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A Model-based Method for Assessing Potentials in Distribution Logistics

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Abstract

Distribution logistics is an essential factor of a company's success by virtue of its great impact not only on logistical performance, but also on logistics costs. For this reason, it deserves special attention. This paper presents a model-based analysis of the distribution logistics potential, with the aim of detecting the logistical and monetary potential within a company. Moreover, further research activities are identified in order to expand and improve the developed method.

Keywords: Distribution logistics, supply chain management, potential analyses

JEL Classification codes: R30, D20, L22

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According to a current study by A. T. Kearney and the European Logistics Association, the logistics costs incurred in the fields of mechanical engineering and electronics in the European companies are on average 7.1 % of the net turnover, and the figure is rising. Companies operating with inefficient logistics may report an even higher cost ratio. These logistics costs are in large part attributable to the storage of finished goods and the cost-intensive and complex transport processes leading through the distribution logistics system to the customer.

Even if reducing operational costs still remains the goal most frequently stated by companies for the coming years, more and more attention is being directed to the task of increasing logistical performance (McKinsey, 2010). Customers are no longer basing their purchasing decisions solely on the price being asked for a product's functionality and quality. Increasingly important are the distinguishing factors such as delivery reliability and short delivery times. A company's logistical performance has now developed into a decisive competitive factor (Kearney & ELA, 2009; McKinsey, 2010; Nyhuis & Wiendahl, 2008). This is where distribution logistics plays an essential role, since it represents the functional side of a company's logistics, with its direct interface to the customer. By virtue of its great impact, not only on logistical performance but also on logistics costs, distribution logistics is an essential factor of a company's success and for this reason it deserves special attention.

It is because of the great significance placed on distribution logistics that the Institute of Production Systems and Logistics (IFA) is currently conducting a model-based analysis of the potential of distribution logistics, with the aim of detecting logistical and monetary potential within a company. No such model-based potential assessment can currently be found either in the literature or in practice, which justifies the high investment level of the project (Groß, Fronia, & Nyhuis, 2014a; Groß, Fronia, & Nyhuis, 2014b). The aim of this article is to give an overview of the results attained so far in the research project entitled "Development of a model-based method for assessing potentials in distribution logistics". Attention is also given to further research intensities. To begin with, the elements, tasks, and goals of distribution logistics are described and a literature review is given. The methodology is then derived from this foundation along with its validation within the industrial practice. The article concludes with a summary and an outlook towards further research activities.

Tasks and Goals of Distribution Logistics

Distribution logistics forms a direct link between production and the sales market. It is divided into three elements, as shown in Figure 1: order processing, warehousing, and transport.

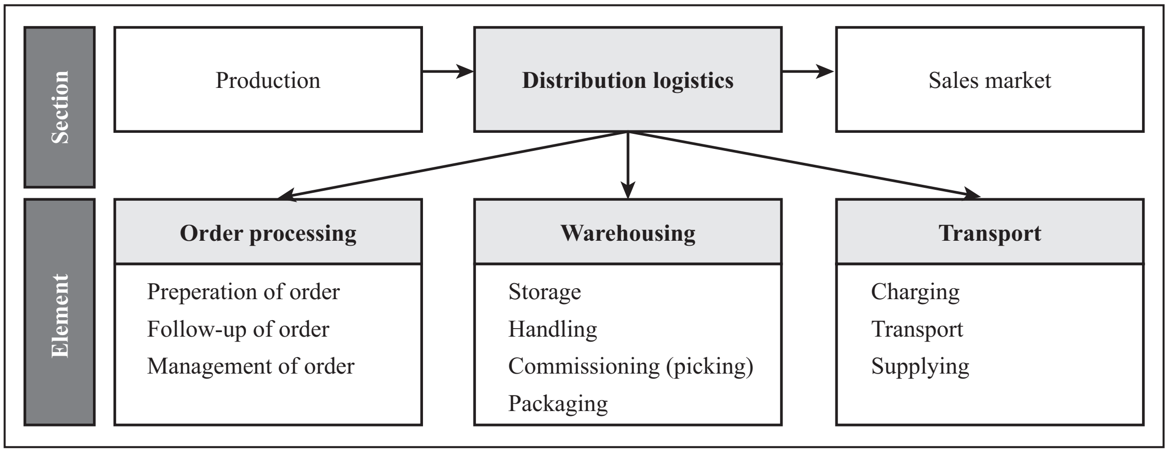

Figure 1. Sections and elements of distribution logistics.

Order processing comprises the acceptance, preparation, management, forwarding, and documentation of customer orders, from the time of their receipt until the delivery of goods and invoice to the customer. This also involves forwarding information and communicating with the customer, and takes in the respective internal functional areas, e.g., production (Schulte, 2009). *Warehousing* in distribution logistics comprises all those tasks associated with moving goods in and out of storage and providing, handling, picking, and packaging the finished goods. *Transport* in distribution logistics performs the function of spatial balancing, which denotes the distribution of goods within the logistics system by means of suitable forms of transport and carrier (Groß et al., 2014a). A distribution structure is understood as the physical form of a distribution system, taking into consideration the spatial-geographic distribution of warehouse sites, their number, and the demarcation and allocation of delivery zones (Schönsleben, 2011).

Efficient distribution logistics is an essential factor of a company's cost-effectiveness. The aim is therefore to secure the efficiency of distribution-logistical processes. The definition of the target system of distribution logistics which underlies this article is based on VDI Guideline 4400 (VDI, 2002). The efficiency of distribution logistics is determined by the primary goals of high logistics performance and low logistics costs. The logistical performance of distribution corresponds with delivery performance and can be divided into the subgoals of short delivery time, high delivery reliability, high delivery integrity, and high delivery flexibility. The logistics costs of distribution comprise the process costs of distribution logistics and capital tie-up costs.

Literature Review

The already existing methods of potential evaluation in the field of distribution logistics can be classified into four categories according to Jacob (2006) and Wriggers (2010):

- Analytical approaches to individual situations,
- Experience-based profitability analysis,
- Model-based simulation approaches, and
- Model-based profitability analysis.

Analytical approaches to individual situations consider sub-aspects of distribution logistics, e.g., transport (Wriggers, 2010). A well-known example is the so-called "Travelling Salesman Problem" and its various solution approaches in the area of operation research. The goal is to identify the shortest possible route that visits each location exactly once and returns to the origin location (Fandel, 1983). The analytical approaches to individual situations are limited to a certain subaspect of distribution logistics and, therefore, do not consider the interaction with associated areas. With the compliance of the boundary conditions, which are valid for the model, those approaches may supply detailed results and exact solutions. However, there is a risk that those results only provide a local optimum since other aspects are being excluded. For this reason, the procedure is suitable if the substantially action fields have been identified and the measures need to be developed.

Experience-based profitability analysis tries to use the know-how of previous problems (experience) by transferring it onto new applications. This type of procedure estimates the impacts of modification based on preceded comparable difficulties. The mode of action of such process can be presented according to the profitability assessment for supply chains developed by Wildemann (2004). The connections arise from the user's experiences and are not modeled. Since the sample size is too low, the approach does not lead to statistically significant results. Therefore, experience-based profitability analysis is not suited for a holistic potential assessment in distribution logistics.

Model-based simulation analysis aims at the extraction of the realization of the underlying system through the analysis of a model (Zeigler, Praehofer, & Kim, 2000), in which the model parameters and variables are being changed and the resulting system status is registered by means of a simulation (Pfohl, 2004). Thereby, a variety of arithmetic operations are being carried out. Moreover, the model has to be regenerated or at least adapted and validated for every single specific application (Nyhuis, Cieminski, & Fischer, 2005). In distribution logistics, partial models are used which support decisions in one other subdivision (Kistner & Steven, 1993). The individual models of the subdivisions could theoretically be summarized into an overall model to consider the interactions between them. This requires a very high effort of preparation and application which leads to its avoidance in practice (Merchiers, 2008). The model-based simulation has the advantage to completely and precisely describe interactions compared to the previous concepts (Jacob, 2006). Impacts from various measures on the field of distribution logistics may be described more precisely by modeled interactions between the different parameters and target figures. Therefore, they are basically qualified for a holistic potential assessment in distribution logistics and quite common in their application (Bowersox & Closs, 1989). It requires a broad and detailed modelling of distribution logistics. In addition, the simulation approach has to be adjusted elaborately to every single application so that the specific boundary conditions are taken into consideration (Nyhuis et al., 2005). Furthermore, the procurement of the numerous necessary data is often difficult or the data is not available in the considered company (Pfohl, 2004; Drexl & Klose, 2005). Therewith, this approach does not satisfy the demand of a quick application with minimal effort.

Model-based profitability assessment is established, similar to the model-based simulation approach, on the depiction of reality with help of a model. The models used here for analyzing profitability are, however, not as dependent on specific applications. The only adjustments that tend to be necessary are limited to data that has to be collected in the enterprise. Clearly, less effort is thus required to apply them than with model-based simulation analyses and they are more user-friendly (Wriggers, 2010). Despite being easier to apply the quality of the reproduction is almost as high, since the object of observation and the interactions are completely reproduced. Such a procedure does not exist in distribution logistics yet, but is already developed in the fields of procurement (Wriggers, 2010). In the following section, the model-based profitability assessment is used to model the three elements of distribution logistics: order processing, warehousing, and transport.

Modelling Distribution Logistics

The aim of the potential analysis to be developed is to enable a realistic assessment of distribution logistics monetary and logistical potentials, by modelling the essential target variables and causal relationships. The potential assessment focuses on European companies operating in the manufacturing industry. The aim of the potential assessment is to determine the logistical and monetary potentials of a company at one site. A single-stage order process is presupposed, i.e., customer orders are processed directly at the company site under investigation. Similarly, a single-stage distribution structure is assumed. The potential assessment does not consider the distribution structure in terms of changes to warehousing stages and number of warehouses. The primary variables are logistical performance and logistics costs. The article does not focus on the secondary logistical factors of the nature of goods or flexibility of delivery, for which reason the possibility of optimization is not considered. By limiting the area under investigation, it is possible to model the distribution logistics in a generally valid way, despite its high level of complexity. It also guarantees the fast and uncomplicated application of the methodology to potential assessments in industrial practice.

The following sections present the standard distribution models, followed by the mathematical modelling of the order processing, capital and transport costs.

Standard Distribution Models

Six standard distribution models have been defined, which—as shown in Figure 2—are characterized by the time of transition of ownership and the type and place of storage. These represent the most commonly encountered distribution models in industrial practice (Frühwald & Wolter, 2006, pp. 69; Nyhuis & Wolter, 2002) and are therefore ideally suited to a practically oriented potential assessment. *Stock procurement* (SP) involves consciously placing goods into stock. The supplier performs all distribution processes independently and supplies his customers from stock in accordance with their orders. The *consignment concept* (CONSI) envisages that the supplier places contractually agreed products into the customer's consignment stock. The latter only becomes the owner of the products upon removing them from stock, but he already has the power to dispose over stock as soon as the items are placed therein. *Standard part management* (SPM) is usually used for C parts. In this case, the supplier performs all picking processes and supplies the customer with the products directly at their place of consumption. In the *contract stock concept* (CSC), the supplier maintains a (spatially and organisationally) separate stock area for an individual customer. By determining a contractually defined minimum stock level, it is possible to effect supply in line with requirements in a short space of time.

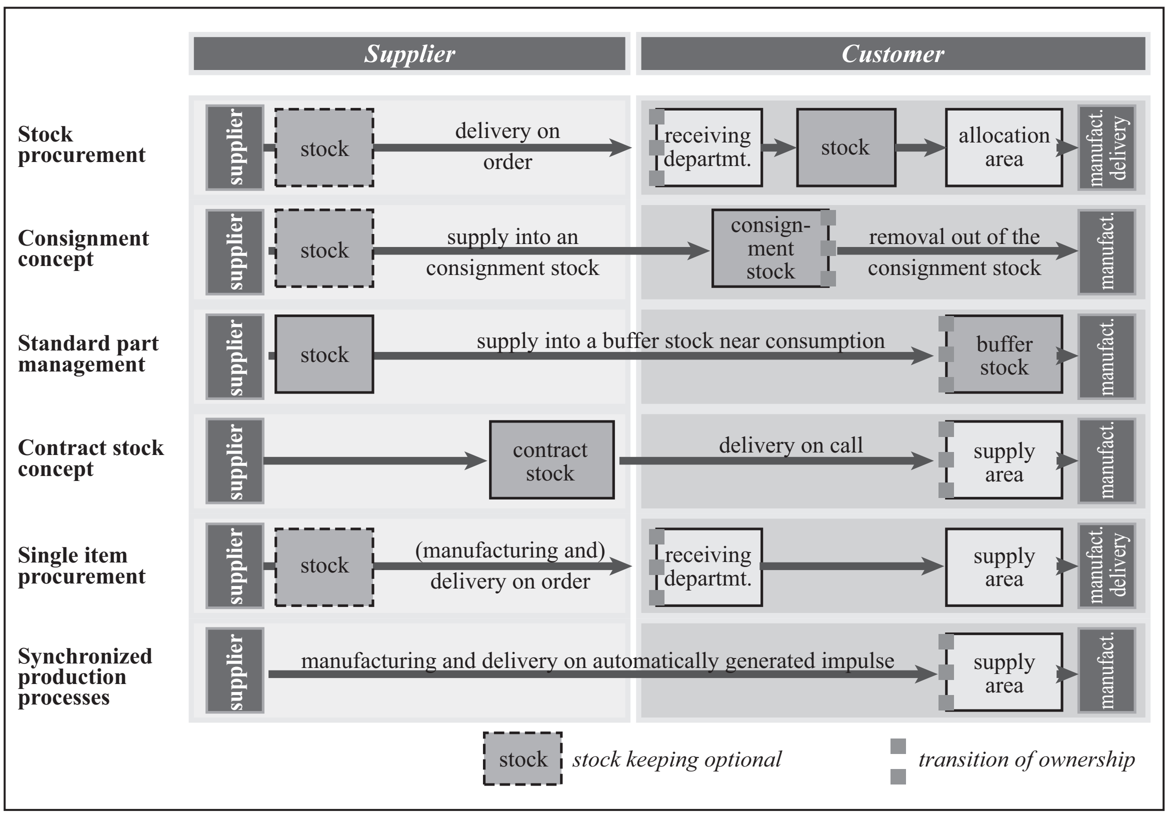

Figure 2. Overview of standard distribution models.

For very specific and sporadic customer orders, *single item procurement* (SIP) is generally used. This is performed in line with requirements and only in the existence of a concrete customer demand, directly after manufacture (manufacturing and delivery on order), without holding goods separately in stock. Where there is a very close interplay between customers and suppliers, coupled with a high predictable demand, *synchronized production processes* (SPP) may be employed. Here, distribution is triggered by an automatic call signal generated by synchronised production processes (manufacturing and delivery by automatically generated pulse) with no buffer stock. The standard distribution models differ not only in terms of the transition of ownership and stock stages but also, and significantly, in terms of the necessity, form and complexity of the subprocesses defined in the SCOR model (SCC, 2012; Fronia, Brunner, & Nyhuis, 2009). The subprocess *enquiry, issuing and submission of offer*, for instance, only occurs with stock procurement and single item procurement. With the other distribution models, it is not necessary to draw up a new offer proposal for enquiries on the basis of long-term customer contracts.

The next stage discusses the mathematical modelling that builds on the defined standard distribution models.

Mathematical Modelling of Distribution Logistics

To assess the potential of distribution logistics, it is necessary to model all the relevant variables and the correlations that exist between them. This is the only way in which the respective current situation can be presented together with the effects of measures on the variables. The respective process costs, capital costs, and logistical performance vary greatly in terms of their modelling, depending on the distribution logistical element, and on the subprocesses to be performed. Due to the specific details of the various elements, modelling is performed separately for each of the three elements: order processing, warehousing, and transport.

The method of modelling distribution logistics developed in the research project is described in detail in Fronia (2015). Since this article aims to provide an overview of the current project status, the following section will present the modelling of the order-processing element, as an example.

According to the SCOR model, order processing in distribution logistics comprises the following subprocesses: enquiry, issuing and submission of offer, receipt, recording and determination of order, order scheduling / picking, determination of delivery date, order summary, selection of transport provider and determination of freight rates, delivery to and inspection by customer, installation and commissioning, customer acceptance, and invoicing and payment procedures (SCC, 2012). The necessity of performance and the intensity of the individual subprocesses differ with respect to the distribution model. The subprocess *enquiry and offer processing*, for instance, only occurs in the event of processing with customer-neutral stock or single item procurement. With the other distribution models, it is not necessary to draw up a new offer proposal for enquiries on the basis of long term customer contracts.

Process costs of order processing are caused by the process expenditures of the subprocesses to be performed. When devising the model, it should be noted that process costs of order processing are composed of variable personnel costs, fixed costs (e.g., infrastructure) and other variable process costs (e.g., for software licenses). The variable *personnel costs* usually form the biggest share of cost in order processing. They are calculated as the product of the number of employees deployed per subprocess MA_i, the average working hours per employee and year AS_i, and the mean hourly rates PS_i. Other variable costs, such as software licenses and computers, are calculated per employee. Thus, the process costs involved in order processing for the subprocesses are as follows:

$$PK_{AA} = \Sigma_{i \in I} TPK_{AA,i} = MA_i \cdot AS_i \cdot PS_i + K_{Fix,i} + K_{Var,i} \cdot MA_i, \quad (1)$$

where:

PK_{AA} = process costs of order processing,

$TPK_{AA,i}$ = subprocess costs of order processing for subprocess I,

MA_i = number of employees deployed in subprocess I,

AS_i = average working hours per employee in subprocess i per year,

PS_i = mean hourly rate of employees in subprocess I,

$K_{Fix,i}$ = fixed costs of subprocess i per year, and

$K_{Var,i}$ = variable costs of subprocess i per year and employee.

The assessment of process cost potentials for order processing with respect to various measures is performed by means of a process cost calculation. The subprocesses of order processing are induced by output volume, since the process costs are dependent on an output volume (Schulte, 2009). A suitable key indicator has been defined for each subprocess, which quantifies the process expenditure in terms of volume, and displays a high level of correlation between the number of key indicator units achieved and the amount of cost. The key indicators for each subprocess in order processing were determined for the six standard distribution models by means of expert interviews. Once these key indicators are known, the process cost rates can be determined by dividing the process costs of each subprocess by the respective process quantities of the key indicators. The process-cost rates represent the average costs of a single performance of the subprocess. For instance, with *stock procurement*, the key indicator of the subprocess order receipt, recording and determination is the number of customer orders. The actual customer orders within the investigation period represent the process quantity of the key indicator. Dividing the current process costs of the subprocess by the process quantity gives the process cost rate for a single performance of the subprocess.

With the aid of process cost rates, it is possible to quantify the potentials of the various measures. For instance, some subprocesses in order processing cannot be performed at all when the distribution model is changed or the process quantity can be reduced by systematic complexity reduction measures. However, it is not possible to determine the extent to which the process quantity can be reduced by means of the key indicators. For this purpose, it is necessary to break the key indicators down into so-called *cost drivers*. The key indicators are then the product of the respective cost drivers of the subprocess.

Besides process costs, capital commitment costs can also be allocated to order processing. Capital costs of order processing comprise as yet uninvoiced receivables, receivables not yet settled by the customer (outstanding claims), and any defaults in payment on the part of the customer. To calculate capital costs, it is necessary to determine the capital cost rate for the company in question. If it is not known, the calculation can be made using the Weighted Average Cost of Capital (WACC) method (Miles & Ezzell, 1980). This results in the overall capital costs of order processing for the six standard distribution models:

$$KK_{AA} = \Sigma_{m \in M} \left(\frac{U_{netto,m}}{365} \cdot DUR_m \cdot r_{WACC} \right) + \frac{DSO}{365} \cdot r_{WACC} \cdot \Sigma_{m \in D} U_{netto,m} + U_{netto} \cdot p_{ZA},$$

where:

$M = \{CONSI, \; CSC, SIP, SP, SPM, SPP\},$

$D = M \setminus \{CONSI, SPP\},$

KK_{AA} = capital costs of order processing,

U_{netto} = net annual turnover,

DUR = days unbilled receivables,

r_{WACC} = capital cost rate according to WACC method*,*

DSO = payment period, and

p_{ZA} = probability of payment defaults.

Order processing affects a company's delivery time and delivery reliability. A reduction in order processing time can lead to a reduction in delivery time, if the subprocess is such that it has a determining effect on the delivery time. As to which order processing, subprocesses have a determining effect on delivery time, this depends on the respective distribution model. With *stock procurement, single item procurement*, and *contract stock concept,* all subprocesses except for invoicing, payment processing and selection of transport provider and determination of freight rate can determine delivery time. Reducing the process time for one of these subprocesses leads directly to a delivery time which the customer perceives as shorter. The other distribution models, on the other hand, do not display any order processing subprocesses that determine delivery time. This is because the stock is maintained directly on the customer's premises.

To illustrate the effect of the individual subprocesses on delivery time, it is necessary to determine the process times for each delivery time-determining subprocess. *Stock procurement* can serve as a basis and reference model. Using relative cost factors, it is possible to calculate the respective process times of the subprocesses for the other distribution models. The model-specific order processing time is calculated as follows:

$$LZ_{AA,m} = \Sigma_{i=1} a_{i,m} \cdot KF_{i,m} \cdot PZ_{i,KL},$$

$I = \{subprocess\},$

$$a_{i,m} = \begin{Bmatrix} 0 \text{ If } subprocess\ i\ of\ D.modell\ m\ is\ not\ delivery\ time\ determining \\ 1 \text{ If } subprocess\ i\ of\ D.modell\ m\ is\ delivery\ time\ determining \end{Bmatrix}, \qquad (2)$$

where:

$LZ_{AA,m}$ = order processing time for distribution model m,

$KF_{i,m}$ = relative cost factor for subprocess i of distribution model m, and

$PZ_{i,KL}$ = process time for subprocess i with stock procurement.

It is thus possible to quantify the effects of process improvements on delivery time. At the same time, it is also possible to display a change in delivery time brought about by changing the distribution model.

The effect of order processing on a company's delivery reliability can be modelled by the reliability and temporal consistency of the order processing processes. However, the necessary data expenditure and attainable statement quality contradict the objectives of the potential assessment. For this reason, only delivery time is considered as a logistical performance of order processing.

Logistics costs and logistical performance were also modelled and the modelling functions were defined for warehousing and transport elements in accordance with the logic outlined above. Due to the limited scope of this article, however, it is only possible to present a basic model of distribution logistics here. Figure 3 presents an overview. As with the order-processing element, process costing has also been applied to warehousing. The capital tie-up costs were determined on the basis of the inventory costs resulting from the costs of safety stock and mean stock-level. The delivery time for all three process elements was determined by means of the process time calculation of the subprocesses that determine delivery time. Delivery reliability was modelled using a newly developed service-level-oriented safety stock calculation. The process costs for transport derive from the cargo rate costing per transport model and the costs of mean inventory during transport. Assuming consistency of transport times, delivery reliability should not be subject to any influencing.

		Order processing	**Warehousing**	**Transport**
Logistic costs	**Process costs**	Process costing	Process costing	Cargo rate costing
	Capital tie-up costs	• Unbilled receivables • Outstanding receivables • Payment defaults	Inventory costs = Costs of safety stock + Mean stock-level	Costs of mean inventory during transport
Logistic performance	**Delivery time**	Process time calculation	Process time calculation	Process time calculation
	Delivery reliability	Consistency of process times	Service level-oriented safety stock	Consistency of transport times

Figure 3. Modelling distribution logistics.

Now that the modelling functions have been derived, a quantitative potential assessment can be realised. The potential assessment flow is explained in the following section.

Potential Assessment Flow

The flow of the developed potential assessment method is illustrated in Figure 4. The method is based on the systems engineering problem solution cycle presented by Haberfellner (Haberfellner & Daenzer, 2002).

The three consecutive steps: setting objectives, finding solutions, and selecting solution are explained briefly in Figure 4.

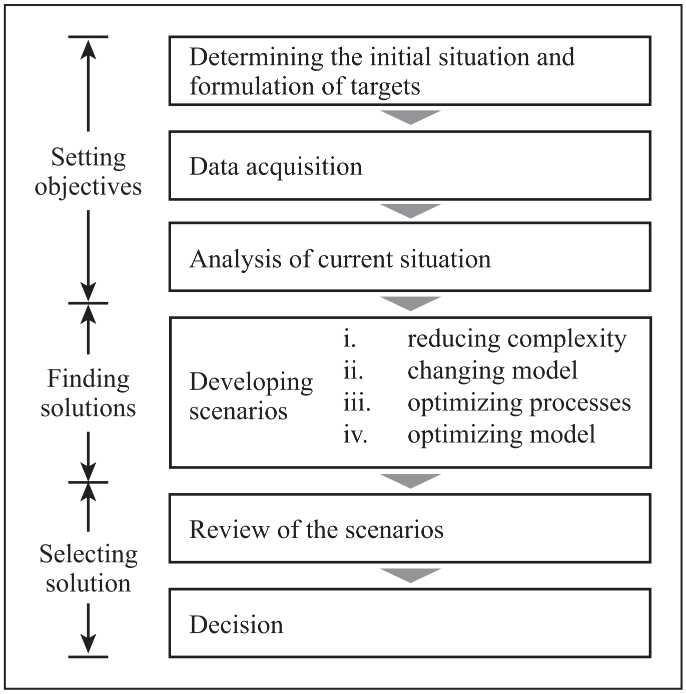

Figure 4. Potential analysis flow based on Groß et al. (2014a).

Setting Objectives

The first step is setting objectives. The purpose is to determine the initial situation and lay down the scope of the analysis. The data requirements of the potential assessment depends on the monetary and logistical target of the selected variables. Data acquisition is followed by an analysis of the current situation, in which the various forms of the different target variables in the investigation period are presented. The available distribution models are checked for their consistency and the current logistics costs and logistical performance of the determined company. It is possible to model the process and capital tie-up costs, as well as the delivery time and delivery reliability of the current situation, on the basis of the parameters determined during data acquisition and using modelling equations for order processing, warehousing, and transport.

Finding Solutions

The decisive step in the methodology is the search for solutions. Valid alternative scenarios can be derived on the basis of the four scenarios: reducing complexity, changing model, optimizing processes, and optimizing model. A scenario is defined by the number of articles and the net sales processed through the respective distribution models and by the specific forms of the model parameters. The four scenarios should be performed in sequence one after the other. The search for solutions is only for the purpose of forming valid scenarios. The monetary and logistical assessment of the scenarios is not performed until the next methodical step: review of scenarios.

The complexity of the distribution logistics is a determining cost factor. Distribution complexity is primarily determined by the company's article structure. The reduction in complexity therefore aims at reducing numbers of articles. One way of doing this, for example, is by reducing the number of article variants. The number of articles to be changed in the complexity reduction process represents cost drivers in the process cost calculation. They lead to changes in the process quantities of the key indicators for the individual order processing and warehousing processes.

After reducing the complexity, the distribution models employed by the company are checked. The aim of a model change is to allocate the articles, in accordance with their specific parameters, to appropriate models that are either the cheapest or the strongest performers for the company. In addition to cost aspects, attention should also be given to requirements placed on the articles by the various distribution models.

The aim of process optimization is to reduce the complexity of certain subprocesses by suitable means. Corresponding measures can have an effect on an individual subprocess or they may affect several subprocesses. In the concluding step, model optimization and the model-specific parameters are checked. These inherent parameters have a substantial effect on logistical performance and cost variables. Model parameters that can be optimized in the distribution logistics might, for example, be the capacity utilisation of direct transport services or the service-level oriented safety stock of the finished goods warehouse.

Selecting Solutions

The target search is followed by an assessment of the scenarios. Each scenario is characterized by the fact that model parameters (sales volume, cost drivers, process quantities, etc.) have been changed with respect to the current situation by specific measures. Once the individual scenarios have been assessed, the company can render a decision for a certain scenario.

The decision is not only based on the expected monetary and logistical variables. The company must also check the costs of the individual measures and estimate their workability. Similarly, special characteristics and requirements of the distribution models that might occur under application of the distribution models must be taken into account. There are various decision theory methods that can be applied to make the decision, such as the utility analysis or stochastic methods of taking uncertainties into consideration.

The ultimate results of the potential assessment represent identified fields of action and measures in a company's distribution logistics that can be expected to have the greatest effect with regard to the defined goals, along with an estimation of the expected change to the target variables.

Evaluation

The development process was accompanied by an ongoing exchange with experts from science and industry. One effect of this was to provide a framework for the validation of the distribution logistics model. The early integration of experts also facilitated the application of the potential assessment methodology in industrial practice.

The first full application of the potential assessment model for distribution logistics took place at a large international company in the field of medical engineering, with over 10,000 employees. The aim of the model-based analysis was to examine existing cost potentials in distribution logistics, with special attention to stock articles. It was essential that the warehouse's current high level of service was maintained to ensure that customers in Europe could continue to be supplied on the next working day.

The current analysis of the company found that the biggest proportion of costs in its distribution logistics was in the form of capital costs. This was primarily driven by the capital costs incurred in maintaining stock resulting from the desire for a high level of service from the warehouse.

The potential measures for creating a scenario were selected by applying the four steps: complexity reduction, model changing, process and model optimization. The company under consideration currently markets, approximately 2,300 active articles. Reducing article numbers by combining parts in kits or reducing the number of variants was seen as difficult to implement, since each article was intended for a specific medical purpose. The potential remained interesting, however, with the result that a scenario with a 10% reduction in article numbers was assessed. The reduction exclusively comprised C parts, which was taken into consideration in the calculation of the process costs.

In the course of a model change, it was considered prudent to expand the customer's goods held on consignment. It was regarded as realistic that the current single-figure share in turnover could be increased by 50%. An increase in turnover generated through the customer's own Internet store was discussed as a possible process optimization measure. The electronic transmission of order data leads to a considerable reduction in process costs in order processing. The cost reduction was devised and determined together with the process managers. The subprocess *enquiry, issuing and submission of offer* was reduced to 10% of the process costs, while for the subprocess *receipt, recording and determination of order*, the figure was reduced to 20%. The scenario assessed was a doubling of turnover through the Internet store.

The most extensive measures were found to be in model optimization, due to the current high capital costs of distribution logistics. The following potential measures were jointly drawn up:

- One-day reduction in days unbilled receivables,
- Average five-day reduction in the granted customer payment period,
- 15% reduction in the probability of a default in payment,
- Service-level-oriented stock dimensioning of the central warehouse,
- 30% increase in the precision of the requirements forecast,
- 20% reduction in own production throughput time, and
- Reduction in replenishment time of resale merchandise to five days by implementing stock holding at the supplier's premises.

The overall potential displayed by distribution logistics was assessed on the basis of the four scenarios, starting with the individual measures. Figure 5 shows that the model optimization step has the greatest potential. An overall potential of 27.3% of annual distribution logistics costs accrues through all measures together. Logistical performance remains unchanged by the measures and remains at a high level.

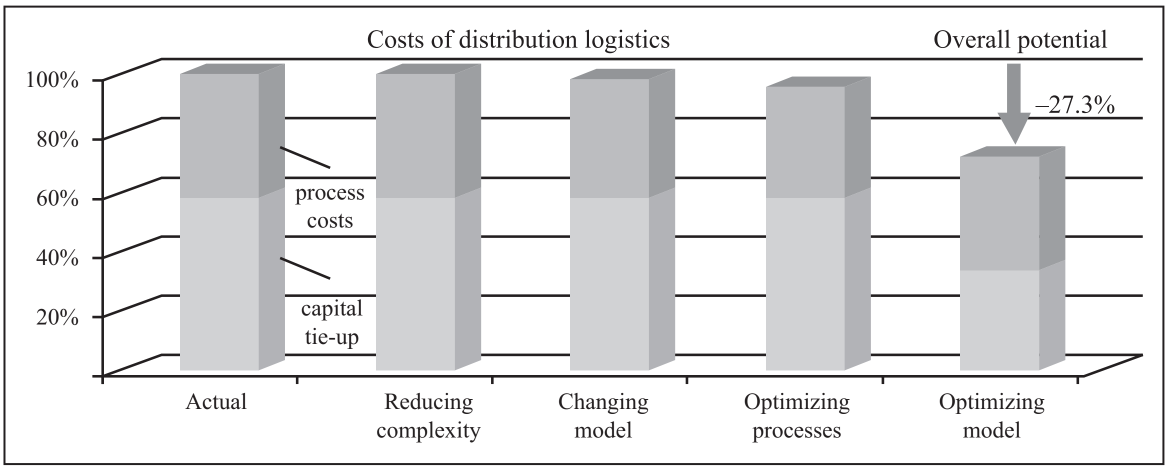

Figure 5. Overall potential of scenarios.

Conclusion

The configuration of distribution logistics has a significant effect on a company's logistics costs and logistical performance. It also represents a considerable levering factor in the success of a company. To assess the potential of distribution logistics, it is necessary to model both logistics costs and logistical performance.

After performing complete modelling of the distribution logistics, the subsequent method of assessing the potential of distribution logistics was described on the basis of the three steps: setting objectives, finding solutions, and selecting. In the decisive step of searching for a solution, it was explained in detail how valid scenarios can be drawn up on the basis of the four measures: reducing complexity, changing model, process optimization, and model optimization. Moreover, the effects on process costs, capital costs, and logistical performance were described in each step. The practical application at a company operating in the field of medical engineering successfully demonstrated that this model-based potential-assessment method is able to assess monetary and logistical potentials quickly and with low expenditure.

There is still a need for further research to follow on from the development of the model-based potential assessment. In addition to logistical performance and logistics costs, there are further strategic key indicators that may be of relevance to a company, such as the adaptability and sustainability of distribution logistics. It would be possible to base research on existing approaches, such as the evaluation of adaptability; however, it would need to be modified accordingly to satisfy the requirements of the potential assessment. Furthermore, it would be possible to expand the defined object of investigation. The restriction to a single-stage order processing and distribution structure could be eased. It would, for instance, be a major challenge to assess a change along a horizontal or vertical distribution structure by reshaping the warehouse stages and sites; the potential here would be considerable. It would also be necessary to take into account the effects of site decisions.

Since the assessment method involves recording numerous datasets, processing the data mathematically in accordance with the determined causal relationships, and presenting the results in a clear fashion, its performance should ultimately be supported by a demonstrator program.

References

Bowersox, D., & Closs, D. (1989). Simulation in Logistics - A review of present practice and look to the future. *Journal of Business Logistics*, *10*(1), 133-148.

Drexl, A., & Klose, A. (2005). Facility location models for distribution system design. *European Journal of Operational Research*, *162*(1), 4-29.

Fandel, G. (1983). *Einsatzmöglichkeiten des Operations Research auf dem Gebiet der Marketing-Logistik*, Teil I, 123–132.

Fronia, P. (2015). *Modellgestützte Potenzialanalyse der Distributionslogistik*. Hannover, Germany: PZH.

Fronia, P., Brunner, A., & Nyhuis, P. (2009). Development of a decision model for supply chain design. *20th ASCOR Conference & the 5th IILS Conference*, September 27th-30th, Sufers Paradise, Australia.

Frühwald, C., & Wolter, C. (2006). Prozessgestaltung. In N. Hagen, P. Nyhuis, C. Frühwald, & M. Felder (Eds.), *Prozessmanagement in der Wertschöpfungskette* (pp. 51-78). Bern, Germany: Haupt.

Groß, B., Fronia, P., & Nyhuis, P. (2014a). Method for assessing potential in distribution logistics. *International Journal of Social, Management, Economics and Business Engineering*, *8*(11), 3227-3232.

Groß, B., Fronia, P., & Nyhuis, P. (2014b). Potentialbewertung in der Distributionslogistik – Analyse bestehender Verfahren und deren Anwendbarkeit. *Zeitschrift für wirtschaftlichen Fabrikbetrieb, 109*(4), 232-235.

Haberfellner, R., & Daenzer, W. F. (2002). *Systems engineering*: *Methodik und Praxis*. Zurich, Germany: Industrielle Organisation.

Jacob, F. (2006). *Quantitative Optimierung dynamischer Produktionsnetzwerke*. Darmstadt, Germany: Shaker.

Kearney, A. T., & European Logistics Association. (2009). *6. Europäische A.T. Kearney-/ELA-Logistik-Studie 2008/2009*: *Supply-Chain Excellence in der globalen Wirtschaftskrise*.

Kistner, K., & Steven, M. (1993). *Produktionsplanung* (Vol. 2). Heidelberg, Germany: Springer.

McKinsey (2010). *McKinsey Global Survey results*: *The challenges ahead for supply chains*. New York, NY: McKinsey & Company.

Merchiers, A. (2008) *Bewertung globaler Standortstrukturalternativen im Maschinenbau*. Aachen, Germany: Apprimus.

Miles, J. A., & Ezzell, J. R. (1980). The weighted average cost of capital, perfect capital markets, and project life: a clarification. *Journal of Financial and Quantitative Analysis*, *15*(3), 719-730. dx.doi.org/10.2307/2330405.

Nyhuis, P., & Wiendahl, H-P. (2008). *Fundamentals of production logistics*. New York, NY: Springer.

Nyhuis, P., & Wolter, C. (2012). Quantifying the rationalization potential in logistics through supply chain design. International Workshop on Performance Measurement IFIP WG 5.7, Hannover, Germany.

Nyhuis, P., von Cieminski, G., & Fischer, A. (2005). Applying simulation and analytical models for logistic performance prediction. *Annals of the CIRP*, *54*(1), 417-422.

Pfohl, H-C. (2004). *Logistikmanagement* (Vol. 2). Berlin, Germany: Springer.

SCC. (2012). *Supply chain operations reference model version 11.0*. Supply Chain Council.

Schönsleben, P. (2011). *Integral logistics management*: *operations and supply chain management within and across companies*. CRC Press.

Schulte, C. (2009). *Logistik - Wege zur Optimierung der Supply Chain*. (Vol. 5). Munich, Germany: Vahlen.

VDI (2002). *Richtlinie VDI 4400 Blatt 3, Logistikkennzahlen für die Distribution*, The Association of German Engineers.

Wildemann, H. (2004). *Bewertung logistischer Leistungen und Kosten in der Supply Chain*. Munich, Germany: TCW

Wriggers, F. (2010). *Bewertung strategischer Beschaffungsmaßnahmen*. Hannover, Germany: PZH.

Zeigler, B., Praehofer, H., & Kim, T. G. (2000). *Theory of Modeling and Simulation*. Orlando, Florida: Academic Press.

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