Katja Windt
Editor

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Description of a configuration model for establishing adaptable logistics chains

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Abstract. Logistics chains are mostly influenced by changes in their business environment. A system's adaptability is seen as one potential to effectively counteract these environmental changes. To consider the effects of adaptability on the whole supply chain, a framework for configuring adaptable logistics chain was developed within the research project "KoWaLo". This paper deduces an approach how to identify adaptable logistics configurations. Furthermore a case study shows the potential of the configuration model.

Keywords: Logistics, Supply Chain, Adaptability

1 Introduction

Nowadays manufacturing companies are increasingly exposed to changes in their business environment. Ongoing globalization does not only lead to new competitors, but also to new markets and new demand potential [1]. Furthermore a change in the customer market can be recognized. The shift from a seller's market to a buyer's market is reflected besides higher service levels in shorter reaction times, increasing individuality of products along with declining prices. The increasing individuality of products leads to a high number of different product variants [2][3][4]. A further indicator of intensified competition and the increasing impact of external influences are declining innovation cycles and product life cycles, caused by the rapid development in information and communication technologies [5][6].

Such events entail more and more turbulent business environment. In order to stay competitive, new strategies have to be applied to face the ongoing changes. Therefore the topic "adaptability", which can be described as the ability of a system to perform both reactive and proactive adaptations by specifically varying processes, is an important approach to deal with turbulence and retain competitiveness [8][9][10][11]. In comparison to flexible systems, which only can deal with changes within a certain range, adaptable systems allow to shift the range of flexibility to a higher or lower level by specific arrangements as shown in figure 1, e.g. through investments and/or organizational arrangements [11].

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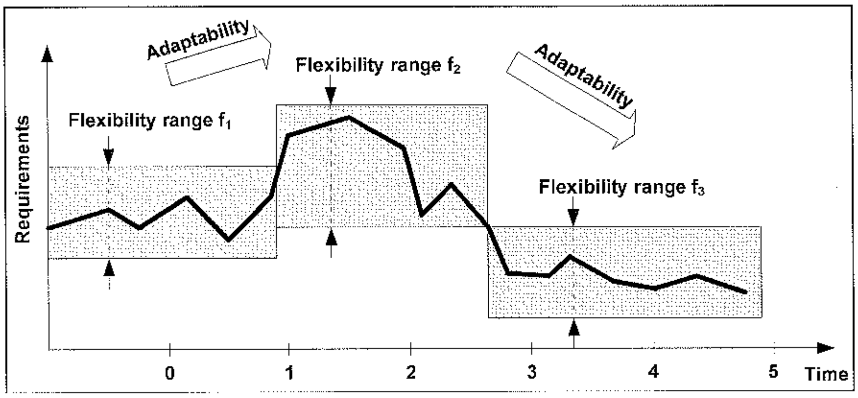

Fig.1. Adaptability as the Capability to Shift Flexibility Ranges [10]

The main focus of previous research activities on adaptability has been on the factory level. Supply Chains as a whole have been taken into account to a lesser extent [12]. First research activities in this matter were carried out by Christopher on a conceptual level without discussing defined constitutive characteristics (i.e. number of warehouses or transport concepts) precisely [13] and Dürrschmidt by developing a concept for planning adaptable logistics systems for serial production without disclosing approaches for configuring logistics chains [14]. More recent research activities focusing on adaptability in logistics chains were carried out by Nyhius et al. by evaluating intra-enterprise logistics chains based on the requirement and the economic value added of an adaptable configuration [15].

Within the research project "KoWaLo" a framework for configuring adaptable logistics chains based on concretely defined constitutive characteristics will be developed in order to consider the effects of adaptability on the efficiency of the whole supply chain. The Austrian Research Promotion Agency funded this project with the partners Knorr-Bremse GmbH Division IFE Austria, Seisenbacher GmbH and the Vienna University of Technology. The focus of this paper is to describe the procedural method to identify the main constitutive characteristics in order to set up the configuration framework.

2 Shifting flexibility ranges in logistics chains

As described in the introduction adaptability offers great potential to cope with turbulences. In this respect adaptability considers structural changes in three basic principles: rapidness, flexibility and costs. Given that until now adaptability was primarily discussed with focus on production systems, factory structures, organizational matters or order processing systems, thus primarily focusing on intra-enterprise issues, and the fact that in many industries 50-70% value added is contributed within a supplier network and therefore the adaptable positioning of an individual company is not sufficient it is inevitable to identify options that allow shifts of flexibility ranges in logistics chains. From the supply chain management point of view, the stability of the supply chain needs to be preserved at its best. While meeting delivery times or coping with an increased demand, companies face the problem of increased logistics costs. This leads to extra or emergency transports with for example low capacity utilization and/or the usage of expensive carriers like planes instead of trucks or trains. Along with these financial issues there are issues like increased emissions and their ecological effects. Longer-term supply shortfalls due to production breakdowns or quality problems may be considered when choosing sourcing strategies whereas changes in demand may be considered when planning distribution networks. These examples show the importance of developing a framework helping companies to empower adaptability in their logistics chains.

In order to identify and asses the main constitutive characteristics and their respective specifications with regard to their ability to enable a logistics system to be (re-)configured continually, rapidly and in a cost effective manner as the major basis for configuring adaptable logistics chains, it is necessary to analysis different environmental dynamics scenarios and their effects on the logistics system [17]. By analyzing these effects together with the ability of the general constitutive characteristics of logistics systems to handle environmental dynamic, the main characteristics can be identified (chapter 3.2). By modifying the respective specifications of constitutive characteristics different logistics chain configurations can be developed.

As to secure cost effectiveness the configuration of adaptable systems has to be carried out in consideration of the systems cost effectiveness during its life cycle or a given time horizon [18]. The total costs of adaptability can be divided in system-costs (initial investments) and process-costs. Process-costs can further be divided in direct costs comprising costs for operating the system and costs for flexibility shifts, whereas the indirect costs comprise inefficiencies of the system caused by over- or under-designed systems.

As there might be possibilities on how to set up an adaptable system, companies need to consider these with subject to the degree of adaptability and related total cost in order to be able to choose the most favorable configuration, i.e. the one with the best adaptability-cost-ratio. Therefore the different scenarios need to be evaluated by appraising the different types of costs for each scenario, as shown in Figure 2.

Chapter 3 presents the configuration model for establishing adaptable logistics chains. The configuration model is a process model which helps the operator to find and assess new logistics chain scenarios. Chapter 4 shows a case study where the configuration model has been applied.

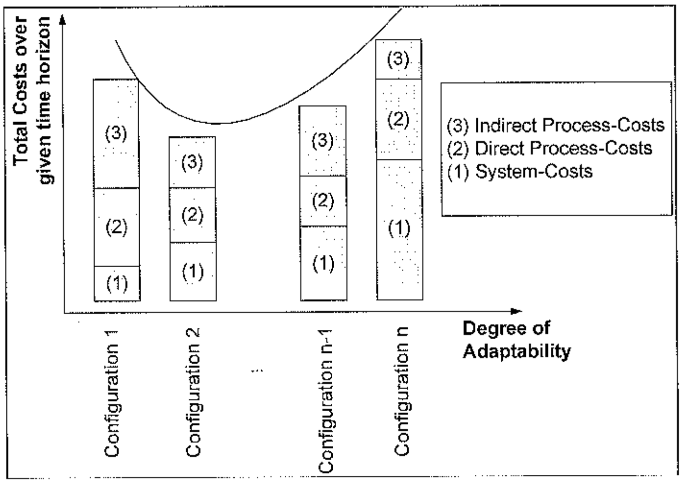

Fig.2. Total Costs Consideration of Different Scenarios [5].

3 Configuration model for establishing adaptable logistics chains

The configuration model for establishing adaptable logistics chains is composed of six steps shown in figure 3. The focus of this chapter is to describe the approach of an operator to identify optimized logistics configuration in order to counteract external influences (load scenarios, i.e. major shifts in demand).

3.1 Definition of load scenarios

Logistics chains have to provide a robust configuration to handle different external influences. Influences which cannot be handled by the current flexibility ranges result in special charges like express or extra transports. Due to different impacts by the external influences on the logistics chain, a classification of these influences is necessary. To provide a thorough and generic approach, the classification was structured in terms of possible influence locations and influence factors. The influence location describes the place in the logistics chain, where the influence can have an impact on. Along the logistics chain the influences can affect the demand side, the supply side or the surrounding of the logistics chain. With regard to the influence factors the external influences can have an impact on the factors described by the 6 R's of logistics (goods, time, location, quantity, quality and price). Within the configuration model only the factors time, location, quantity and quality are considered. The factor price will be considered within the process step monetary valuation and the factor product will not be considered because this model acts on the assumption that the right product is already available [19].

The aim of this process is to identify these external influences that can have an impact on the operator's supply chain. Therefore a logistical scope has to be identified (e.g. a region, a supplier) where the operator identifies the relevant load scenarios by the use of cost analysis, KPI analysis, environmental analysis or other analyses which are required to specify inferences from the external influences on the logistics chain. After the assessment the operator chooses one load scenario for the further approach.

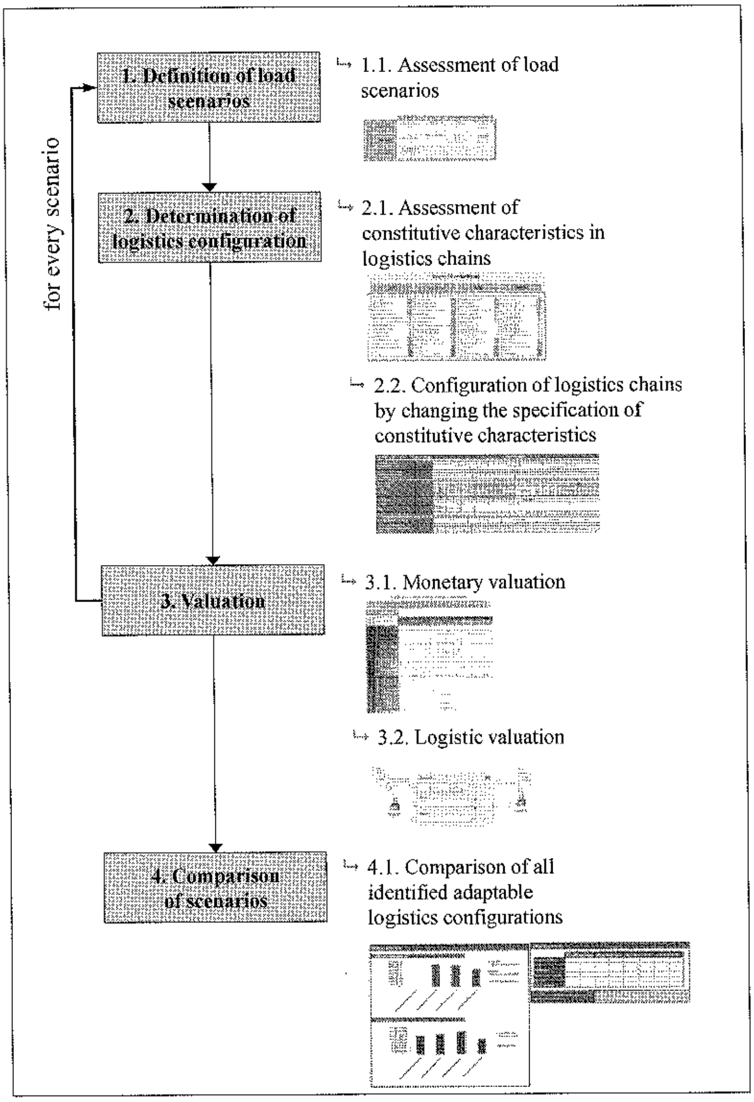

Fig.3. Overview of the configuration model for establishing adaptable logistics chains

3.2 Determination of logistics configuration

In this part of the process the operator has to design new adaptable logistics configurations based on constitutive characteristics which can counteract the chosen load scenario. The first step in this approach is to identify the right constitutive characteristics. Afterwards different logistics configurations can be generated.

Assessment of constitutive characteristics in logistics chains

After defining the scenarios or rather scenario categories it is essential to identify the relevant regulating variables in logistics dealing with the impacts of the load scenarios. Therefore constitutive characteristics directly influenced by the load scenario categories have to be identified. To identify adaptable constitutive characteristics, two separate analysis where conducted and merged by a multidimensional approach. Herein KPIs are used as linkage between load scenarios (analysis 1) and constitutive characteristics (analysis 2) [20].

After the relevant KPIs have been defined analysis 1 can be initiated. Within this analysis KPIs directly affected by the load scenarios (has the load scenario a direct impact on the KPI?) are chosen to be considered in the following. Because the KPI's value is regulated by the configuration and performance of constitutive characteristics, this analysis is relevant for the identification of adaptable constitutive characteristics.

Within analysis 2 the constitutive characteristics have to be evaluated considering the direct influence of a configuration change by changing the specifications within the constitutive characteristic sand the expected impact on the value of the KPI (does a change within a constitutive characteristic has direct impact on the KPI?).

The third step combines the results of analysis 1 and analysis 2 by linking load scenarios and constitutive characteristics: if a specific KPI is expected to be influenced by a load scenario and at the same time is expected to be influenced by the change of a constitutive characteristic it is most likely that varying this characteristic allows counteracting the load scenario. In terms of adaptability those constitutive characteristics that allow counteracting the defined load scenarios form the basis for configuring an adaptable logistics chain. This task has only to be done once because every identified scenario can be supported by a specific load scenario group and the linkage between constitutive characteristics and KPIs are defined by the respective KPI definition. [20]

Configuration of logistics chains by changing the specification of constitutive characteristics

Using the assessment of constitutive characteristics for every load scenario the operator can now identify the right levers to reconfigure the logistics chain. In addition to the identified constitutive characteristics the operators has to estimate which of these characteristics is relevant for his logistics chain. For example the constitutive characteristic supplier strategy is not a right lever when there is only one supplier for the whole industry.

3.3 Valuation

After selecting the new logistics configurations, the operator of the configuration model (i.e. logistics manager) has to evaluate each configuration concerning the factors costs and logistics performance.

Monetary valuation

Within this approach process the different logistics scenarios are evaluated by the factors costs. Therefore the total cost of ownership approach has to be applied to provide a complete view of all investments needed to change the current logistics configuration to the new logistics configuration. The approach considers different categories. On one hand, costs concerning warehousing, transport and administration have to be identified. On the other hand, these costs have to be attributed to adaptable object costs, direct adaptable process costs, indirect adaptable process costs or operating costs, which are not considered in the logistic valuation step. Adaptable object costs bundle all investments needed to realize the new logistics configuration. These costs only occur once (e.g. purchasing of extra bins). Direct adaptable process costs bundle all costs needed to change the current logistics configuration to the new configuration (e.g. costs for adjustment or dismounting). The indirect adaptable process costs bundle all costs which accrue while reconfiguring the logistics chain and affect the logistics or production performance (e.g. loss of production output because of the non-availability of the equipment to be changed). The operating costs are considered, because of the high impact of the external influences on these operating costs. To measure the operating costs in detail, a simulation model has been deployed, which will be described in the next subsection. Underlying cost rates for transport, stock, delay penalties and raw materials allow the evaluation of the systems total cost alongside with time effects like delivery capacity and reliability. [19]

Logistic valuation

To assure a complete logistics valuation two models – the simulation model and the evaluation model – were developed (Figure 4 - for higher resolution see appendix A). The simulation model represents a standard logistic chain, including inbound and outbound logistics as well as aggregated main production processes and their associated behavioral pattern concerning lead-times and deviation of lead-times. In order to assess the effectiveness of one or a set of constitutive criteria and their respective configurations, the simulation model is based on a discrete event simulation algorithm. Furthermore it represents an exemplary order fulfillment process to simulate the entire information and material flow over the logistics configurations. In addition to the simulation model, which only simulates the information and material flow over the defined processes, an evaluation model is required to translate the result data into comparable KPIs. Beside the measurement of the logistics performance (e.g. delivery time, lead time, backlog of orders, stock) within the evaluation model, further results are generated. As mentioned within the subsection "monetary valuation" operation costs are also generated by the evaluation model. Furthermore ecological effects like the CO2 emission can be identified. The identification of these factors within the evaluation model is done in order to generate a realistic image of the actual logistics chain and the processes represented by the simulation model. The identification of the adaption costs (described in subsection "monetary evaluation") is only a part of the evaluation model and not of the simulation model.

With the integrated application of the simulation and evaluation model dynamic effects of certain scenarios on the logistics configurations can be simulated (within simulation model) and bottlenecks can be identified (within evaluation model). By changing the specification of adaptable constitutive criteria and their theoretical effect on the systems behavior by the operator, a statement can be made concerning the probability of an adaptable logistics chains aptitude to counteract these dynamic effects.

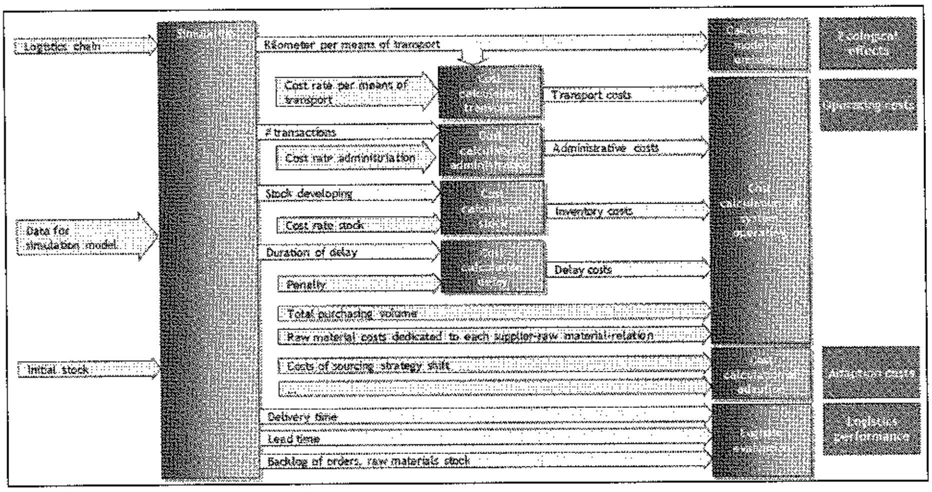

Fig.4. Structure of the simulation and evaluation model.

3.4 Comparison of scenarios

Using the results of the two valuation steps, a comparison of all logistic configurations can be provided in consideration of costs, the logistics performance (as depicted in figure 3) and ecological effects due to transport system changes. This step provides an overview over all logistic configurations and provides the operator a base to make decisions regarding the new logistics configuration.

4 Potential of a configuration model for establishing adaptable logistics chains

Companies in the railway vehicle manufacturing industry have to cope with different external influences. One of these influences is the high individuality of the products. Therefore, customers have to consider long delivery times because of some parts' long production and/or replenishment times. Another reason for these long delivery times are short-termed changes of orders, which can cause delayed delivery. As this long delivery times are not acceptable nowadays, some customers claim shorter delivery times.

To achieve this requirement the configuration model was applied. The first step was to identify the right load scenario. Because of the influence location demand and the influence factor time the right load scenario could be defined. Within the next process step new logistic configurations have to be developed. To shorten the delivery time and handle short-termed shifts of orders different configurations have been considered in the case study:

1. Customer-oriented consignment warehouse (LC1): Storage of three scheduled deliveries (24 items). The replenishment of the consignment stock is based on the scheduled deliveries and not on the stock withdrawal.
2. Production-oriented semi-finished product warehouse (LC2): Storage of three scheduled deliveries in terms of semi-finished products at the manufacturer. The replenishment process is similar to the case study 1.

Results

By reconfiguring logistic chains based on external influences improvements can be realized. The operation of adaptable logistics chains monetary improvements as well as improvements in the logistics performance can be achieved. Within in the case study, the configurationLC1 and LC2 could provide a payback period of nearly one month. Furthermore the logistics performance (delivery reliability, mean delay in delivery) could be improved by about 50%. CO2 emissions could be shortened by about 65%. The immense reduction of CO2 emissions traces back to long logistic chains where extra transports use air-transport and the standard transports uses see-transports.

Overall, an application of the described configuration model allows an operator to handle external influences in an optimal way. In addition to reduced costs, the logistics performance can be improved.

5 Summary

Adaptability constitutes high relevance for systems facing volatilities or continuously changing markets. According to the factors flexibility and reactivity as well as economic factors, structures can be (re-)configured to reach a high performance and low total cost. Adaptable concepts within production systems approve this statement. Nevertheless production systems only constitute one part of the value added chain and therefore adaptable concepts regarding the whole logistics chain have to be developed.

The presented configuration model for establishing adaptable logistics chains shows a structured approach to identify new logistics configurations based on load scenarios which can have an influence on logistic chains. Furthermore the results of the case study underline the need to reconfigure the logistic chains.

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7 Appendix A