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DYNAMIC CONFIGURING OF THE METASTRUCTURE

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ABSTRACT. Background: A trend to create groups of enterprises can be observed; whose model of operation makes use of assets of large, small and medium sized companies. It is a higher level of organisational changes. This trend is described as network organisation. It is based on the so called supply chain. The Authors of this paper proposed authors' analysis dynamic configuration of the supply chain and presents an example. The supply chain is a metastructure. It is an intermediate form between a single enterprise (microstructure/microsystem) and the global economy (macrostructure/macrosystem). The metastructure is characterized by a dynamic holarchy of mutually cooperating holons (enterprises).
Methods: After a brief discussion of the nature of supply chain (metrastructure) and configuration of metastructures, authors present variable supply chains in the light of morphological analysis and presents an example.
Results: The key benefits of this approach are: identifying the characteristics of a supply network and modeling the flow in the entire own supply chain metastructure and possible quick adaptations to new situations.
Conclusions: Configuration of a supply chain with the use of a morphological analysis is a basic action, if its goal is to optimally model the flow of goods and implementation of quick adaptation to new situations.

Key words: supply chain, metastructure, configuration.

INTRODUCTION

Such a metrastructure [Grzybowska 2010] is a system which, at its own level of existences, is a self-functioning whole and self-regulating open system. However, it forms a constitutive element of a larger whole. It also consists of constitutive elements (parts) which function as whole systems of a lower level. Such structures have been referred to by A. Koestler as holons [Koestler 1967] regarded, at the same time, as a whole and a part which "display both the autonomous properties of wholes and the dependent properties of parts".

As reasoned by K. Wilber: there is no whole which would not constitute a part of some other whole. He described the holarchic structure as a holarchy or holonic hierarchy [Wilber 2007]. The whole nature of the systems and holism consists in the conclusion that new levels of organization are formed which cannot be reduced only to dimensions known earlier - they extend beyond the scope of the latter. But at the same time, they contain them, as earlier holons are still the constitutive elements of a new holon. Thus, they are both contained in, and extend beyond the new holon. This means that the higher levels contains basic elements of the lower level and some additional qualities (…) it is another manner of putting the notion laid down for the first time by Aristotle - the whole lower level is contained in the upper level, but the upper level is not fully contained in the lower level [Wilber 2007].

The more the supply chain expands, the less coherent the system is and the relationships within such system lack closeness. This, in turn, results in the fact that the relationships and connections in such metastructure may be more or less durable. Among the links in such structure one differentiates those permanent (so-called core supply chain) and those dynamically changing, e.g. depending on the

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task being executed (so-called satellites, temporarily connected links). Links connected temporarily become separated from the core supply chain and cooperation ends as soon as the task is completed. Supply chains keep evolving - beginning with the supply chains of a functional nature, through creative to adaptive supply chains. Such development is a result of a change in the relation of relationships, dependencies and connections existing between the enterprises in the supply chain [Grzybowska, 2009]. There are two aims of this paper. The first one is to define the term: define the term: configuration of metastructures. The second aim of this research was to propose and use the morphological analysis.

CONFIGURATION

The cooperation of enterprises (flow of materials, information and cash) within the metastructure of a supply chain (network) is a dynamic and changing process. Configuration of the supply chain may take a number of forms and depends upon the links and relationships between these links in the supply chain.

The configuration may refer to a number of aspects. It may refer to transport routes and optimization of long-distance transport and transport processes (e.g. type of transport to be used, which route will be used to transfer goods, etc.). It may also take into account the points in a networks between which the goods and transported. In such case, the analysis and optimization of resources and warehouse localization may be effected (e.g. which warehouses will be used, what costs will be related to localization of warehouses, etc.) [Niemczyk 2009].

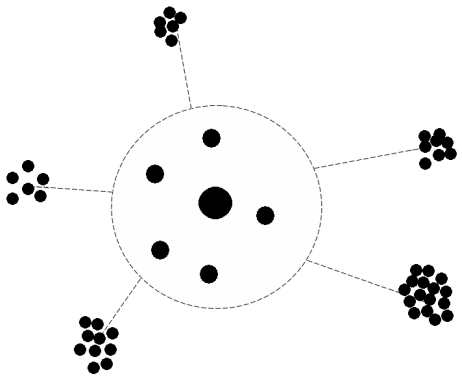
This paper defines the configuration of metastructures as a structure of connected links of a supply chain (metasystem) with dependencies existing between them. According to Ch. Chandra and J. Grabis the configuration is a system of parts of elements which give the form to the whole [Chandra and Grabis 2007]. These authors refer to the theory of systems. They point out that a supply chain is a configurable system which effectively adjusts to the environment in which it operates. They differentiate some of the key factors to correctly design the supply chain and its configuration. These are as follows [Chandra and Grabis 2007]:

- Introduction of new products or updating existing range of products and new processes or improvement of existing processes.
- Allotment of new resources or redistribution of existing resources.
- Selection of new, or reselection of existing suppliers.
- Changes in the structure of demand for manufactured products.
- Changes in production time.
- Product life cycle changes.
- Changes in obligations or relationships between links of a supply chain.

As stated by A. Niemczyk citing M. Fertsch, following rules of logistic conduct (factors) significantly affect the configuration of a network [Fertsch 2006; Niemczyk 2009]: (1) Rule of substitution, (2) Rule of complementariness, (3) Rule of distribution differentiation, (4) Rule of mixed strategy, (5) Rule of rationalization, (6) Rule of standardization, (7) Rule of consolidation, (8) Rule of deferment.

The configuration of a supply chain is one of the major decisions to be made in the scope of supply chain management. It greatly affects all other decisions of a managing nature. In the process of configuring the supply chain, a whole range of possibilities should be taken into account: from the deterministic system to stochastic systems. Ch. Chandra and J. Grabis propose a configuration of a supply chain as an integral part of a general process of supply chain management. Complexity of metastructures depends on the configuration of a supply chain. The supply network is a type of configuration in which some links are multiplied in order to deliver a variety of products.

D. Kempny notes that the configuration may be more dynamic in nature. Citing D. Birchall and L. Lyons, he presents a dynamic network with a central point consisting of a single, offensive business which is capable of connecting with similar businesses" [Kempny 2001; Birchall and Lyons 1995]. Such business is an integrator (Fig. 1). By joining a dynamic system, the members of a metastructure often contribute unique capacities (a quality of holons).



Source: Birchall and Lyons 1995; Kempny 2001

Fig. 1. Dynamic network with an offensive integrator
Rys. 1. Sieć dynamiczna ofensywnym integratorem

In the course of creating and functioning of a supply chain or supply network in accordance with the holarchic scheme, one may differentiate two significant rules that govern the process: rule of synergy and rule of elitarism (elitarism consists in participation of the best enterprises which constantly develop in their core businesses). This dynamic metastructure consisting of specialized links (nodes) - holons being a whole, is at the same time, a part of another hole. The structure that used to be a whole yesterday, tomorrow may be a part of a larger structure. Links have some common qualities. It should be underlined that these holons must retain their autonomy. Otherwise, if they lose their separateness, they disintegrate into elementary parts. At the same time, they have to gain the ability to adjust to other parts of a whole and adjust to the environment.

The metastructure of a holarchic type may disintegrate, but may also merge to form new systems. It may form new mutations and interim forms. It is a sign of intelligence and evolution. K. Wilber refers to it as a self-transcendence of holons which allows discontinuity, shifts and creative transitions.

Supply chains are created in a holarchic manner. As a result of created metastructure, more depth is created. It means that each higher level created with holons becomes more complex, higher level exceeds and contains lower levels which means that higher level is more abundant than the lower level. There is no exception to this rule.

As stated by D. Kempny "holonic network is more than just an association of businesses in which various companies operate (…) it is a system of almost organic nature in which all information is available at the same time (in real time) to all participants" [Kempny 2001]. It is a dynamic information network which allows all its nodes to make rapid decisions.

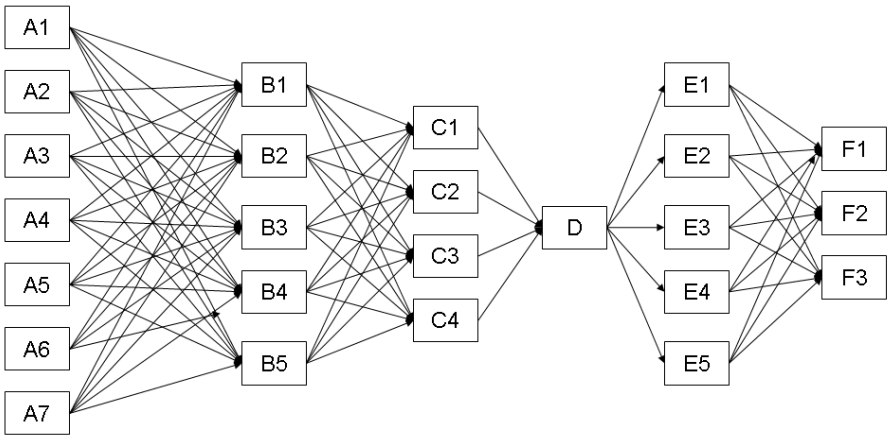
MORPHOLOGICAL ANALYSIS IN THE CONFIGURATION OF METASTRUCTURES

An unquestionably useful tool to identify the configuration manner of individual (variable) metastructures is morphological analysis. It allows to determine the number and nature of all links of a supply network.

Referring to the concept of dynamic networks with specialized nodes called holons, as laid down by D. Birchall and D. Kempny, and by analyzing the network phenomena and variable supply chains in the light of morphological analysis developed by F. Zwicky, one may come to interesting conclusions. It is a method belonging to heuristic methods which may be applied to solving complex problems of research or creative nature. A supply network may be broken down into partial elements and, subsequently, in accordance with the rules of morphological method, all solutions possible as far, and those entirely new, based on the analysis of structure of these solutions may be reached.

Determining the characteristics with the use of morphological analysis

The first stage of work is the determination of full characteristics of a supply chain - constitutive elements of a network are determined: kinds and types of suppliers, intermediate parties and recipients (Fig. 2). Knowing the characteristics of a supply network, one may proceed to the task consisting in the analysis of solutions which form a part of practice of each characteristic. Parameters for each type of link are defined and described in detail. Next, one may proceed to analysis of parameters of characteristics based on all versus one another approach.



Source: own work

Fig. 2. Determining the characteristics of a supply network
Rys. 2. Wyznaczenie charakterystyki sieci dostaw

A morphological matrix is created (Table 1). As a result of detailed analysis, combinations of various variables may be obtained (Fig. 3). The number of possible combinations may be calculated with the use of formula below:

$$\text{number of possible combinations} = \prod_{i=A}^{N} I_i$$

where:

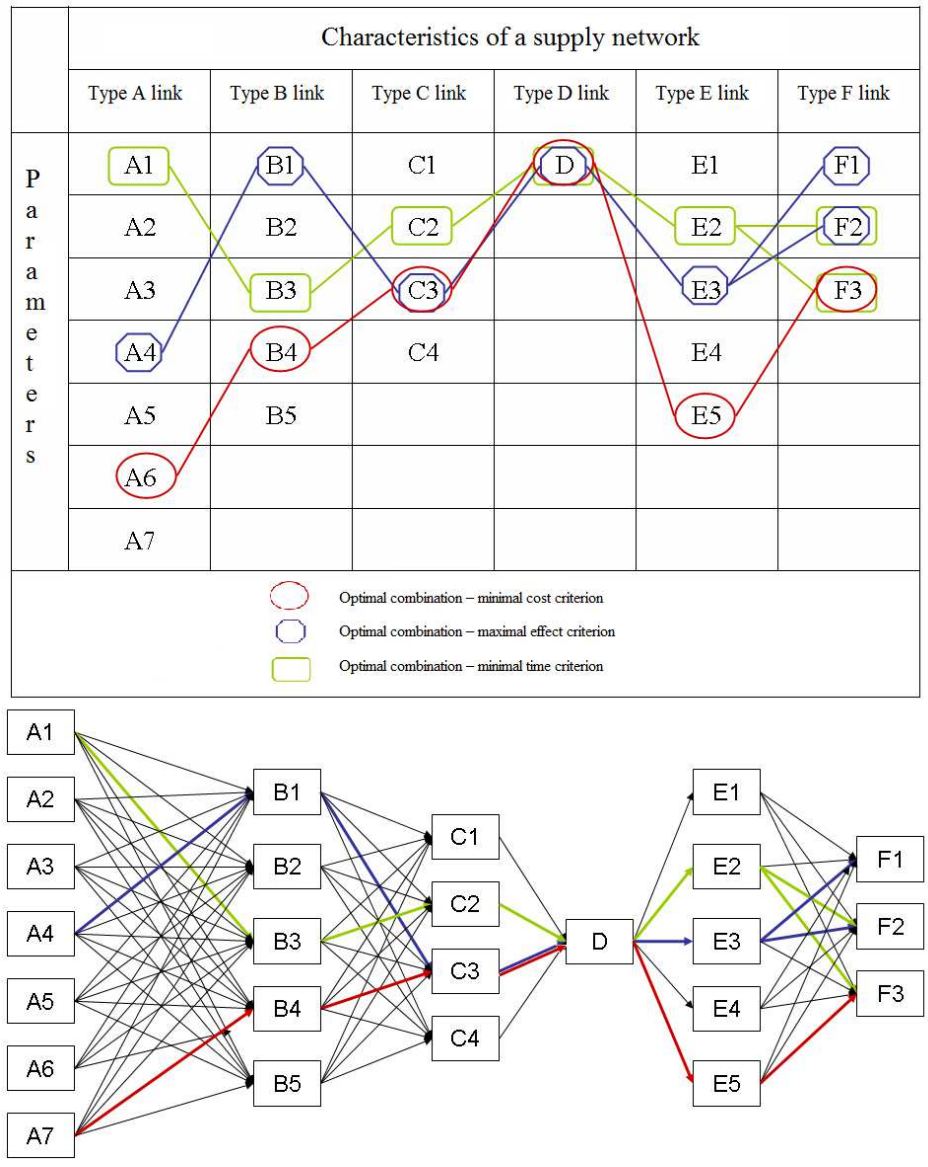
I - number of variable value *i*.

For the example shown in Table 1, the number of all combinations equals 2 100. The list of created solutions (as in example) may be long, hence some selection measures should be applied. Solutions obtained will be of possible, admissible, optimal and contradicting nature (~30%). The latter should be discarded. As a result of analysis, so-called optimal combinations are determined which is a result of analysis in terms of a specific criterion (cost-related, minimization of execution time, maximization of effects, durability, etc.).

Table 1. Morphological matrix of a supply network
Tabela 1. Macierz morfologiczna sieci dostaw

	Characteristics of a supply network					
	Type A link	Type B link	Type C link	Type D link	Type E link	Type F link
Parameters	A1	B1	C1	D	E1	F1
	A2	B2	C2		E2	F2
	A3	B3	C3		E3	F3
	A4	B4	C4		E4	
	A5	B5			E5	
	A6					
	A7					

Source: own work



Source: own work

Fig. 3. Determining the characteristics of a supply network with indication of selected combinations
Rys. 3. Wyznaczenie charakterystyki sieci dostaw ze wskazaniem wybranych kombinacji

The drafted system (Fig. 3) shows how a metastructure may undergo changes in relationships between enterprises and how such system may dynamically change. Cooperation between enterprises, depending on the criterion determined, will flexibly change.

If the final recipient presses for lower price, the cooperation within the supply chain will be affected between enterprises: *A7, B4, C3 D, E5* and *F3*. If, in turn, the client presses for time gains, cooperation will be affected in favour of a new supply chain: *A1, B3, C2, D, E2* and *F2* or *F3*.

The system presented above constitutes a flexible and variable metastructure, depending on the task specified or criterion selected. The enterprises which are "replaced" become temporary links. Links connected temporarily become separated from the core supply chain and cooperation ends as soon as the task is completed.

Benefits from configuring the supply chain (network) with the use of morphological method

A configured metastructure may be used to develop a model of a complex network of dependencies of cooperating enterprises which indication of limitations such system contains. Another action may consist in improving the synchronicity and coherence in a supply chain, planning of material flow (including emergency or extraordinary flows) in the entire supply chain. Configuration of supply chains increases the effectiveness of dynamic balancing of supply and demand between respective links of this chain, and improvement of effectiveness of all links. It also allows for specifying the method and timeline of resource planning in a dynamic manner.

The configuration of a metastructure is of particular use for the leader of a given supply chain or economic organization which manufactures the product for the final client. These organizations are particularly interested in proper functioning of an entire supply chain. Their role is to integrate suppliers and intermediate parties. Hence, configuring is useful in modeling the flow in the entire own supply chain metastructure and possible quick adaptations to new situations (example of application of the morphological analysis). By using this analysis and possibilities made available by IT systems, it is possible to carry out simulations of inclusion of a new supplier or a new key client in the supply chain metastructure.

THE DYNAMIC CONFIGURATION OF METASTRUCTURES - FLEXIBLE SUPPLY CHAIN AND AGENT'S THEORY

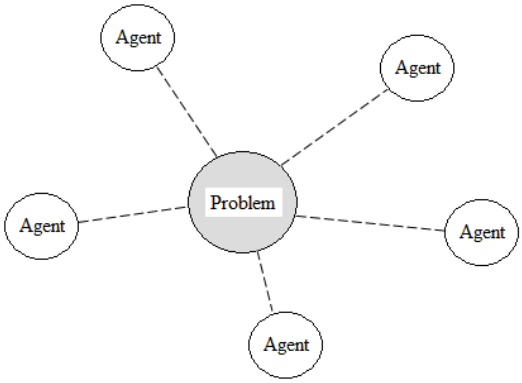
Dynamic configuring allows flexible supply chains to be created. Contrary to the most typical, permanent and stable supply chain which is created in long-term perspective and based on long-term relationships with business partners to maximize synergy effects, a flexible (called also dynamic) supply chain is very variable. It is an opposite of stable supply chains. Dynamic configuration is, in this aspect, understood as often and constant changing of business partners within a supply chain.

Another concept of a flexible supply chain is presented by H. L. Lee. He lists six premises ensuring flexibility to a supply chain. These premises are as follows [Lee 2007]: (1) Supplying business partners, on an on-going basis, with information on changes in supply and demand so that they can react and adjust to changing demand, (2) Entering into cooperation with business partners already at the stage of designing and implementation of new products, as well as designing and implementation of new technological and logistic processes, (3) Optimal product designing to use modular components in the initial phase, so as to defer finishing works (works differentiating products) until the time the clients' needs are determined, (4) Maintaining minimum resource in such amount which prevents interruptions in the supply chain due to lack of resources (particularly those inexpensive), (5) Development and implementation of a flawless logistic system by entering into collaboration with other independent economic organizations, (6) Development of a team which will be prepare and be able to implement emergency plans.

The flexibility of supply chains was described by V. Kumar, K. A. Fantazy, U. Kumar and T. A. Boyle as an ability of business partners functioning in a supply chain to easily adjust to arranging joint policy and scope of responsibility and changing one's actions according to current needs. They state that such changes allow to manufacture differentiated products at differentiated prices, quality and at variable cost.

A. Kawa proposes to pay attention to future technologies as an important factor in configuring dynamic supply chains [Kawa 2008]. He points to the agent's technology, i.e. a piece of software which remotely performs a task at a given computer workstation or in a dispersed network of computers (Internet). Referring to S. Russel and P. Norviga, A. Kawa defines a so-called agent as "anything that may be perceived as able to examine its environment with sensors and carry out actions in this environment by effectors" [Kawa 2008]. An agent - in the form of software, is able to gather information on a given subject and, most importantly, draw conclusion from such information and use them to take actions. If such software's tasks are complex, the structure of the program will be complex too. It may also be given "competences" concerning the cooperation, communication and negotiation with other agents representing other enterprises. Complexity of an agent system means that following categories of agents may be differentiated [Kawa 2008]:

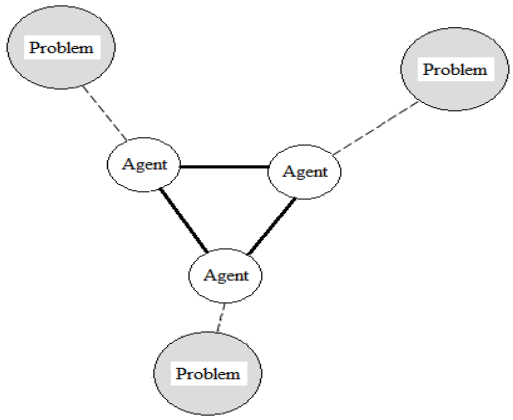
- Exploring agent which is mobile and based on indicated criteria, responsible for seeking business partners for new cooperation,
- Offering agent which represents an economic organization in placement of sales offers,
- Information agent which informs on changes in an offer (e.g. at the electronic exchange market servers),
- Negotiating agent which represents an enterprise in the process of negotiation of cooperation conditions,
- Verifying agent which verifies available and proposed cooperation scenarios.



Source: Pawlak and Małyszek 2000; Kjenstad 1998

Fig. 4. Cooperative problem solving
Rys. 4. Kooperacyjne rozwiązywanie problemów

In the literature on the subject, the authors point to two directions of research: *Cooperative Problem Solving* (CPS) and use of agent solutions (*Multi Agent Systems*, MAS). First allows to decompose metastructure into a network, in accordance with the structural division of economic organization participating in a supply chain (Fig. 4).



Source: Pawlak and Małyszek 2000; Kjenstad 1998

Fig. 5. Autonomy of agents in a Multi Agent System
Rys. 5. Autonomia agentów w systemie wieloagentowym

Second solution allows for greater autonomy of agents. Each of them solves problems based only on local goals whereas any contradictions are being removed by method of negotiations with other agents" [Pawlak and Małyszek 2000]. Local knowledge is merged with coordination knowledge. These two directions of research are presented on a simplified chart below (Fig. 5).

CONCLUSION

The aims assumed at the beginning of this paper were achieved by the consistent presentation of morphological analysis. A supply chain/network may be understood as a dynamic (variable or stable) metastructure. It is understood as a self-sustaining form. It should be noted that a metastructure enters into dependencies with other metastructures and is a component of a larger whole. The more complex the metastructure, the more stable is its nature. Hence the configuration and adjustment of individual links in a supply chain/network is that important. The problem of configuration may be perceived in the light of dependencies between elements of a system. Configuration of a metastructure with the use of a morphological analysis is a basic action, if its goal is to optimally model the flow of goods in an entire metastructure and implementation of quick adaptation to new situations.

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DYNAMICZNA KONFIGURACJA METASTRUKTUR

STRESZCZENIE. **Wstęp**: Można zaobserwować tendencję do tworzenia grup przedsiębiorstw, których model działania wykorzystuje aktywa dużych, małych i średnich przedsiębiorstw. Jest to wyższy poziom zmian organizacyjnych. Tendencja ta jest opisana jako organizacja sieci. Jest ona oparta na tzw. łańcuchu dostaw (metastrukturze). Autorka proponuje analizę dynamicznej konfiguracji łańcucha dostaw oraz przedstawia jej przykład. Łańcuch dostaw jest metastrukturą. Jest to pośrednia forma pomiędzy pojedynczych przedsiębiorstwem (mikrostruktura, mikrosystem) a ekonomią światową (makrostruktura/makrosystem). Metastruktura charakteryzuje się dynamiczną holarchią wzajemnie współpracujących holonów (przedsiębiorstw).
Metody: Po krótkiej dyskusji dotyczącej natury łańcucha dostaw (meta struktura) i konfiguracji meta struktur, autorzy przedstawiają różne łańcuchy dostaw w świetle analizy morfologicznej oraz przedstawiają przykład.
Wyniki: Kluczowymi zaletami takiego podejścia jest identyfikacja charakterystyk sieci dostaw oraz modelowanie przepływu w całej metastrukturze łańcucha dostaw jak również wdrożenie szybkiej adaptacji w nowych sytuacjach.
Wnioski: Konfiguracja łańcucha dostaw przy zastosowaniu analizy morfologicznej jest podstawowym działaniem, w sytuacjach gdy celem jest optymalnie wymodelowaniem przypływu dóbr oraz wdrożeniu szybkiej adaptacji w nowych sytuacjach.

Słowa kluczowe: łańcuch dostaw, metastruktura, konfiguracja

DYNAMISCHE KONFIGURATION VON METASTRUKTUREN

ZUSAMMENFASSUNG. Einleitung: Heutzutage beobachtet man eine Tendenz zur Bildung der Gruppen von Unternehmen, derer Wirkungsmodell die Aktiva von Groß-, Klein -und Mittelstand-Unternehmen in Anspruch nimmt. Dies bedeutet ein höheres Niveau von organisatorischen Veränderungen. Diese Tendenz wird als Organisation des Netzes beschrieben. Sie stützt sich auf die sog. Liefferkette (Metastruktur). Die Autorin schlägt die Analyse einer dynamischen

Konfiguration der Liefferkette vor und stellt ein entsprechendes Beispiel dafür dar. Die Liefferkette zeigt dabei eine Metastruktur auf. Sie bildet eine Mittelform zwischen einem einzelnen Unternehmen (Mikrostruktur/Mikrosystem) und der Weltwirtschaft (Makrostruktur/Makrosystem). Die Makrostruktur charakterisiert sich durch eine dynamische Holarchie, die eine Reihe von zusammenarbeitenden Holonen (Unternehmen) umfasst.
Methoden: Nach einer kurzen Diskussion bezüglich der Natur einer Liefferkette (Metastruktur) und der Konfiguration von Metastrukturen stellen die Autoren unterschiedliche Liefferketten angesichts der morphologischen Analyse dar und bieten ein entsprechendes Beispiel dafür dar.
Ergebnisse: Die Hauptvorteile einer solchen Vorgehensweise sind: die Identifizierung von Charakteristika der Liefferketten, ferner die Modellierung des Durchflusses innerhalb der ganzen Metastruktur einer Liefferkette sowie die Inanspruchnahme der Möglichkeit einer schnellen Anpassung an die neuen Gegebenheiten.
Fazit: Eine zweckmäßige Konfiguration der Liefferkette bei Anwendung der morphologischen Analyse macht eine grundlegende Handlung aus, in den Situationen, in denen bezweckt wird, den Güterstrom optimal zu modellieren und eine schnelle Anpassung an die neuen Gegebenheiten einzuführen.

Codewörter: Lieferkette, Metastruktur, Konfiguration

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