Resilient Supply Chain Management Model

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Abstract. The strategy for the development of the supply chain should ensure a high level of fault tolerance of all links when exposed to adverse factors. The article analyzes the impact on the stability of the supply chain of two types of influences: failure and disruption. The low stability of the supply chain appears in the stoppage of work in case of any disruptions and failures. With moderate stability, disruptions do not give up a significant impact on the operation of the supply chain, and failures lead to an increase in operating costs to maintain the stability of work processes. With a high level of stability, failures can cause disruptions in the operations of individual links. In case of disruptions, response models are applied based on the control of process parameters, the subsequent analysis of the causes of disruptions and the development of measures to restore the normal operation of the links in the supply chain. Effective disruption response involves the use of proactive response models. For this, it is necessary to ensure flexibility and transparency of processes in all links of the supply chain based on digital services for material flow control and mining of big data.

1 Introduction

In modern conditions, various factors introduce uncertainty in the prospects for economic development at the local and global levels. These factors include Brexit, the trade war between the United States and China, various armed conflicts. The coronavirus pandemic (COVID-19) has had and continues to have a strong impact on macroeconomic stability. The pandemic has shown how highly integrated the modern world has become. Having originated in a particular region, the infection spread over the entire planet in a short time. Restraining measures to spread it caused a wave of economic crisis, which also began to spread rapidly and shocked many economies on all continents.

Restrictive measures have shown a low degree of resilience of supply chains to various kinds of emergency impacts. Research by the consulting company Accenture shows that 94% of Fortune 1000 companies have experienced supply chain disruption due to COVID-19, for 75% of companies, these disruptions have had a negative or severely negative

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impact on their business, 55% of companies are planning to scale down their business. As a result, many transport and logistics holdings faced a decline in revenue, operating profit and business profitability. The majority of domestic and foreign representatives of the logistics sector do not expect to achieve last year's results in 2020. If the negative trend in the work of the transport and logistics sector continues, then the crisis in the industry may reduce the effectiveness of measures taken by the world community in the fight against the COVID-19 pandemic. Both the supply of the resources to the manufacturers of vital medical supplies and the subsequent delivery of the manufactured products to the consumers depend on the sustainable operation of transport. Therefore, in modern conditions, many companies need to adjust their strategies for the development of the supply chains. At the same time, the emphasis should be strengthened on ensuring their stability in conditions of active influence of unfavorable factors.

2 Materials and methods

The stability of a system is understood as its ability to return to its previous state after its undesirable changes under the influence of external disturbing influences. The concept of "sustainability of the supply chain" includes a set of components that characterize its ability to maintain high standards of service for ecosystem participants in compliance with environmental, social and economic requirements, despite various kinds of external influences. The stability of supply chains is supported by a system of incentives for participants for effective decisions made to reduce the negative consequences of such impacts at all stages of the life cycle of goods (services).

The work of the supply chains is associated with various kinds of undesirable effects, which, as a rule, cannot be completely excluded, manifest themselves in a random way and create risks of reducing the efficiency of companies and the quality of customer service [1]. Unwanted impacts fall into two categories: failure and disruption.

Disruptions refer to a potentially negative change in the outcome of operations in the supply chain that can be recovered after standard response measures had been adopted. It is important to note that these kinds of disruptions generally do not propagate to other links (downstream or upstream) of the supply chain. Disruptions include various inconsistencies between the actual and planned (or standard) values of the indicators of production processes (delay in transport, incomplete deliveries, damaged cargo, etc.), usually caused by the influence of factors of a random nature. Disruptions in supply chain parameters are considered as recurring risks, which are a kind of operational risks and appear when one or more parameters of the supply chain operation deviate from the norm and go beyond the acceptable thresholds. To control the disruptions in practice, the performance indicators of logistics operations recommended by SCOR standard (Supply Chain Operations Reference) are often used. This standard was developed and updated by the experts of the international "Supply Chain Council". The risk level of the operational disruptions is determined taking into account the likelihood of their occurrence and the magnitude of the negative impact. The actual level of risk is determined depending on the combination of these criteria ("low - high probability" and "weak - strong impact").

A disruption in the supply chain is understood as the manifestation of unforeseen events, under the influence of which the operation of the entire chain or its individual links is radically disrupted. In the technical field, the term “failures” is usually used instead of the term “crash”. Disruptive risks are the consequences when the focus company stops operating or customer service ceases. This can happen due to the complete cessation of access to limited and non-renewable resources for economic or political reasons, due to man-made disasters, hacker attacks, pandemics, etc. Geographically dispersed supply chains are most affected by the disruptions, where the stable supply of the resources is

highly dependent on the regional factors. Any emergencies and restrictions in the regions where the main raw material bases are located or their transit lead to disruptions in the entire chain.

The main difference between the disruptions and failures is the level of impact of supply chain performance. In case of disruptions, the supply chain does not stop, and the values of the operational parameters can be returned to the thresholds by means of rapid response. As a result of failures, the flow of the material along the supply chain stops. For example, during the first wave of the spread of coronavirus infection in Asian countries, Korean car manufacturers were forced to stop production due to the disruption in the delivery of components from Chinese factories. In turn, a number of European automakers, assembling their cars at Russian factories, began to stop conveyors due to a lack of the components from the suppliers from the western part of the continent.

Various metrics are used to assess the impact of the failures on the supply chain resilience. For example, a number of nongovernmental organizations such as CDP and the Global Reporting Initiative offer a set of standards and integrated metrics for assessing various impacts on supply chain sustainability. The International Integrated Reporting Council (IIRC), which includes regulators, investors, manufacturers, standards makers, academics and non-governmental organizations, emphasizes the importance of using integrated thinking in ensuring the sustainability of the supply chains. Integrated thinking is about understanding the relationship and interdependence between various factors and their impact on the organization's ability to create value in the future [2].

3 Results and Discussion

Studying the structures and mechanisms of sustainable supply chain management is an urgent task. Modern supply chains act as the infrastructural background that powers the global economy, delivering resources and goods to all stakeholders, regardless of geographic, sectoral, cultural and administrative boundaries. Therefore, the sustainable operation of supply chains should not only ensure the stable operation of the business, but also create social, economic and environmental effects for society.

The supply chain sustainability management model should include mechanisms for responding to unwanted impacts, as well as preventing their negative impact. A typical supply chain sustainability management model includes six main stages [3]. At the first stage, the so-called "setting expectations" of the participants in the chain is carried out. The focus company informs partners (suppliers and distributors) of the requirements used (standards, norms, rules, etc.) that all participants in the supply chain must adhere to in order to ensure its sustainability. These terms can be included in the terms of contracts. In doing so, it is useful to set not only the requirements, but also the incentives to achieve the sustainability standards.

At the second stage, the risks and impacts of the focus company and other participants in the chain on the environmental, social and economic interests of stakeholders shall be assessed. It is recommended to divide the supply chain into segments, each of which should be assessed for the presence and magnitude of the largest actual and potential risks of adverse effects on people, the environment and the ecosystem. As a means of collecting information, standard methods are used, including self-assessment, external audit, employee and customer surveys, official statistics, etc. In the third stage, previously collected data is used to assess the sustainability of the supply chain. If necessary, at the fourth stage, the existing organizational or technological processes in the supply chain are adjusted to increase their efficiency and meet the established requirements. As a rule, operational and organizational improvement is carried out on an ongoing basis. For this, there are two following stages. At the fifth stage, partnerships are strengthened, interaction

between participants in the chain is developed for continuous improvement. At the sixth stage, the monitoring reveals the remaining problems in individual links of the supply chain, which reduce its sustainability. This information is needed to further improve the operations, adjust the standards used, and develop case studies to educate stakeholders on how to solve the real sustainability issues.

Currently, sustainability standards in most supply chains contain a set of environmental, social and even ethical criteria for assessing the performance of the participants. These requirements apply not only to the suppliers or the first-tier consumers, but also apply to the entire supply chain from primary raw material producers to end-users. Such a management mechanism ensures real integration of the activities of the participants in the supply chain, organizes their work on the basis of uniform rules and stimulates compliance with the sustainability standards.

For the systematic organization of work on the assessment of the suppliers, it is recommended to create special structures that will collect and study information about the circumstances of the extraction, trade, processing, handling and export of the resources used. The methodological framework for sustainable procurement policy is the OECD Guidelines for Due Diligence of Responsible Supply Chains for Minerals from Conflict-Affected and High-Risk Areas [4]. These guidelines help to identify the resources that could be obtained from the so-called conflict zones and areas of increased risk of supply chain sustainability. Conflict zones are characterized by institutional weakness, political instability, insecurity, armed confrontation, physical violence and illegal labor.

The peculiarities of the influence of disruptions and failures on the stability of the supply chain have been considered in [5]. The level of stability of the supply chains is characterized by its ability to maintain stable values of the parameters of working processes, and the range of their possible deviations shall not exceed the threshold values. With low resilience, almost any disruptions and failures will lead to a stop in the supply chain. With moderate stability, disruptions do not give up a significant impact on the operation of the supply chain, and failures lead to an increase in operating costs to maintain the stability of work processes. With a high level of resilience, failures can cause disruptions in the operations of individual links without affecting the operation of adjacent sections (downstream or upstream) of the supply chain.

For disruptions, models of managerial decision-making are used, which should ensure the reduction of negative consequences from impacts and prevent their recurrence. Reactive models provide for the organization of ongoing monitoring of process parameters, identification of disruptions, determination of the reasons for their occurrence, and then the development of management decisions, the implementation of which will lead to the restoration of the normal operation of the supply chain links. For these purposes, standard methods of conducting a cause-and-effect analysis and improving the quality of production processes are used [6, 7].

Models for responding to the failures in the supply chains are more proactive and must either prevent the failures or ensure that the state of the supply chain changes in advance so that the emerging failures do not lead to a shutdown of links or other negative consequences. These failure response models provide for the transformation of supply chain management systems into “flexible” and “transparent” structures. Agile Supply Chain characterizes the ability of its participants to quickly respond to failures and disruptions in the supply parameters. To reduce the risks of disruptions in operations, various response measures are applied, including the redistribution of resources, personnel, attraction of additional equipment, machines, etc. between the areas. Taking operational measures can restore the normal operation of the supply chain. Potential losses from undesirable impacts can be compensated by the created reserves. Well-established interaction between chain participants and stakeholders provides an early warning of potential risks of disruptions in

sustainability and allows mobilizing the necessary resources before negative consequences appear.

The flexibility of the supply chain in the event of failures manifests itself in a quick response to changes in "downstream" demand due to fluctuations in the sales of finished products. At the same time, it is important to ensure a rational level of flexible response to changes in demand, so as not to provoke the "whip effect", which will spread "upstream" of the supply chain and further increase the imbalance in the work of its links [8]. Supply chain flexibility also translates into the ability to quickly find alternative suppliers of critical materials to keep the focal company running smoothly in the event of failures in the old supply chain. Therefore, diversifying supply sources is an effective means of increasing the flexibility of supply chains and maintaining their resilience without creating excess insurance stocks.

Supply Chain Transparency characterizes the ability of stakeholders to obtain the necessary information about its work, participants and operations performed. This information includes data about the resources used, including how they are mined, the amount of taxes, royalties and fees paid by the supplier to government agencies, and other information that allows you to establish compliance with environmental and social sustainability requirements.

Digital technologies of tracing of material flows and transactions play a significant role in ensuring the transparency of supply chains. For example, many industries use Blockchain technology to trace the path of resources along the supply chain. For a number of years, RCS Global has been collecting data on the passage of raw materials from fields to production facilities, oil refineries, metallurgical plants. RCS Global recently teamed up with IBM to create a blockchain supply monitoring platform. The platform provides a reliable and secure communication environment, which improves control efficiency and reduces supply chain audit costs. Blockchain platforms are used for more than just material flow monitoring and supplier verification. On their basis, many companies are developing infrastructure for building Smarter Supply Chains, which ensure a high level of transparency, visibility and trust.

Ensuring flexibility and transparency is key to achieving proactive supply chain management as disruptive influences are becoming the norm. For proactive management, it is necessary to organize a continuous identification of "weak signals" (signs of failure) in each link of the supply chain, which in the long term can threaten the stable operation of the supply chain. If there are such signs, the management company (4PL operator) should take the response measures. In particular, sources of supply can be changed, safety stocks formed, alternative modes of transport are involved, work is organized on duplicate routes, the supply chain is reconfigured, or other necessary measures are taken.

Digital technologies are actively used to obtain information about failures in the early stages of their inception. For example, the "Internet of Things" technology allows you to collect information from multiple sensors. The value of the "Internet of Things" technology lies in the organization of virtually continuous collection of a large amount of various data about the working conditions of participants in the supply chain for subsequent automated processing of information, rapid exchange of information about transactions, while providing the so-called Supply Chain Visibility. Radio-frequency identification (RFID) means are among the fairly widespread digital technologies for the automated collection and transmission of information.

The tag memory can contain information about the product, its manufacturer, order, recipient, shipment time, location (pallet, container, etc.). This information is used to identify and track products throughout the supply chain, from production to final consumption (sale and, if necessary, disposal). RFID tags are also successfully used for managing goods in a warehouse, monitoring the location of vehicles or equipment while

moving inside the warehouses. Information from the tags is promptly transmitted to dispatch services and data processing centers ("Control Towers").

The main feature of the information collected in an automated mode on work processes in supply chains from distributed devices is its scale, heterogeneity, unstructuredness and significant volume. Therefore, for its processing, special technologies for analyzing Big Data are used, which systematize disparate information and extract from them “new knowledge” (Data mining) about controlled processes for making management decisions. The "mined" information is used in the following management tasks. First, control of the actual state of work processes in supply chains and in the external environment. Secondly, the formation of forecasts regarding the likely dynamics of the development of events of various natures (economic, technogenic, etc.), on which the stability of the supply chain depends. Third, identifying the bottlenecks in supply chains. For example, interrelationships between trends in changes in foreign exchange rates, market prices for assets used, demand for manufactured products, etc. may be of interest. The identified dependencies are taken into account when developing recommendations for a preventive response to deviations and potential failures. Artificial Intelligence technologies can be used to develop such recommendations.

4 Conclusion

The traditional model of responding to disruptions and failures in supply chains provides for the creation of the reserves of production capacity and safety stocks of material resources and marketable products, which, in turn, increases the need for companies in financial resources to maintain the reserves. Therefore, improving the sustainability of the supply chains allows its participants to work more efficiently, save money, eliminate duplication and, as a result, reduce the cost of maintaining a high level of reserves.

The supply chain resiliency models include a system of responses to disruptions and failures. In case of disruptions, response models are applied based on the control of process parameters, the subsequent analysis of the causes of disruptions and the development of measures to restore the normal operation of the links in the supply chain. Effective disruption response involves the use of proactive response models. For this, it is necessary to ensure flexibility and transparency of processes in all links of the supply chain based on digital services for material flow control and mining of big data. Systemic measures to introduce proactive supply chain management based on a wide arsenal of digital technologies create conditions for automating business processes and optimizing them, taking into account the dynamics of the analyzed factors. This approach will help mitigate the negative impact of extreme factors that disrupt the sustainable operation of supply chains.

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