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The Concept of Dedicated Agility: A Literature Review and Research Framework

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Abstract:

Purpose: *The aim of this research was to propose a solution that would enable enterprises to adapt to the changing conditions of manufacturing operations and improve the management of information and material flow within the production network. It was assumed that this improvement would be achieved by building and analysing a model that would enable achieving a dedicated level of agility within the production network.*
Design/Methodology/Approach: *The concept was based on estimating the variability of impact factors and the balance between the benefits and costs incurred in achieving agility. Factors were modified through three parameters: the allowable range of deviations, the dynamics of change, and the speed of adaptation. The foundation of the proposed solution is the implementation of a feedback mechanism, deployed at the level of an individual enterprise, but also at the level of the production network. A multi-level control system was created, encompassing the planning and supervision of production activities of multiple business entities. It was assumed that data transfer between entities would be subordinated to the data structure of integrated IT systems. It was assumed that material flow destabilization in the production network could be mitigated through a harmonious flow of information between organizational units and business entities within the network.*
Findings: *In response to the challenges of the VUCA environment, the author proposed a model that is a three-step approach to creating a dedicated level of agility in the production network.*
Practical Implications: *The proposed solution enables enterprises to adapt to the changing conditions of manufacturing operations, but also allows for adjustments to the network's agility level. It leads to the identification of required technical and material resources, essential intangible assets, and necessary human resources, by balancing the benefits with the costs incurred by network enterprises in connection with manufacturing operations.*
Originality/Value: *The proposed methodology allows for tuning the level of agility of the production network based on balancing benefits with costs and the use of feedback between planning and supervising the production activities of many economic entities.*

Keywords: *VUCA environment, agile production network, cost efficiency, process management*

JEL Codes: *L23, J24, M11, D24.*

Paper type: *Conceptual paper.*

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1. Introduction

The contemporary business environment is characterized by Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) (Bennett and Lemoine, 2014; Kienl and Blokhina, 2024). Competitive advantage is currently determined by enterprises' ability to adapt to changing environmental conditions. Market globalization, the increase in the number of breakthrough innovations, and rising consumer expectations force enterprises to continually adapt products to preferences, expand their product range, and undertake activities related to business process reorganization.

In the context of manufacturing enterprises, accommodation and assimilation of organizational and management structures are dictated primarily by the availability of resources (material, human resources, technical, and intangible assets), timely delivery, the scope of cooperative services, but also by amendments to legal acts, technological progress, and maintaining standardization in the areas of digitization, quality management, and safety.

The economic conditions described above make it highly desirable to continuously track the progress of planned deliveries, monitor the performance of production resources, and implement solutions and tools that automate processing. Capturing the dynamics of changes occurring within the system and acquiring the ability to control the flow of information and materials is often supported by IT systems.

Given the disruptions occurring in the production process, this is particularly important for manufacturing companies. Responding to changes both internally and externally in a timely manner and with adequate force enables the company to maintain operational stability while simultaneously maintaining process efficiency and innovation (Kienl and Blokhina, 2024).

In response to the challenges described above, the author of this article developed a concept that represents a three-stage approach to creating a dedicated level of agility in a production network. He based his proposal on estimating the variability of internal and external influencing factors. He proposed that the modification of these factors be achieved through three parameters: the allowable range of deviations, the dynamics of change, and the speed of adaptation.

Furthermore, the solution developed encompasses the search for a balance between the benefits and costs incurred in achieving agility. This is particularly challenging, as most investment or reorganization activities generate additional expenditures. However, the foundation of the solution is the implementation of a feedback mechanism, implemented at the individual enterprise level and also at the production network level. It was also assumed that information transfer between business entities would occur via integrated IT systems.

The described design activities were therefore based on five assumptions. It was assumed that the analyzed production network operates in a VUCA environment and is adaptable. It was assumed that agility control dimensions, as grouped influence factors, must be characterized by active fluctuation of values.

It was recognized that specific actions are necessary to increase network agility. It was assumed that model scaling and agility level tuning would be achieved by balancing benefits with costs. Furthermore, it was assumed that the implementation of adaptive actions would be based on a feedback mechanism, distributed across multiple levels of the agility control system.

2. Literature Review

Reflections on corporate agility are placed within the realm of management and quality sciences. The first definitions of agility were presented by Gehani (1995), Goldman *et al.* (1995) and Kumara and Maotwani (1995). Agility is understood as the level of ability to respond to change (Cegarra-Navarro *et al.,* 2016; Sharifi, 2001), as the ability to adapt to fluctuations in demand and supply (Christopher, 2000), but also as the efficient management of resources and production capacity (Chen and Chiang, 2011; Saaty and Sodenkamp, 2008).

Many authors discussing agility also use the term flexibility (Nazir and Pinsonneault, 2021). Most often, however, agility describes externally focused activities, i.e., the perspective of adapting a company to the conditions of the business environment. The concept of flexibility, on the other hand, refers to internal changes, i.e., the transformation of a company's organizational structures.

Furthermore, the literature recognizes the importance of continuous information flow, which connects internal and external stakeholders (Lanza *et al.,* 2019; Mohsen, 2023; Nazir and Pinsonneault, 2021; Weber *et al.,* 2026). In the context of data transfer, communication methods, data synchronization methods, and tools supporting data exchange are discussed (Milde *et al.,* 2023; Mohsen, 2023).

Because the pursuit of competitive advantage forces enterprises to acquire adaptive skills, many different concepts have emerged, aimed at designing the desired agility. They are dedicated to individual companies in various industries (Gartzen, 2025), logistics networks (Fleischmann *et al.,* 2015; Hopp, 2013; Mohsen, 2023), and also production networks (Kroeger *et al.,* 2025; Kroeger and Zaeh, 2022; Lanza *et al.,* 2019; Milde *et al.,* 2023).

They describe both the identified expectations, the accompanying conditions, and the necessary actions that, according to the authors of the individual concepts, should be taken. Generally, they attempt to eliminate waste, revolve around developing certain behavioral patterns, and emphasize resource substitutability. Some represent scenario methods (Kroeger *et al.,* 2025), while others utilize multidimensional factor optimization (Pakurár *et al.,* 2020). Recent literature describes agility as a response to the challenges of a VUCA world.

They outline the transformation path and present maturity models for agile organizations. They often identify the causes of uncertainty, confirm the need for continuous monitoring of the business environment, and strive to shorten technology cycles or implement cost-effective solutions (Gartzen, 2025; Kroeger and Zaeh, 2022; Pakurár *et al.,* 2020). Unfortunately, most of these concepts are not easily transferred to production networks.

This literature review confirms that there are many diverse approaches to agility. Although most concepts take into account changing influence factors, they do not provide solutions that sufficiently adapt to the needs of business entities. Above all, they lack specific measures for achieving agility in production networks.

Furthermore, the issue of selecting the appropriate and dedicated level of agility, which is achieved by balancing organizational flexibility with financial outlays, has been addressed by only a few authors to date. There is no methodology that allows for fine-tuning the agility level of a production network based on balancing benefits and costs and implementing a feedback loop between the planning and supervision of production activities of multiple business entities.

3. Research Methodology

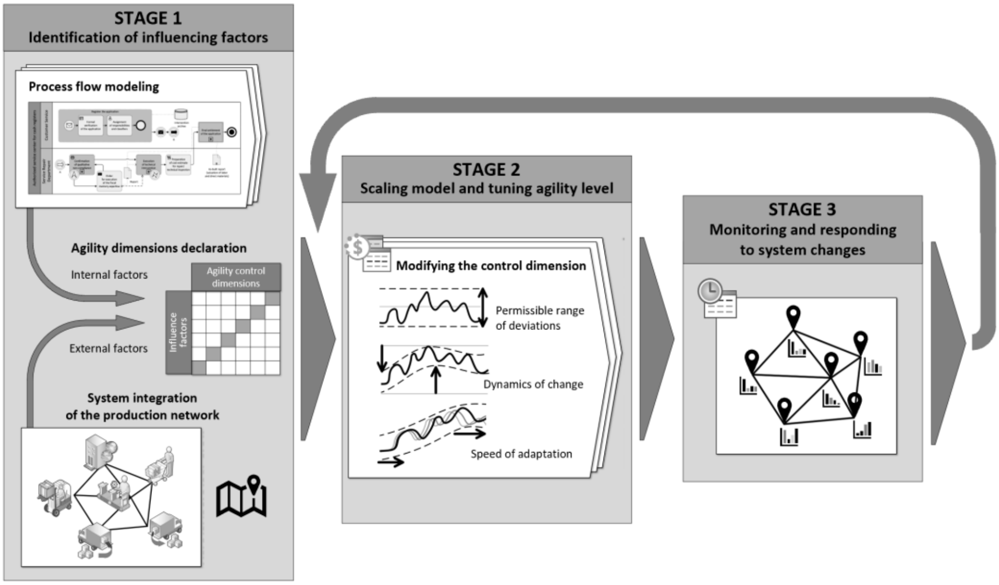
Based on the requirements described above, the author of this article has developed a three-step approach aimed at enabling companies to achieve a dedicated level of agility in their production networks. The following steps are distinguished (Figure 1):

- Identification of influencing factors.
    - Process flow modelling.
    - System integration of the production network.
    - Agility dimensions declaration.
- Scaling model and tuning agility level.
- Monitoring and responding to system changes.

3.1 Identification of Influencing Factors

The first stage of work is to identify factors influencing the agility and adaptability of each enterprise within the network, as well as the entire system—that is, a distinct group of manufacturing companies. This is achieved by modeling the processes occurring in the analyzed system, highlighting constraints within the analyzed network, and establishing correlations between individual factors. This activity should take into account both internal factors, reflecting the flow of materials, information, and finances within each enterprise, and external factors, i.e., signals from the companies' environment and their interactions.

Figure 1. *The methodology for achieving a dedicated level of agility.*



Source: *Author's own elaboration.*

3.1.1 Process Flow Modeling

The main internal factors are the areas of a company's operations that integrate core manufacturing activities with auxiliary processes, distribution, and sales of products and services. Particular attention should be paid to the supervision of manufacturing processes, support for production planning, product and service quality control, and inventory management of raw materials and finished goods. IT systems are an essential tool supporting these activities.

Their effective use depends on a detailed representation of the production process flow within the system's data structure and the ongoing updating of changes in this area (Alcácer and Cruz-Machado, 2019; Flintsch and Bryant, 2006). The functionality of IT systems allows for the generation of production schedules, the issuance of job instructions to employees, and the precise determination of inventory levels for each material/product.

System use also allows for resource planning, monitoring and analysis of operational activities, and the synchronization of material flows. IT system support translates into increased efficiency, minimized inventory, and improved company competitiveness in the context of flexible product adaptation to market needs and possible personalization of products or services (Taddei *et al.,* 2024; Wiggins and Ruefli, 2002). It is assumed that the use of IT systems in production management is conditioned by the declaration (Milewska and Senczyna, 2025):

- machinery in the form of machines and technical equipment, along with their assigned parameterization, which describes their production capabilities;
- human resources, including employee skills and availability calendars;
- material resources, including their assigned units of measurement, key characteristics, source of origin, default storage location, and billing method;
- production technology for manufactured products;
- a method of converting market demand (product orders) into production process events, i.e., generating a production schedule that controls the load on the enterprise's machine and employee resources;
- a method of converting market demand (product orders) into material requirements for raw materials and semi-finished products used in the production process and generating material flow within the enterprise;
- the method of transmitting job instructions to direct production employees, the frequency of generating the production schedule in the IT system, the frequency of updating data describing the status of resources and the method of disposing of the company's production capacity.

It's important to note that tools supporting recruitment, training, and payroll activities, as well as invoicing, expense control, budget planning, and bookkeeping, also have a significant impact on agile product development. They play a significant role in the context of a company's organizational culture and the personal culture of its employees.

The internal system of values, norms, beliefs, and behavioral patterns shape not only the functioning of production employees but also the decision-makers who influence company management processes. Therefore, they should be considered in process modeling, both in a cause-and-effect context and through prioritization, i.e., assigning them to identified factors.

3.1.2 System Integration of the Production Network

Global production networks (GPNs) are assumed to consist of geographically dispersed economic entities that are interconnected through material, information, and financial links. GPNs encompass a group of enterprises of varying sizes, performing diverse functions within the group and utilizing different management systems.

These enterprises interact directly with one another. However, the primary area of economic activity of these entities is production. It is assumed that production processes can be implemented collaboratively and that the transfer of semi-finished products can occur multiple times within the logistics value chain (Kroeger, 2025).

Each enterprise assumes a specific role in this process, reflecting its responsibilities to the group. These responsibilities may take the form of providing raw materials or other resources necessary for production (e.g., customized tools, specialized machinery, skilled workers), transforming raw materials into semi-finished products, or transforming semi-finished products into finished products.

Additional elements of the logistics chain may include distributors, retailers, or end customers. It is important to remember that faithfully replicating the network structure ensures increased flexibility and adaptability of the entire group. This creates a synergy effect, where coordinating the collaboration of separate business entities, leveraging their unique experiences, allows for mutual complementarity between enterprises, fosters innovation and the achievement of better results, and enhances the organization's operational efficiency (Milewska and Senczyna, 2025).

It is important to note that each enterprise within the network aims to optimize its business processes (Kück, 2016; 2017), focusing primarily on minimizing costs, inventory, and shortening production times. Production management is based not only on the internal factors described above but also on environmental conditions, market signals, and information about the activities of collaborators. These signals typically reach the enterprise with a certain delay, leading to various problems.

Therefore, they constitute a limitation for the coordination of production activities and the synchronization of resource flows. They cause supply bottlenecks, delays, or interruptions (Hofmann nad Rüsch, 2017). Considering the above, external factors include: the methods of data exchange between cooperating economic entities (Mohsen, 2023), the predictive analytics tools used (Nawaz *et al.,* 2019; Scholz-Reiter *et al.,* 2014), and the adopted inventory management models (VMI systems - Vendor-Managed Inventory) (Laaper *et al.,* 2017).

In this context, information distribution encompasses the form of communication, the scope of transmitted data, and the frequency of synchronization of available resources. Furthermore, specific local factors may include the availability of raw materials or qualified personnel, legal regulations, requirements for technical infrastructure, or environmental (geological and biological) safeguards. These are most often related to the country's territory, specific terrain, or area of political influence.

3.1.3 Agility Dimensions Declaration

For the factors identified above to be considered system control dimensions, their impact on the agility of the analyzed network must be confirmed. The first step is to determine the permissible range of changes in the values of each factor and identify their permissible boundary conditions.

It is also necessary to identify additional constraints that represent unacceptable states or support the detection of anomalies occurring in the business process. It is important to remember that these constraints should faithfully reflect the conditions surrounding the manufacturing activity.

Furthermore, the identified factors can be grouped. To combine multiple factors into a single dimension, one can use a specific area of business activity, a product range, or the location or regionalization of business entities in relation to the distribution or supply area.

In addition, dimensions can represent the selected manufacturing technology, the specification of technical resources, required employee competencies, or the supply chain area. These dimensions may encompass process standardization, centralization of organizational structures, management methods, motivation techniques, communication methods, data exchange methods, or IT systems used.

The second step in defining dimensions should be a correlation analysis, which examines the relationships between the grouped factors and confirms the significance of the identified dimensions' influence on system control. It is important to identify general interdependencies, but also to identify industry affinities that will reveal deviations between business entities or industries.

This activity involves conducting three types of analysis. The first step is to determine the interdependencies within the identified factors. This should include a separate analysis of the interdependencies of internal factors, i.e., those occurring within a single business entity, and an analysis of the interdependencies of external factors, which is used to eliminate redundancies.

The second step is to compare the impact of each factor on the performance of the dimension in which it is included (in which it is grouped). This analysis allows for determining the significance of individual factors, thus leading to a prioritization that takes into account the benefits they bring.

The third step is to analyze the correlations between the identified dimensions.

This study aims to identify potential reinforcements or obstacles to system control and allows for dimension prioritization. It demonstrates the potential to impact operational effectiveness and the efficiency of adapting a network element to changing business needs. This translates into flexibility in scaling manufacturing operations and the ability to adapt to uncertain and unreliable environments.

3.2 Scaling Model and Tuning Agility Level

Agility means implementing changes in resource configuration, organizational structures, and applied strategies in response to transformations in the local market. Agility requires the ability to organize resource work and continuously adapt to the conditions of a dynamically changing environment. It is the ability to respond to signals from the environment by perceiving uncertainty, monitoring the speed and scale of change, and taking prompt and appropriate actions (in scope and magnitude) that stabilize the production operations of enterprises.

Activities that increase the efficiency of production network operations and improve supply chain flexibility within established business connections undoubtedly constitute dimensions of network agility control. They enable the regulation of the system's operation within a specific scope and within a precisely defined area of the enterprise's business activity.

For this reason, it is necessary to conduct an assessment that describes the conditions accompanying the functioning of entities and identifies likely disruptions occurring during production. Furthermore, the assessment results should indicate the extent to which process standardization or digitization of manufacturing operations reduces fixed costs, increases production efficiency, maintains machine reliability and continuity of production processes, or influences changes in manufacturing technology. Different actions imply different implementation effects, the consequences of which may overlap and reinforce each other, or even exclude and eliminate each other.

Each dimension of system control is modified through three parameters: the permissible range of deviations, the dynamics of change, and the speed of adaptation. In the literature, the permissible range of deviations is also called the flexibility corridor. It is described by the lower and upper limits of the space between which the values of a given dimension fluctuate. The second parameter (dynamics of change) determines the frequency and intensity of changes that occur during the observation period.

Changes can occur smoothly and gradually, occur regularly/cyclically, or be sudden and unexpected, accompanied by extreme transformations. The final parameter is the speed of adaptation. It defines the time lag between the signal coming from the environment and the reaction of the economic entity, which attempts to adapt its activities to the changing environmental conditions. It is assumed that the adaptation process is continuous and encompasses both accommodation and assimilation, i.e., the creation of new organizational and management structures, as well as the modification of existing ones.

To be able to observe changes occurring in manufacturing operations and determine the degree of flexibility of the system, redundancy is required within network entities. This may include the scope of employee competencies or the availability of machinery resources. However, it should confirm that entities have excess production capacity.

It is also advisable to remove cost drivers from the main dimensions of system control in favor of a multi-level factor structure, the levels of which determine network agility. The hierarchization of dimensions allows for qualitative balancing of the cost-benefit ratio at each stage of network design.

Furthermore, the permissible range of deviations in the values of individual dimensions (flexibility corridor) should be modified by converting fixed costs into variable costs. Fixed costs can be reduced or replaced through: outsourcing services, using flexible employment options or additional payroll components, operational leasing instead of asset purchases, or billing based on actual consumption (e.g., based on the number of active users running the IT system, computing power, etc.).

Production network agility is also influenced by three types of delays: detection, decision, and implementation. Detection delay can be eliminated through automated tracking of market and technical signals and mechanical anomaly detection. Decision delays are reduced through standardization of procedures, while implementation delays are minimized through integration of IT systems used by collaborating entities.

To sum up, the necessary condition for achieving dedicated flexibility of the production network is the synergy of speed of operation and cost flexibility of the enterprises participating in the network.

3.3 Monitoring and Responding to System Changes

IT systems are a key tool used in monitoring and managing production processes (Büyüközkan and Göçer, 2018). They enable the control of information and material flows. They support the supervision of processes related to the transformation of raw materials and semi-finished products, support transportation activities, and integrate various areas of a company's operations. This is because core manufacturing activities are integrated with auxiliary, distribution, and sales processes.

Furthermore, IT systems often encompass production planning, quality control, and inventory management of raw materials and finished products. It should be noted that the priority of each company within a production network is the optimization of its own business processes (Kück, 2016; 2017). Also, support is most often provided at the level of an individual business entity. This means that internal factors are primarily considered in running a business.

External factors are treated as secondary, as a background, or even ignored. Market signals or information about partners' activities reach the enterprise with a significant delay. Taking them into account in system control is therefore a significant challenge. Systemic integration of network entities offers a solution (Chukalov, 2017; Pérez-Lara, 2020; Trelleborg, 2024; Zekhnini *et al.,* 2021). This allows enterprises to seamlessly exchange information, making collaboration more effective and resource planning and management more efficient.
It can be implemented through: communication and synchronization of production plans, centralization of forecasting and planning (Abbaspour Ghadim Bonab, 2022; de Carvalho *et al.,* 2023; Rüßmann *et al.,* 2015; Schuh, 2017), the use of artificial intelligence (AI) and predictive analytics (Nawaz *et al.,* 2019; Scholz-Reiter *et al.,* 2014), VMI (Vendor-Managed Inventory) systems (Laaper *et al.,* 2017), or virtual supply chains (Digital Twin) (Kritzinger, 2018; Rodič, 2017; Saanen, 2002; Tao 2017; 2018; Tu, 2018).

Regardless of the option chosen, the accuracy of mapping the physical flow of work and materials in the IT system is important. It translates into the results of the analysis related to the network behavior, anomaly detection and the way of reacting to disturbances (Agostino *et al.,* 2020; Barykin *et al.,* 2021; Frazzon *et al.,* 2018; Koh *et el.,* 2003; Luo *et al.,* 2024; Suryawanshi and Dutta, 2022).

The implementation of adaptive actions is based on a feedback mechanism, which is extended between the planning and supervision of production activities. The alternating and cyclical implementation of the two phases (planning and supervision of production activities) provides information that allows for drawing conclusions and implementing adaptive actions.

Information about the current system output state is used to modify input signals to bring the system's operation closer to the desired value. This increases the precision, stability, and efficiency of control, and the tuned output signal ensures automatic compensation of disturbances and the implementation of preventive measures for discrepancies.

The basis for these decisions is the mapping of the manufacturing technology and the product's material structure in the system data structure (Milewska and Senczyna, 2025). The technology is achieved by assigning a list of possible technological operations to a list of workstations, declaring employee skills, and defining a calendar for the availability of each of the company's resources.

These activities enable allocation, i.e., the issuance of a job order, which allocates human and machine resources to a task while maintaining the boundary conditions for execution and the substitutability of designated resources. A properly identified operation should enable resource substitution in the allocation, and the assignment of alternative resources to a task should not result in differential production outcomes (Milewska and Senczyna, 2025).

4. Research Results and Discussion

The concept presented above represents a systematic approach aimed at enabling companies to create a dedicated level of agility within their production network. It encompasses three stages of activity. The first stage involves analyzing factors that impact the production capacity of network entities and the flow of business processes, as well as sudden and unexpected events that disrupt production. Both internal and external factors should be appropriately selected, based on the industry, company specifics, or legal regulations applicable to each network entity. Grouping them allows for the identification of agility control dimensions. The second stage involves scaling the model and tuning the agility level.

To correctly select the agility level, an analysis of the variability of the previously identified factors should be performed. Modification of each factor/dimension should be achieved through three parameters: the allowable range of deviations, the dynamics of change, and the speed of adaptation. It should be noted that the cost estimation and assessment of benefits achieved at each agility level, included in the concept, are based on the predicted probability of factor fluctuations.

However, a forecast of the factor's occurrence was omitted. Furthermore, it is important to encompass all network companies in the analysis, include many different locations, and conduct it for multiple observation periods/time frames.

These activities will allow for the identification of required technical and material resources, essential intangible assets, and necessary human resources that will balance the benefits and costs incurred by network companies in conducting manufacturing operations. The aforementioned proactive activities, i.e., automated monitoring of manufacturing processes, constitute the third stage of implementing the described concept.

Their goal is to continuously adapt entities to changing market demand. This is the foundation of the proposed solution, as the feedback mechanism, which typically occurs at the level of an individual company, was applied at the level of a group of companies within the network. Therefore, a multi-level control system was created, spanning the planning and supervision of manufacturing activities of multiple entities.

Adaptability of both the individual company and the group of companies was achieved through reasoning and the alternating and cyclical implementation of two phases (planning and supervision of manufacturing activities). Furthermore, it was assumed that data transfer occurs exclusively between IT systems and is subordinated to the data structure of the systems being integrated (Milewska and Senczyna, 2025).

This means that continuous updating of delivery dates and mutual fine-tuning of production plans requires ensuring data consistency across all stages of the chain, from activities related to raw material sourcing, manufacturing, and distribution, to planning, demand, and customer service. This stage not only adapts enterprises to changing manufacturing conditions but also improves the network's agility.

5. Conclusions, Proposals, Recommendations

The topic of agility in production networks is currently being addressed in publications by numerous authors. They analyze issues related to the ability of economic entities to respond to change (Cegarra-Navarro *et al.,* 2016; Sharifi, 2001), the ability to adapt to fluctuations in demand and supply (Christopher, 2000), tracking product genealogy (Chen and Chiang, 2011; Saaty and Sodenkamp, 2008), as well as the broadly understood improvement of management processes (Hülsmann and Grapp, 2005; Hülsmann and Wycisk, 2005; Marker, 2024; Schary and Skjøtt-Larsen, 2001).

In response to the challenges described above, the author of this article developed a concept that represents a three-stage approach to creating a dedicated level of agility in a production network. His proposal was based on estimating the variability of influencing factors and the balance between the benefits and costs incurred in achieving agility.

Factors were modified through three parameters: the allowable range of deviations, the dynamics of change, and the speed of adaptation. The foundation of the proposed solution, however, is the application of a feedback mechanism, deployed at the level of both the individual enterprise and the production network. A multi-level control system was created, encompassing the planning and supervision of production activities of multiple entities. It was assumed that data transfer between entities would be subordinated to the data structure of integrated IT systems.

Furthermore, the hypothesis was adopted that mitigating material flow destabilization in the production network is possible through a harmonious flow of information between organizational units and business entities within the network. It is assumed that further research is necessary to precisely define possible measures to increase agility.

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