Parallel Logistics as a Model for Global Supply Chain Synchronization in Complex Environment

DR. JUMMAI ZAINAB UMAR-AJIJOLA
Garden City Premier Business School

Abstract—The model for global supply chain synchronization in a complicated context is parallel logistics, according to the paper. Examining parallel logistics as a paradigm for coordinating global supply chains in intricate settings is the goal of this research. For businesses to obtain raw materials and transform them into completed goods that meet consumer wants, logistics is an essential procedure. In order to meet supply, production, and demand requirements in parallel, the parallel logistics model enables several alternate routes from suppliers to customers to function simultaneously in order to receive the same kind of resources or products. Real-time alignment of material, information, and financial flows throughout the supply chain is known as supply chain synchronization. Production planning, distribution planning, transportation planning, and customer reaction monitoring are the elements of parallel logistics that are highlighted. This research was grounded in two theories: the Resource Based View and network theory. The optimization and planning of the traffic infrastructure system, traffic systems, and transportation technology contained in the overall logistic system are therefore understood by the planning of the parallel logistic and supply chain synchronization. This is the exact rationale behind the development of the logistic and distribution process parallel planning model, which comprehends the simultaneous planning of every logistic process component. Based on real-time data, the end result is a synchronized, optimized planning of the entire logistic process.

Keywords—Parallel Logistics, Supply Chain Synchronization, Complex Environment

I. INTRODUCTION

Over the past ten years, organizations and their network of enterprises have experienced substantial transformations. The business climate became more complex and uncertain as a result, and there were more operational issues including late deliveries, quality issues, lead time gaps, order cancellations, and the like. A supply chain's complexity arises from two distinct features: first, the quantity and variety of organizations that make up the chain; and second, the interdependence of component interactions that may result in complex behavior (Maisam & Liz, 2022).

According to Andrés and Henry (2021), Aghajani et al. (2020), and Vahdani et al. (2018), "these two aspects produce supply chain dynamics, with various uncertainties facing the members over time, such as the level of consumer demand or available capacity." Furthermore, complex environments can react to their ecosystem in multiple ways (Maisam & Liz, 2022). The comprehension of how supply chains are better managed—that is, guided, evaluated, enhanced, and changed toward desired results—can also be aided by a complex environment perspective. Over the past three decades, there has been a significant change in the synchronization of global supply chains (Maisam & Liz, 2022; Hoogeboom & Wilderom, 2020; Asthana et al., 2020). Globalization has increased efficiency and market reach, but it has also made businesses more vulnerable to disruptions like pandemics, geopolitical conflicts, climate-related events, and technological failures (Andrés & Henry, 2021). These advancements in transportation, information and communication technologies (ICT), and trade liberalization have made it possible for businesses to fragment production across borders and coordinate activities on a global scale (Maisam & Liz, 2022).

This has enabled the parallel logistics model to successfully tackle the difficulties.

For businesses to obtain raw materials and transform them into completed goods that meet consumer desires, logistics is an essential procedure (Maisam & Liz, 2022). Supply, manufacturing, and demand activities are all integrated into a sequential pipeline curve that runs from suppliers to customers in traditional logistics. Only when demands have been identified and made can products be produced. Increased product variety, shorter life cycles, and unforeseen disruptions can make these sequential pipelines long and limited, making it difficult to respond quickly to shifting demand (Aghajani et al., 2020). The worldwide logistics market, according to Allied Market Research, was estimated to be worth $8.6 trillion in 2020, making the industry itself a pillar of the global economy (Pindi, 2025). According

to the same estimate, the market is expected to increase at a compound annual growth rate of 6.5% from 2020 to 2027, reaching $12.9 trillion by that time (Pindi, 2025). The rise of e-commerce and the use of cutting-edge technologies throughout the logistics value chain are two of the main drivers of this expansion. Because of its adaptability and wide-ranging infrastructure networks that encompass the majority of existing and developing regions, road transport is the largest sub-segment of the transportation segment, which dominates the logistics market (Pindi, 2025).

The purpose of the parallel logistics model is to reduce these limitations. To meet supply, production, and demand requirements in parallel, the parallel logistics model enables several alternate routes from suppliers to customers to function simultaneously in order to receive the same kind of resources or products (Creazza et al., 2012; Andrés & Henry, 2021). Parallel logistics incorporates various lanes and modes to promote price competition, adds redundant input and output capacity to deal with uncertainties, and offers stepwise detailed decision rights for clarity and gradual convergence (Andrés & Henry, 2021). In order to maximize the performance of logistics operators, it is therefore essential to describe the logistics and distribution processes, their components and interrelations, their effects, and the planning process methodologies. One interesting alternative paradigm is parallel logistics. Parallel logistics allows several logistical processes, scenarios, and decision routes to function concurrently rather than depending on a single, centralized, sequential flow of choices and operations. With the help of digital twins, distributed intelligence, and real-time data analytics, parallel logistics enables businesses to plan ahead for disruptions, assess multiple strategies concurrently, and synchronize informational and physical flows across networks (Maisam & Liz, 2022; Hoogeboom & Wilderom, 2020; Asthana et al., 2020).

Many worldwide supply chains still suffer from synchronization issues, which show up as delays, inventory imbalances, the bullwhip effect, and service interruptions, despite the increased interest in digital and intelligent logistics solutions. The logistics coordination systems that are already in place are frequently reactive, compartmentalized, and inadequately integrated across organizational and geographic borders. Although the idea of parallel logistics has been covered in newer works, little systematic research has been done on how well it works as a model for synchronizing global supply chains, especially in complex and unpredictable contexts. Businesses could find it difficult to convert the idea into successful operational plans if they don't have a solid grasp of the mechanisms, supporting technologies, and governance requirements of parallel logistics. The aim of this study is to examine parallel logistics as a model for synchronizing global supply chains in complex environments. The specific objectives are to:

i. conceptualize parallel logistics within the context of global supply chain management.
ii. analyze the characteristics of complex environments affecting supply chain synchronization.
iii. develop a framework explaining how parallel logistics enables global supply chain synchronization.
iv. identify the benefits, challenges, and risks associated with implementing parallel logistics.

II.   LITERATURE REVIEW

2.1 Concept of Global Supply Chain Synchronization
Networks of businesses, individuals, activities, data, and resources that move goods and services across national borders from suppliers to consumers are referred to as global supply chains (Maisam & Liz, 2022). Interdependence, organizational fragmentation, and geographic dispersion are characteristics of contemporary global supply chains. According to scholars, attaining efficiency and responsiveness in these networks requires efficient coordination and synchronization (Hoogeboom & Wilderom, 2020). Aligning material, information, and financial flows throughout the supply chain in real time is known as supply chain synchronization (Asthana et al., 2020). Synchronization improves service levels, decreases inventory buffers, and cuts down on delays. However, attaining synchronization becomes increasingly challenging as uncertainty and complexity rise (Maisam & Liz, 2022; Hoogeboom & Wilderom, 2020; Asthana et al., 2020).

2.2   Parallel Logistics
According to Hoogeboom and Wilderom (2020), parallel logistics is a logistics paradigm that allows for real-time synchronization across supply chain networks by executing and evaluating several logistical processes, decision scenarios, and

operational pathways concurrently. The idea is inspired by cyber-physical systems, parallel systems engineering, and parallel computing. Decision parallelism, process parallelism, information parallelism, and adaptive coordination are important aspects of parallel logistics (Maisam & Liz, 2022; Hoogeboom & Wilderom, 2020; Asthana et al., 2020). Parallel planning scenarios, route alternatives, inventory policies, and coordination mechanisms backed by digital technologies like artificial intelligence and digital twins are all part of logistics (Hoogeboom & Wilderom, 2020). In global supply chains, the parallel logistics model signifies a fundamental change in the planning, management, and operation of logistics systems (Maisam & Liz, 2022).

Parallel logistics embraces simultaneity, decentralization, and ongoing adaptability in contrast to conventional linear logistics models, which depend on sequential planning and centralized management (Maisam & Liz, 2022). The underlying premise of the parallel logistics model is that global supply chains cannot completely eradicate uncertainty. Single-path logistics planning is intrinsically vulnerable to demand instability, geopolitical upheavals, infrastructure limitations, and environmental shocks (Hoogeboom & Wilderom, 2020). In response, parallel logistics keeps several logistics solutions operational or prepared simultaneously. Alternative sourcing agreements, shipping routes, inventory positioning plans, and fulfillment channels are a few examples of these choices. Organizations continually assess and alternate between options as circumstances change, as opposed to choosing a single "ideal" plan ex ante (Maisam & Liz, 2022; Asthana et al., 2020). Another key component of the concept is information synchronization. High-frequency data flows produced by enterprise systems, IoT devices, and external data sources are essential to parallel logistics. Cybernetics and complex adaptive systems are reflected in the parallel logistics concept. The parallel logistics concept redefines efficiency from a strategic standpoint. While parallel logistics may have higher short-term costs due to redundancy and digital investment, it provides long-term value through reduced disruption impact, faster recovery, and improved service reliability (Piya et al., 2019; Statsenko et al., 2018; Tu et al., 2019). Efficiency is now measured by the system's ability to sustain performance under stress rather than just cost minimization or asset utilization. The following are parallel logistics components (Piya et al., 2019; Statsenko et al., 2018; Tu et al., 2019):

Production Planning: The goals of the company's overall operations provide the basis for production planning. Minimizing production time, minimizing capital bonding, adhering to production terms, optimizing capacity utilization, minimizing equipment expenditures, and minimizing transportation costs are the production and economic goals of production planning. Determining the production operations' timetable and the amount of commodities produced are the responsibilities of production planning. Data on the anticipated overall demand and inventory levels are analyzed during the planning process, and the goal is to ascertain the production level that will meet actual demand without generating needless surpluses.

Distribution Planning: The processes of packaging, storing, and physically delivering the final product to the client are all included in the distribution of finished goods. One aspect of supply chain management is distribution organization. Improved distribution planning can result in significant cost savings and higher customer satisfaction. Distribution network planning is an extremely difficult process that takes a lot of work to get the best result. It involves analyzing a lot of data, and the process itself would be impossible without information technology.

Transportation Planning: Determining the mode of transportation (rail, road, sea, and air), distribution routes, shipment volumes, fleet size and type, and other factors are all part of transportation planning. In addition to producing quantifiable savings that are manifested in tangible transportation indicators, rationalization of transportation also contributes to a decrease in overall expenses by standardizing packages, implementing handling technologies, transportation methods, infrastructure, etc. It is crucial that the transportation processes—that is, the use of technology—are the only ones that have an impact on traffic, and that more traffic on roads need greater regulation. It is clear that as the role of transport in the structure of social reproduction grows, so does the requirement for regulation of this transport's operation.

Monitoring Customers' Reactions (ECR – Efficient Consumer Response): One branch of logistics that emerged from the supply chain is ECR, which

emphasizes supplier-organization collaboration as a creative way to approach supply chain collaboration. It is possible to identify two core ideas that are present in every ECR: A focus on the customer; dedication to the idea that delivering goods and services that continuously meet or exceed the needs and expectations of clients is the only way to achieve long-term company success; Cooperation; Realization that in order to remove the obstacles that impede efficiency and effectiveness, trade partners must collaborate both inside their own organization and with their trading partners in order to provide the best possible consumer value.

2.2 Parallel Logistics and Supply Chain Synchronization

Alignment across three interconnected dimensions—material flows, information flows, and decision flows—is necessary for supply chain synchronization. By allowing these dimensions to function concurrently rather than sequentially, parallel logistics improves synchronization. Parallel logistics facilitates flexible distribution systems, multi-sourcing, and multi-routing in material flows, which lessen reliance on individual nodes. Digital platforms facilitate real-time visibility and predictive analytics in information flows. Distributed intelligence enables local players to stay in line with global goals while making context-sensitive decisions in decision flows. According to Olivares et al. (2018), three factors are essential for a supply chain synchronization: transformation (facilitating interactions, expanding capacity and capability when needed), robustness (i.e., maintaining some level of functional parts and pathways or the ability to run the system at different flow levels, or the ability to cope with errors during synchronization), and Asokan et al. (2017).

Theoretical Framework

Resource Based View: According to the Resource Based View (RBV), the firm's sustainable competitive advantage stems from its resources, which are valuable, uncommon, imitable, and non-substitutable. The knowledge-based perspective of the company (Grant, 1996), core competency (Prahalad & Hamel, 1990), capabilities theory (Helfat & Peteraf, 2003), and the dynamic capabilities view (Teece et al., 1997) are some of the theoretical improvements that have resulted from extensions of the idea. Resource-Based View: How specific resources and skills provide a basis for

greater performance and competitive advantage (Barney, 1991). This theory explains how firms may be able to achieve a lasting competitive advantage through the special deployment and combination (referred to as "capabilities") of tangible and intangible resources (Grant, 1996; Prahalad & Hamel, 1990). Viewing the company as a collection of resources and claiming that resource heterogeneity exists among corporations is the core tenet of the RBV. Over the past ten years, the implementation of the resource-based concept in organizational supply chain management has received increased attention. The main areas of application of RBV in supply chain management include structural analysis (Miller & Ross, 2003) and determining the supply chain's antecedents for competitive advantage (Ashish & Rajkiran, 2019). In Ashish and Rajkiran's (2019) investigation of the capacity and performance of global supply chains, Morash and Kill (2002) employed a resource-based perspective. According to Halldórsson et al. (2007) in Ashish and Rajkiran (2019), RBV serves as the implicit foundation for most supply chain management choices.

The application of RBV to the influence of IT on organizational supply chain capabilities and performance was demonstrated in a different study by Yeniyurt et al. (2005) in Ashish and Rajkiran (2019). In Ashish and Rajkiran (2019), Gold et al. (2009) expanded the use of the resource-based paradigm to include inter-organizational relationships within businesses. Additionally, they used this relational aspect of RBV to "collaborate across the supply chain." This viewpoint has drawn criticism, nevertheless, for not suggesting ways for businesses to obtain the resources required for expansion and gaining a competitive edge.

Network Theory: Value creation through inter-organizational relationships was the main focus of the networks approach, which is often referred to as networks theory in the literature (Ashish & Rajkiran, 2019). The concepts of strong and weak ties are central to network theory. As the titles imply, businesses with tight relationships have strong ties, while businesses with many weak ties have loose ties (Ashish & Rajkiran, 2019). Each type offers supply chains certain benefits. It explains, characterizes, and forecasts relationships between related entities (Thorelli, 1986 in Ashish & Rajkiran, 2019). Since supply chains are essentially a kind of network, network theory may be able to uncover some

intriguing facts about them. However, organizational supply chains are vulnerable to a wide range of dangers when supply chain networks are extended to many different professional and geographic areas. Both international supply chain studies and supply chain studies in particular industries or nations have made use of the networks concept (Ashish & Rajkiran, 2019).

A more comprehensive explanation of the inter-organizational interactions in a network environment is offered by the network theory (NT). It acknowledges the impact of partner relationships on an organization's operations and draws attention to the dynamics of network environments (Ashish & Rajkiran, 2019). According to the Network Theory, a network resource view helps managers create a lot of accurate assessments of individual node resources and their business implications by highlighting the idea of strong and weak linkages. Additionally, the theory is useful for examining bilateral partnerships' duration and trust (Gadde & Håkansson, 2001 in Ashish & Rajkiran, 2019). By using a network strategy, businesses will plan their supply chains to take advantage of features like strong linkages, which establish dependability, and weak ties, which provide flexibility in managing responsiveness. By illustrating network-wide knowledge-sharing processes and management, the NT also has implications for supply chain innovation (Miles & Snow, 2007).

2.3 Review of Related Review of Literature

The logistic optimization of a complicated manufacturing system with parallel production lines was studied by Bucki et al. (2013). The challenge of mathematically simulating a complex manufacturing system—a possible artificial depiction of an actual production environment—is highlighted in the paper. There are parallel production lines. Work stations are arranged serially along a predefined trajectory on each production line. Every workstation has the specified tool needed to produce the specific product. Heuristic algorithms are used to govern the system in order to satisfy the manufacturing requirements. The article highlights models for additional optimization and simulation processing while demonstrating the fundamentals of contemporary manufacturing systems. The general background information about this subject is provided first. The paper's second section focuses on a particular manufacturing system

and offers heuristic algorithm-based optimization strategies to achieve the specified criteria.

Pindi (2025) looked into how supply chains and logistics contribute to interconnectedness and globalization. Advanced warehouse facilities combined with the integration of multimodal transportation systems have produced sophisticated networks that can handle intricate patterns of international trade. Cloud computing, blockchain, artificial intelligence, and the Internet of Things are just a few examples of the digital technologies that have transformed logistics operations by increasing efficiency and visibility. These systems speed up the spread of knowledge worldwide by facilitating the exchange of technology advancements and cultural components in addition to tangible items. Notwithstanding these developments, the industry still faces several obstacles, including those relating to environmental sustainability, geopolitical conflicts, regulatory inequalities, infrastructural deficiencies, and disruption susceptibility—problems that call for creative solutions and teamwork.

Supply chains are complex systems, and the best way to manage them is to steer them toward desired outcomes rather than control them, according to study by Maisam et al. (2022). Both an exploratory and an explanatory design were incorporated into the research project. A thorough literature research procedure was used to gather data from secondary sources. Analyses and syntheses of the data were conducted concurrently with data gathering. In order to explain why supply chains possess characteristics of complex systems and how to manage their complexity while guiding them toward desired outcomes, the primary finding was the establishment of an inductive framework for steering supply chains from a complex systems perspective. The evaluation of supply chains as complex systems is made possible by the four interdependent categories of complexity properties—structural, dynamic, behavioral, and decision-making.

III. METHODOLOGY

Examining parallel logistics as a paradigm for coordinating global supply chains in intricate contexts is the main goal of this research. Instead of gathering fresh primary data, this non-empirical study synthesizes, analyzes, and interprets existing literature utilizing secondary data from the Review of

Related Literature (RRL). Meta-analyses were employed to gather empirical data in order to draw conclusions and support findings using a larger sample. The report examines research on the logistic optimization of complex manufacturing systems with parallel production lines conducted by Bucki et al. (2013). Their findings highlight models for additional optimization and simulation processing while highlighting fundamental aspects of contemporary industrial systems. A study on the function of supply chains and logistics in globalization and interconnectedness was conducted by Pindi (2025). The study identified the problems with infrastructural gaps, geopolitical conflicts, environmental sustainability, regulatory inequities, and disruption susceptibility—problems that need for creative solutions and teamwork. Supply chains are complex systems, and the best way to manage them is to steer them toward desired outcomes rather than control them, according to study by Maisam et al. (2022). In order to explain why supply chains possess characteristics of complex systems and how to manage their complexity while guiding them toward desired outcomes, the primary finding was the establishment of an inductive framework for steering supply chains from a complex systems perspective.

IV. META-ANALYSIS DATA PRESENTATION

4.1 Rethinking Logistics in Complex Global Environments

Conventional logistics models presuppose centralized decision-making, linear flows, and generally stable surroundings. On the other hand, volatility, uncertainty, complexity, and ambiguity (VUCA) are characteristics of complex global environments. Sequential planning and control are useless under these circumstances. Emergent behaviors, feedback loops, time delays, and nonlinear cause-effect linkages are all features of complex settings (Pindi, 2025). As a result, logistics systems need to be flexible, foresighted, and able to handle several situations at once. In order to address this issue, parallel logistics substitutes several, concurrent logistical procedures for single-path logistics planning. Parallel logistics enables different choices to coexist, be assessed in real time, and be dynamically chosen as circumstances change, as opposed to committing to a single prediction, routing strategy, or inventory policy (Bucki et al., 2013).

4.2 Enabling Technologies and Infrastructure

Digital infrastructure is essential to the seamless operation of supply chain synchronization through parallel logistics. According to Bucki et al. (2013), Maisam et al. (2022), and Pindi (2025), some important technologies are:

Digital twins: Digital twins are digital copies of supply chain systems that enable parallel simulation of several scenarios. Tools for adaptive optimization, disruption detection, and predictive demand forecasting are provided by artificial intelligence and machine learning.

Internet of Things (IoT): Real-time tracking and condition monitoring are made possible by sensors and networked devices.

Blockchain technology: Tools that improve supply chain participants' cooperation, trust, and transparency.

Cloud computing: Scalable systems that facilitate collaboration and real-time data processing. When combined, these technologies turn logistics systems into cyber-physical networks that can synchronize and operate in parallel.

4.3 Complexity Properties of Supply Chain Synchronization

Uncertainty, dynamism, non-linearity, and interconnectedness are characteristics of complex environments. According to complexity theory, tiny disruptions can have disproportionate consequences in global supply chains, which act as complex adaptive systems. The intricate environmental elements influencing supply chain synchronization are as follows (Maisam et al., 2022; Pindi, 2025):

Structural Properties: These characteristics shape the nodes or vertices of relatively static heterogeneous supply chain synchronization subsystems (Pindi, 2025).

Dynamic Properties: These characteristics shape the edges, linkages, and links of supply chain synchronization by defining dynamic heterogeneous inter-flows and inter-processes. The number, volume/degree, frequency, variety, and extent of various product (goods, services) flows, as well as the movable physical/tangible, human, informational,

and financial resources, as well as value-adding business/work processes that move between subsystems or are changed by them, are additional factors that contribute to complexity (Maisam et al., 2022).

Behavioral Properties: This study highlights several properties that were adapted from the properties of complex adaptive systems (CAS), such as self-organization due to the openness and autonomy of their subsystems, emergence due to interactions among subsystems and their nonlinearities over time, and the adaptive and evolutionary capacities of their agent-based subsystems (Maisam et al., 2022).

Emergence Properties: The degree and scope of interactions between the subsystems—that is, the degree and scope of impacts on other subsystems while altering the structural or dynamic qualities of a subsystem—also contribute to complexity. Both linear and nonlinear behaviors can result from these interactions, which are sensitive to the subsystems' past and present circumstances (Maisam & Liz, 2022; Cilliers, 2005; Merali, 2006; Nilsson & Gammelgaard, 2012). Examples of these interactions include demand, lead times, delivery windows, supplier quality or quantity, processing and manufacturing schedules, and employee behavior (de Leeuw et al., 2013; Serdarasan, 2013; Maisam & Liz, 2022).

Decision-Making Properties: As complex systems are interwoven systems which involve interactions at various scales and contexts, decision making by optimizing one parameter might lead to restrictions or conflicts with the other parameters (Serdarasan, 2013; de Leeuw et al., 2013). As a result, decision making in complex systems involves the capacity to semi-optimize the system as a whole when making perfectly separated decisions.

4.4 Mechanisms for dealing with the Complexity of Supply Chain Synchronization

With respects the mechanisms for dealing with the complexity of supply chain synchronization, five mechanisms were inductively conceived from the systematic literature study, namely: categorization, measurement, modeling, relational analysis and handling.

Classification Mechanisms: As mentioned in the previous section, nearly all of the literature that has been systematically reviewed elaborates on the classification of complexity by exposing one or two of the properties of supply chain synchronization complexity.

Modeling Mechanisms: Modeling mechanisms can be summed up as follows: evolutionary game theory, network dynamics, swarm intelligence, simulation-based, and miscellaneous models. Simulation-based models dominated the literature that was systematically reviewed, and they are primarily represented by "agent-based modeling," which offers promising methods for comprehending the dynamic, behavioral, and decision-making properties of complex adaptive SCs by simulating how each agent makes decisions on its own based on interactions with the environment and other agents (Surana et al., 2005).

Measurement Mechanisms: The first group of measurement mechanisms is based on entropy, which is a measure of the dimension of variety, disorder, and uncertainty—the amount of information required to describe or monitor the static/structural or dynamic/operational state of a system (Pindi, 2025). The fourth group of measurement mechanisms includes mechanisms that elaborate on the relational analysis between the complexity properties of supply chain synchronization and various variables, including flexibility, resilience, responsiveness, adaptability, integration, disruptions, risk, costs, innovation, and performance.

Managing Mechanisms: The final group focuses on methods for managing the complexity of supply chain synchronization, which can be summed up as accommodating and mitigating strategies. While accommodating strategies primarily address the behavioral and decision-making aspects of supply chain synchronization complexity, mitigating strategies emphasize the handling of the structural and dynamic aspects of the complexity (Maisam et al., 2022; Pindi, 2025).

Mitigating Strategies: As suggested by Fernandez Campos et al. (2019), the first type of mitigating strategies focuses on a smaller range of elements (e.g., products, suppliers, customers, shipping points, distribution centers, outsourcing partners, and geographies); reduces duplication and redundancy; removes low-volume or low-contribution products from offerings; and uses modular product architecture. This reduces internal diversity while

minimizing the impact of this diversity on the scope of the firms' operations. By reducing non-value-added steps and processes, reducing the range of activities that must bear structural and dynamic complexity in supply chain synchronization while maintaining firm responsiveness, and decoupling practices like assembly sequence planning and postponement, the second type of mitigating strategies highlights optimal supply chain synchronization. Examples of these strategies include: assigning efficient suppliers, partnering firms, or bespoke distribution channels to contain the complexity within a reduced domain, where specialized resources can be leveraged (Maisam et al., 2022; Pindi, 2025).

Accommodating Strategies: According to de Leeuw et al. (2013) and Nilsson & Gammelgaard (2012), accommodating strategies are dominated by those that focus on managing reciprocal interdependencies and interrelationships. This includes the following: the benefits of cooperation; coordination and collaboration among stakeholders, including suppliers, customers, and service providers; decision support through the sharing of information and [both tacit and explicit] knowledge; communication, synchronization, and alignment between learning teams, processes, and functions, both inside and outside the internal supply chain synchronization; intelligent monitoring, connectivity, clustering, pattern recognition, end-to-end visibility and transparency, using big data as well as neural network monitoring and smart parts; and delegated responsivity and risk sharing.

V. CONCLUSION

Direct sales of items from the maker to the final customer are becoming less common in modern goods flows. One may argue that, when taken into account, logistic-distribution systems represent the systems of spatial-temporal transformation of assets and the flowing processes as logistic-distribution processes. There are an increasing number of mediators between the two ends of social reproduction—production and consumption—and each mediating role is given a distinct name. preparing for supply chain synchronization and parallel logistics can be thought of as preparing for all the technologies involved in a process. The optimization and planning of the traffic infrastructure system, traffic systems, and transportation technology contained in the overall logistic system are therefore understood by the planning of the parallel logistic and supply chain synchronization. This fact makes it evident that the logistic and distribution network is a very complex system whose functionality cannot be simply described. Thus, the model of parallel planning of the logistic and distribution process was developed, which understands simultaneous planning of all the logistic process elements, resulting in a synchronized, optimal planning of the logistic processes as a whole, based on real time data. All the elements are interconnected by the flows of goods from the starting points, over the traffic nodes, to points of receipt.

REFERENCES

[1] Aghajani, M., Torabi, S. A., & Heydari, J., (2020). A novel option contract integrated with supplier selection and inventory prepositioning for humanitarian relief supply chains. *Socio-Economic Planning Sciences,* 100780. https://doi.org/10.1016/j.seps.2019.100780

[2] Andrés, G. A. M. & Henry, L. D. (2021). A parallel programming approach to the solution of the location-inventory and multi-echelon routing problem in the humanitarian supply chain. 14th Conference on Transport Engineering: 6th – 8th July 2021, *Transportation Research Procedia, 58*(21), 495–502

[3] Ashish, K.umar Gautam, & Rajkiran Prabhakar (2019). Theories of supply chain management: a literature review. *International Journal of Innovative Social Science & Humanities Research, 1*(6), 88-98

[4] Asokan, V.A., Yarime, M. & Esteban, M. (2017). Introducing flexibility to complex, resilient socio-ecological systems: a comparative analysis of economics, flexible manufacturing systems, evolutionary biology, and supply chain management, *Sustainability, 9,* 1-17.

[5] Asthana, S., Gradinger, F., Elston, J., Martin, S. & Byng, R. (2020). Capturing the role of context in complex system change: an application of the Canadian context and capabilities for integrating care (CCIC) framework to an integrated care organisation in the UK", *International Journal of Integrated Care, 20,* 1-10.

[6] Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17,* 99-120.

[7] Bozarth, C.C., Warsing, D.P., Flynn, B.B. & Flynn, E.J. (2009). The impact of supply chain complexity on manufacturing plant performance, *Journal of Operations Management, 27,* 78-93.

[8] Bucki, R., Suchánek, P. & Chramcov, B. (2013). Logistic optimization of the complex manufacturing system with parallel production lines. *Journal of Applied Economic Sciences, 8*(3), 1-11

[9] Cilliers, P. (2005). Complexity, deconstruction and relativism, *Theory, Culture and Society, 22,* 255-267.

[10] Creazza, A., Dallari, F., & Rossi, T. (2012). An integrated model for designing and optimising an international logistics network. *Computers and Industrial Engineering, 65,* 503-513.

[11] de Leeuw, S., Grotenhuis, R. & van Goor, A.R. (2013). Assessing complexity of supply chains: evidence from wholesalers, *International Journal of Operations and Production Management*, 33, 960-980.

[12] Fernandez Campos, P., Trucco, P. & Huaccho-Huatuco, L. (2019). Managing structural and dynamic complexity in supply chains: insights from four case studies, *Production Planning and Control, 30,* 611-623.

[13] Grant, R. (1996). Towards a knowledge-based view of the firm. *Strategic Management Journal, 17,* 109-122

[14] Helfat, C. E., & Peteraf, M. (2003). The dynamic resource-based view: capability lifecycles. *Strategic Management Journal, 24*(10), 997–1010.

[15] Hoogeboom, M.A.M. & Wilderom, C. P. (2020). A complex adaptive systems approach to real-life team interaction patterns, task context, information sharing, and effectiveness, *Group and Organization Management, 45,* 3-42.

[16] Maisam, A. & Liz, V. (2022). Steering supply chains from a complex systems perspective. *European Journal of Management Studies, 27*(1), 5-38. Emerald Publishing Limited. DOI 10.1108/EJMS-04-2021-0030

[17] Merali, Y. (2006). Complexity and information systems: the emergent domain. *Journal of Information Technology, 21,* 216-228.

[18] Miles, R.E., & Snow, C.C. (2007) Organizational strategy, structure, and process, *The Academy of Management Review, 3*(3), 546-562.

[19] Nilsson, F. (2005). *Adaptive logistics – using complexity theory to facilitate increased effectiveness in logistics,* MediaTryck AB

[20] Olivares, A. J. & El-Maraghy, W. (2018). Structural complexity and robustness of supply chain networks based on product architecture. *International Journal of Production Research: Modularity and Supply Chain Management, 56,* 6701-6718.

[21] Pindi, M. (2025). The role of supply chain and logistics in globalization and interconnectivity, *European Journal of Computer Science and Information Technology*, *13*(18), 65-75

[22] Piya, S., Shamsuzzoha, A. & Khadem, M. (2019). An approach for analysing supply chain complexity drivers through interpretive structural modelling, *International Journal of Logistics Research and Applications, 23,* 1-26.

[23] Prahalad, C. K., & Hamel, G. (1990). *The Core Competence of the Corporation.* Harvard Business Review Onpoint Article

[24] Serdarasan, S. (2013). A review of supply chain complexity drivers, *Computers and Industrial Engineering, 66,* 533-540.

[25] Statsenko, L., Gorod, A. & Ireland, V. (2018). A complex adaptive systems governance framework for regional supply networks, *Supply Chain Management: An International Journal, 23,* 293-312.

[26] Surana, A., Kumara, S., Greaves, M. & Raghavan, U.N. (2005). Supply-chain networks: a complex adaptive systems perspective, *International Journal of Production Research, 43,* 4235-4265.

[27] Teece, J. D., Pisano, G., & Sheun, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509-533.

[28] Tu, H., Mao, X. & Wang, X. (2019). Complexity of a dynamic hybrid supply chain game model with a service factor, *Nonlinear Dynamics, 97,* 2055-2066.

[29] Vahdani, B., Veysmoradi, D., Noori, F., & Mansour, F., (2018). Two-stage multi-objective location-routing-inventory model for humanitarian logistics network design under uncertainty. *International Journal of Disaster Risk Reduction, 27*(17), 290–306. https://doi.org/10.1016/j.ijdrr.2017.10.015