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Stable Supply Chain in Terms of Geopolitical Risks

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Abstract: A stable supply chain is the key to the success of every company, especially in the context of current challenges such as globalization and geopolitical instability. This paper addresses the issue of supply chain stability and management (SCM) through an analysis of domestic and foreign literary sources, utilizing systems theory to examine the interconnectedness of supply network elements. The study identifies critical pressures including capacity constraints, skilled worker shortages, and climate change impacts. It emphasizes the necessity of sustainability, presenting the "9R" closed-loop supply system as a vital model for minimizing waste and resource inputs while maintaining economic value. Furthermore, the results highlight the increasing role of digitalization and artificial intelligence in ensuring comprehensive visibility and forecasting. The research concludes that logistics must evolve from a cost-optimized operation into a strategic tool for risk management. To ensure future stability and resilience, companies must focus on supplier diversification, invest in automation, and integrate cyber resilience into their organizational culture.

Keywords: Supply chain stability, sustainability, closed-loop supply chain, logistics, cyber resilience

1. Introduction

Globalization brings new opportunities but also complications in supply chain management. Increased competition in the international market forces constant process optimization. Different legislative requirements in individual countries complicate the delivery of goods. Logistics is becoming more complex due to the variability of cross-border transport.

Differences in cultural norms and customer preferences are emerging, requiring flexible adaptation of strategies. Diverse languages also present communication barriers between partners. Effective collaboration across different regions becomes the formula to success.

Sustainability across the supply chain involves ecological, social, and economic aspects. Green initiatives help reduce greenhouse gas emissions and waste. Creating transparent supply networks ensures ethical practices throughout the chain. Customers prefer suppliers who adhere to sustainable practices, which influences their purchasing decisions.

The paper presents the first part of the research, which outlines the current barriers disrupting the stability of the supply chain. Based on this section, the authors will use a set of proposed questions for further research that address supply chain stability through supplier diversification. These questions will be posed to industry experts as part of applying the brainstorming method of creative thinking.

2. Literature Review and Methodology

The presented findings result from an analysis of domestic and foreign literary sources. The main philosophy of most companies and supply chains is to maximize added value for the customer, optimize offered services with a strong emphasis on customer service from the perspective of all three of its components: pre-sales, sales, and after-sales [1,2].

According to [3], a supply chain is defined as a network of interconnected and independent organizations cooperating in control and management, but also in improving the flows of materials and information from suppliers to users. Furthermore, in [4] it is stated that a supply chain represents a sequence of organizations directly connected by one or more upstream or downstream flows, not only of materials and information, as stated in [3], but also of products, services, and funds.

Source [5] specifies that the supply chain includes not only manufacturers and suppliers but also transporters, providers of other logistics services, retailers, and customers. Authors [6] describe supply systems oriented towards providing services to end customers as open, dynamic, and stochastic systems.

From the perspective of systems theory, supply systems are gradually expanding with additional elements and logically with additional links (mutual and feedback). It is, therefore, a system with a complex structure supplemented by feedback loops. For this reason, the term "supply system" is often replaced by the expression "supply network". The concept of Supply Chain Network, translated as supply network, is also used by [7], according to whom a company's supply network includes its suppliers, direct customers, customers of their customers, and end customers.

Before solving problems associated with managing supply systems, their classification is necessary according to [6]. The first step requires defining the elements of the system itself. Subsequent steps focus on identifying essential elements of the system's environment, the links between individual system elements, and the links between system elements and environmental elements.

In work [8], the author also defines logistics chains and logistics systems, which are closely related to supply chains and systems. He describes logistics chains as interconnected sequences of activities whose realization is a necessary condition for achieving a set final effect of a synergistic nature. The author defines a logistics system as a purposefully arranged set of all technical means, equipment, buildings, routes, and personnel participating in the realization of logistics chains. Logistics chains are, according to the above characteristics, a subset of supply chains, and a supply system can be understood as a set of logistics systems connected horizontally and vertically.

According to [9], a crucial step in the supply chain is the identification of individual links (elements) that are part of it or enter it during business operations. It is necessary to determine the links between these elements, as the intensity and depth of relationships between individual supply chain elements can be one of the key factors for its successful management. The supply chain should be viewed as a purposefully created set of organizations that realize a sequence of activities within the chain and have links between them. From the perspective of systems theory, it is actually a supply system consisting of a certain number of elements – carriers of activities that need to be realized. To ensure supply chain management meets its set goals, a wide range of aspects must be considered; from the perspective of systems theory, this primarily concerns the properties of the system and its structure regarding material flows.

In addressing the study of supply chain stability, basic scientific methods were applied, such as analysis, synthesis, and methods of information collection and classification. The conclusions are used for the next phase of the research, where the brainstorming method of creative thinking will be applied. Saaty's method will be used to analyze and solve this decision-making problem. The criteria and alternatives will be compared pairwise to determine preferences and the weight of each preference.

3. Results

Supply chains have come under pressure due to geopolitical conflicts, technical failures, bottlenecks (capacity constraints), shortages of skilled workers, inflation, and growing impacts of climate change. Expected changes in the global power structure may trigger high import tariffs affecting the automotive industry. Tensions in global trade create a potential impact on critical sectors of the global economy. Regulatory changes may result in longer lead times, inventory shortages, and potentially higher production costs. Companies must stay ahead of trade policy developments and mitigate some of these changes through comprehensive supply chain visibility combined with AI forecasting.

3.1 Current Challenges and Trends

Balance between talent and technology. Companies must pay more attention to employee mental health and develop motivational strategies for the new generation of professionals. They should consider how AI will affect the workforce and train employees to use these tools. AI tools should be user-friendly with low entry barriers.

The role of third-party logistics (3PL) providers is growing in importance. Outsourcing to 3PL is about ensuring reliability, scalability, flexibility, and sustainability, but brings cost pressure challenges. To meet demands, 3PLs must increase efficiency and productivity while addressing talent shortages. This involves increased automation and partnering with robotics system providers to integrate the best technologies adapted to 3PL and end-customer needs [10].

Surveys in Germany show unstable logistics due to supply chain disruptions (48.7%), skilled worker shortages (71.8%), and cybercrime (64.1%). Political risks (43.6%) and climate change (18%) followed as general dangers. Data-driven business models offer increasing interfaces for cybercriminals to penetrate logistics chains [11].

3.2 Sustainability and Structural Changes

Decreasing trade barriers and the development of new technologies have allowed supply chains to expand across regions and countries. The long-term functionality of managing such a system increases the requirements for its sustainability [12].

Sustainable supply chain management is understood as the management of raw materials and services between chain elements that considers the social and environmental impacts of its activities. Delivering a product to a customer makes economic sense but increases traffic intensity and negatively affects the environment [13].

In current market world, there is no way for a business to support sustainability only from the perspective of its own company [12]. The entire supply chain must demonstrate sustainability elements to remain competitive. Advantages include strengthening the company name, customer loyalty, satisfaction of all participants, and reducing negative impacts. A sustainable supply chain appears more transparent, helping companies react quickly to unexpected market changes.

As a result of pressure for sustainability, many companies are developing their own certification programs for suppliers [14]. These are adapted to their specific needs, though few use resources for continuous monitoring, which can lead to inefficiency.

The supply chain manages supply activities to maximize value for the customer [15]. Effective management increases competitive advantage. Coordinated effort affects cost management from input material to final distribution.

The basis for successful functioning is the effort of all chain links to achieve common goals, but this strategy can be problematic. Supply chain members may have different agendas and plans that conflict with common ones [16].

For a better understanding of the chain, a description of the general structure is suitable. A classic supply chain is essentially linear (Supplier → Manufacturer → Distributor → Retailer → Customer). With the advent of the internet, businesses began connecting into more complex structures. Outsourcing is used for many activities. The chain loses its linearity and contains multiple entities connected by various forms of standard or electronic business (e-business) [17].

There are three cross-industry priorities for effective logistics chains:

1. **Transparency:** Important for all participants to have accurate information on inventory status.
2. **Connectivity:** Ability to exchange and interpret information.
3. **Agility:** Necessary for partners to use information for effective changes. Current information loses meaning if the company cannot develop a fast enough response to adapt flexibly to the real situation [18].

The supply chain is defined in literature in various mutations. Authors in [19] define it as: A set of interconnected links (companies, facilities) participating in material and information flow and its necessary transformations into the final product to maximally satisfy the end customer. According to this, it is a dynamic connection of the consumption market with markets of raw materials, tangible and intangible elements, bound to a specific order or product raw material [18].

A chain link is a grouping of passive and active elements performing similar functions (factory, warehouse, etc.). The supply chain should contain only necessary links; others must be removed [19].

For managing a larger number of companies within a chain, establishing common goals is crucial. Their setting is the first step of partnership within the supply chain [20]. When focusing on sustainable functioning, these goals submit to the concept of three sustainability pillars (economic, ecological, social). A sustainable supply chain definition doesn't arise just by adding the word "green"; it must have a realistic financial structure and contribute value to our society [13].

Sustainable supply chain management combines current logistics trends: Lean logistics (economic), Green logistics (environmental), and socially responsible logistics [21]. It is important to create a concept integrating these trends to be meaningful.

The topic of sustainability is more than a fashion trend. Companies realize that introducing this concept can save significant financial resources. According to research published by the Natural Resource Defense Council, fashion brands like Target, Levi Strauss, H&M, and Gap managed to save amounts in the range of up to 15 million USD [22].

3.3 Closed-Loop Supply Systems

The closed-loop supply system "9R" is shown in Fig. 1.

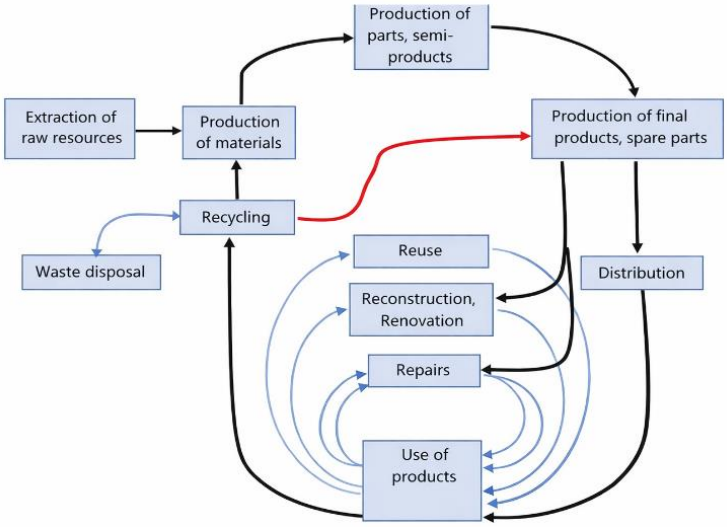

Fig. 1 Scheme of closed supply system "9R". Source: [23]

This involves configuration and coordination of marketing, sales, R&D, production, logistics, etc., to close, slow down, and streamline the loop to minimize resource inputs and waste.

Phases of the closed-loop supply system:

- **Refuse:** Eliminating the satisfaction of needs that burden the environment.
- **Rethink:** Reevaluating ownership vs. renting.
- **Reuse:** Reuse of products.
- **Reduce:** Reducing material/energy consumption and losses.
- **Repair:** Extending life through repairs.
- **Remanufacture:** Renovations to restore original functionality.
- **Refurbish:** Updating products (e.g., furniture).
- **Recycle:** The last option.
- **Repurpose:** Changing the purpose of recycled material.

Within a closed-loop supply chain, companies utilize waste from their production processes to create new goods. This is a sustainable way to protect resources and save energy. Strategies for waste reduction and optimal use of available resources are key to successfully executing the closed approach, which allows manufacturers to better utilize end-of-life products and eliminate waste.

Although a traditional supply chain is often described as a linear process that ends with the customer, the closed-loop approach views the customer as an active part of a circular system. A Closed-Loop Supply Chain (CLSC) consists of two main flows: forward logistics and reverse logistics. Forward logistics focuses on producing and delivering new products to the market. Reverse logistics, on the other hand, takes place after the product has been used. This stage may involve activities such as repairing products, reselling them, or disassembling them so that materials and

components can be reused or recycled. The overall goal is to preserve the value of products and materials while reducing environmental impact and minimizing waste. By returning used products or materials back into the production process, CLSCs help move toward more efficient resource use and reduced waste generation.

The functioning of a CLSC can generally be described through seven key stages. Adopting this model provides advantages not only for the environment and consumers but also for companies that implement it. Businesses can benefit from improved efficiency, cost savings, and additional revenue from recycled or recovered products. At the same time, the need for new raw materials is reduced. Meeting environmental standards also supports a company's reputation and helps maintain good relationships with customers and business partners while ensuring compliance with regulations. Efficient use of energy and materials can further lower operational costs. In addition, well-organized return systems, repair services, and accessible recycling options can improve customer experience, which often leads to higher satisfaction and stronger customer loyalty. Finally, analyzing the full product life cycle provides useful information that can support product improvements and encourage further innovation.

4. Discussion

According to the World Economic Forum, a non-profit international organization founded in 1971 to connect entrepreneurs, politicians, academics, and other key actors [24] to jointly solve global economic, social, and environmental challenges, collaborating with governments, large corporations, and experts from academia, three key paths to ensuring supply chain security are highlighted:

a) **Embedding cyber resilience into organizational DNA**, cyber resilience should be considered a core value of the organization. This includes a top-down management system, ensuring management engagement, and integrating cybersecurity into corporate culture. Creating a strong framework for risk and responsibility management and ensuring necessary resources and training for employees. This approach helps organizations better respond to cyber threats and minimize potential damage.

b) **Using advanced technologies for risk measurement and assessment**, with the growing complexity of supply chains, emphasis is placed on implementing automated monitoring and data analysis to identify vulnerabilities; creating complete lists of software components that allow tracking and evaluating security risks. Using artificial intelligence to predict and detect potential threats in real-time. This technological approach allows organizations to respond faster to incidents and protect their digital ecosystems more effectively.

c) **Proactive and adaptive approach to new cyber threats**, organizations should collaborate with partners and share information about threats and best practices; ensure integration of key

suppliers into continuity planning and conducting joint cyber incident exercises, reducing individual points of failure, and ensuring transparency across the entire supply chain. This approach helps organizations better prepare for unexpected cyber incidents and minimize their impact.

5. Conclusion

The mentioned analytical approaches to solving supply chain stability are part of the solved topic "Stable Supply Chain Management" for a future dissertation. Logistics currently is no longer just an operational matter regarding the transport of goods from point A to point B and inventory management regarding supply or demand variability or both of these parameters. Supply chains were optimized according to costs, but today emphasis is placed on resilience, flexibility, and geopolitical diversification (this is influenced by political and economic tensions between the USA and China, war conflicts, and protectionism in some regions). To prevent goods shortages, it is important to have diversified and redundant supply chains with alternative transport routes.

Logistics is becoming a strategic tool for risk management, growth, and sustainability. Firms that can flexibly react to environmental changes, invest in technologies, and build resilient chains will have an advantage in this turbulent time. Without investments in education, digitalization, and automation, it will not be possible to handle the growing complexity of supply chains, pressure for speed and flexibility, and simultaneously requirements for sustainability. Digitalization, artificial intelligence, and automation increase predictability, efficiency, and resilience of the supply chain. New knowledge and skills focused on data processing, planning, and managing complex systems will be required from workers. Emphasis will be placed on social corporate responsibility.

The research is conducted in a real company that depends on the supply of key components for its final product from single suppliers, which significantly affects the incompleteness of final products when deliveries are unreliable. The analysis of literature sources summarizes the key criteria influencing supply chain unreliability. The method of creative thinking will be used to implement supplier diversification.

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