Extended logistical factors for success in international trade

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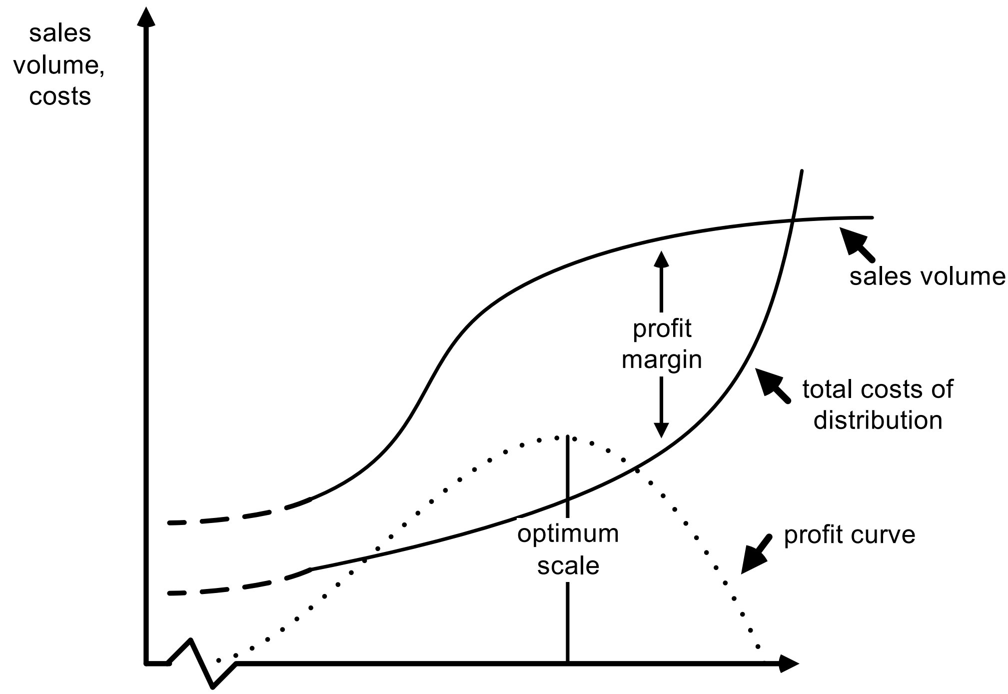
Abstract

Current empirical studies on countries' logistics performance do not fully reflect the main logistical principles of flow, system and total-costs theory. The authors provide a model which fills this gap. The approach is essentially based on the standard Supply Chain Operations Reference model (SCOR) viewed from the perspective of an integrated supply chain. This new, holistic model makes it possible to evaluate the process-related steps of administrative tasks and all modes of transportation and warehousing in terms of time and costs. The model starts with the estimated customer order and takes account of country-specific conditions, such as infrastructure and the legal framework. This process-based approach allows the flows of material and information to be analysed and planned in order to optimise all elements having regard to a company's specific strategy. Accordingly, the model defines various evaluation and calculation methods, thereby revealing a number of interdependencies. It also allows the calculation to be based on data sources from international organisations or the historical operational data of companies (if available). The model also allows countries to be evaluated in terms of their business processes.

1. Introduction

Success in national and international competition depends on the competitive advantages that companies enjoy when pursuing their business activities (Zentes, Swoboda & Morschett 2004, p. 217). Only a systematic study of all company activities and their interdependencies can reveal the reasons for these competitive advantages and their potential. One of the most important activities in the value chain is distribution logistics, which is closely related to customers and therefore able to directly generate competitive advantages (Porter 2010, pp. 70-85). In general, distribution logistics is expected to 'provide the right goods at the right time and place, in the right amount and quality, and at the right price', thereby ensuring the availability of goods and information (Jünemann & Daum 1989, p. 18; Wenzel 2011, pp. 442-3). As part of the overall entrepreneurial goal, distribution logistics also gives top priority to the maximisation of profit and can be defined by the triple aims of cost, time and quality. The company can boost its profits by planning activities in a way that improves the cost-benefit ratio for the customer (Ihde 2001, p. 297). In most cases, however, the planning of the logistical structure is based on the assumption that the customer is not particularly interested in it provided that logistics performance is guaranteed. This means that the company's profit-making activity remains unaffected. It follows that there is only one way to optimise profits, namely by minimising costs (Wöhe & Döring 2005, pp. 564-5).

Figure 1: Cost-profit relation depending on degree of services



Source: Wenzel 2011, p. 445, with modifications

Although writers examine international trade and production in great detail, they pay less attention to the underlying logistical aspects (Schary & Skjøtt-Larsen 2001, p. 378). Admittedly, when it comes to international logistics, there is no difference between companies' basic problems and goals. Nevertheless, certain framework conditions lead to greater complexity and higher risks in relation to country-specific logistical processes. (Arnold 1989, p. 1340; Flaherty 1996, p. 281; Stock & Lambert 2001, p. 376; Schieck 2008, p. 70; Pfohl 2010, p. 337). Generally-speaking, companies cannot influence many of the underlying conditions and therefore have to respond appropriately (Kummer, Schramm & Sudy 2010, p. 84). International distribution logistics is characterised by a high degree of complexity since companies usually accept national boundaries and organise their planning on a county-specific basis (Mayer, Thiry & Cay-Bernhard 2009, p. 33; Bretzke 2010, p. 164). In the following, we provide a procedural model for this planning process and apply it to two countries by way of illustration.

2. Studies, rankings and benchmarking reports as information bases

Data relating to external logistical framework conditions is indispensable for evaluating foreign markets. That said, collecting this information in advance is expensive and companies lack a procedural model to systematically evaluate countries using freely accessible secondary data (Holtbrügge & Ehlert 2009, p. 4; Berndt, Fantapié Altobelli & Sander 2010, pp. 63-4; Kutschker & Schmid 2011, pp. 216-26). The country-specific framework conditions for shaping logistical processes are compared by The World Bank's Logistics Performance Index (LPI), Doing Business Report and Enterprise Surveys, and the World Economic Forum's Global Competitive Index (GCI). Their data is usually based on hard and soft factors and is predominantly collected from questionnaire-based surveys.

The LPI compares national and international logistical performance in terms of cost, lead times, administrative effort, resources and quality (Arvis et al. 2010). The Doing Business Report, on the other hand, evaluates the environment of entrepreneurial activities in terms of legal guidelines and other general conditions. The two indicators of the report relevant to logistics show how legal regulations affect the construction of a simple warehouse and import of a 20-foot container (World Bank 2011a). The Enterprise Surveys consider 12 thematic areas but choose to present them as a separate evaluation of 30 indicators rather than as a summarising index (World Bank 2011b). The GCI's calculation is far more complex because of the broad spectrum of macroeconomic factors upon which it is based. Overall, the index lists 11 indicators relevant to logistical planning (Schwab 2010, p. 11).

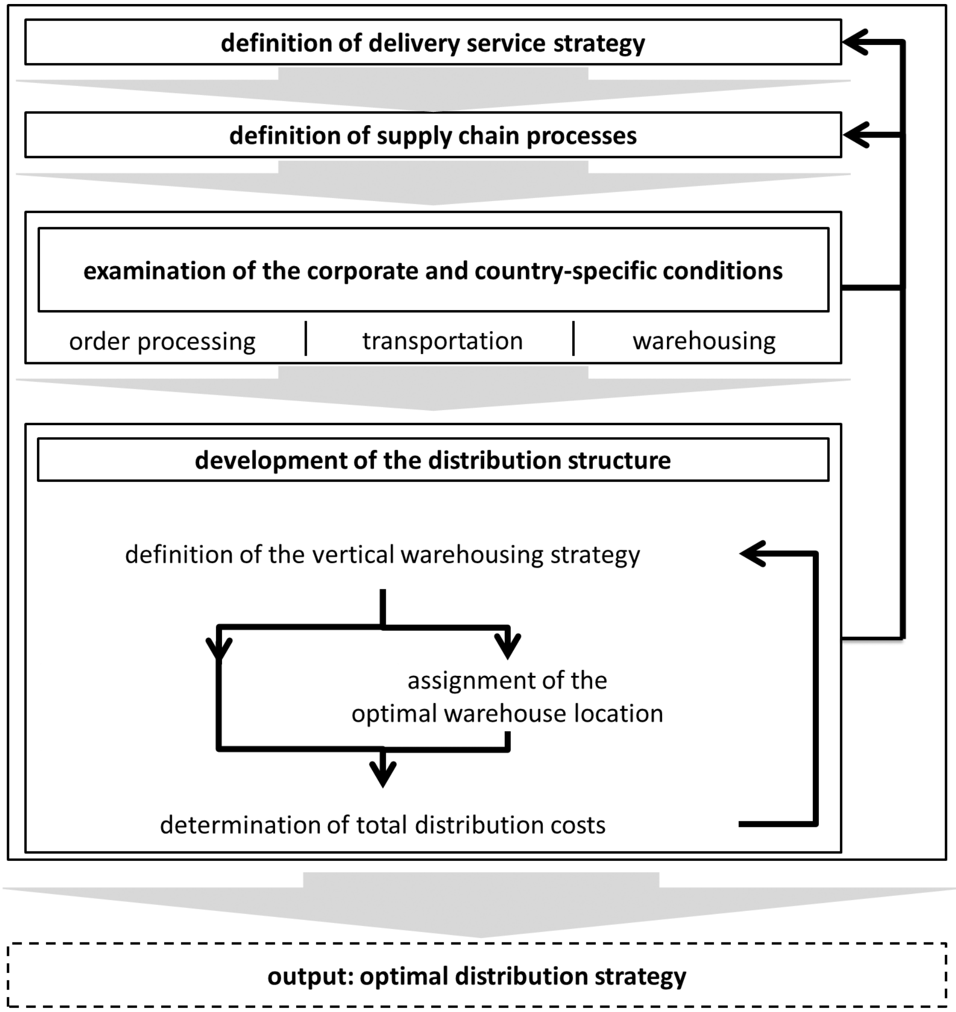
In addition to these general indexes, three more specific ones are used to evaluate countries' transportation networks: the Liner Shipping Connectivity Index (LSCI) deals with international scheduled ocean shipping, the Air Connectivity Index (ACI) with international scheduled flights and the Rural Access Index (RAI) with road infrastructure in rural areas (Hoffmann 2007; World Bank 2007; Arvis & Shepherd 2011).

The key function of the studies briefly presented above is to assess country-specific conditions as well as their competitive status, with assessments being carried out without reference to industries, companies or goods (Matthes 2005, pp. 78-9). Comparing country rankings using logistical criteria paints a more complex picture and suggests that the divergent results of country assessments are explained by the different data sources and calculation procedures used (Berndt, Fantapié Altobelli & Sander 2010, p. 119). The selected criteria and publications aim to assess and compare factors relevant to the country in order to identify the potential for optimisation. However, this selective and isolated approach stands in sharp contrast to efforts in the field of logistics which aim to capture the process-orientated, holistic interplay of activities. Optimisations limited to individual activities may not be ideally effective because of interdependencies and interfaces (Ihde 2001, p. 246). Over and above our criticism of assessment methods, we also have serious doubts about the way data is collected. One often finds that assessments not only use hard, objective data but also soft, subjective data such as opinions and personal estimates. In international logistics research, this 'supremacy of enquiry' has already been noted by Kotzab, who challenges the validity of qualitative logistics research on the basis of its failure to define survey samples as well as the complex problems arising in the collection and explanation of data (Kotzab 2007, p. 81; Bretzke 2010, pp. 64-8). Therefore, one should always sift through and analyse secondary data on the basis of a well-defined research project or application scenario (Holtbrügge & Ehlert 2009, p. 125).

3. Setting up the optimal distribution strategy

Distribution logistics is the link between a company and its customers (Sierke 1997, p. 1272). As a performance indicator, the service level is crucially important in assessing a distribution system. It shows the value or proportion of orders delivered within an agreed or planned timeframe (Wildemann 2010, p. 237). The service level provides a performance indicator for analysing completed transactions as well as a benchmark for developing new distribution systems. For this purpose, planning assumes that delivery times which do not comply with the relevant customer requirements will lead to extra costs in the form of opportunity costs caused by shortages in deliveries. In order to offer and maintain optimal delivery times in light of the usual market-related fluctuations in demand, a distribution system requires either a very high level of flexibility or a certain stock level (Liesegang & Wohlgemuth 1997, p. 963).

Figure 2: Procedural model for creating the optimal distribution strategy



Source: Vallée & Dircksen 2011

The methodology adopted by the authors reflects a linear structure starting with the delivery strategy. The first step is to define the process chain using each company's specific concepts or models of process chains as a basis. The Supply Chain Operations Reference model (SCOR model) is independent of project, product, company or industry and today represents the *de facto* standard for the description and analysis of supply chains. The current version of this normative model includes more than 200 described process elements, 550 defined criteria and 500 leading business practices which are hierarchically organised on four levels. The cross-sector supply chain offers an ideal type of process and consists of the following elements: procurement (Source), manufacturing (Make), delivery (Deliver), return deliveries (Return) and planning (Plan). The second level of the model identifies the following delivery types on the basis of a product's concept and structure:

- Deliver Stocked Product – sD1 (Made-to-stock production): This process is based on projected customer orders or internal orders to re-stock. When receiving an order from an external customer, the product should be available from stock so that it can be delivered immediately.

- Deliver Make-to-Stock Product – sD2 (Contract manufacturing): With this process, the products are either customer or contract-specific. In other words, products are specified by customers or contracts.
- Deliver Engineer-to-Order Product – sD3 (Custom made): This process concerns individual made-to-order products that can only be developed and manufactured once the orders have been received. The goods are delivered immediately after production without being stored.
- Deliver Retail Product – sD4 (Trade products): Retail trade goods are delivered via a subsidiary and collected by the customer.

The performance indicators defined in this model measure performance immediately and display the state of the entire value chain. These strategic parameters can help companies to perform internal and external benchmarking as well as define their goals. They are made up of the external attributes *costs, responsiveness, agility* and the internal attributes *costs* and *asset management efficiency*; the planning approach used in this model assesses the attributes costs and responsiveness for each country. Due to the top-down approach, each attribute can be observed right through to the level of a single process step (level 3) (Bolstorff, Poluha & Rosenbaum 2007, pp. 81-5; Poluha 2010, pp. 85-7; Supply Chain Council 2010).

Since this model does not take the countries' geographical conditions and prevailing circumstances into consideration, one can surmise that Version 10 of the SCOR model is not able to provide the answer to our research question. Therefore, our findings represent an extension of the SCOR model insofar as they examine how country-specific circumstances affect the given performance indicators and processes. This increases the model's relevance for international logistics.

Having defined the process chains, the fourth step is to examine the internal and external circumstances. Internal conditions are, for example, existing logistics structures and cost restrictions which can be optimised 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 situation in question (Kummer, Schramm & Sudy 2010, p. 84). By examining the effects of internal and external conditions, one can assess whether the delivery strategy and processes can be implemented as planned. If the requirements cannot be met, the processes will have to be revised or the delivery strategy adapted. If the prevailing conditions present no obstacles to the planned procedure, one can go ahead and establish the future distribution structure.

Before the vertical distribution structure can be established, the number of warehouses along the delivery route must be planned. Every additional storage step will make it possible to store available stocks closer to the customer. This benefits customer supply by increasing the speed of deliveries and availability of stocks. More warehouses initially reduce transport costs since it is possible to achieve more comprehensive bundling effects when supplying warehouses. Decisions will be influenced by the factories, storage levels, storage space, transshipment points and customers as well as the transport arrangements between them (Stich 2004, p. 249; eds Klaus & Krieger 2009, p. 127; Schulte 2009, p. 462; Business Optimization Lab, Hewlett-Packard 2010, p. 165).

In addition, the internal and external conditions are important criteria in the design of the distribution structure. By adding all costs, companies can calculate the expense of the service level and therefore set optimal total costs during the planning process (Stich 2004, p. 327; Reichmann & Richter 2006, pp. 428-30; Wenzel 2011, pp. 443-4). If the efficiency of the planned distribution system corresponds to the requirements of the delivery service in question and the costs, the planned scenario can be deemed effective. The distribution strategy can be further optimised by incremental changes to individual components and variations in the degree of delivery services. The following develops and defines the most important criteria for decision-making.

4. Definition of criteria for decisions

4.1 Definition of the process chain

As already mentioned, the second level of the SCOR model identifies different types of delivery services. 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 and after checking orders, additional configuration and production steps may be necessary which do not allow for the storage of finished goods. At this stage, it is possible to distinguish between the configuration of processes and planning of storage stages which, during the course of our research, leads to a synthesis of processes sD1, sD2 and sD4. For the engineer-to-order product process (sD3), the focus is therefore on delivery times and delivery efficiency while goods which are pre-produced for the market or specific customers (sD1, sD2, sD4) have to be geographically available and ready for delivery (Ihde 2001, pp. 300-7). The distribution process sD4 is an extension of the process sD1 for branch-specific elements which will not be further considered within the scope of our examination.

If one looks more closely at the contract-based delivery process within the framework of our examination, it becomes clear that it is necessary to arrange delivery from the production site when planning the order. The administrative processes, transport and transshipment processes can only take place once an order has been placed. When planning such distribution structures, it makes sense to use the precedence diagram method which shows all steps of the procedure in a process-orientated sequence and the delivery in an appropriate timeframe. This allows the effects on delivery times and costs for alternative operations (for example, transport via airfreight instead of sea freight) to be evaluated. Once customer orders have been placed, the necessary procedural steps relate to internal order processing such as order entry, planning and checking of the customer's order (sD3.1-sD3.3), transport planning (sD3.5, sD3.6, sD3.7, sED.6), formal export processing (sD3.5, sD3.6, sD3.7, sED.6), transport (sD3.12) as well as delivery (sD3.12). These are all determined by external conditions.

Interim storage is possible when distributing pre-produced goods (sD1, sD2). The process then divides into two phases: that is, the planned provision of space and delivery to the customer. For supply to storage, the internal planning processes of the company (sP2.4 and sP4.4) have been defined in such a way that the relevant production process ends once the finished products (sD1.8, sD2.8) have been delivered to the intended warehouse. For international distribution logistics, this means that the formal export process (sED.8) and transport processes can be carried out before the order processing procedure (sD1.1-sD1.3, sD2.1-sD2.3) and subsequent delivery (sD1.4-sD1.7, sD2.4-sD2.7, sD1.9-sD1.15, sD2.9-sD2.15) (Supply Chain Council 2010).

4.2 Examination of internal and external framework conditions

The key tasks of international logistics are processing, warehousing and transport (Specht & Fritz 2005, p. 115). The impact of the framework conditions on these areas should therefore be ascertained during planning to ensure the distribution logistics are strategically aligned.

4.2.1 Processing

Processing concerns internal company operations but it also interacts with other actors. As borders are crossed, companies interact with the authorities of both the exporting and destination country. In order to compare countries, this model assumes that 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 also play a decisive role and affect expenditures in terms of staffing costs, investment in IT systems as well as lead times. Although international organisations have long striven to standardise processes and data worldwide, they have been frustrated by the diverse interests involved (Lewis 2009, pp. 6-7). Further measures provide for greater transparency, advance checks without physical inspection, or the elimination of duplicate procedures or requests for information, and so on (Organisation for Economic Co-operation and Development 2003, pp. 4-5).

There are many different types of processes relating to the flow of information in distribution logistics and the application of information technology. There is the communication with business partners, status tracking of consignments, and information transfer between various locations. Ideally, data transfer requires uniform and centralised information technology for all locations. In this context, centralised maintenance and long distances are particularly challenging which suggests that localisation is more suitable (Krcmar 2003, p. 318). As far as the design of hardware is concerned, the spectrum ranges from purely central mainframes to widely-spread systems (for example, cloud computing). Apart from the internal company resources described, transfer processes also rely on telecommunication and electricity infrastructures. Their capacities are usually in line with local economic development and so companies can only regionally implement their technologies to a limited degree (Davidenkoff & Werner 2008, p. 87). Sometimes, public infrastructure has to be supported by companies' own terrestrial communication systems and electricity supplies (Buxmann & König 2000, pp. 32-3). Thereby, considerations relating to the benefits of information technology and the related infrastructure do not depend on the country but rather on the company and processes and can be justified by transaction costs (Swoboda 2005, pp. 46-8). Performance indicators can help assess the internal efforts and costs by a comparison with international levels (for example, the number of documents required for an import process or relevant country information) but they should at least be defined in terms of transport mode. The availability and speed of the telecommunications infrastructure can be measured by an automatic monitoring process such as that used in the CloudSleuth project, for example (Arvis et al. 2010, pp. 38-40; Compuware 2010; Eriksdotter 2011; World Bank 2011a, pp. 49-54).

4.2.2 Transport

Depending on the processes and distribution structures, it may be necessary to assess the transportation required in advance as part of the planning processes (Wildemann 2010, p. 214). Various transport carriers are used to transport goods (Claussen 1979, p. 15). The design and performance of transport-related tasks aim at efficiency and effectiveness and require, first of all, a selective approach based on the correlation of performance, costs and interaction. Since it is not possible to compare specific variables directly, detailed knowledge of the conditions, prices and terms is indispensable for planning and evaluating the transport options available (Klatt 1997, p. 1209; Pfohl 2010, p. 338).

As far as the significance of transport is concerned, ocean shipping is the most important carrier and transports 80% of international goods. The advantage of ocean transport lies mainly in the vast quantity of goods that can be transported over great distances. This is reflected in the low transport cost per weight and distance (Kummer 2010a, pp. 91-2). Liner shipping is an internationally significant operating mode and is mainly used for container traffic. In terms of demand, liner shipping service providers serve an anonymous transport market (Böhme 1997, p. 544). The increasing relevance of container shipping has led to the modernisation of entire ports and their infrastructures in major trading nations and resulted in a certain heterogeneity of worldwide infrastructure (Nuhn & Hesse 2006, p. 273). Along with ocean shipping, airfreight makes up over one-third of transport volume based on the value of the goods, although this still accounts for only 3% of movements worldwide (Crabtree et al. 2011). As a means of transport, only 15% of aircraft are 'freight only' since the joint transportation of passengers and freight offers the advantage of more flight routes (IATA 2010, p. 3). Compared with other means of transport, the regional extension of markets increases the difficulty of accurately forecasting demand and the high concentration of value goods for the carrier (Herron 1968).

Generally speaking, the simplest form of transporting physical goods (that is, only one loading operation which is immediately followed by delivery to the consignee) is neither economical nor even completely achievable in terms of international logistics. Among the inland carriers, inland navigation shows a very heterogeneous state of development worldwide and, in most cases, uses natural conditions (Hilling

1996, p. 38). Trends in rail transport reveal that modern logistics tends to restrict the use of carriers to regular block train and single wagon transport between highly developed handling centres whereas, in an international context, complexity increases markedly due to technical specifications and case-specific requirements and their organisation (Heidmeier & Siegmann 2008, pp. 743-5; Kummer 2010b, p. 131). Pipeline is another transport mode where the product and case-specific requirements have contributed to its relative unpopularity (Proft 1997, pp. 906-8).

On the other hand, evidence shows that there are only a few states where road transport is not the dominant mode of transport. In most countries, the supply side of transport services can be described as 'atomised' since it is dominated by a large number of small and medium sized companies. The structures and the more informal way of processing goods negatively affects the willingness to change and a carrier's innovation in using modern IT systems to carry out business processes. However, the versatility of road transport cannot be matched by any other mode of transport (Hilling 1996, pp. 157-96; Klaus 2010, pp. 202-3). Road freight transport requires roads and transshipment facilities in addition to vehicles and various actors involved in infrastructure. While transshipment facilities are mostly set up and run by private institutions, roads are planned, built and maintained by public institutions (Aberle 2009, pp. 162-7). Since calculating distances is extremely costly for a great number of transport-related aspects of country studies and it is not possible to use fixed schedules of transport, calculations during the planning phase are usually based on linear distance plus a detour factor (Berens & Körling 1983; Wildemann 2010, p. 215). The interplay between actors and means of transport is expressed in the quality and speed of transport. So far, it has not been possible to establish reliable figures – even in highly developed countries – due to the complexity of research. As a result, benchmarks are used during planning phases (Spiekermann & Wegener 2005). The known facts and spread of international transport services lead to planning being focused on the models of container shipping, airfreight and inland road freight transport.

4.2.3 Warehousing

The number of warehouses depends on the geographical size of the distribution area, the customer's expected response time, value of the goods stored, lead time, respective transport costs, transshipment points and other qualitative factors (Ihde 2001, p. 44). The decision whether or not to warehouse in a new distribution region will depend primarily on the expected supply service. However, it can also be influenced by bundling the effects that can be realised by the temporal decoupling of supply from transport (Bretzke 2010, pp. 172-82). An article's value is defined as a reference which correlates to its total procurement costs plus the pro rata costs of deployed transformation (Wood 2002, p. 256). This is multiplied by the inventory interest (%) which includes the capital commitment costs (%) plus further costs such as loss of value, deterioration and spoilage, shrinkage as well as insurance costs. There can also be company- or product-specific variables (Bowersox & Closs 1996, p. 257; Flaherty 2003, p. 337; Long 2004, p. 345; Schieck 2008, p. 356; Bretzke 2010, pp. 180-1). The formula for warehouse optimisation, taking service level and transport costs into account, can therefore be defined as follows (Liesegang & Wohlgemuth 1997, p. 963; Bretzke 2010, p. 219):

$$Z = \frac{\text{Annual requirement}}{Optimal\ order\ quanity} * Transaction\ costs + Value\ of\ goods * Inventory\ interest * \left(\frac{Optimal\ order\ quantity}{2} + Safety\ stocks\right) \rightarrow MIN$$

The level of safety stocks depends on the spread of demand which is expressed by σ (standard deviation of forecasting errors) (Pfohl 2010, p. 102). The safety factor can be calculated by an interpolation to the delivery service level (Gudehus 2005, p. 386).

$$Safety\ stocks = Safety\ factor * \ \sigma Safety\ stocks = Safety\ factor * \ \sigma$$

*Safety factor = (2 * delivery service level - 1)/(1 - delivery service level)^0,2*

In addition to warehousing costs, the geographical location plays a part in the planning process. During the strategic planning phase, it is possible to establish the point where minimal transportation costs are achieved. The decision about where to locate the site is influenced by the geographic sales area of a product, sales quantity and transportation costs. The formula for determining the position coordinates for the optimum warehousing location for transport (Gudehus 2005, pp. 861-4) is as follows:

$$x_s = \sum_i \Lambda_i * x_i / \left((x_i - x_s)^2 + (y_i - y_s)^2\right)^{1/2} / \sum_i \Lambda_i / \left(\left(x_j - x_s\right)^2 + \left(y_j - y_s\right)^2\right)^{1/2}$$

$$y_s = \sum_i \Lambda_i * y_i / \left((x_i - x_s)^2 + (y_i - y_s)^2\right)^{1/2} / \sum_i \Lambda_i / \left(\left(x_j - x_s\right)^2 + \left(y_j - y_s\right)^2\right)^{1/2}$$

Xs,i,j = x-Coordinate of potential location (s), source (i) and sink (j)

Xs,i,j = y-Coordinate of potential location (s), source (i) and sink (j)

Λ_i *= detour factor*

Detailed location factors and local conditions are excluded at the early stages of planning and postponed to the later practical planning and implementation stages since their parameters are very hard to define (Specht 1998, p. 95; Schieck 2008, p. 348; Bretzke 2010, p. 163).

4.3 Developing the distribution structure

The framework for developing the distribution structure requires the processes and delivery strategy to be defined. As no storage is envisaged for contract-specific deliveries, the framework conditions have a direct effect on the value chain as soon as the orders are received. Depending on the configuration of the transport chain, one has the choice of either quick delivery by airfreight or slower, less expensive delivery by sea freight. If pre-produced goods are to be distributed, the products can be put into storage, which leads to a decoupling within the distribution process. The delivery service must span the distribution site and customer, which means that there always has to be enough stock available. Replenishing stock at the distribution site will therefore only indirectly affect the delivery service (although it constitutes an important criterion for the optimisation of volume bundling). In this case, the optimal distribution strategy consists of achieving optimal storage and delivery costs whilst maintaining the same level of delivery service (Ballou 2004, p. 73).

Once the distribution structure has been defined (taking into account the framework conditions), the next step is to establish the aim of the delivery service strategy as well as the total costs involved. Alternative methods of constructing the entire system can be generated and evaluated by varying the adjustable parameters. The procedural model created can also be used to perform country assessments within this framework. In the following, we apply our abstract assessment model to German exports to Nigeria and Ecuador.

5. Two case studies: German exports to Nigeria and Ecuador

Both countries rank among the major petroleum exporters whose markets have not yet been opened up by German companies to any great extent. In the following case studies, demand is calculated by reference to the geographic distribution of the ten largest cities (*World Gazetteer* 2010). Besides the model calculations, we list information sources that can be used to analyse secondary data. Our criterion for choosing data analyses was that they be publicly available, and we primarily used data from the aforementioned publications (see section 2).

5.1 Processing

The differing costs for processing and the security of the entire value chain affect the performance indicator *CO1.1-Total Supply Chain Management Costs*, which is listed in the SCOR model as an absolute value. Possible surcharges are multiplied with the planned sales volume and concern the performance indicator *CO2.4-Cost to Deliver* (Supply Chain Council 2010, 2.4.1-2.4.12).

$$CO2.4 = sales * (pc_p + pc_s + pc_r)$$

Table 1: Costs of processing and security

	Nigeria	Ecuador
Value lost to power outages (% of sales) - (pc_p)	8.9%	3.4 %
Security cost (% of sales) - (pc_s)	2.6%	2.0 %
Losses due to theft, robbery, vandalism, and Arson attack against company (% of sales) - (pc_r)	4.1 %	3.5 %

Data source: World Bank 2011c

Besides costs, transactions also impact the temporal component, which is represented by the performance indicator of *RS1.1-Order Fulfilment Cycle Time*. However, due to the sequence of processes, it is placed in step *D3.12-Ship Product*. The calculation of the cycle time of customs processes at border crossings (clearance time) is based on this formula:

$$RS1.1 = pt_{po} * (100 - pt_{ps}) + (pt_{pi} * pt_{ps}) + (pt_{pi} * pt_{ps} * pt_{pm}$$

$$RS1.1 = pt_{po} * (100 - pt_{ps}) + (pt_{pi} * pt_{ps}) + (pt_{pi} * pt_{ps} * pt_{pm})$$

Table 2: Cycle time of customs processes at border crossings

	Nigeria	Ecuador
Clearance time without physical inspection (days) - (pt_{po})	3.81	1.86
Clearance time with physical inspection (days) - (pt_{ps})	6.40	3.13
Shipments with physical inspection (%) - (pt_{pi})	61	27
Shipments with multiple physical inspections (%) - (pt_{pm})	9	2

Data source: Arvis et al. 2010, pp. 38-40

5.2 Transport

The model divides the transport process into two stages: the initial leg (which is performed via air or sea freight), and the final leg (carried out using road transport). In the former, the factors of costs and transport time show opposing trends which affect the performance indicators CO1.1 und RS1.1. The calculation of the throughput times can be based on the values listed in the published schedules of airlines and shipping companies.

Throughput time runs from the end of the export procedures at the German airport to touchdown in the destination country. As connections are not offered throughout the week, this affects the waiting time of the dispatched freight in the departure airport. Average throughput time is calculated by adding the flight time to the waiting time at the departure airport. For the target airports, it was calculated on a day-by-day basis and the resulting value related to the number of airlines in the country. This approach reflects the ranking of the destination airport. The sum of the calculation factor results in the average throughput time (abbreviated to TT in the three tables below).

Table 3: Air transport to Nigeria

Target airport	Number of airlines	Number of flight days	Ø-TT	Calc. factor
Abuja (ABV)	2	7	1	0.5
Lagos (LOS)	1	7	1	0.25
Port Harcourt (PHC)	1	4	1.75	0.44

TT-flight: Germany to Nigeria ≈ 1 day

Data source: UBM Aviation 2010

Table 4: Air transport to Ecuador

Target airport	Number of airlines	Number of flight days	Ø-TT	Calc-factor
Quito (UIO)	3	4	1.75	1.75

TT-flight: Germany to Ecuador ≈ 2 days

Data source: UBM Aviation 2010

The assessment of sea freight transport basically adopts the same approach although there are important differences in the way the routes are arranged. Those flights where the ship departed early and arrived late at the destination seaport are irrelevant and were eliminated from the model (that is, they were not taken into account either by the average throughput time or calculation factor).

Table 5: Sea transport to Nigeria

Target port	Total number of lines	Relevant lines	Ø-TT	Calc. factor
Apapa (NGAPP)	60	13	21	7.38
Lagos (NGLOS)	12	3	21	1.70
Onne (NGONN)	38	8	28	6.05
Tincan (NGTIN)	81	13	19	6.68

TT-sea transport: Germany to Nigeria ≈ 22 days

Data source: INTTRA 2010

Table 6: Sea transport to Ecuador

Target port	Total number of lines	Relevant lines	Ø-TT	Calc. factor
Esmeraldas (ECESM)	20	7	26	11.38
Guayaquil (ECGYE)	61	7	21	9.19
Manta (ECMEC)	2	2	50	6.25

TT-sea transport: Germany to Ecuador ≈ 27 days

Data source: INTTRA 2010

Road haulage is used to complete the terminal leg from the seaport or airport. The structure of the supply side of the industry and the heterogeneity of transport modes means that there is no directly usable data available. In order to compute the distances involved, the detour factor was calculated by mapping the point-to-point aerial transit path (*patp* in the table below) to the real road distance for a significant number of transport routes. In addition, the route-related detour factors were weighted according to their demographic relevance (the latter calculated using the number of inhabitants of the respective end-destinations). For additional calculations, the road distance can be calculated by multiplying the weighted detour factor by the airline. In the case of direct delivery, the average distances to customers were calculated from the unloading/delivery site to the relevant cities, with the distances being weighted by the respective numbers of inhabitants. The unloading site was weighted either by the number of shipping lines or airlines from Germany.

Table 7: Road transport

	Nigeria	Ecuador
Detour factor (patp/road km)	1 / 1.245	1 / 1.299
Distance from airport to customer	472 km	257 km
Distance from port to customer	452 km	263 km

5.3 Warehousing

The warehouse site was established with the help of the calculation process for the optimal warehouse location for transport (see section 4.2), that is, the location which determines the distances of the initial leg from port or airport. The calculation was based on the nearest port or airport with a sufficient number of scheduled connections to ensure a good combination of carriers. Ports or airports with relatively few transport lines were given a lower value than those with a greater number even if the latter were closer. The relevant service level is represented by the distance of the warehouse from the customer, since this is where the delivery commences (depending on sufficient stocks).

Table 8: Warehouse

	Nigeria	Ecuador
Warehouse location (city nearby)	4^{o}24’0 N 7^{o}09’0 E (Ibadan)	2^{o}05’0 S 79^{o}88’0 W (Eloy Alfaro)
Distance warehouse to airport (IATA-Code)	178 km (LOS)	346 km (UIO)
Distance warehouse to port (UN/LOCODE)	181 km (NGAPP, NGTIN)	42 km (ECGYE)
Distance warehouse to customer	343 km	151 km

The different transport distances show the average costs of servicing the delivery area. This factor has to be multiplied by the transport costs of the carriers in the destination country in order to show how the distribution logistics affects the transport costs and thus the performance indicator CO1.1. As far as transit time is concerned, a valid country-specific speed factor is absent which would allow conclusions to be drawn from transport distances according to time requirements. Therefore, the calculation of the performance indicator RS1.1 cannot be entirely country-specific although model comparisons are possible if a benchmark figure of 60 km/hour per truck is used (Gudehus 2000, p. 248; Spiekermann & Wegener 2005). For example, a useful rounding factor on a daily basis would be 200 km = 0.5 days, 200 km up to 600 km = 1 day, and so on.

Table 9: Order-related delivery process

	Nigeria		**Ecuador**	
Carrier into target country	Air transport	Sea transport	Air transport	Sea transport
TT into target country (days)	1	22	2	27
TT processing (days)	6	6	2	2
TT to customer (days)	1	1	0.5	0.5
Total days	**8**	**29**	**4.5**	**29.5**

Table 10: Distribution of pre-produced goods

	Nigeria		**Ecuador**	
Carrier into target country	Air transport	Sea transport	Air transport	Sea transport
TT into target country (days)	1	22	2	27
TT processing (days)	6	6	2	2
TT to warehouse (days)	0.5	0.5	1	0.5
Total days	**7.5**	**28.5**	**5**	**29.5**

The performance indicator CO1.1 in the order-specific delivery process can therefore be expanded to reflect the effects of the chosen mode of transport as well as country-specific conditions. The more time taken to replenish warehouse stock, the larger the warehouse inventory and the greater the uncertainty in planning; the framework conditions for distributing pre-produced goods affect tied-up capital in warehouses and thus performance indicator CO2.4. Moreover, the effects can be analysed specifically in terms of the respective mode of transport (for example, by looking separately at the expense of airfreight compared to sea freight).

6. Conclusions and further research

The model shows that success in distribution logistics is heavily dependent on the external framework conditions. Moreover, when discussing the methodology, we presented a planning model which offers assessment methods using publicly available data and which can also be adapted to the needs of the case in question. For example, the determination of demand based on the number of inhabitants can be adjusted through more specific analyses of the customer base. Furthermore, the model can provide the decision-taking bodies of a country with a process-orientated identification, as well as suggestions for generally improving the weaknesses revealed by a comparison with other countries.

Standardised primary data represents another area of research and will enable future models to be designed in even greater detail. At present, the objects of analysis are the turnaround times for the various modes of transport, the import procedures for ports and airports and the travelling times in road transport. In the last case, data from the tracking of consignments and analysis of the vehicles' GPS-data would be most helpful. In addition, the complex effects and interdependencies could be captured more realistically by developing further calculation models (that is, for international road transport, inland water navigation, non-scheduled air and sea freight, as well as rail freight). A further promising area of research is the analysis of information flows and country-specific assessments taking company-specific requirements into account. Finally, with respect to the SCOR model, more research is needed to achieve both greater precision in the performance indicators for country-specific factors and their extension by replenishing processes in multi-stage storage systems.

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