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EXTENDED LOGISTICAL FACTORS FOR SETTING UP THE OPTIMAL INTERNATIONAL DISTRIBUTION STRATEGY

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ABSTRACT

International trade is an essential factor in economic growth and has enormous potential to foster or hinder sustainable development. For this reason continuous measurement of effectiveness of trade performance is of central importance for countries. But current empirical studies about the logistical performance of countries, such as the *"Logistic Performance Indicator"* (The World Bank) or *"Global Enabling Report"* (World Economic Forum), do not fully match the main logistical principles of flow, system and total-costs mentality. The core approach of the presented model consists of an integrated supply chain perspective based on the Supply Chain Reference Model (SCOR).

The holistic character and the process view of the model enable planning and analysis of the material flow in order to optimize all elements of the transport chain under consideration of company specific strategies. Companies, scientists and interested parties can use the model to build up different distribution scenarios. The model has exemplarily been calculated on a case study of two German companies, in which the countries Nigeria and Japan were examined. The standardized evaluation of external conditions within the model finally enables the direct comparison of the two target countries.

Keywords: International distribution structure planning, SCOR, country evaluation.

1. INTRODUCTION AND METHODOLOGY

International trade is an essential factor for economic growth and has enormous potential to affect sustainable development. For this reason continuous measurement of trade performance effectiveness is of central importance for countries.

For the evaluation of foreign markets, information about external logistical framework conditions is indispensable. However, to collect this information in advance is an expensive task and companies lack a procedural model for the systematic evaluation of countries on the basis of freely accessible secondary data. [1, 2] The country-specific framework conditions for the shaping of logistical processes are compared by the *Logistics Performance Index (LPI)* and the *Doing Business Report.* Their data base is regularly formed by hard and soft factors predominantly collected from questionnaire-based surveys. Summarized, these studies illustrate that current evaluations of countries have no sufficient expressiveness in the planning process of companies. This is due to the fact that there is no differentiation of the choice of carriers in the LPI in the illustration of throughput times of exports, thus the throughput time of air freight is equal to sea freight. Furthermore, there are large variances and inconsistencies concerning the examination of the data determined through questionnaires, which is the reason why the planning basis has to be questioned. [3, 4] Nevertheless, empirical studies about the logistical performance of countries do not fully match the main logistical principles of flow, system and total-costs mentality. [5] This gap is filled by a model developed by the authors.

The research process is based on mixed approach of Nyhuis which contains deductive as well as inductive elements to solve logistic problems using modeling. The initial point of a model implementation is the problem-description. Based on the analysis of the current state of research for this paper, the authors construct a new model. As a first step, chapter two shows an approach to define processes and to plan distribution structures. Based on the defined framework of corporate and country specific conditions, processes and distribution structure opportunities, the evaluation of different action alternatives becomes possible. Predefined action alternatives enable a structured description of the decision area. The definition of the decision criteria is described in chapter four whereas these criteria derive from the performance attribute of the distribution processes to guarantee an adequate design of the structure. Moreover the comparability of different distribution processes becomes possible.[6, 7]

The scientific approach of this paper does not end with the conceptual structure of the research model. Due to the high complexity of the developed model the necessary depth of the study cannot be fulfilled by a questionnaire based empirical study but is reached by a case study research approach.[8] According to this the developed model will be evaluated on the data of companies, what makes it to a common sample in the academic research.[9] The critical appraisal in chapter five summarizes the most important innovation of this paper and points out the knowledge gain from the scientific perspective.

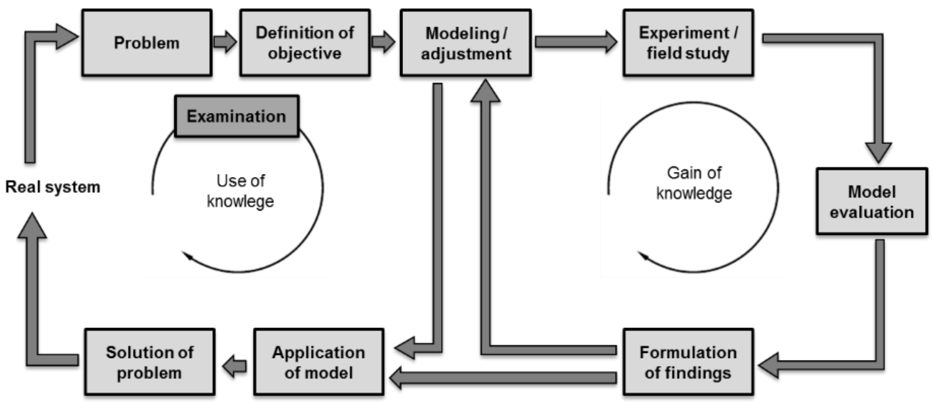

Figure 1 – Model building process by Nyhuis. [6]

2. SETTING UP OPTIMAL INTERNATIONAL DISTRIBUTION LOGISTICS

Success in national and international competition is defined by the competitive advantages of business activities. Among the primary activities, distribution logistics, which is closely related to customers and can therefore generate competitive advantages directly, is one important factor in the value chain. [10] As performance indicator, the service level represents the key or crucial value for the assessment of a distribution system. It shows the value or the share of orders that are delivered within an agreed or planned time frame. [11] The methodological approach presented in this paper proceeds successively, starting with the delivery service strategy. The first step involves the definition of the process chain based on individual company specific ideas or reference models of process chains. For the description and analysis of supply chains, the Supply Chain Operations Reference model (SCOR model) is used, which forms a de-facto standard. The developed cross-sector supply chain offers an ideal type of processes made up of the elements procurement (Source), manufacturing (Make), delivery (Deliver), return deliveries (Return) and planning (Plan). [12, 13] On the second level the model is segmented into the types of deliveries, based on product concepts and orientation of the product structure. As described before, the SCOR model distinguishes on the second level between the kinds of delivery services as following: [12]

- Deliver Stocked Product - sD1
- Deliver Make-to-Stock Product - sD2
- Deliver Engineer-to-Order Product -sD3
- Deliver Retail Product -sD4

At the planning stage of the distribution structure the question arises whether a product is suitable for interim storage. Depending on the decoupling point in the value chain, more configuration and production steps are necessary after checking and delivering orders. For the configuration of processes and the planning of the storage stages a differentiation is possible at this stage which in the course of this research question leads to a synthesis of the processes sD1, sD2 and sD4. For the engineer-to-order product process (sD3) the focus therefore lies on the delivery times and delivery efficiency, while anonymously or customer specific pre-produced goods (sD1, sD2, sD4) have to be geographically available and ready for delivery. [10] The distribution process sD4 is an extension of the process sD1 for branch-specific elements which will not be further assessed within the focus of this research question.

After defining the process chains in a third step, the internal and external circumstances are to be examined. The internal conditions are for example existing logistical structures and cost restrictions which can be optimized in the planning phase. As far as external transport or country-specific conditions are concerned, companies can only act accordingly and have to adapt to the prevailing situations. [15] According to the definition of the processes and the investigation of the framing conditions, companies have different alternatives to organize the supply of the target market under the restriction of the defined service level. The evaluation of the different options occurs under the examination of the different characteristics of the resources that can be adopted when setting up a distribution system. Under consideration of the objective, the presented approach enables a standardized comparison of the different distribution system alternatives which ensures a setup at the total cost minimum under consideration of the required service level. The following sections of this article are built up in accordance with the steps of the hierarchical approach that is displayed in figure 1.

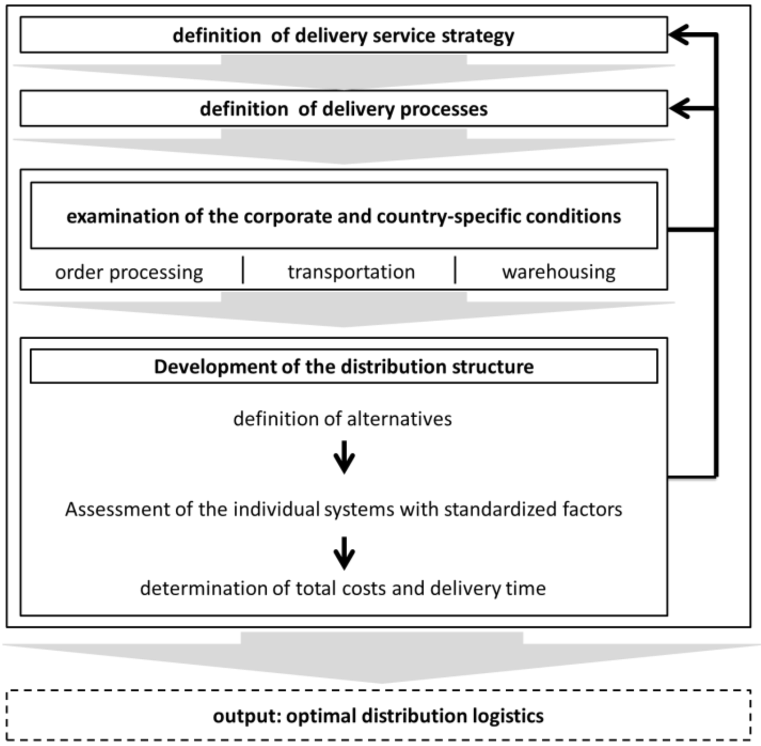

Figure 2 – Procedural model for the setup of the optimal distribution strategy.

The following sections of this article are built up analogously to the steps of the hierarchical approach which is displayed in figure 1. Therefore section 3 deals with the examination of the corporate and country-specific conditions as well as with the configuration possibilities differentiated between processing, transportation and warehousing. Section 4 examines two structuring options for designing a cost optimal distribution system. Based on these options a standardized performance measurement model is developed in order to evaluate the different possibilities and consequently enable companies to plan their distribution system purposively under total cost consideration.

3. CORPORATE AND COUNTRY-SPECIFIC CONDITIONS

3.1 Processing

On the one hand processing is concerned with company-internal processes, on the other hand it interacts with external actors. As borders are crossed, companies have to deal with custom authorities. In order to be able to compare countries, this model assumes that customs duty has already been paid on the goods and the product is free for transport. However, the import regulations and processes in the target country play a decisive role which has an effect on expenditures as well as lead times. [16, 17] Due to these basic conditions, customs represent a significant part of the lead time while importing and have to be integrated into the model approach as a central evaluation parameter.

The design of information flow processes in distribution logistics and the areas of application of information technology are manifold. The ideal-typical concepts in terms of data transfer require an identical and central information technology for all locations. [18] Aside from the described internal company resources, transfer processes also rely on telecommunication and electricity infrastructures. Their capacities are usually in line with local economic development and companies therefore can implement their technologies regionally only to a limited scope. The deliberations to the benefits of information technology as well as to the required infrastructure are not made country-specific but company- and process specific and can be justified by transaction costs. [19] Because the required infrastructure and the companies' software systems are strongly dependent on the configuration of the internal soft- and hardware systems, a neutral consideration on a country-basis can hardly be made. Thus, the evaluation of the infrastructure can first reasonably be implemented when the measurement parameters within the framework of the internal planning have been quantified. The consideration for the model development can therefore be excluded from the present question.

3.2 Transport

Depending on the respective processes and distribution structures the evaluation of transport options has to be done in advance as part of the planning process. Since a direct comparable abstraction of specific variables cannot be achieved, detailed knowledge of the conditions, prices and terms is indispensable for the planning and evaluation of the respective transport options. [11, 20, 21]

Ocean shipping is, when transport weights are measured, the most significant carrier with a share of 80% of international goods transport. The advantage of ocean transport mainly lies in the vast quantity of goods that can be transported over great distances. [15] The internationally significant operating mode of liner shipping is mainly deployed in container traffic. The providers of line shipping services face an anonymous transport market on the demand side. [22] Along with ocean shipping, air freight makes up more than one third of the transport volume based on the value of the goods; however, this still accounts for only 3% of the worldwide movements of goods. [23] As means of transport, air freight only uses 15 % "freight-only" aircrafts, since the joint transport of passengers and freight offers the advantage of more flight routes. [24]

For rail transport, trends show that the use of carriers in modern logistical concepts is restricted to regular block trains between well-developed handling centres. In international context, the complexity increases noticeably due to technical specifications and case specific applications and their organization. [25, 15] It is established that there are only few states where road transport is not the dominant mode of inland transport. The supply-side of transport services can be described as "atomized" in most countries since it is dominated by a large number of small and medium sized companies. Road freight transport requires, aside from vehicles and the various actors, roads and transshipment facilities on the infrastructural level. [26]

Even the CEP-services face an anonymous transport market on the demand side. In contrast to liner services, in form of air freight and container shipping, a door-to-door carriage is provided. This is why the consideration of specific ports or airports is not necessary. The integration of these service providers is covered by calculated lead time factors for the whole value chain. The illustrated facts as well as the spread of international transport services lead to planning in the model being focused on container shipping, air freight, inland road freight transport and CEP- services.

3.3 Warehousing

The number of warehouses for example depends on the geographical size of the distribution area, the customer's expected response time, the value of the goods stored, the lead time and the respective transport costs.[14] The basic decision for warehousing in a new distribution region primarily depends on the expected supply service. However, bundling effects that can be realized by temporal decoupling of supply from transport can also lead to warehousing. [9]

In addition to warehousing costs, the geographical location plays a role in the planning process. During the strategic planning phase it is possible to establish the point where minimal transport costs are achieved. The geographical sales areas of a product, the sales quantity as well as the transport costs together determine the location of the site. [27] Detailed location factors and local conditions are being excluded in early planning stages and postponed to later concrete planning and implementation processes since they are very hard to parameterize. [9, 28]

4. DEVELOPMENT OF THE OPTIMAL DISTRIBUTION STRUCTURE

4.1 Examination of structuring options

Previous analyses of the distribution logistic configuration were carried out on the basis individual systems and modes of transport. In this context the specific characteristics of the means of transportation were pointed out. Beside this, several systems could be excluded from further investigations so that the concentration of the evaluation model is set on road freight transport, containerized line shipping services, cep-services, warehousing and customs. The isolated consideration of individual systems is not leading to the desired results. This is caused by the frame conditions and the characteristics of the different transport modes which requires the planning and implementation of a complex transport chain in most cases.

In general carriers are substitutable in the context of international transport logistics. In the model restrictions can be made. As road haulage mostly cannot be employed as direct carrier in global export, the distribution in the starting country is done in the model examination via shipping line service, air freight or via CEP service. At the transition points in the target country the carriers are unloaded and the customs clearance is accomplished. The process elements transhipment and customs clearance are supposed to be considered in the model as process module customs clearance. For the parcel service the consideration of carriers, transition points and customs clearance procedures can be dropped because it is a door-to-door service where all elements are integrated. The further forwarding of air and sea freight into the interior is done, after the release of customs, in the model exclusively through road haulage. Furthermore the model is supposed to contain the possibility to hold inventory in the target country for a direct distribution whereby the entire demand area is combined in one distribution area. Therefore the entire demand can be distributed from one warehouse location in the target country. The supply of the warehouse happens through replenishment processes that can be evaluated temporarily separated from delivery time of customer orders.

After the definition of the single process elements they can be combined to a transport chain. Thereby five action alternatives arise for the development of the distribution system. The alternatives 1 and 2 represent distribution systems with warehousing in the target country whereby the delivery of customer orders can be served directly from the domestic inventory. For the alternatives 3, 4 and 5 there is no warehousing in the target country planned. Under consideration of the planned distribution processes the alternatives 1 and 2 therefore cannot be combined with the delivery of custom-built products (sD3) because after the order entry production steps follow and the products cannot be stored in advance.

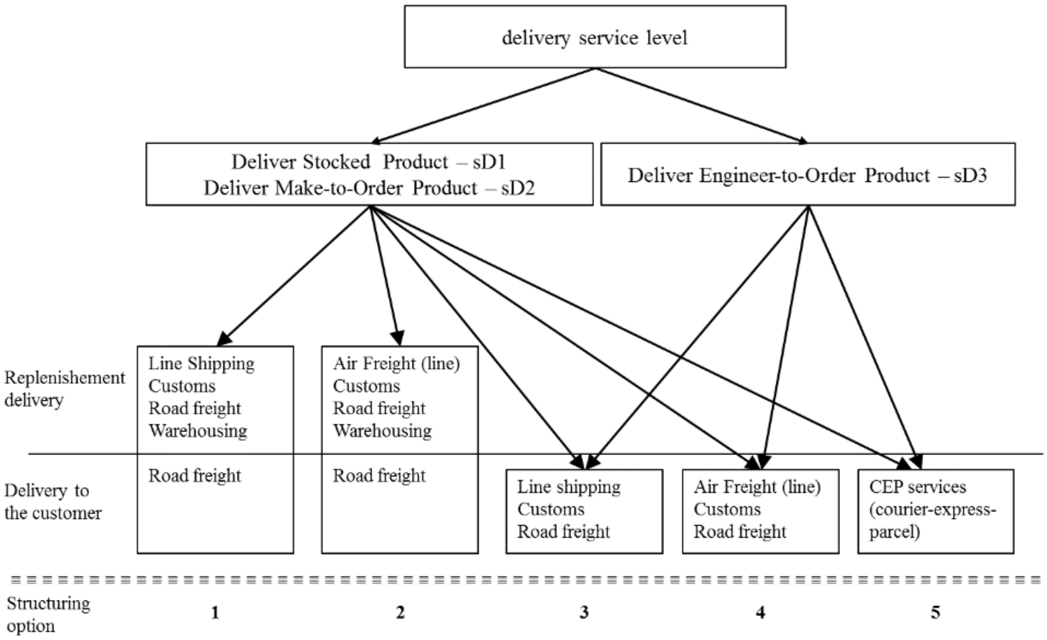

Figure 3: Options for structuring a distribution system.

The objective of the paper is the optimization of the distribution costs under withholding the delivery time that is defined in the delivery service. For the evaluation of the action alternatives time- and cost related aspects have to be defined in order to being able to solve the problem sufficiently. Thereby in the following the evaluation aspects are to be connected with the processes of the SCOR-Model with the defined measures in order to fulfill the systematic thinking of distribution logistics. The performance indicators defined in this model measure performance immediately and illustrate the state of the entire value chain.

4.2 Description of the case studies

The practical application of the model was proofed by the authors in collaboration with two companies. The trading company within the case study „Japan“ is a worldwide operating enterprise with its headquarter in Germany. In 2011, the company with its 5,000 employees could generate a turnover of 482,9 mio €. 60% of the total turnover could be generated by the 20 foreign branches. A very important one is the subsidiary in Japan. It has 500 employees and is very well integrated into the global Supply Chain.

The examination for the country Nigeria was made for a company of the construction industry where especially the spare parts logistics for equipment used was considered. The company is a minority holding of a German concern, which is doing business in Nigeria since 1965. In 2010, the company had 18,690 employees, who generated a turnover of 173 bn. NGN (ca.

885m EUR). Despite of difficult frame conditions, the company sticks to its German quality standards and is stamped by knowledge transfer and high support from Germany.

In the focus of both examinations was the optimal supply of articles that are different in terms of value where each is supposed to show a constant consumption throughout the year. Furthermore, the total weight of the load carriers was standardized in order to assure a comparability of the scenarios and the different case studies. Table I summarizes the respective parameters for the goods to be transported.

Table I – Overview of company specific input parameters

parameter	Value	unit	describtion
W_u	300	kg	weight of one pallet
V_u	1,15	m³	volume of one pallet
P_u	Variable	€	price/value of one pallet
N	104	pallets	total demand of products on pallets
V_B	33	m³	volume of a 20 ft container
$W_{B,max}$	21.700	kg	maximum load of a 20 ft container
$S_{r,cc}$	12	%	capital commitment rate

In order to standardize the model and therefore to enable a transport mode comparison, the calculation is based on an imaginary demand of the products. Due to the fact, that the infrastructural situation of a country as well as the location of potential customers are important for setting up the optimal distribution system, these factors have to be integrated in the model. Therefrom, the geographic allocation of demand will be calculated in analogy to the geographic distribution of the ten largest cities in combination with a country specific detour factor.[29]

Table II – demand in the example data set; data source [30]

Nigeria					Japan				
i	city	P [no]	latitude	longitude	i	city	P [no]	latitude	longitude
1	Lagos	9.968	6°50'N	3°35'O	1	Tōkyō	8.877	35°67'N	139°77'O
2	Ibadan	5.175	7°38'N	3°93'O	2	Yokohama	3.762	35°47'N	139°62'O
3	Benin	2.407	6°34'N	5°62'O	3	Ōsaka	2.650	34°68'N	135°50'O
4	Kano	2.376	12°00N	8°52'O	4	Nagoya	2.277	35°15'N	136°91'O
5	P. Harcourt	2.101	4°81'N	7°01'O	5	Sapporo	1.947	43°06'N	141°34'O
6	Kaduna	2.061	10°52'N	7°44'O	6	Kōbe	1.562	34°68'N	135°17'O
7	Aba	1.597	5°01'N	7°35'O	7	Fukuoka	1.480	33°59'N	130°41'O
8	Abuja	1.353	9°06'N	7°49'O	8	Kyōto	1.466	35°01'N	135°75'O
9	Maiduguri	1.126	11°85'N	13°16'O	9	Kawasaki	1.419	35°53'N	139°70'O
10	Ilorin	1.084	8°49'N	4°55'O	10	Saitama	1.271	35°87'N	139°64'O

In the case of the two investigated companies only two structuring option were eligible. These were option 1, delivery of stored products from a warehouse in the country whereas the replenishment is done via sea freight transports, and structuring option 5. Within option 5 the customer delivery process is handled via air freight under usage of a cep-service provider which is integrating the complete supply chain from the exporting country to the final customer. To build up an own air freight delivery process (options 2 and 4) was not worthwhile of investigation for the companies because of high implementation costs and the comparable low transport volume. Option 3 has not been investigated because it did not fulfill the delivery time requirements of the companies.

4.3 Determination of delivery costs

4.3.1 Declaration of parameters and variables

C_{CEP} = Total cost cep provider [€]
$C_{CEP,N}$ = Cost cep provider [€/pallet]
C_{cc} = Capital commitment cost [€]
$C_{r,p}$ = Freight cost on road per km and pallet [€/km/pallet]
$c_{r,stop}$ = Costs per stop on road [€]
$C_{RE,s,transit}$ = costs for stock in transit [€]
C_{RH} = Total cost road haulage [€]
C_S = Stockholding costs [€]
C_{SF} = Total cost sea freight [€]
$C_{SF,B}$ = Cost sea freight per container [€]
D_r = Distance on road [km]
E = costumer
H = Harbour/Port
K = Container capacity [pallets]
L_B = Maximum Load Container [kg]
N = Demand [pallets]
P_u = Price per pallet [€/pallet]
Q_{SF} = Quantity of sea freight transports [no]
Q_{CEP} = Quantity of cep freight pallets [pallets]
Q_U = Quantity of pallets [pallets]
Q_{RE} = Replenishment quantity [pallets]
S_A= Average stock [pallets]
S_r = Total stock keeping expense ratio [%]
$S_{r,cc}$ = Capital commitment rate of stocks [%]
$S_{r,i}$ = Stock keeping insurance rate [%]
$S_{r,p}$ = Cost rate for physical storage [%]
$S_{r,r}$ = Stock keeping risk rate [%]
T = Time [days]
$T_{d,W,Z}$ = Delivery time from warehouse to customer [days]
V_B = Volume of container [m³]
V_U = Volume of one pallet [m³]
W = Warehouse
W_U = Weight of one pallet [kg]
Z = Customs

4.3.2 Cost determination for structuring option 1

Optimum replenishment quantity

The considerations refer to the calculations of the transport relevant factors when a warehouse is embedded into the distribution system. Despite this examination, the actual warehousing costs have to be calculated as well as those that arise due to inventory. Therefore, the amount of replenishment has to be calculated for the mode where the replenishment costs and the warehousing costs are at a minimum. For the available research paper it has to be proved if the classical formula for ordered quantities for the calculation of the optimal amount of replenishment [24, 17] on the basis of the carrier can be determined. The restriction of the fix cost price can be kept within the system of distribution logistics whereby the price is represented by the imputed product price (P). The missing consideration of financing- and storage borders does not play a role in the present problem, because the area of resource optimization in the context of new planning is supposed to be depicted by the decision model. Due to standardized containers, constant replenishment costs ($C_{RE,SF}$) can be illustrated. The variable is composed of the transport costs for sea freight and the transport costs for containers on land.

$$Q_{RE,SF,opt} = \left\lceil \sqrt{\frac{2 * N * C_{RE,SF}}{P * S_r}} \right\rceil \quad (1)$$

Due to these restrictions, the classical lot size formula can be used for the calculation of the optimal amount of replenishment. The calculation of replenishment underlies the costs of a container ($C_{RE,SF}$).Therefore, the result of the model can only be valid, if the quantity can be transported within one container. Hence, it is necessary that the replenishment quantity, measured in volume and weight, is smaller than the capacity of the container. If the determined quantity requires more capacity, then the replenishment quantity ($Q_{RE,SF}$) has to be reduced.

$$Q_{RE,SF} = \begin{cases} Q_{RE,SF} & | \; Q_{RE,SF,opt} \leq K \\ K & | \; Q_{RE,SF,opt} > K \end{cases} \qquad K = \left\lfloor \min \begin{pmatrix} \frac{V_B}{V_U} \\ \\ \frac{W_B}{W_U} \end{pmatrix} \right\rfloor \tag{2}$$

For the given products the capacity of a 20ft container is limited to 28 pallets (K) because of its volume which is the dimension that becomes restrictive first. The result is the number of required transports (Q_{SF}) which is needed to calculate the total distribution costs for a transport mode.

Determination of replenishment costs

In the following the input parameters that are necessary to calculate the optimum order quantity are presented and used on the example of Japan and Nigeria. Under the usage of this value, the total distribution costs of the whole demand under the usage of sea freight into the focused country can be determined and consequently be compared with the cost of air freight transport. The providers of liner conducted transport services (sea freight) operate with fixed transport relations on a market with an anonymous demand. Because of the transport execution in form of defined routes, the actual transport distance does not play a vital role from the demander's point of view for the pricing, but rather the evaluation of costs per transport relation from the load- to the unload-point. In the liner conducted container sea freight, which shall be depicted in the model, the prices will be calculated as FCL. The costs for replenishment by sea freight ($C_{RE,SF}$) consists of the price per container to the destination country ($C_{SF,B}$) and the transport cost within the country via road from the port to the warehouse ($C_{r,H,W} = D_{r,H,W} * c_r$).

$$C_{RE,SF} = C_{SF,B} + D_{r,H,W} * c_r \tag{3}$$

Sea freight costs per container

In the example case "Nigeria" the company charters an own ship each month due to the bad connection to the regular services of maritime shipping. For the entire transport distance from Germany to the target place the costs are distributed on the basis of the transported containers. Those are internal cost rates. The fares for the transport of one container via sea freight to the destination country ($C_{SF,B}$) is based on data of the case study companies which is about 1.600 € for a 20ft container from Germany to Nigeria and 1.100 € for the transport from Germany to Japan.

Warehouse location and road haulage costs to the warehouse

To calculate the road transport and capital commitment costs the location of an imaginary warehouse has to be determined. Storage is used as an internal optimization element in the distribution structure. The planning can be differentiated into three branches: the geographic location planning, the distribution area planning and the stock planning.

In terms of the geographic location planning on the plane it is tried, on an area with discrete delivery points, to find the place from where the sum of delivery costs for the distribution area are the lowest. One possibility is the determination of the tonne kilometric minimal point where the freight transport volume is evaluated with regard to the delivery points and the distances are measured by the Euclidean distance measure. The cost evaluation can be done by the cost rate per kilometer (C_r) because the number of stops is distributed proportionally to the freight transport volume at the delivery points and therefore does not have to be considered in the optimization. Mathematically the problem can be expressed through an approximate formula where the weighted middle of the transport distance is to be minimized. For the considered example case a warehouse near the city Ibadan (4°11‘0 O, 7°12‘0 N) was calculated for Nigeria and one near Yokohama (139°62’ O, 35°6’ N) for Japan.

In order to make sure that the warehouse can be supplied with products after the sea freight transport, the replenishment has to be, done via road haulage starting at the port. For the costs of replenishment the calculation of the distance from the port to the warehouse is necessary. Replenishment was determined after the calculation of the warehouse for each harbor. For Japan the harbor Yokohama (JPYOK) and for Nigeria the harbor Warri (NGWAR) is used. The distance via road ($D_{r,H,W}$) from the port to the warehouse in Japan is about 254 km and 285 km in Nigeria. At this point the complete data is known which allows the replenishment cost calculation ($C_{RE,SF}$). In sum, the replenishment cost of one container to Nigeria amounts to 3.196 € and to 2.399 € to Japan.

Table III: Replenishment costs for Nigeria and Japan
Source: Own.

	parameter	Nigeria	Japan
Sea freight container costs	$C_{SF,B}$	1.600 €	1100 €
Distance from port to warehouse	$D_{r,H,W}$	285 km	254 km
Cost rate for road haulage	c_r	2 € / km	2 € / km
Road haulage cost from port to warehouse	$C_{r,H,W}$	570 €	508 €
Sea freight replenishment costs	$\mathbf{C_{RE,SF}}$	**2.170 €**	**1608 €**

Stock keeping expense ratio

The last parameter that is needed to calculate the optimum order quantity is the total stock keeping expense ratio (S_r). The stockholding cost rate consists of the capital commitment costs, the proportional inventory costs, the costs of the stock risk and the costs of insurance. [31]

$$S_r = S_{r,capital} + S_{r,physical} + S_{r,risk} + S_{r,insurance} \quad (4)$$

A part of the entire stockholding costs are capital commitment costs, which can be ascertained with an inventory cost rate. Until the transfer of ownership to the customer the inventory in the system of the distribution logistic has to be financed by the company. For the calculation of the inventory costs the definition of a capital commitment rate as well as a temporal and value based evaluation of the inventory is necessary. Since the inventory binds value-based assets, it has to be valued at least with the basic rate of interest level which companies pay for the financing. [32, 33] In the model the evaluation of the capital commitment costs shall be done through the variable $S_{r,capital}$, which pertain for the inventory both during transport and during storage. The second factor is the partial warehousing costs which are evaluated de facto with a firm-specific assessment system and are therefore strongly dependent on the considered products. For the standardization of the evaluation the assessment system as a result should have a percentage cost rate – based on the product price of the stored good, which is involved in the model with the variable $S_{r,physical}$. A higher country-specific relevance however have the costs of the stock risk $S_{r,risk}$ as well as the costs of insurance $S_{r,risk}$ which can also be determined as a percentage cost rate of the stock value. A point of reference for the assessment of these two factors is offered by the Enterprise Surveys study [31] whose values have exemplary been depicted in the following table IV:

Table IV: Empirical stock risk- and stock insurance rate for Nigeria [30]

	parameter	Nigeria	Japan
Losses due to theft, robbery, vandalism and arson in %	$S_{r,risk}$	4,1 %	0 %
Security costs in % of sales	$S_{r,insurane}$	2,6%	0 %
Company specific capital commitment rate	$S_{r,capital}$	12 %	12 %
Cost for physical storage/handling	$S_{r,physical}$	0,1 %	1,0 %
S_r = Total stock keeping expense ratio [%]		18,8 %	13 %

Total costs for sea freight

At this stage all input parameters have been calculated that are needed to determine the optimal order quantity which is presented in formula one. In the concrete cases of the companies, the optimal order quantity was seven pallets per transport in Nigeria and eight pallets in Japan. Due to the reason that the optimal replenishment order quantity ($Q_{RE,SF,opt}$) is smaller than the maximum capacity, no adjustments following formula two have to be done. The total sea freight costs can be determined by multiplying the number of needed containers (Q_B) by the costs per container to the specific destination.

$$C_{SF} = C_{SF,B} * Q_{SF} \tag{5}$$

Table V: calculation of the total sea freight costs for Nigeria and Japan

	parameter	Nigeria	Japan
Optimal order quantity	$Q_{RE,SF,opt}$	$\left[\sqrt{\frac{2*104*2.170\text{ €}}{45.000*0{,}188}}\right] \approx 7$	$\left[\sqrt{\frac{2*104*1.608\text{ €}}{45.000*0{,}13}}\right] \approx 8$
Number of needed containers for the complete demand	Q_{SF}	15	14
Cost per sea freight container	$C_{SF,B}$	1.600 €	1.100 €
Total cost sea freight	$\mathbf{C_{SF}}$	**24.000 €**	**15.400 €**

Warehousing costs

After the definition of the replenishment quantity (Q_{RE}) and the safety stock (S_s=0) the average inventory can be calculated. It consists of the safety stock and the average replenishment, which can be estimated with a constant outward stock movement. [27]

$$S_A = \left[\frac{Q_{RE,SF}}{2} + S_S\right] * P \tag{6}$$

The average inventory illustrates the quantity dimensions, which have to be evaluated with specific cost rates to use the decision criterion inventory costs in the model. The assessment of the inventory costs can be summarized with the following formula for the country-specific evaluation in the model:

$$C_S = [S_A * \mathrm{P} * S_r] \quad (7)$$

The composition of the stock related cost rate is presented in table VI. Summarized, the following stockholding cost can be determined for the two example cases:

Table VI: Calculation of the total stock keeping costs for Nigeria and Japan

	Variable	Nigeria	Japan
Average Stock	S_A	156.000 €	167.143 €
Total stock keeping expense ratio	S_r	18,8 %	13 %
Total stock keeping costs	C_S	**29.380 €**	**21.795 €**

Road freight costs for customer delivery

Other than in the standardized quotations frames, the planning and evaluation of the flexible road freight transport. The transport offer of the service providers is therefore not based on concrete transport relations, but is rather offered with distance- and customer-specific attributes. For the modeling the transport distance is multiplied with a distance cost rate. For the modeling of further costs, the assumption of exclusive transports shall be assumed. Therefore the possibility of bundling of shipments as well as the consideration of empty runnings is not further regarded in the strategic planning scenario. [34] The consideration of the different shipment sizes in the model, especially during pre-carriage through the use of air and sea freight, happens with the following assumptions:

- The onward transport of the sea freight container takes place with road freight transport, whereby each time one container can be transported per trip to the warehouse.
- The supply of the customer takes place with the road freight transport, whereby the freight costs per load carrier are calculated distance dependent.

Therefore for the modeling of the transport costs of road freight transport two variables have to be defined. The cost rate per kilometer per pallet (C_r) depicts the distance dependent costs of the transport on the road and is multiplied each time with the distance (D_r). The model is calculating with a truck utilization of 30 pallets. The overall costs of a load carrier through road transport can be calculated with the following formula:

$$\mathrm{C_{RH}} = \mathrm{C_{r,p}} * \mathrm{D_r} * \mathrm{N} \quad (8)$$

The already defined formula can also be used for the calculation of the distance from the warehouse of the customer across the street. Instead of the transition point the coordinates of the storage place are assumed. In order to compute the respective distances, a detour factor is determined by relating, for a significant number of transport routes, the point-to-point aerial transit path to the real road distance. [29] In addition, the route-related detour factors were weighted according to their demographic relevance, which is calculated by using the number of inhabitants of the respective end points. The determined weighted detour factor measures for Nigeria 1.2587 and 1.9123 for Japan. [5, 35] This factor simplifies further calculation of surface transport distances (D_{ri}) by multiplying each with the linear distance to arithmetically determine the distances on the road (see formula 9).

$$D_{ri} = D_{r,linear} * d \tag{9}$$

As a result, the calculation of the average distance from a specific point to the average customer is possible by using formula 10.

$$D_{r,W,E} = \left\lceil \frac{\sum_{i=1}^{x} D_{r_i} * P_i}{\sum_{i=1}^{x} P_i} \right\rceil \tag{10}$$

Table VII shows the calculation for the transport from the warehouse to the average customer. The result is an average transport distance via road of 346 km in Nigeria and 461 km in Japan.

Table VII – Calculation of the average distance from warehouse to customer

Nigeria				Japan			
City	**Inhabitants**	$D_{r,linear}$	D_r	**City**	**Inhabitants**	$D_{r,linear}$	D_r
Lagos	9.968	109	137	Tōkyō	8.877	18	34
Ibadan	5.175	35	44	Yokohama	3.762	11	21
Benin	2.407	188	237	Ōsaka	2.651	464	887
Kano	2.376	726	914	Nagoya	2.277	303	579
Port Harcourt	2.101	411	517	Sapporo	1.947	667	1275
Kaduna	2.061	526	662	Kōbe	1.563	500	956
Aba	1.597	422	531	Fukuoka	1.481	1035	1979
Abuja	1.353	430	541	Kyōto	1.466	433	828
Maiduguri	1.126	1.122	1.412	Kawasaki	1.420	11	21
Ilorin	1.084	160	201	Saitama	1.272	23	44
$d_{Nigeria} = 1,2587$		$D_{r,W,E}$ [km]	**346**	$d_{Japan} = 1,9123$		$D_{r,W,E}$ [km]	**461**

Finally the average imputed transport costs via road can be determined for the two example cases.

Table VIII: Calculation of the total road haulage costs for Nigeria and Japan

	parameter	**Nigeria**	**Japan**
Cost rate for road haulage [€/km/pallet]	$C_{r,p}$	0,07 €	0,07 €
Road distance from warehouse to customer	$D_{r,W,E}$	346 km	461 km
Total road haulage costs for customer delivery	C_{RH}	**2.399 €**	**3.196 €**

4.3.3 Cost determination for structuring option 5

Similar to the cost calculation of sea freight, the costs of air freight (C_{CEP}) can be evaluated. Air freight charges are determined not only by the actual weight of the contents but by the dimensional weight of the package. The package is conceded per each kilogram of transport weight with 6,000 cm^3 volume, whereby all packages are consolidated to one shipment for the calculation. The dimensional weight enters into the model for the calculation of the air freight costs. Within this article the air freight costs will be examined by the use of a door to door service provider. To calculate the total costs for sea freight transports, the air freight rate per unit ($C_{CEP,B}$) is multiplied by the quantity of transport packages (Q_{CEP}).

$$C_{CEP} = C_{CEP,B} * Q_{CEP} \tag{11}$$

Table IX: Calculation of the total air freight costs for Nigeria and Japan

	parameter	Nigeria	Japan
Number of transported pallets	Q_{CEP}	104	104
Cost per sea freight container	$C_{CEP,B}$	876,00 €	530,20 €
Total cost sea freight	$\mathbf{C_{CEP}}$	**91.104,00 €**	**55.140,80 €**

The definition of freight costs by parcel services can take place similar to the line-oriented transportation cost rate. Her too, the transport service is offered on an anonymous market, where, due to the door-to-door-service no pre-carriage or on-carriage costs have to be included during planning.

4.3.4 Costs for in-transit-inventory (Structuring option 1 and 5)

Temporal inventory binds capital during the transport as well as during the laytime in the warehouse. The inventory cost rate ($S_{r,capital}$) in the warehouse has been taken into account as a variable in the storage costs (S_r). The inventory costs during the transport are dependent on the transport quantity and the transport time which have been defined through the definition of the cycle time for transport processes. The used consideration of the single process elements during the planning provides the advantage, that with the decision for the composition of the transport chain the effects of the inventory costs can directly be considered. The capital commitment costs of the inventory during the transport process of a replenishment delivery ($C_{RE,s,transit}$) can be determined with the product price (P), the temporal duration of the process ($T_{RE,SF}$) and the inventory cost rate ($S_{r,capital}$).

$$C_{RE,s,transit} = \left\lceil \frac{P * T_{RE} \; S_{r,capital}}{365} \right\rceil \tag{12}$$

During the direct delivery of customers or the delivery from a distribution center the value of a delivery has to be defined, which consists of the delivery volume (N) multiplied with the product price (P). The value of the delivery is then multiplied with the delivery time (T_d), consisting of the transport time as well as possible time for customs during border crossing, and the inventory cost rate ($S_{r,capital}$) to determine the inventory costs during the supply of customers ($C_{E,s,transit}$).

As already depicted, the risks in the international outbound logistics are very eclectic and can hardly be quantified without own experience values in the destination country. The different risks display costs for the companies, which can be represented in the decision model by the variable. Through this variable risks from empirical surveys or agreed insurance rates can be projected, which lower the profit of the companies in the destination country. The study *Enterprise Surveys* tries to gather a part of the risks through an empirical survey, by inquiring the value share of stolen products of sales within the domestic distribution market.

Table X: Empirical country risk rate for distribution in Nigeria
Sources: The World Bank (Washington/USA) [Date: 06.06.2011], Company Japan

	parameter	Nigeria	Japan
Share of stolen products during transport as part of sales	$C_{r,risk}$	0,91 %	0 %

At this point the lead time for the replenishment (T_{RE}) transport chain is needed to calculate the in-transit-inventory costs. Table XI summarizes the transport lead times which are based on the company data set.

Table XI – Replenishment time from Germany to Nigeria and Japan

		Sea freight		CEP-services	
	parameter	**Nigeria**	**Japan**	**Nigeria**	**Japan**
Liner shipping	$T_{SF,H}$	22	40		
Airfreight					
Customs	T_Z	7	1		
Road port to warehouse	$T_{r,H,W}$	1	1		
CEP-service	T_{cep}			8	5
Total time T_{RE} [days]		**30**	**42**	**8**	**5**

The following table displays the costs for in-transit-inventory in the sea freight and air freight replenishment process.

Table XII – Total cost for in-transit-inventory replenishment process

		Sea freight	
	parameter	**Nigeria**	**Japan**
Product price/value	P	45.000 €	
Total replenishment time	T_{RE} [days]	30	42
Capital commitment rate	$S_{r,cc}$	12 %	
Total costs for in-transit-inventory replenishment	$C_{RE,s,transit}$	**46.159 €**	**64.622 €**

The last cost factor that has to be considered is the cost for the transport from the companies' warehouse to the final customer. This cost factor consists of the capital commitment costs for the needed transport time and a specific share of goods that are stolen within the transport.

Table XIII – Total cost for in-transit-inventory in the customer delivery process

		Sea freight		CEP-services	
	parameter	**Nigeria**	**Japan**	**Nigeria**	**Japan**
Share of stolen goods	$C_{r,risk}$	0,91 %	0 %	0,91 %	0 %
Transport time for customer delivery	$T_{R,E}$ [days]	1	1	8	5
Capital commitment rate	$S_{r,cc}$	12 %			
Total costs for in-transit-inventory customer delivery	$C_{E,transit}$	1.667€	1.538€	12.309€	7.693€

4.4 Determination of total time and costs

According to the objectives, the decision model is supposed to help finding alternatives that can maintain the required delivery service under the condition of an optimal design of total costs. Following the definition of time and cost related evaluation aspects, the determination of delivery time to the customer and the calculation of the total time can be done separately. For transportation via air we assumed that the demand in the target country is directly delivered to the customer. In that case no inventory is necessary. Due to long lead times for the transport mode sea freight, inventories in the target country can reduce the demand related delivery times.

Table XIV – Total cost for in-transit inventory customer delivery process

		Structuring option 1		Structuring option 5	
	parameter	**Nigeria**	**Japan**	**Nigeria**	**Japan**
Sea freight	C_{SF}	24.000 €	15.400 €		
CEP-service	C_{CEP}			91.104 €	55.141 €
Road seaport to warehouse	$C_{r,H,W}$	7.980 €	7.112 €		

Road warehouse to customer	$C_{r.w,z}$	2.399 €	3.196 €		
Warehouse	C_S	29.380 €	21.795 €		
In-transit inventories replenishment	$C_{RE,S,transit}$	46.159 €	64.622 €		
In-transit inventories delivery	$C_{E,transit}$	1.666 €	1.538 €	12.309 €	7.693 €
Total costs		**111.584,69 €**	**113.664,79 €**	**103.413,04 €**	**62.833,95 €**

Furthermore, through the temporal decoupling of the replenishment processes, bundling effects can be achieved. The costs for inventory are moving opposed, whereby these can be decreased by ordering smaller replenishment lots. Moreover, longer cycle time causes higher costs for the in-transit inventory during the replenishment processes. Because of the optimization of the total system the transport costs have to be considered next to the storage and inventory costs. The following figure three shows the allocation of the total distribution costs for the total demand of 104 pallets in the target market under comparison of the two considered supply chain alternatives. The value in euro per pallet is used as a variable. This parameter has been detected as the most important variable which has increased by steps of 500 € per pallet in order to illustrated the effect of capital commitment costs in setting up the optimum distribution system.

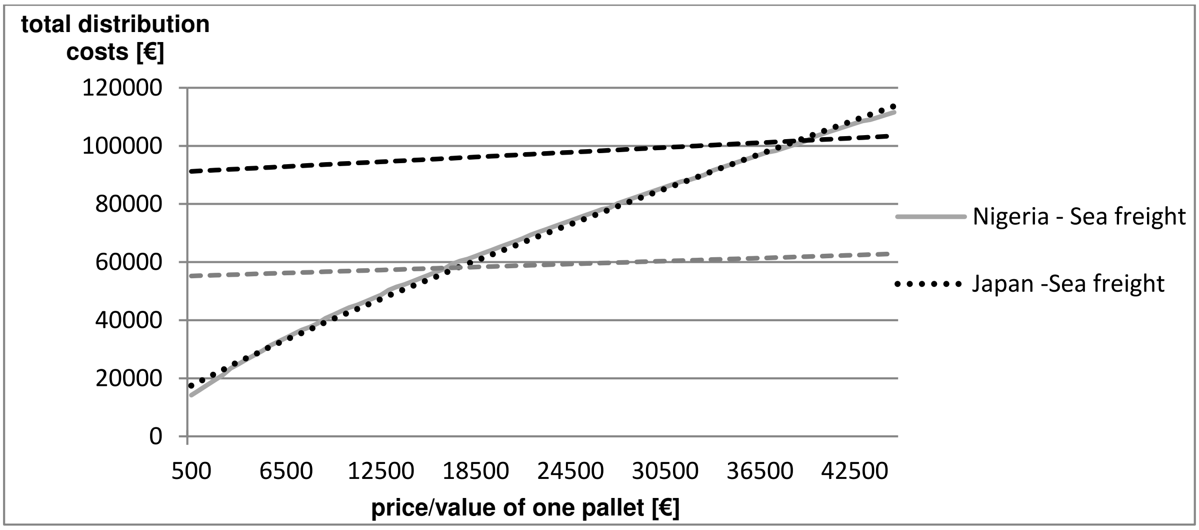

Figure 3– Development of the total distribution costs for sea freight and CEP-sercives under dependency of an increasing product value.

The main question in the case studies has been the change of total delivery costs by the product value. In practice the product value can vary and is depicted in the model through the variable. In the variation there are changes in transport costs for sea freight, because rising inventory costs result in an increased transport frequency - depicted in the model through the number of containers. Furthermore, capital lockup increases in total within the examination period due to the increase of the sales value of the pallet. Because of the short transport times of air freight the capital lockup is just a minor part of total costs. Moreover, the amount to be transported can be scaled up to the single customer delivery, so that only the low capital lockup increases with the increasing value of the sales unit. Comparing the transport modes sea for the delivery to the target markets, it results in low total costs via sea freight when the sales unit has a low value. Those however rise with the increase of the sales price. Therefore at a certain value the transport costs of the alternative sea freight exceed the total costs of air freight. At this value it would make sense to change the mode of transport to supply the market.

In addition, the decision model enables the comparison of transport costs in different target countries when there is an identical value of the sales unit. The diagram shows the total costs for each carrier in both target countries. Here it shows that costs for sea freight are almost identical for both target countries whereas there are marginally decreasing transport costs when the sales value is increasing for the case study Nigeria which can be explained by the ratio of transport- to inventory costs. Moreover the total costs for air freight for Japan are distinctly lower than those for Nigeria whereby the break-even point for Japan, when comparing the carriers according to the sales value, is much lower.

5. CONCLUSION

The article aims at improving the systematic evaluation of countries and transport scenarios. To achieve this aim, external parameters of the destination countries are integrated through defined measurement parameters, such as the geographical coordinates. Furthermore, discretionary rankings and statistics of public organizations, such as the World Bank or the UN Conference on Trade and Development (UNCTAD), have been integrated into the analysis frame. The result is an adaptable model for companies to compare delivery scenarios and countries under the consideration of external parameters.

The practical applicability of the research work has been examined within the framework of two case studies. The provision of actual cost rates and product-related characteristics by companies, the decision model was extended with the internal parameters and completely calculated. Moreover, the coherence of product price variations has been investigated for the assessment of different delivery scenarios.

By comparing German exports to the countries Nigeria and Japan, it has been demonstrated that the structural configuration of a logistic system can depend on the product value. By application of the total cost calculation, the transport with the alternative sea freight showed cost benefits with products of low value per packaging unit. In a direct comparison the boundary value for the alternation from the sea freight delivery scenario to a direct supply of the market via air freight lies considerably lower for Japan than the boundary value for Nigeria. The reasons for this are high storage costs as well as the long replenishment times of the inventory. These facts cause that the scenario using the cheaper sea freight transport mode is getting unfavorable when the product value is increasing (compare figure 3). This is based on the capital commitment costs which directly depend on the transport time for the different structuring options. An adaption of the logistical system can only take place if the delivery time does not exceed the customer requirements.

The developed model illustrates a possible new evaluation standard which allows a clearly distinguished cross-country comparison that is superior to a qualitative evaluation by questionnaires like it is common today. Country specifics like the land surface and the quantity as well as the spatial distribution of road infrastructure are covered by the new approach. Moreover, the model offers a high degree of flexibility since the methodology allows the estimation of variable factors. Through the addition of respectively process-relevant costs, as asked in the total cost mentality, meaningful results can be achieved, which far exceed the isolated consideration of single transport carriers. This was especially depicted by the case study analyses with actual market prices. Herewith, at this point, a statement for the researched cases was acquired; A complete evaluation of the comparison between countries has not been given yet. The reason for this is the high case-specific and temporal variance of the prices, which are offered on the market, which makes generalizable conclusions virtually impossible. Because of the detailed description, the model can be adopted for practical application. The application can therefore be appreciated as a further evaluation, without having to be finalized temporarily.[1]

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