Concept of Maturity Model for Evaluation of Supply Chain Resilience

***Tomáš Malčic*[1], *Radim Lenort*[2]**

Škoda Auto University[1, 2]
Department of production, logistics and quality management
Na Karmeli 1457, 293 01, Mladá Boleslav
Czech Republic

e-mail: tomas.malcic@savs.cz[1], *radim.lenort@savs.cz*[2]

Abstract

The aim of the paper is to present the concept of maturity model for evaluation and continuous improvement of business and managerial capabilities that sustainably increase the resilience of logistics processes and the supply chain to severe and unpredictable disruptions. The development of presented model is a reaction on research gap consisting in the absence of a maturity model for building resilience in logistics and supply chain processes. Presented model also aims to overcome shortcomings of standard logistics maturity models, which are obsolescence over time, high subjectivity of assessment, absence of managerial competencies and lack of direct link to sustainable business performance. The research is also a response to the increasing number of serious and unpredictable crisis events in the current turbulent business environment, which significantly disrupt logistics processes and supply chains of industrial companies. The ultimate goal of whole research effort is to develop a tool that will help companies effectively deal with the increasing number of severe and unpredictable crisis events disrupting their logistics processes and supply chains. This goal will be achieved by development of a SCM resilience enhancing capacities maturity model.

Keywords: benchmarking, maturity model, logistics, supply chain management, resilience

JEL Classification: D200, L620, O140

1. Introduction

The purpose of the research is to develop a tool that will help companies to effectively deal with the increasing number of severe and unpredictable crisis events occurring in the current turbulent business and social environment and disrupting their logistics processes and supply chains. Examples of such disruptions include natural disasters (e.g. large-scale fires or floods), economic crises (e.g. energy or semiconductor crises), political conflicts (e.g. war in Ukraine or terrorist attacks in Israel) or pandemic crises (Covid 19). This tool will be conceptually based on the theory of resilient SCM. The key idea behind the application of this theory in the research is the premise that building resilient capabilities (a combination of a company's long-term knowledge, skills, abilities and experience in the field of resilient logistics and SCM) can effectively help to increase the resilience of logistics processes and supply chains to unpredictable disruptions. The output in terms of experimental development will be a maturity

model for building supply chain resilience. The developed model will enable self-assessment of the resilience of a particular enterprise's logistics processes and supply chain, benchmarking with enterprises of different types and recommending a process for continuous improvement of resilience enhancing capabilities. The model will be programmed in the form of a database-based publicly available tool in a web interface.

2. Literature review

2.1 Logistics and SCM maturity models

Maturity models are considered to be an effective tool for building and continuously improving corporate capabilities. Previous research carried out by the authors has shown that no maturity model for building resilience in logistics and supply chain processes has been developed so far. A total of 21 different maturity models were analysed during the literature review. Table 1 shows the five of the most recent models.

Table 1: SCM and maturity models

Author(s)	Model	Focus
Caiado et al., 2021	Fuzzy rule-based Industry 4.0 maturity model for operations and supply chain management	SCM
Elibal et al., 2021	Maturity model for assessing the Logistics 4.0 transformation level of industrial enterprise	Logistics 4.0
Chaopaisarn and Woschank, 2021	Maturity model assessment of SMART logistics for SMEs	Logistics 4.0
Zoubek and Simon, 2021	Model assessing the readiness of internal logistics for Industry 4.0 in industrial companies	Logistics 4.0
Modica et al., 2023	Maturity model for the Logistics 4.0 transportation process	Logistics 4.0

At the same time, the shortcomings of existing standard logistics maturity models were identified:

1. Obsolescence over time – the current business environment and technological advances are so rapid that models do not reflect a realistic level of maturity very soon.
2. High subjectivity of assessment – maturity models are typically based on subjective scoring scales or qualitative assessments that do not adequately reflect the uncertainty and insecurity in the assessment of the processes being assessed.
3. Primary focus on business capabilities – maturity models neglect the capabilities of managers to improve logistics processes. In the framework of the previous research of corporate logistics and supply chain resilience capabilities both business and managerial resilience capabilities were mapped and a primary questionnaire survey was prepared on the basis of these capabilities, which will be the source of data for the development of model.
4. Lack of direct linkage to measuring sustainable business performance, or linkage only to economic performance – the solution should be to integrate a set of

sustainable key performance indicators (SKPIs) into the maturity model. Monitoring SKPIs, especially at times of supply chain disruption, and comparing them with the achieved maturity level will allow verification of the success of implemented corporate and managerial capabilities.

Based on this findings the need for the development of a maturity model for the continuous improvement of business and managerial capabilities that sustainably increase the resilience of logistics processes and the supply chain to severe and unpredictable disruptions was identified. The development of this model will be based on the data from the prepared primary survey. The developed tool will be publicly available in the form of a web interface. Its use by the business community will be a source of continuous data collection for updating of the model.

2.2 Resilience capabilities

A systematic literature review was used to identify resilience capabilities. The Scopus database of scientific articles was used for this purpose. A combination of keywords focused on resilience capabilities/strategies/practices and supply chain/logistics were searched to find the most relevant scientific publications. In the first phase, article titles, abstracts and keywords were searched.

Table 2: Most frequent identified resilience capabilities

Resilience capability / Author(s)	Michel-Villarreal (2023)	Nagariya et al. (2023)	Sun et al. (2023)	Carissimi et al. (2023)	Vann Yaroson et al. Silva	and Ruel (2022)	Furstenau et al. (2022)	Malik et al. (2022)	Vanany et al. (2021)	Frequency
Information sharing	x	x	x		x	x	x	x	x	8
Flexibility in order fulfilment	x	x	x	x		x		x	x	7
Flexibility in product and production	x	x		x	x	x		x	x	7
Information digitalisation and visibility	x	x		x	x	x	x	x		7
Inventory management	x		x	x	x		x	x	x	7

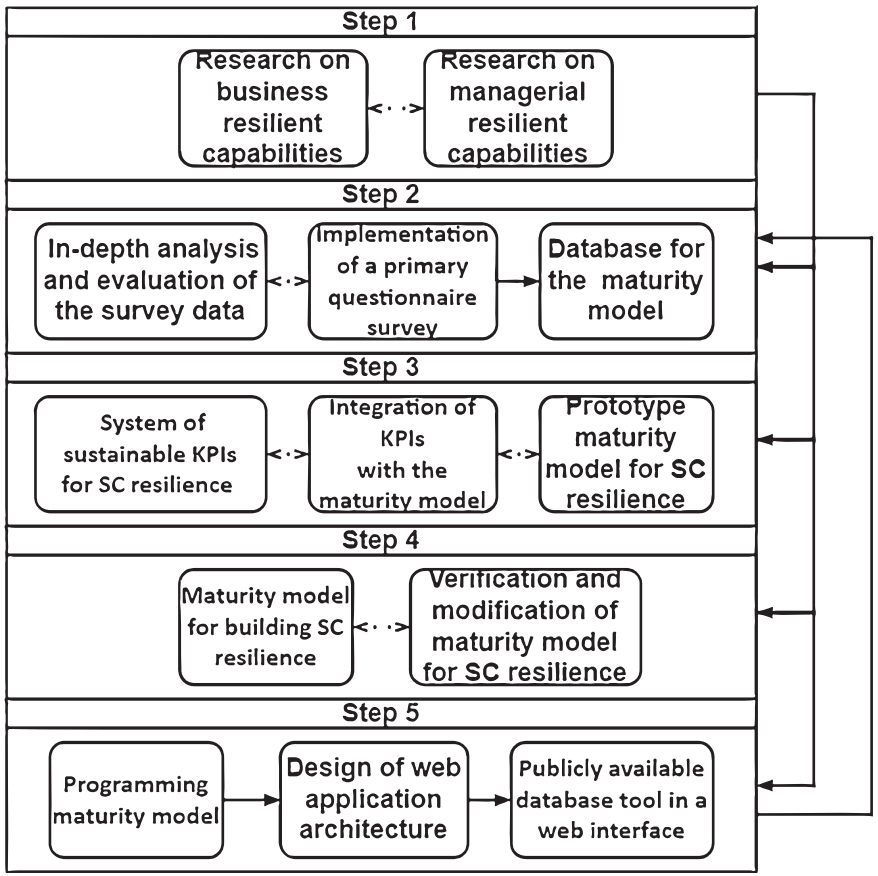
A total of 323 articles were identified, but a significant proportion of these dealt with resilience capabilities only marginally. For this reason, only article titles were searched in the second step. In this way, 49 articles were identified and their content was analysed. The list of capabilities recommended for building supply chain resilience included 37 articles. The aim was to focus on articles that conducted primary research on the resilience capabilities in supply chains. Thus, 23 articles identifying these capabilities based only on a literature review were excluded from further examination. Another criterion for the selection of articles was the year of publication. An analysis

of the articles showed a rather significant shift in the understanding of resilience capabilities after 2019, which was the beginning of new large-scale disruptions (the Covid 19 pandemic, the war in Ukraine, the semiconductor shortage or the energy crisis). Therefore, 5 articles published before 2019 were also excluded from the original set. The final set of articles for the detailed analysis of resilience capabilities thus contained 9 articles. These articles included a total of 172 resilient capabilities, some of which overlapped either completely or partially. Based on the synthesis, 34 unique capabilities were identified. These articles are shown in the Table 2 together with 5 identified resilience capabilities with the highest frequency.

3. Research methodology

The research strategy and methodology involves the implementation of five overlapping and iterative steps. The individual steps including their interrelationships and dependencies, are shown in the flowchart in Figure 1, followed by a textual description of the five main steps.

Figure 1: Methodology for Development of Maturity Model for Evaluation of Supply Chain Resilience



Step 1: Conduct a primary survey and systematic literature review of supply chain resilience management and the capabilities needed to build and improve it. The research will build on and develop existing and published findings in this area. Goal of this phase is to identify key capabilities whose maturity, when applying the proposed maturity model, will be the main object of evaluation and comparison.

Step 2: Implementation of a primary questionnaire survey, which was already prepared during previous research of corporate logistics and supply chain resilience capabilities. The survey was developed on the basis of a systematic literature review of resilience capabilities and semi-structured interviews with experts and managers of companies in both countries. The aim is to obtain primary data for the developed maturity model focusing not only on business competencies but also on managerial competencies enhancing logistics process and supply chain resilience, which have not received sufficient attention in the formation of supply chain resilience theory. The data collected will be subjected to in-depth analysis and evaluation. Using advanced statistical analysis methods, priorities, dependencies and behavioural patterns will be sought.

Step 3: Experimental development of a system of sustainable key performance indicators in the context of supply chain resilience and research on how it can be integrated with the maturity model under development. The aim is to link the building and continuous improvement of resilience of logistics and supply chain processes through the qualitative findings of the application of maturity models to quantified and measured sustainable logistics and supply chain performance. This will provide feedback to assess the effectiveness of the corporate and managerial capabilities being built.

Step 4: Experimental development of a maturity model for building supply chain resilience by integrating the results of the previous phases. The actual development will be carried out using the design thinking method (developed by the Hasso Plattner Institute of Design). This method is used to creatively develop innovative applications, products or processes. It includes prototyping and testing phases, in which a prototype of a maturity model will first be developed and verified through focus groups composed of experts and business managers.

Step 5: Creating a publicly available database tool in a web interface. In order to enable the developed model to be used extensively by business practices for assessment, benchmarking and continuous improvement of resilient capabilities, it will be programmed in the form of a database system with a web interface. The use of this tool by the business sphere will thus be a source of continuous data collection for updating of the maturity model over time.

4. Current results

Currently, the research is at the end of the first phase of basic research on resilient capabilities. Next step is the implementation of a primary questionnaire survey. The purpose of the questionnaire is to design a benchmarking tool for the continuous improvement of corporate and managerial capabilities that increase the resilience of logistics processes and the supply chain of an industrial enterprise to crisis situations. The created tool will enable self-assessment of the resilience of logistics processes and the supply chain of a specific enterprise, comparison with enterprises of different types

and recommendations for a course of action for continuous improvement of resilience-enhancing capabilities. Target respondents of the questionnaire are managers of industrial enterprises responsible for solving crisis situations in logistics and supply chain.

A prototype maturity model will be developed based on the results of the questionnaire survey. The baseline levels of each criterion will be defined based on the analysis of the results of the questionnaire survey. These results will be used to define the maturity levels. A major challenge for future research activities will be to determine the interrelationships and weights between business and management capabilities, core capabilities, sub-capabilities and research sub-questions. For an accurate and objective determination of the priority weighting system, it will be possible to use the AHP decision model and to determine the weights through a focus group, a workshop, or to include their determination as part of a questionnaire survey. Currently, the concept of the Maturity Model for Supply Chain Resilience Assessment has been developed, which is based on the MM matrix concept. This concept is illustrated in Figure 2 below. The whole matrix is divided into two main parts, Business Capabilities and Management Capabilities. These are further divided into 4 core capabilities. Each of the main capabilities is made up of a number of sub-capabilities ranging from 3 to 8. This can be seen in Table 3, which shows the section of the questionnaire dealing with the business capability A.1 Re-engineering of logistics and SC, which consists of 7 sub-capabilities.

Table 3: Example of questionnaire – Business capability A.1

A.1 Reengineering of logistics and supply chain (1 = the best, 5 = the worst)	Is it important?	Do we have it?	Is it demanding?
A system of contracted back-up suppliers and logistics service providers (multi-sourcing).			
Geographical diversification of suppliers based on a long-term evaluation of the riskiness of the regions.			
High modularity and standardization of supplied and manufactured parts, which enables their production and delivery from different regions.			
Relocation of suppliers' production after the occurrence of such a crisis event that does not allow the continuation of their production.			
Maintaining higher inventories with critical partners and parts in the supply chain.			
Corporate culture enabling changes in logistics paradigms (basic principles) applied in logistics and supply processes.			
Contractual provision of backup capacities and production equipment in other own plants or with partners in the supply chain.			

The weighted averages of the sub-capabilities define the maturity level for a given core capability. However, the assessment of the current maturity level is only a partial contribution of the proposed MM. The main added value for organisations will be the set of recommended actions to increase the required maturity in each area. The Maturity Model concept works with 6 Maturity Levels according to the CMMI system. Concept of the Maturity Model presented in this paper is just a first draft and could be considered as a mental model. As the whole methodology for development of final maturity model is an iterative process this matrix will be subject of many changes and through the iterations the desired model will evolve. It has to be decided if the final model will follow the structure of this concept based on the primary survey or if based on the outputs of primary survey the whole logic of final model will change significantly. However the presented concept will be used for the definition of each level initial specification.

Figure 2: Concept of Maturity Model for Evaluation of Supply Chain Resilience

Level of Maturity									
	LEVEL 5 Optimizing								
	LEVEL 4 Quantitative								
	LEVEL 3 Defined								
	LEVEL 2 Managed								
	LEVEL 1 Initial								
	LEVEL 0 Incomplete								
Main capabilities		A.1 Reengineering of logistics and SC	A.2 Cooperation in logistics and SC	A.3 Logistics and SC agility	A.4 Crisis management in logistics and SC	B.1 Effective leadership in uncertain times	B.2 Personal	B.3 Ethical and sustainable thinking	B.4 Proactivity
Resilience-enhancing capabilities		A. Business capabilities				B. Managerial capabilities			

5. Conclusion

In response to the growing need for effective strategies to deal with severe and unpredictable disruptions in logistics processes and supply chains, this paper introduces the concept of a SCM resilience enhancing capacities maturity model. The development of this model addresses critical gaps in existing logistics and supply chain maturity models, which often lack adaptability, objectivity and managerial competencies.

An extensive literature review identified that existing maturity models suffer from obsolescence, subjectivity and a primary focus on business capabilities. In contrast, the proposed maturity model provides a comprehensive framework for assessing and improving resilience capabilities at both business and managerial levels.

The research methodology outlined in this paper involves a systematic approach by integrating primary survey data and advanced statistical analysis, the model aims to capture the complex interdependencies and behavioural patterns inherent in SC resilience. The research is currently in the early stages of implementation, focusing on fundamental research into resilience capabilities, and the development of a primary

survey. This survey will serve as a key tool in the design of a benchmarking system to assess and improve the crisis management capabilities of companies and managers.

In the future, the development of a SCM resilience enhancing capacities maturity model promises to enable industrial companies to manage crises with greater agility and effectiveness. By providing a dynamic framework for continuous improvement, this model has the potential to transform the way organisations approach supply chain resilience in the face of unprecedented challenges. In conclusion, the proposed maturity model represents a significant advancement in the field of logistics and supply chain management, offering a tangible solution to the pressing need for improved resilience in current dynamic business environment.

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