Method for Assessing Potential in Distribution Logistics

B. Groß, P. Fronia, P. Nyhuis

Abstract—In addition to the production, which is already frequently optimized, improving the distribution logistics also opens up tremendous potential for increasing an enterprise's competitiveness. Here too though, numerous interactions need to be taken into account, enterprises thus need to be able to identify and weigh between different potentials for economically efficient optimizations. In order to be able to assess potentials, enterprises require a suitable method. This paper first briefly presents the need for this research before introducing the procedure that will be used to develop an appropriate method that not only considers interactions but is also quickly and easily implemented.

Keywords—Distribution Logistics, Evaluation of Potential, Methods, Model.

I. INTRODUCTION

IN globalized markets, enterprises are increasingly exposed to competitive pressure and therefore have to find ways to distinguish themselves from their business rivals. Along with high quality products, customers demand sinking prices and high logistic performance. Lower prices can be realized through lower costs, whereas the required level of logistic performance is reflected in high delivery reliability and short delivery times [1]-[4]. To ensure this, enterprises have to improve their logistic processes in regard to their costs as well as their performance. Logistical costs describe both the capital costs and the process costs. As a functional part of the entire corporate logistics and a link between the production and the customers' procurement logistics, distribution logistics are generally responsible for the largest share of the total logistical costs. Distribution logistics play a pivotal role. Depending on the branch, the costs of distribution logistics often equate to 8%–11% of revenues. However, in branches where logistics play an intensive role such as the food industry, it is not rare for this figure to range up to 30% [5].

Distribution logistics include the planning, control and monitoring of all physical processes regarding the flow of goods as well as logical processes involved in the flow of information [6]. The main responsibility of distribution logistics is the supply of goods to customers. In doing so, distribution logistics aim to minimize the costs while maintaining the defined logistic performance [7], [8]. The vicious cycle of distribution logistics lies in the fact that

increasing the logistic performance is usually tied to higher logistical costs [5] i.e., a make-to-stock production's readiness to deliver (expressed by its service level) is dependent on stock. Maximizing the service level means supplying goods without any delivery delay. For this to occur the goods have to already be in stock, thus causing capital tie-up costs. An economically practical positioning within the thus defined field of tension opens up significant potential for an enterprise to distinguish itself from their rivals [9].

In the following, we will provide an overview of distribution logistics including the tasks involved, after which the requirements for a method suitable for assessing potential in the distribution logistics will be derived. Already existing methods will then be identified and compared with these requirements, revealing the need to research a new method that will be developed in a project at the University of Hannover's Institute of Production Systems and Logistics. The procedure for developing this method will then be described in four key phases.

II. DISTRIBUTION LOGISTICS TASKS

As depicted in Fig. 1, distribution logistics is sub-divided into three areas (or sectors) of responsibility: order processing, warehousing and transport [10].
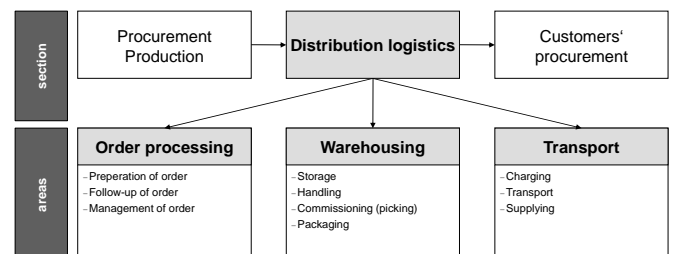

Fig. 1 Distribution Logistics Sectors [9]

Distribution logistics thus entail all of the processes related to receiving, preparing, realizing, transferring, and documenting customer orders [9].

The order processing begins when a customer places their order and ends when the goods are delivered to 'said party' or when the customer receives the invoice. The order processing is thus comprised of the preparation, follow-up and management of the order as well as all of the communication between the customer and internal functional areas [8], [10].

Warehousing describes the storage, handling, commissioning (picking) and packaging of goods [6].

By bringing goods from one location to another in suitable containers the transport sector serves to neutralize the space difference between producers and consumers [6]. This can apply to both a centralized supply as well as a decentralized

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supply. Moreover, transport entails supplying goods for consumption within the enterprise (internal supply) as well as from the enterprise to customers (external supply) [6].

In optimizing the logistics, not only the interactions between the distribution logistics and the neighboring areas (e.g., production and procurement logistics) need to be considered, but also the interactions within and between the described tasks [9].

The areas with potential first need to be made assessable so that enterprises are in the best possible position to fulfill the abovementioned goal of minimizing costs while at the same time maintaining or improving the logistic performance. This is only conceivable though with a suitable method, which also takes into account the interactions. Since the costs of the analysis ultimately reduce the generated savings, the method used should be as economically efficient as possible. This can only be achieved when the applied method allows strategic measures to be quickly and easily derived [9].

III. Existing Methods for Assessing Potential in Distribution Logistics

In order to analyze existing approaches to assessing potential, the following four categories can be formed based on Jacob [11] and Wriggers [12]:
- analytical approaches to individual situations,
- experience-based profitability analysis,
- model-based simulations, and
- model-based profitability analysis.

A. Analytical Approaches to Individual Situations

With analytical approaches to individual situations the object of observation is limited to specific aspects. Such approaches therefore aim to optimize an explicit sector of the distribution logistics or even an individual aspect within a sector [12]. Common examples of this include the so-called 'traveling salesman problem' and the numerous related solutions in operations research. These improvements intend to optimize the sequence of locations for the material flow [13], [14] and thus belong in the transport sector. In the transport sector these types of approaches can for example reveal potential in the route planning. When the model's conditions are complied with these approaches deliver very precise and detailed results [9].

Since analytical approaches to individual situations only focus on one aspect of distribution logistics and therefore fail to consider interactions with related areas there is a risk that the solution found only represents the local optimum [9]. These approaches are thus suitable for situations in which the basic areas of action are already identified. Appropriate solutions can then be found for designing measures for these areas. However, as a result such approaches are not well suited for the desired comprehensive analysis of potential [9].

B. Experience-Based Profitability Analysis

With experience-based profitability analysis the aim is to transfer knowledge gained from experiences with previous problematic situations to new situations. Thus only the effects of measures from comparable situations in the past are estimated. The impact of such approaches can be depicted with the aid of a tool developed by Wildemann for analyzing potentials in supply chains [15]. With this method the user enters and stores business data along with the importance of criteria for the enterprise in the software tool [15].

In contrast to analytical approaches to individual situations, experience-based profitability analyses do not model the correlations, but rather try to completely chart the object of consideration through the experiences of the user [9]. Nevertheless, precisely because of this procedure there is no statistical significance. The test strength in this approach is too weak and the causal relations are not only too difficult to verify, but also not necessarily correct. A user can thus conclude that a measure which led to desired results in the past will also deliver the desired results in the new situation. However, the user usually completely fails to take into account the numerous internal and external influences on the enterprise since it is barely possible to test a measure in isolation. Furthermore, this procedure frequently leads to the same measures being selected since there are empirical values for them. In order to circumvent this there has to be empirical values for all of the measures and all of the conceivable combinations from different enterprises. Since this is impossible to implement in practice, this approach does not deliver substantiated, generally valid results [12]. Experience-based profitability analyses are therefore not suitable for comprehensively analyzing the profitability of distribution logistics [9].

C. Model-Based Simulations

Model-based simulations emulate reality in a model [16]. Within the model, parameters and variables are changed by means of a simulation and the system states are compiled in order to obtain knowledge about the underlying system [17]. Simulations demonstrate the specific correlations very precisely, but in order to do so the core model has to be newly developed for each application or at least adjusted. Moreover, each time the model is adapted it also has to be re-validated [18].

Due to the amount of effort required for development, adjustments and computations, partial models are frequently used in distribution logistics. Similar to analytical approaches to individual situations partial models only provide support in making decisions about a specific aspect of the distribution logistics e.g., planning routes [19]. Theoretically, it would also be possible to link the individual sub-sectors so that a complete model is created allowing interactions between the sub-sectors to also be taken into account. However due to the extreme amount of effort required to do so, this is not typically realized in practice [20].

In comparison to the previously described approaches, model-based simulations describe interactions fully and exactly [11]. Through the reproduced interactions between the various parameters and objectives it is possible to describe the effects of different measures on the distribution logistics very precisely. They are thus commonly applied in logistics and are

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generally well suited for comprehensively analyzing potentials [21]. This requires an expansive and detailed modeling of the distribution logistics though. Furthermore, the developed model has to be adjusted to every application in order to take into account the specific conditions [18]. In addition to these difficulties, enterprises frequently do not have all of the required data or can only obtain it with great effort [17], [22]. Model-based simulations are thus not well suited for the sought method since they do not meet the requirement of being quick and easy to apply [23].

D. Model-Based Profitability Analysis

Model-based profitability analysis is also based on emulating reality in 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 [12]. 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 [18]. Nevertheless, this type of approaches does not exist for use in distribution logistics, but rather is only available for procurement and production [12]. However, approaches from the procurement tool developed by Nyhuis and Rottbauer [24] and further developed by Wriggers can be transferred to distribution logistics [9].

Fig. 2 depicts the four different approaches in view of the expenditure required to use them and the expected quality of their representations. It is evident that only the model-based approaches (model-based simulations, model-based profitability analysis) produce high quality representations and thus have a high level of precision. Furthermore, it is obvious that model-based profitability analysis is the only model-based approach that fulfills the requirement of being economically efficient to employ.
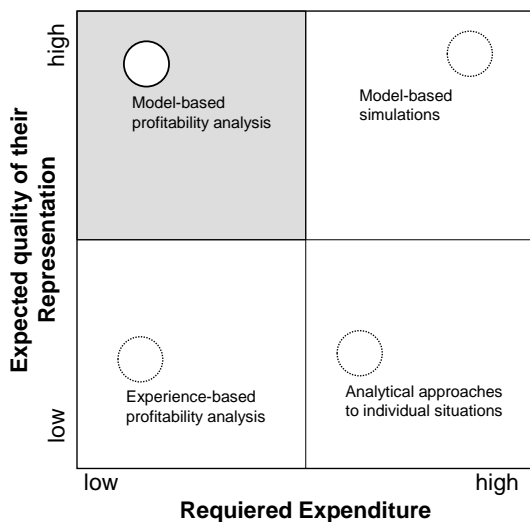
Accordingly, model-based profitability analysis is the only one to exhibit an acceptable cost-quality ratio [9]. Nonetheless, up until now this method has not yet been developed for use in distribution logistics [25].

IV. DEVELOPMENT OF A MODEL-BASED METHOD FOR ASSESSING POTENTIAL IN DISTRIBUTION LOGISTICS

In comparison to existing approaches, the method that will be developed at IFA should be able to be applied in enterprises quickly and easily without a need for major adjustments. In order to ensure this, the required data should be kept to a minimum and be easily compiled. In addition to indicating potential for reducing costs, it should be possible to point out ways in which the logistic performance capability and competitiveness can be improved by taking into account strategic objectives. The method will not aim to indicate concrete actions for a detailed optimization of individual processes, but rather will form a strategic tool that provides support in deciding which areas of potential and measures are anticipated to have the greatest effects [9]. By combining the developed method with analytical approaches to individual situations, specific aspects can then be subsequently optimized. This new method will be advantageous in that the aspect optimized will be the one with the greatest anticipated effect.

The basis for establishing this method is the business administrative research design by Ulrich and Hill [26]. It was chosen since business administration, as an applied social science [27] and management theory, is concerned with designing, controlling and developing productive social systems aimed at creating practical decision-making models [28].
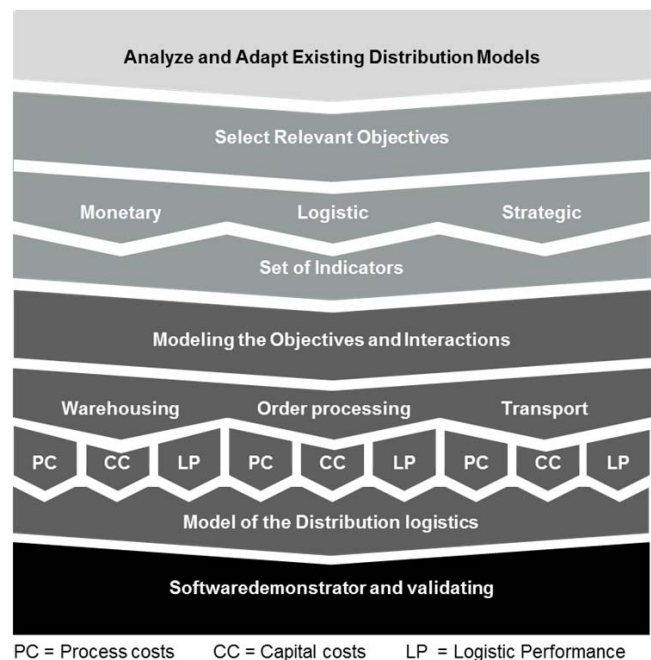

Fig. 2 Comparison of Expenditure and Quality of Representation for the Various Categories of Methods (per ([12])

Fig. 3 Procedure for Developing the Method

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The procedure for developing this method is thus organized into four primary phases. In the first phase, the basis is established by analyzing and adapting existing distribution models. Following that, in a second phase, suitable objectives are selected so that a set of indicators can be obtained. In the third phase, the selected objectives are modeled and fused into a single comprehensive model. Finally, in the fourth and last phase, the model is transferred to a software demonstrator and the method is validated. The individual phases are explained in more detail below and are depicted schematically in Fig. 3. The grouping into the four phases is emphasized through the scale of grey tones.

A. Phase 1 – Analyze and Adapt Existing Distribution Models

In order to generate a functional concept system and to have a solid basis for developing the method, existing models need to be first analyzed and verified. To do this, a uniform description of the processes within the models has to be created. These distribution models such as "non-batch processing" or "processing with customer-neutral warehousing" [29] and their sub-processes such as "handling" or "transportation" [29] are the foundation for the modeling. The models (which were generated with another focus in mind) are thus examined in regards to their suitability for assessing potential in the practice. This is achieved by conducting expert interviews in industrial enterprises. In order to evaluate this data, the limits and distinguishing features of the models have to be determined in advance by researching literature. Based on the literature research and expert interviews it will be determined whether the existing models just have to be adapted or if new models have to be formulated. This analysis may also show that several models together offer a less complex but sufficiently good description. Furthermore, through the expert interviews the conditions and limitations of the applications will be discussed. *Results* of this phase include standardized and practice relevant reference process models for describing distribution logistics with a functional concept system.

B. Phase 2 – Select Relevant Objectives

In the second phase, relevant objectives are selected for describing the actual situation of an enterprise and for evaluating potentials in the distribution logistics. The objectives can be sub-divided into monetary, logistic, and strategic variables. These highly aggregated indicators need to be further detailed and thus satisfy both the demand for a high quality representation as well as an easy and economical application (data acquisition and availability in enterprises). These indicators are then analyzed based on the performance measurement system developed by Wiendahl for logistic-benchmarking [30]. This system already contains a variety of indicators that can be influenced by logistic measures for both the logistic performance and logistical costs. Moreover, in accordance with VDI-Guideline 4400 this system is proven to be highly relevant for use in the industry [31]. Due to the scope of this system however, the complexity of it must first

be reduced in order to be suitable for this method. This is accomplished by sensibly selecting and aggregating key figures.

Since the chosen objectives have to be modeled in the next phase, the selection of objectives represents a significant success factor for the method being developed. It is therefore important that attention is paid to ensuring an appropriate ratio between the effort required for the modeling and the quality of the representation already during the selection.

Results of this phase include a set of indicators, which not only contains all the relevant monetary, logistic and strategic key figures, but is also necessary for a quick and accurate analysis of potentials in the distribution logistics.

C. Phase 3 – Modeling the Objectives and Interactions

Once the set of objectives is defined, the selected variables are mathematically modeled. Since the objectives differ strongly depending on the task areas within the distribution logistics, the modeling is conducted for each task and the modeling approach is described separately for the order processing, warehousing and transport. For each task selected variables such as process costs, logistic performance and tied-up capital costs are first modeled individually. However, for a complete mathematical description all relationships between the variables must also be ascertained. This is necessary in order to be able to determine the impact of measures (target situation) in contrast to the current (actual) situation.
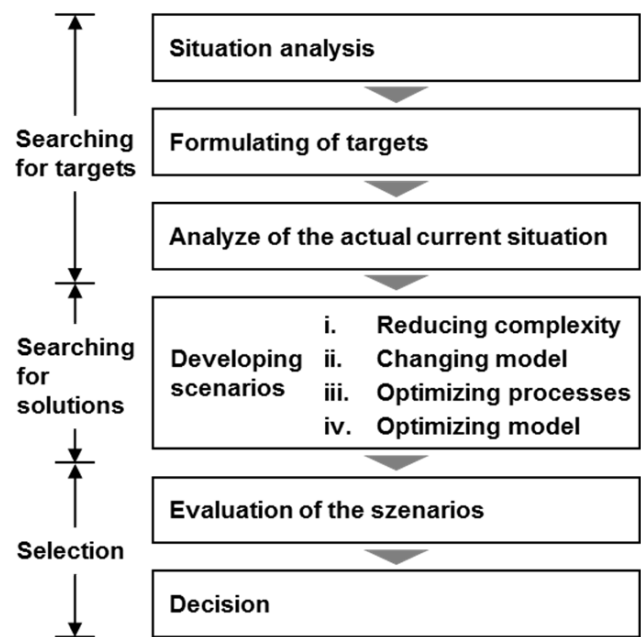

Fig. 4 Possible Procedure for Method

Following this modeling procedure allows changes in the objectives caused by modifying the drivers to be evaluated. It does not however allow potential to be assessed specifically for individual enterprises. This requires the correlation between a realistic change in individual drivers and the consequential change in the objectives to be known. Only then conclusions can be drawn about which changes are expected

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to have the greatest monetary and logistic effects. In order to quickly and easily conduct this analysis, a method has to be developed which limits the solution space by forming scenarios. A scenario is characterized by a bundle of measures, which change the drivers – and thus the distribution logistic objectives – in a realistic order of magnitude.

Fig. 4 depicts a possible sequence for the method that is to be developed. This procedure is based on the problem solving cycle developed by Haberfellner for System Engineering [32].

The procedure can be subdivided into three steps: searching for targets, searching for solutions and selection whereby the search for targets can be further divided into three sub-steps.

In searching for targets, the situation is first analyzed so that the problem can be clarified and the scope of the related analysis can be set. Following that, based on the results of the situation analysis, targets are formulated from which a list of required data can be generated. The data that has to be compiled can then be ascertained as a function of the selected monetary, logistic or strategic objectives and in conjunction with the objective-specific lists of required data that have been saved in the software tool. The data requirement lists that are needed for this can be derived from the modeling of the distribution logistics. This procedure simplifies the application and helps meet the research project's goal of developing an economically efficient application since only the data that is actually required for the target has to be compiled. In the third sub-step of the target search, the actual current situation is analyzed in relation to the target and the selected objectives during the observation period are depicted. Key figures are then calculated based on the created model.

The search for solutions is accomplished by developing scenarios. So that the developed scenarios depict the impact of the changes on the entire system, the determined calculation basis of the objectives is utilized. Scenarios are generated in view of

- reducing complexity (e.g., reducing the amount of article numbers),
- changing models (e.g. changing the distribution model),
- optimizing processes (e.g., streamlining individual sub-processes) and
- optimizing model (e.g., adjusting the parameters of the distribution model).

In order to generate valid scenarios which promise success, a guide for developing scenarios is prepared in advance and specifications are formulated in the form of conditions. Furthermore, a catalogue of measures that contains standardized descriptions of measures and allocates them to the four different approaches has to be developed. In doing so, particular attention must be paid to the interactions.

By comparing the monetary, logistic and strategic objectives of the actual state with those of the scenarios, the scenarios and thus the impact of the individual measures can be evaluated once the scenarios have been developed. Based on these results, the scenario most suitable for attaining the targets prioritized by the enterprise can be selected. An applicable depiction of these outcomes and the related catalogue of measures should also be created.

Results of this comprehensive phase include a driver tree with all the monetary, logistic and strategic objectives relevant to distribution logistics which are completely modeled. While the objectives of the logistic performance and logistical costs are mathematically described, the strategic objectives are hierarchically ordered and can be used for an ordinal evaluation of the driver variables. Moreover, this phase should result in a comprehensive description of the method and the respective data such as the catalogue of measures.

D.Phase 4 – Developing a Software Demonstrator

In order that the developed method quickly and easily assesses potentials a supportive software tool is created in the fourth phase. The tool swiftly processes the determined data mathematically and generates suitable depictions of the results. Despite the call for a fast and economically effective method, without this type of support, this procedure would still require considerable resources. The software tool is developed in the form of an Excel application using Visual Basic for Applications (VBA). This not only ensures that it can be broadly applied, but also makes certain that is it easy to program and to maintain. Here too, the goal of facilitating a cost-effective analysis is taken into consideration since many enterprises already use Excel. This allows enterprises to apply it economically as well as to extend it. The procedure for creating the software demonstrator is outlined in Fig. 5 and is oriented on the phases of software development described by Demarco: problem analysis, design, implementation, testing and maintenance [33]. The maintenance phase is excluded in this context, because the software demonstrator is only meant as support and is not the core of the research project. So as to facilitate the possibility of a maintenance phase in the future, care will be taken when programming to ensure that it is well commentated.
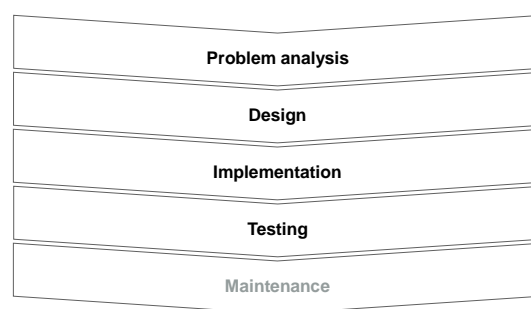

Fig. 5 Procedure for Developing the Software Tool

Additionally, the software demonstrator is used to comprehensively validate and where needed adjust the interactions processed within it.

V. CONCLUSION

Due to the large share of overhead costs that can be attributed to distribution logistics and increasing customer demands on the logistic performance, distribution logistics offer significant potential for improving an enterprise's competitiveness. Nevertheless, analyzing the distribution

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logistics' potential is characterized by its numerous possible measures and their interactions. Potentials are thus also difficult to forecast. Moreover, along with potential for reducing costs, opportunities for strategic improvements should also be considered. Although there are already a few approaches that can be applied to assess potential, they do not meet the demand for a quick and easy comprehensive analysis. Four different approaches were examined and it was found that only model-based profitability analysis exhibited an adequate cost-quality ratio. A model-based profitability analysis has not yet been developed for assessing potential in the distribution logistics. The research project "Developing a Model-Based Method for Analyzing Potentials in Distribution Logistics" thus aims to create an economically efficient potential analysis based on Wriggers approach for procurement [9]. This project is sponsored by the German Research Foundation (DFG) and is being conducted at the Institute of Production System and Logistic, University of Hannover.

To do so a functional concept system has to be created for distribution logistics. Its applicability for describing the research object then needs to be tested in order to subsequently operationalize the (to some degree abstract) terminology and make it empirically useful. In doing so, relevant distribution logistics dimensions and objectives will be isolated. Following that, causal relationships between the distribution logistics drivers have to be explored and correlations formulated. Here both the logistic and monetary figures are to be modeled as well as their interactions. The method for evaluating potential will be created by integrating the individual hypotheses into a complete model which will then be implemented into a software demonstrator so as to simplify applying and extending it. Generally, this paper has demonstrated the research need for developing a suitable economically efficient method for evaluating potentials in distribution logistics and presented the planned procedure for accomplishing this.

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