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PROCEDURE FOR ANALYZING EFFECTS OF CHANGEABILITY ON LOGISTICS STRUCTURES IN VALUE CHAIN NETWORKS

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Abstract

Logistics structures in value chain networks are faced with dynamically changing influences and flexible adaptations in a short-term horizon are seldom sufficient. Rather, changeable network structures are necessary. This paper describes an analytical procedure to bring out changeability effects on logistics structures in value chain networks.

Keywords: *changeability, logistics, value chain networks*

Track: *supply chain management*

1 Introduction

The advanced globalization of markets and the resulting continuous internationalization in production sites, supplier networks and sales markets lead to new and increasing turbulences and thereby requirements for industrial companies. These requirements and turbulences imply an enormous challenge for manufacturing companies and therefore, cannot be ignored. [1] In response to the incoming market-driven turbulences, manufacturing companies in the past carried out isolated improvements, which were applied in the internal organization and management processes. [2] [3]

In the recent years, the trend can be observed that manufacturing companies line up in the form of cross-company networks. These networks allow the participating companies to concentrate on their competences by the shifting of non-core activities to other network partners. This division of labor within networks provides the chance of creating added values flexibly and efficiently. Otherwise, the coordination effort by reducing the vertical integration of the individual company is reinforced, because now the process is not only limited to one company, but regards the whole network of companies, which are involved in the performance assessment process [12] [13]. At the same time the steady growth in customer demands for

more individual goods leads to a raised number of products variations and enlargement in coordination expenditure for the whole logistics process execution. [14] [15]

The creation of added values within networks contains all processes and activities that are necessary for the production and delivery of material and immaterial achievements. The sequence of these processes is firstly described in [6] as value added chain and can be differentiated into sequential activities of development, manufacturing, distribution, delivery and support. Therefore, the processes and activities enclose all companies' functional areas, e.g. storage and retrieval or picking of goods.

Value added chains can be distinguished between internal and inter-company ones. Thereby, the internal value added chain refers to all activities within a concerned company. In contrast, the inter-company value chains also relate the upstream and downstream value chain to network partners, including suppliers and distribution channels (wholesale, retail, etc.). [7] In our research, we refer to the inter-company value chains in value chain networks (VCN). In such VCN, the inter-company processes stand in focus, because more and more companies attach crucial importance to the efficient creation of the strategic business relations, for the increase of the enterprise value for all participating network partners. [8] [9] [10] Thus, for companies operating in VCN it is necessary to understand, organize, guide, develop and continuously improve inter-company processes. This includes the consideration of logistics structures within the inter-company value chain. Thereby, the logistics structure is defined as the structure of the logistics systems elements and their interrelations.

Due to the extent of the mutual interdependencies of logistics structures elements in VCN and a large number of dynamically changing factors, such as transport costs, product developments, subject to political conditions, etc., logistics structures can be characterized as complex. In order to maintain competitiveness and to strengthen VCN, these must have the ability to react quickly and efficiently to volatile conditions. In this context, a flexible response just by adjusting the logistics structure is often not sufficient. Rather, the existing logistics struc-

tures have to be modified or changed. Besides, the kinds of change demands as well as the point of time and intensities are hardly predictable, so that only reactive adaptations of logistics structures are often not sufficient. Rather, a proactive implementation of changeable logistics structures is demanded, which admit short-time reconfigurations in cases of occurring change demands. This, so-called changeability of logistics structures can have direct and indirect effects with positive as well as negative influences on VCN. To decide about the extent of changeability in the considered network, these effects have to be detected in detail. In this context, the paper on hand presents a procedure for analyzing the effects of changeability on logistics structures during the process of network configuration. For this purpose, we consider the logistics structures of VCN and investigate the structure elements with the focus on changeability. During the process of configuration we aim onto the maximization of the robustness of the investigated VCN, affected by change drivers. The aim of the procedure is to seek the influences of changeability for logistics structure elements which can be positive or negative by direct or indirect effects.

The outline of this paper is as follows. In Section 2 we provide a literature review that elucidates the comprehension of changeability in former research areas. Furthermore, logistics structures in VCN will be addressed. Section 3 presents the procedure that is used to analyze the effects of changeability on logistics structures in VCN. The paper is finalized by some conclusions and an outlook.

2 Literature Review

Nowadays due to the continuously changing influencing factors, companies nowadays are more than ever confronted with the challenge of reconfiguring the economically sensitive interlinking of value added chain elements on intra- as well as inter organizational level. These network reconfigurations often require complex affiliated changes with complex coordination processes. Today, in order to successfully cope with these challenges networks have

to possess changeable network structures. [16] [17]. Up to know the concept of changeability is mostly applied to production systems and factory elements. Therefore, a production system is described as changeable if it shows variability with regard to its processes, structures and behaviors. Thus, it cans response reactively as well as anticipative to modifications. [18] Hernández defines in [19] the ability to change with the addition of change enablers as follows: changeability is the potential of a factory to perform reactively or proactively targeted a new or reconfiguration of factory elements by system-and structure immanent change enablers. Thereby, the approach of Reinhart and Zäh comes closest to the understanding of changeability that is used in our research. According to [20] [21] changeability describes the potential of conducting reactive and proactive modifications outside provided flexibility corridors if needed. Hereunder, flexibility describes the systems' ability to adapt due to occurring disturbances. Hence, adaptability has some defined limits, which reflect the achievability of flexibility corridor within adjustments, see Figure 1. Thus, a flexible configuration of a system can help to enable adjustments within specified limits. Thereby, the elements of a system remain constant, only the arrangement of their relationships can be adjusted.

Contrary to the described flexibility, the configuration of changeable systems implies a reconfiguration of existing systems in a higher degree. This means that the reaction does not only take place within a predetermined corridor. Rather, the adaption exceeds the existing flexibility and can require a new determination of the systems flexibility. Consequently, an effective response to occurring disturbances becomes possible. These disturbances, the so-called change drivers, are distinguished by the fact that they are mostly not predictable and assessable regarding the time of influence and the extent of their impact. [19]. A system is valid as changeable if it disposes applicable process and structural variability and hence, has the ability to react efficiently to the occurring change drivers. [22]

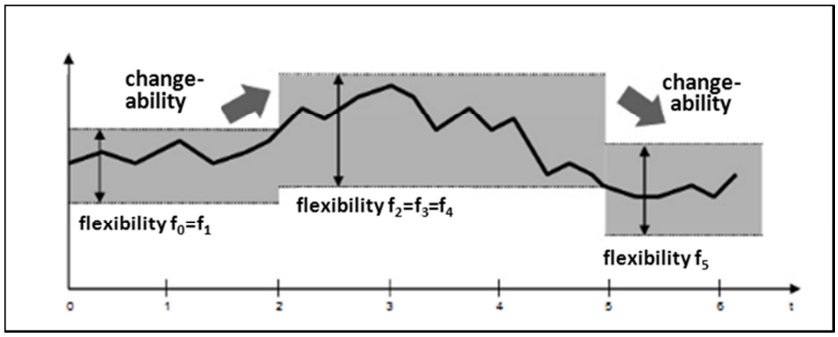

Figure 1: Corridor of flexibility and changeability [20]

As mentioned before, the researches´ main focus in the area of changeability is limited to in-plant production systems and factory elements. So, they are limited to internal structure elements or processes. Nevertheless, these attempts do not do justice to the demands of a companies-covering investigation. A companies-covering approach for VCN needs the investigation of inter-company processes. These processes have internal as well as companies´ covering process dependencies.

3 The Procedure

The procedure to analyze the effects of changeability on logistics structures in value chain networks includes three steps. After getting an overview about an existing VCN, which is the first step, the procedure shows the identification of change drivers in the second step. Then, the approach to analyzing the effects of identified change drivers and general changeability on the logistics structure of a VCN is the final step. The specific steps will be described in the following.

3.1 Analyzing the existing value chain network

To analyze the effects of changeability in logistics structures it is, firstly, necessary to get an overview about the existing logistics structure in a given VCN. Through a detailed as-is analysis of existing VCN with its logistics objects, the logistics structure can be determined. This includes logistics elements, logistics processes and interactions between the logistics elements. To analyze the effects of changeability, we contemplate a three level model which we

have developed in our research for the as is analysis of a VCN with a top down consideration, as seen in Figure 2.

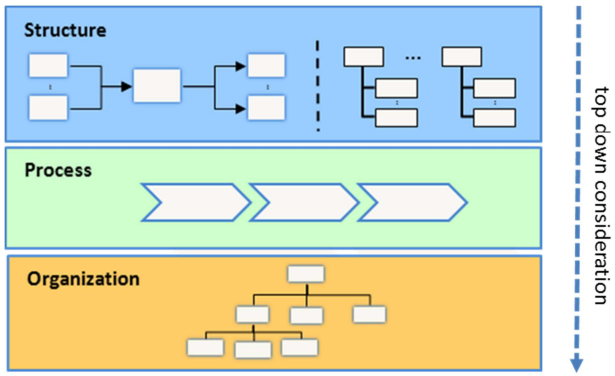

Figure 2: determining the existing VCN

Thus, the top down consideration means that we initially examine the logistics structure of the VCN and identify the logistics processes of the structure elements in detail.

Basically, on the structure level, the existing network and product structures will be examined. The evaluation of network structures includes the identification of the function areas within the company in focus as well as external company sides and network partners including their function and geographical dispersion. Within the product structure the companies' product range will be evaluated and analyzed regarding its specific characteristic. In order to link network and product structure, it will be determined which network partners are relevant for which product areas. Additionally, the systems load will be determined by evaluating the quantities of final products, components and raw materials that have been purchased or produced over time for a specific product.

Within the process level the main processes that are necessary for the order processing will be identified. The processes will be assigned to the main categories procurement logistics, production logistics and distribution logistics. This includes the operational processes that are necessary for the order fulfillment like handling, storing and transportation processes. [21]

Although the organization level can have different effects on the VCN, it can be neglected for this procedure, by reason that its elements cannot mostly be quantified with logistics operation figures.

Besides the determination of the VCN's structure elements and logistics processes, the main aim of this step is to detect and parameterize the logistics objects'existing flexibility. Thus, the first step is the detection and parameterization of the subordinate objectives of all logistics objects. These can in turn be realized by the operating figures which either exist in companies' specific enterprise resource planning systems or have to be evaluated by detecting the available process data. Depending on the logistics structure the subordinate objectives can have distinguished characterizations and operating figures. Thereby, the operating figures that are necessary are mainly the following:

- The operating figure *process costs* includes the costs of all specific logistics processes like production, transportation, personal and material costs in the VCN.
- The operating figure *stock* includes all stored materials and products within the process of procurement, production and delivery and indicates the companies' flexibility to disturbances. It is also a rate for the goal conflict between security of supply and inventory costs.
- The operating figure *adherence to delivery dates* marks the processing of detailed orders and evaluates their adherence to agreed delivery dates.
- The *cycle time* (throughput time, lead time) is the needed time of an entity for passing through the system. The calculation of the processing time depends on the respective system and entity type.
- The amount of planned or produced products during a certain period of time for a company is measured with the operating figure *utilization*. The upper limit for the utilization is determined by the capacity.
- The operating figure *schedule variance* marks the comparison between the actual finish date and scheduled finish date of the preceding process.

After bringing out the relation between processes and their subordinate objectives to the operating figures, the existing flexibility of the network elements has to be detected. Depend-

ing on the subordinate objectives and their operating figures, the flexibility can be measured in time, costs and quantities. These in turn have specific upper and lower limits that define the flexibility corridor of each operating figure.

However, the central task of the logistics structure is the achievement of logistics and economic objectives. The scope is a logistics goal of objectives that can be divided into three objective and target levels. In our research, the superior level is allegorized by the logistics economy of the logistics structure. The logistics economy, thereby, consists of logistics performance and logistics costs in the intermediate target level. The logistics performance is reflected by the operating figures high adherence to delivery dates, short cycle times and low schedule variance. In contrast, the operating figures process cost, adapted utilization and low stocks can be assigned to the logistics costs. These operating figures describe the subordinate objectives of the processes as mentioned before.

Between the named operating figures there is a conflict of objectives so that no overall optimum can thereby be defined. Hence, it is necessary to consider the interactions between the subordinate objectives' operating figures and, if necessary, to carry out a weighting of the objectives. Figure 3 pictures the logistics goal of objectives in our research and their interactions.

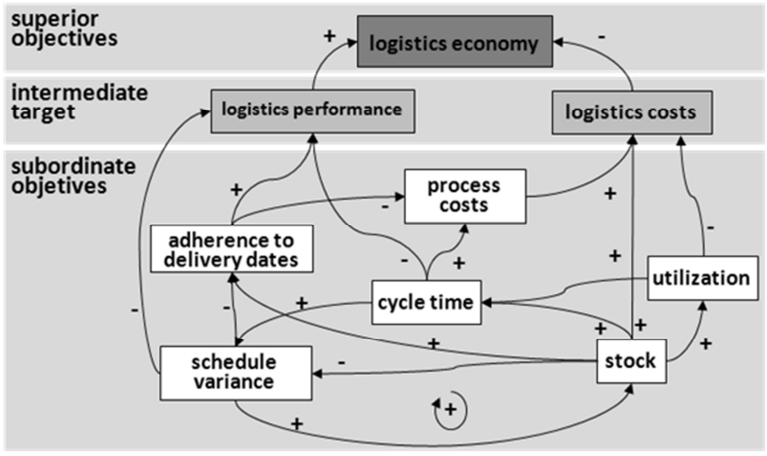

Figure 3: logistics goal of objectives and their interactions

As mentioned before and shown in figure 3, the intermediate targets logistics performance and costs are affected by specific operating figures directly. In addition, the interactions of the remaining operating figures affect the intermediate targets indirectly by influencing the direct affecting operating figures. This logistics goal of objectives with its operating figures and the identified interactions surfs as a basis in our research and for the quantitative description of a logistics objects' characteristic in the process level of a VCN. Nevertheless, depending on the considered VCN this logistics goal of objectives must be changed and be adapted to the examined structure with their parameters and their flexibility corridors. Then, in case of the consideration of the whole VCN these can be aggregated to one logistics economy of the VCN.

3.2 Identifying change drivers and analyzing their effects on logistics structures

As mentioned before, logistics structures in VCN are faced with dynamically changing influences. By using the identified operating figures as subordinate objectives of logistics objects, the logistics objects within VCN, that need the ability of adaption can be identified by the monitoring of these objectives, in cases of occurring change drivers. These logistics objects are the so called changeable objects. The correlation between influencing factors and changeable objects then leads to the identification of the change drivers. If the effect of an influencing factor has the potential to drive the operating figures over or below defined limits, these factors have to be defined as change drivers for the considered network.

Then the identified change drivers can then be classified, according to their origin, into external and internal change drivers. In our research we have identified change drivers, which can be classified as follows.

External change drivers:

- Political and legal conditions are external change drivers which are given by the judiciary of a country or an institution, like trade barriers for countries or environmental laws.
- Sectorial change drivers (competitors) refer to, e.g., the quantity or prices of competitors.

- Sectorial change drivers (supplier) contain all influences which come from the procurement site in the VCN. These can be geographical distribution of suppliers or material availability.
- Sectorial change drivers (customer) are influences which affect the VCN on distribution sites. One of these influences is, for instance, individual customer requirements to distributed goods.

Internal change drivers

- Defensive internal change driver often results out of existing weaknesses and afford reactions in disguise. These drivers have their basis in, e.g., problems with product and process quality.
- Offensive internal change drivers results out of the companies conscious strategic considerations. Some examples for these are process and product innovations and strategic decisions for new distribution markets.

Although this influences can individually affect a VCN. But it is more likely that these influences appear in different combinations together.

3.3 Analyzing the effects of change drivers on logistics structures in VCN

After setting up the goal of objectives and its interactions for all logistics objects, the effects of change drivers have to be analyzed. This is the first step to analyze the effects of changeability in our research. Only if the effects of change drivers are known, targeted changes of the logistics structure can be initiated. For analyzing the effects of change drivers on the whole VCN, we pursue a bottom up consideration by using the goal of objectives of all existing logistics objects, as seen in figure 4.

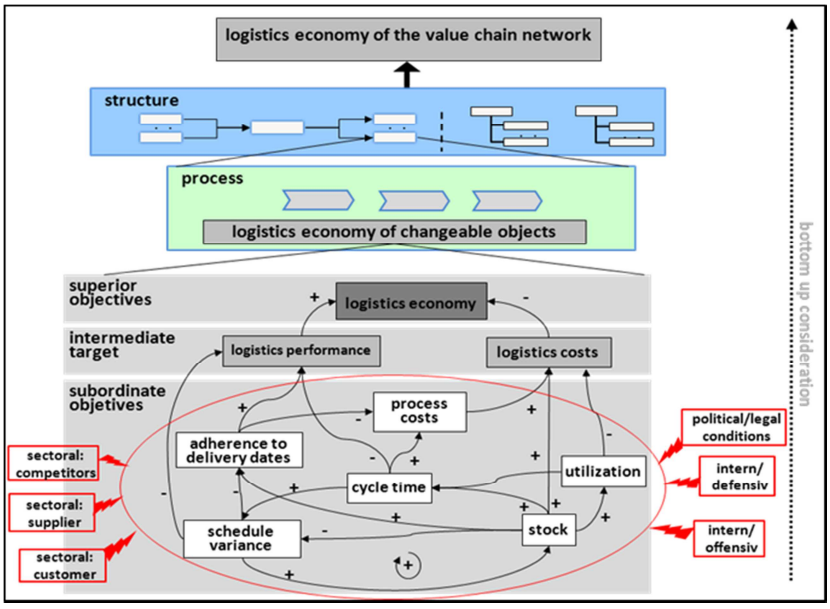

Figure 4: Procedure for analyzing the effects of change drivers on logistics structures in VCN

By the fact that, on the one hand, the existing logistics structure was analyzed and, on the other hand, the logistics goal of objectives was set up, the challenge is the identification of the operating figures' changes caused by change drivers.

Nevertheless, these parameters must be determined exactly together with the actors in the VCN. If the change drivers have a distinctive effect on the operating figures that their flexibility corridor do not manage around on reacting to this, the companies objectives that are measured by these operating figures needs the ability of adaptation. Then these effects then have an influence on the superior objective of the logistics economy of logistics objects on the process level. By considering these effects in a bottom up view, the affected superior objectives out of the process level can be consolidated to a logistics economy of the whole VCN. The relation between the logistics economy of the existing VCN and its state after affecting these with change drivers brings out the change necessity of the VCN.

3.4 Analyzing the effects of changeability

By using these identified effects of change drivers in the process and structure level, different change enablers can be used to enable the affected objects to react against the change drivers

and their impact. In doing so, change enablers can be summarized to handling instructions or methods that can be implemented within the network.

After implementing the methods, the logistics structure or processes within the VCN, the network has achieved the ability for necessary changes or can be changed more efficiently compared to its original status. While the effects of only ability the logistics structure changeable the logistics performance can only be exactly evaluated even after change driver ties and the change takes place.

Certainly, this prophylactic provision of change enablers does also include high cost efforts. So, changeability affects first and foremost the logistics costs in the logistics goal of objective. The value of these effects on logistics costs is addicted by the change enablers, which have to be conceived and developed. Besides, human resources inputs to conceive or develop the change enablers and therefore the changeability of the logistics structure, logistics structure and process changeability have an effect on the logistics costs, too. Even if change drivers have a so immense effect on the logistics costs that a reaction to these has to be executed in short term, possible network structures and processes have to be provided. This means that, for example, geographical segmentation of procurement and distribution structures on the structure level or production process changes due to possible spontaneous changing market trends (mostly in the food industry) has to be provided.

Therefore, all costs that are related with the provision of changeability as well as the expected benefits have to be detected by actors in the VCN, before providing the changeability and can be measured. Even though effects of changeability on logistics performances of the VCN cannot be exactly determined, as mentioned before, we analyze the effects by creating a medium term simulation model of a specific VCN. In this model the current logistics structure and processes of the VCN will be compared to possible network configurations by monitoring their logistics performance. The comparison of logistics costs for providing changeability and the results of the simulation run, according to the logistics performance, results in a logistics

economy of the changeable VCN. This operating figure can be used as a decision support by the actors in the VCN.

4 . Conclusion and outlook

Value chain networks are confronted with dynamically changing influences. Some of these influences (change drivers) force the value chain network to reconfigurations beyond existing flexibility corridors. For this reason, our research aims at providing methods and procedures for the configuration and optimization of changeable value chain networks.

The paper on hand describes a procedure to analyze the effects of changeability on logistics structures in value chain networks. In doing so, firstly a procedure to analyze effects of change drivers is presented and the effect of changeability is explained. Both investigations use logistics operating figures, which are aggregated to a superior objective logistics economy. So the effects of change drivers and changeability in general can be pictured in this objective.

The practical applicability of the procedure will be verified by means of two industrial partners. This requires the knowledge about their existing network structures. Thus, further steps of investigation will be the detailed consideration of the network structure and the determination of the effects of specific for each VCN identified change drivers. Following up is the evaluation of specific change enablers that enable the industrial partners to react to potential change drivers and examine the effects of it on their VCN.

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