesses.

Design/methodology/approach: A case of cross-border supply chain from Thailand to Laos is chosen for this action research study. International trade from Thailand are crucial to drive Laos economic growth and uplift the living standards of population. The research team works with key practitioners in developing the framework for analysing and identifying vulnerabilities of Thai suppliers. Then, the developed framework is validated with actual cross-border supply chains. Mitigation action plans are recommended to increase supplier resilience capacity.

Findings: The developed framework is able to identify vulnerabilities of Thai suppliers. Mitigating supplier vulnerabilities improve reliability and resilience capacity of Thai suppliers. Cross-border supply chain risks can eventually be mitigated.

Originality/value: This paper is among the first to put efforts in improving the supply chain resilience from the perspective of suppliers. Mitigating supplier vulnerabilities can reduce cross-border supply chain risks. Supply chain can be more resilient on one hand. Supplier can maintain their businesses on the other hand.

Keywords: Supplier vulnerability, Supply chain resilience, Risk mitigation, Risk identification, Cross-border supply chain

Introduction

A cross-border supply chain comprises a series of value-added processes and activities (Yan *et al.*, 2020) conducted by different actors (or stakeholders) along the chain including manufacturers, shippers, suppliers (i.e. tier-1, tier-2, and so on), distributors, exporters, traders, and service providers of an exporting country as well as buyers (i.e. including importers, firms, retailers, markets, and final consumers) of an importing country. Figure 1 maps the cross-border supply chain.

The supply chain is as strong as its weakest link (Jazdzewska-Gutta and Borkowski, 2022). It has been observed that one of the most vulnerabilities (or the weakest links) in the cross-border supply chain is the cross-border supplier (i.e. supplier tier-1 in figure 1) who deals with distributing commodities across the border. Over the past few years, the cross-border supply chains and their suppliers have been impacted by numerous uncertainties, risks, and catastrophes such as the coronavirus pandemic, disasters, political tensions, and global economic recessions. Consequently, more complexities of mobilisation, especially when crossing the border, have been remarked. Some borders were temporarily closed and disrupted.

Empty shelves and stockouts in markets occurred. Many populations have been exposed to suffering, hunger, malnutrition, and perhaps disease. In addition, there was a severe issue of labour shortage at all stakeholders, resulting in inflation and the rising costs on one hand and the delays (and/or absences) of production and distribution of commodities on the other hand. Last but not the least, some businesses along chain faced loss of business opportunities, bullwhip-effect inventories, exceeding expenses, cash flow problems, layoffs, and business shutdown (Mefford, 2009; Zighan, 2021).

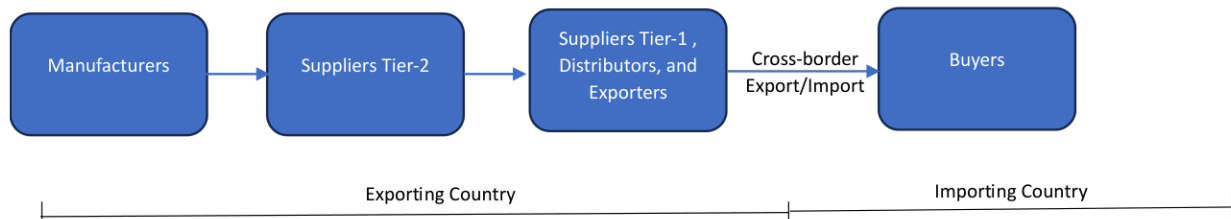


Figure 1: Cross-border supply chain mapping
Source: adapted from Yan *et al.* (2020)

Many scholars have attempted to help businesses and supply chains to better anticipate, prepare, respond to, and recover from the next disruption of any unprecedented incident within short timeframe. This is the so-called building supply chain resilience (Adobor and McMullen, 2018). One of the vital steps of building supply chain resilience is to identify, evaluate, and quantify potential capabilities of the supply chain to be able to respond to and cope with negative consequences of disruptions (Agarwal *et al.*, 2022). Hence, more precise mitigating strategies, recommendation policies, and supply chain resilient initiatives could accordingly be devised and implemented to enhance the resilience. Common supply chain resilient capabilities include flexibility, redundancy, agility, and collaboration (Shekarian and Parast, 2021; Tukamuhabwa *et al.*, 2015).

As far as the authors are concerned, however, evaluating supply chain resilience are commonly conducted using complex mathematical calculations (e.g. Agarwal *et al.*, 2022; Aguila and ElMaraghy, 2019; Zhang *et al.*, 2023), which could not easily be replicated. Another type of evaluation is conducted through a qualitative basis (see examples in Alem-Fonseca *et al.*, 2023). In addition, almost all supply chain resilience evaluations and resilience initiatives recommended by scholars have attempted to evaluate and build supply chain resilient capabilities through the lens of enterprises (or the buyers in our case) (Jain *et al.*, 2017). Some initiatives were not appropriate (or applicable or incomplete) in the context of cross-border supply chain. Also, they might affect and worsen cross-border supplier tier-1.

Therefore, this paper aims at quantitatively evaluating cross-border supply chain resilience. In particular, the supplier tier-1 is the focus for measuring its supply chain resilient performances. Our goals are to adopt the well-known concept and consequently develop the conceptual framework containing essential resilient enablers and a set of questionnaires to evaluate supplier tier-1 resilient capabilities. The proposed framework can also measure resilient performances on the perspectives of supplier (i.e. when supplier tier-1 engages with buyers) and buyer (i.e. when supplier tier-1 engages and/or procures with other suppliers or manufacturers). Results from the questionnaires can computationally be converted to the supplier resilient performance index. This is a more user-friendly way to quantitatively evaluate the qualitative performances. Last but not the least, the proposed framework is validated with the experts so that the framework is assured to be used accurately and widely. The conceptual framework and its evaluation can be considered as a stepping-stone to precisely building supplier resilient capabilities and improving the cross-border supply chain resilience.

The organisation of the paper is as follows. Next session is the literature review, followed by an explanation of the methodology. Next, the conceptual framework is described in results and discussions. Last session concludes the paper.

Literature Review

Definition of supply chain resilience

The supply chain resilience is an evolving concept, which has been built on top of the supply chain risk management (SCRM) (Pettit *et al.*, 2013). In the SCRM, the enterprises (or buyers) are encouraged to mitigate losses by identifying risks and vulnerabilities — possibilities of affecting supply chains and their performance measures — occurred in the supply chains due to previous, existing, foreseen, and predefined incidents (Shahbaz *et al.*, 2017). Common risks include supply risk, demand risk, operation process risk, control risk, environmental risk, and so on. Then, risks can be measured by considering level of likelihoods together with consequence magnitudes. Mitigation actions can eventually be proposed to cope with given incidents and their high risks (Tummala and Schoenherr, 2011).

Supply chain resilience differs from the SCRM by proactively adding supply chain capabilities to enable the enterprises (or buyers) to anticipate and prepare their supply chains to cope with unprecedented incidents (Ponis and Koroni, 2012). Tukamuhabwa *et al.* (2015) comprehensively defined the supply chain resilience as follows: “*The adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost effective recovery, and therefore progress to a post-disruption state of operations – ideally, a better state than prior to the disruption*”.

Building supply chain resilience through adaptive supply chain capabilities (and their key enablers)

Different adaptive supply chain capabilities have been proposed to assist the enterprises (or buyers) in preparing and dealing with supply chain disruptions. In each supply chain capability, there are a few key enablers to enable the achievements of the respective supply chain capability. According to Shekarian and Parast (2021) and Tukamuhabwa *et al.* (2015), these supply chain capabilities can systematically be grouped into four categories as follows. Supply chain flexibility is an ability (of the enterprise) to adapt (the supply chain) to be more flexible to cope with the changing requirements. It can be considered having alternative options, having spare resources, and increasing skillset and productivity. Key enablers to achieve the supply chain flexibility include flexible supplier/supply base and flexible resource. Supply chain redundancy is an ability to withstand any failure or disruption by using backup (or alternative) resources. Their key enablers include having backup resource or diversifying supply network. Supply chain collaboration is an ability to work effectively and efficiently with other stakeholders towards mutual objectives. Their key enablers include supply chain visibility, supply chain coordination, and supply chain communication. Supply chain agility is an ability to rapidly respond to changing requirements. Their key enablers include supply chain visibility and supply chain velocity (Tukamuhabwa *et al.*, 2015).

Since supply chain resilience is dependent on a supply chain’s ability to prepare and respond to unprecedented incidents. Evaluating supply chain resilience can be conducted by measuring resilient capabilities of the supply chain (i.e. there are four main supply chain resilient capabilities in our case as mentioned above). This is called supply chain resilient index measurement (Soni *et al.*, 2014). As mentioned, many scholars have proposed to measure the supply chain resilient index using complex mathematical calculations (e.g. Agarwal *et al.*, 2022; Aguila and ElMaraghy, 2019; Soni *et al.*, 2014; Zhang *et al.*, 2023), which could not easily be replicated. Our proposed concept of supply chain resilient performance index measurement is an alternative (and user-friendly) way to quantitatively evaluate the cross-border supplier resilient performances.

Methodology

In the initial steps of our research work, the concept to measure cross-border supplier resilient performance index has been constructed. The proposed concept was adopted from the well-known Logistics Performance Index (LPI). The LPI is an interactive benchmarking tool created by World Bank, which aims at providing feedback and indicators on national logistics performances of 139 countries. The logistics performances, which are the weighted average index of each country on six key logistics dimensions, can be computed using the surveys of international logistics operators on the ground. Survey participants are requested to rate (i.e. very low to very high or much worsened to much improved) each survey questionnaire of the six key dimensions (see more details in (<https://lpi.worldbank.org/>)).

In our supply chain resilience performance index measurement, key dimensions to measure resilient performances are four supply chain resilient capabilities. However, the proposed concept integrates two supply chain capabilities, supply chain flexibility and supply chain redundancy, into one dimension. The rationale behind this integration is that both capabilities are interrelated and share some common characteristics. Flexibilities of the supply chain can be achieved by having backup or alternative resources (i.e. definition of the supply chain redundancy) (Tukamuhabwa *et al.*, 2015). Both also result in similar enablers and supply chain resilient initiatives in the cross-border supply chain context. Supply chain collaboration and supply chain agility are also interrelated, which can be integrated into one dimension. For instance, supply chain visibility plays a vital role in achieving supply chain agility. Visibility gives better visualisation and clearer view of the end-to-end supply chain, which assists in detecting negative signals of potential disruptions and accelerating decision making ahead of time (Tukamuhabwa *et al.*, 2015). To achieve the end-to-end visibility, collaboration and information sharing among stakeholders need be established. Therefore, the proposed concept also integrates these two supply chain capabilities.

After the concept was constructed, the conceptual framework containing key enablers of each respective supply chain capability and a set of questionnaires was developed. The proposed concept as well as the conceptual framework have then been validated with cross-border experts and practitioners in Thailand who were members of Federation of Thai Industries. Feedback from the validation resulted in the revised conceptual framework, which could be described in the next session.

Results and Discussions

The conceptual framework

Tables 1 and 2 show key enablers and sub-enablers to achieve the integrated supply chain flexibility & redundancy capabilities as well as the integrated supply chain collaboration & agility capabilities, respectively. As mentioned, the proposed conceptual framework needs to focus on measuring resilient performances on two perspectives of the cross-border supplier tier-1, including supplier (i.e. when supplier tier-1 engages with buyers) and buyer (i.e. when supplier tier-1 engages and procures with other suppliers or manufacturers). Summary of each enabler can be found below.

In table 1, there are three key enablers. The first enabler is flexible supply. This is an ability of the supplier tier-1 when acquiring, sourcing, and procuring commodities (i.e. materials/products). This capacity is to ensure that the supplier tier-1 always has alternative commodities or alternative sourcing options to fulfil the changing requirements. On the other hand, when engaging with buyer, it is also defined as an existing (or potential) ability of the supplier tier-1 to provide flexible supply to serve the buyer. To have (or to provide) flexible supply, the supplier tier-1 should possess 1) an ability to apply (or to assist the buyer in having) appropriate purchasing portfolio categorisation (note that purchasing portfolio categorisation is a foundation of building supply chain resilience (Bhusiri *et al.*, 2021)), 2) an ability to have (or to provide) an expansion and/or diversification of locations and/or sources of supply (Juttner and Maklan, 2011), 3) an ability to have (or to provide) a strengthened partnership with its strategic supplier (or the buyer) and request (or prepare)

to have safety stock of important commodities to ensure smooth supply (Juttner and Maklan, 2011; Scholten *et al.*, 2020), and 4) an ability to have (or to provide) a strengthened partnership with its strategic supplier (or the buyer) and request (or provide) for increased supplies in a short notice (having spare capacity) (Qazi *et al.*, 2022).

Next enabler is flexible inbound (or outbound) transport and distribution channel (Tukamuhabwa *et al.*, 2015). This capacity is to ensure that the supplier tier-1 always has (or provide) alternative transport options and distribution channels for constant inbound (or outbound) deliveries. Under this enabler, the supplier tier-1 should possess 1) an ability of the supplier tier-1 to have (or to provide) an expansion (or diversification) of inbound distribution channels (and/or transport modes), 2) an ability to redeploy and expand own transport resources for inbound (or outbound) deliveries, and 3) an ability to have (or to provide) an expansion and/or diversification of transport outsourcing options.

Another enabler is flexible workforce arrangement (Tukamuhabwa *et al.*, 2015). This enabler is to ensure that supplier tier-1 always has (or provide) alternative workforce options including: 1) an ability to have (or to provide) a strengthened partnership and request other suppliers (or to be requested by the buyer) to build capacities of workforces to be more productive and multi-skilled and 2) an ability to have (or to provide) a strengthened partnership and request other suppliers (or to be requested by the buyer) to redeploy and expand workforce.

Supply Chain Resilient Capabilities: Flexibility & Redundancy		
Sub-enablers in perspective of buyer	Enablers	Sub-enablers in perspective of supplier
1) an ability to have (or apply) appropriate purchasing portfolio categorisation 2) an ability to have an expansion and/or diversification of locations and/or sources of supply 3) an ability to have a strengthened partnership with its strategic supplier and request to have safety stock of important commodities to ensure smooth supply 4) an ability to have a strengthened partnership with its strategic supplier and request for increased supplies in a short notice (having spare capacity)	Flexible supply	1) an ability to assist (or provide information or participate) buyer in analysing and categorising purchasing portfolio 2) an ability to provide expansion of locations of supply by having inventories in multiple locations domestically and internationally 3) an ability to provide a strengthened partnership and store spare inventory (i.e. important commodities) for buyer 4) an ability to provide a strengthened partnership and increase supplies to be delivered within short notice (having spare capacity)

<p>1) an ability to have an expansion (or diversification) of inbound distribution channels (and/or transport modes)</p> <p>2) an ability to redeploy and expand own transport resources for inbound deliveries (in case the supplier tier-1 uses own transport resources)</p> <p>3) an ability to have an expansion and/or diversification of transport outsourcing options</p>	<p>Flexible transport and distribution channel</p>	<p>1) an ability to provide expansion (or diversification) of outbound distribution channels (and/or transport modes)</p> <p>2) an ability to redeploy and expand own transport resources for outbound deliveries</p> <p>3) an ability to provide an expansion and/or diversification transport outsourcing options</p>
<p>1) an ability to have a strengthened partnership with its strategic supplier and request to build capacities of workforces to be more productive and multi-skilled. Also, an ability to build own capacities of workforces to handle inbound deliveries</p> <p>2) an ability to have a strengthened partnership with its strategic supplier and request to redeploy and expand workforce. Also, an ability to redeploy and expand own workforces to handle inbound deliveries</p>	<p>Flexible workforce arrangement</p>	<p>1) an ability to provide a strengthened partnership and prepare to build capacities of workforces (to handle outbound deliveries) to be more productive and multi-skilled</p> <p>2) an ability to provide a strengthened partnership and prepare to redeploy and expand own workforce (to handle outbound deliveries)</p>

Table 1: Key enablers of the integrated supply chain flexibility & redundancy capabilities

In table 2, there are also three key enablers. The first enabler is supply chain visibility. This is an ability of the supplier tier-1 to have (or to assist in having) an efficient tracking performance of its supplier (or of the buyer) (Shekarian and Parast, 2021) including: 1) an ability to have (or to provide) information and performances exchanged, shared, received, tracked, and monitored from its suppliers (or for the buyer) and 2) an ability to analyse and evaluate the performances of the supply (or the forecasted demands). Next enabler is relationship orientation. This enabler is related to an ability of having (or assist the buyer in having) purchasing portfolio categorisation (Bhusiri *et al.*, 2021). After purchasing portfolio and supplier are categorised, the supplier tier-1 should possess 1) an ability to prioritise its suppliers (or to assist the buyer in prioritising supply base) and 2) an ability to have an appropriate establishment of different levels of relationships with other suppliers (or to assist the buyer in establishing appropriate relationships). Last but not the least, supply chain communication is the enabler to have (or to provide) proactive, regular, and responsive communicate with other suppliers (or the buyer). Also, it includes an ability to have (or to provide) an alignment of communication channels.

Supply Chain Resilient Capabilities: Collaboration & Agility		
Sub-enablers in perspective of buyer	Enablers	Sub-enablers in perspective of supplier
1) an ability to have information and supply chain performances exchanged, shared, received, tracked, and monitored from other suppliers 2) an ability to analyse and evaluate the performance of supply (from other suppliers)	Supply chain visibility	1) an ability to share and exchange its information for the buyers to track and monitor the performances and receive useful information from the buyer 2) an ability to analyse and forecast demands from the buyer
1) an ability to prioritise its suppliers 2) an ability to have an appropriate establishment of different levels of relationships with other suppliers	Relationship Orientation	1) an ability to assist the buyer in prioritising supply base 2) an ability to assist the buyer in establishing appropriate relationships
1) an ability to have proactive, regular, and responsive communicate with other suppliers. Also, it includes an ability to have an alignment of communication channels	Supply Chain Communication	1) an ability to provide proactive, regular, and responsive communicate with the buyer. Also, it includes an ability to provide an alignment of communication channels

Table 2: Key enablers of the integrated supply chain collaboration & agility capabilities

Examples of questionnaire

After defining key enablers and sub-enablers, a set of survey questionnaires has been developed and revised according to feedback and comments from the validation. There might be more than one question corresponded to each sub-enabler. Each question requests survey participants to rate (or answer at the most appropriate level). The ratings have five levels. Scores from 0 to 2 can be computed and consolidated to feedback the resilient performances of the supplier tier 1. Table 3 shows an example of questions related to the first sub-enabler of flexible supply of supply chain resilient capabilities; flexibility & redundancy.

Enabler	Question	Please choose an appropriate answer				
		Not at all/ Hardly ever/ Very low/ Disagree	Rarely/ Low/ Somewh at agree	Sometimes / Average/ Agree	Often/ High/ Very agree	Nearly always/ Very High/ Totally agree
Flexible supply (1 st sub-enabler)	Do you know who is your strategic supplier or what is your strategic item?					
	Do you involve risks and difficulties of acquiring and procuring items as criteria when you differentiate between strategic supplier (strategic item) and others?					
	Do you know (or have you applied) the concept of Kraljic model (or something similar) when differentiating between strategic supplier (strategic item) and others? (i.e. it can result in four categories; non-critical, leverage, bottleneck, and strategic)					

	Do you know what (or have you implemented) appropriate sourcing strategies for the above-mentioned four categories are?					
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Table 3: Example of survey questionnaires

Examples of supply chain resilient performance index

To calculate the resilient performance index, the survey questionnaires need to be fulfilled by of staff from different levels (i.e. from operators, managers until C-suite) of the supplier tier-1. Figure 2 depicts an example of supply chain resilient performance index on integrated supply chain flexibility and redundancy capabilities. It can be said that there is a room for improvement in flexible transport and distribution channel and in flexible workforce arrangement when this supplier tier-1 engages and/or procures with other suppliers. More transport outsourcing options for inbound deliveries, more delivery routing options, and multi-skillset capacity building are recommended resilient initiatives.

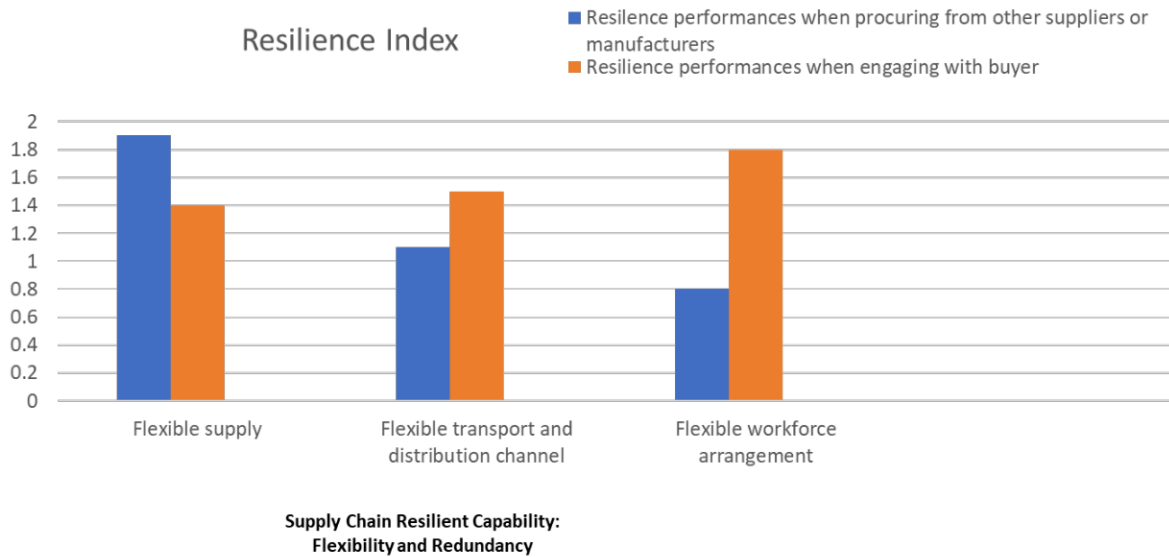


Figure 2: An example of supply chain resilient performance index on integrated supply chain flexibility and redundancy capabilities.

Source: the authors

Conclusions

This paper aims at quantitatively evaluating cross-border supplier resilient performance index by adopting the concept of the well-known LPI. Consequently, the conceptual framework containing essential resilient enablers, sub-enablers, and a set of questionnaires to evaluate cross-border supplier resilient capacities has been developed. The proposed framework could measure the resilient performances on the perspectives of supplier (i.e. when supplier tier-1 engages with buyers) and buyer (i.e. when supplier tier-1 engages and/or procures with other suppliers or manufacturers). This is a more user-friendly way to quantitatively evaluate the qualitative performances. Validation of the conceptual framework with the experts could ensure its applicability. Evaluation of supply chain resilient performance index can be considered as a stepping-stone to precisely building supplier resilient capabilities and improving the cross-border supply chain resilience. Building supplier resilience eliminate the supplier from being the bottleneck of the cross-border supply chain. The cross-border supply chain can also increase its resilience to ensure the continuous supply and distribution of commodities across the border for the benefits of both communities

and population along the border. In the next steps of our research work, the conceptual framework will be used on the case study of Thai-Laos cross-border supply chains to evaluate and measure the supplier resilient performances on actual cross-border supply chain operations between Thailand and Laos.

References

- Adogor, H. and McMullen, R.S. (2018), "Supply chain resilience: a dynamic and multidimensional approach", *The International Journal of Logistics Management*, Vol. 29 No. 4, pp. 1451-1471.
- Agarwal, N., Seth, N. and Agarwal, A. (2022), "Evaluation of supply chain resilience index: a graph theory based approach", *Benchmarking: An International Journal*, Vol. 29 No.3, pp735-766.
- Aguila, J.O. and ElMaraghy, W. (2019), "Supply chain resilience and structure: an evaluation framework", *Procedia Manufacturing*, Vol. 28, pp. 43-50.
- Alem-Fonseca, M., Nie, W., Tsolakis, N. and Kumar, M. (2023), "Evaluating supply chains from a resilience and cost perspective: a scoping literature review and future research directions", paper presented at the 30th EurOMA Conference 2023, 3 July 2023.
- Bhusiri, N., Banomyong, R., Julagasingorn, P., Varadejsatitwong, V. and Dhami, N. (2021), "A purchasing portfolio model for humanitarian supply chain resilience: perspectives from a development aid context", *Journal of Humanitarian Logistics and Supply Chain Management*, Vol. 11 No. 4, pp. 639-660.
- Jain, V., Kumar, S., Soni, U. and Chandra, C. (2017) "Supply chain resilience: model development and empirical analysis", *International Journal of Production Research*, Vol 55, pp. 1-22.
- Jazdzewska-Gutta, M. and Borkowski, P. (2022), "As strong as the weakest link. Transport and supply chain security", *Transport Reviews*, Vol. 42 No. 6, pp. 762-783.
- Jüttner, U. and Maklan, S. (2011), "Supply chain resilience in the global financial crisis: an empirical study", *Supply Chain Management. An International Journal*, Vol. 16 No. 4, pp. 246-259.
- Mefford, R.N. (2009), "The financial crisis and global supply chain", *AIB Insights*, Vol. 9 No. 3, pp. 8-11.
- Pettit, T. J., Croxton, K.L. and Fiksel, J. (2013), "Ensuring supply chain resilience: development and implementation of an assessment tool", *Journal of Business Logistics*, Vol. 34 No. 1, pp. 46-76.
- Ponis, S. and Koronis, E. (2012), "Supply Chain Resilience: Definition of Concept and Its Formative Elements", *Journal of Applied Business Research*, Vol. 28 No.5, pp. 921–930.
- Qazi, A.A., Appolloni, A. and Shaikh, A.R. (2022), "Does the stakeholder's relationship affect supply chain resilience and organizational performance? Empirical evidence from the supply chain community of Pakistan." *International Journal of Emerging Markets*, <https://doi.org/10.1108/IJOEM-08-2021-1218>
- Scholten, K., Stevenson, M. and VanDonk, D.P. (2020), "Dealing with the unpredictable: supply chain resilience", *International Journal of Operations & Production Management*, Vol. 40 No. 1, pp. 1-10.
- Shahbaz, M.S., Rasi, R.Z.R.M., Ahmad, M.F.B. and Rehman, F. (2017), "What is supply chain risk management? A review", *Advanced Science Letters*, Vol. 23, pp. 9233-9238.
- Shekarian, M. and Parast M.M. (2021), "An integrative approach to supply chain disruption risk and resilience management: a literature review", *International Journal of Logistics: Research and Application*, Vol, 24 No. 5, pp. 427-455.
- Soni, U., Jain, V. and Kumar, S. (2014), "Measuring supply chain resilience using a deterministic modeling approach", *Computers & Industrial Engineering*, Vol. 74, pp. 11-25.
- Tukamuhabwa, B.R., Stevenson, M., Busby, J. and Zorzini, M. (2015), "Supply chain resilience: definition, review and theoretical foundations for further study", *International Journal of Production Research*, Vol. 53, pp. 5592-5623.
- Tummala, R. and Schoenherr, T. (2011), "Assessing and managing risks using the supply chain risk management process (SCRMP)", *Supply Chain Management: An International Journal*, Vol. 16 No. 6, pp. 474-483.
- Yan, C., Wang, X., Zhang, Y. and Ding, Q. (2020), "Analysis of cross-border supply chain network system", proceedings of the 5th International Conference on Electromechanical Control Technology and Transportation (ICECTT), Nanchang, China, pp. 603-606.

- Zhang, H., Jia, F. and You, J.X. (2023), "Striking a balance between supply chain resilience and supply chain vulnerability in the cross-border e-commerce supply chain", *International Journal of Logistics: Research and Application*, Vol. 26 No. 3, pp. 320-344.
- Zighan, S. (2021), "Managing the great bullwhip effects caused by COVID-19", *Journal of Global Operations and Strategic Sourcing*, Vol. 15 No. 1, pp. 28-47.