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"Evaluation of Alternative Procurement and Distribution Network Designs for the Doka GmbH in Terms of Transportation Costs"

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List of Abbreviations

SC	Supply Chain
SCM	Supply Chain Management
MNE	Multinational Enterprise
CSM	Centralized Supply Management
DC	Distribution Center
DPR	Doka Production Site
FTL	Full Truckload
LTL	Less Than Truckload
LT	Lateral Transshipment
ELT	Emergency Lateral Transshipment
PLT	Preventive Lateral Transshipment
EOS	Economies of Scale
EOI	Economies of Information
EOP	Economies of Process
RD	Reference Day

1. Introduction

Supply chain (SC) network design is a crucial factor especially for Multinational Enterprises (MNEs) due to increasing global competition. In order to cope with worldwide competitors while minimizing costs, an efficient supply network needs to be designed and implemented globally. An organization's success depends on the assimilation of the corporate strategy and the supply strategy. In this respect, the organizational design determines the potential contribution of supply processes to the overall organizational business performance [1]. The supply strategy needs to fit the overall corporate strategy and the supply network structure needs to be aligned to the organizational structure. Consequently, involved supply processes such as purchasing, transportation planning, inventory control as well as warehousing need to harmonize.

In order to establish a worldwide integrated supply system, several managerial integration mechanisms can be applied. These managerial tools include the possibility of centralization, formalization, as well as the establishment of cross-locational relations [2]. Those integration mechanisms can be divided according to their information processing capacity and cost of use in terms of managerial and financial costs. As a result, two broad directions are observed, namely vertical mechanisms and lateral mechanisms [2]. Standardization, formalization, centralization and vertical information systems refer to vertical mechanisms, whereas lateral mechanisms encompass cross-national or cross-departmental teams and job rotation [2]. The deployment of either of those mechanisms has to be chosen reasonably according to their respective benefits. Although lateral mechanisms have a higher ability to improve information processing, they require higher investments than vertical mechanisms [2]. Therefore, each organization needs to find the appropriate deployment of those mechanisms and adapt their organizational structure accordingly. A central managerial decision is the definition of the degree of centralization. This decision has to run like a golden thread through the entire SC. Depending on the allocation of managerial decision-making power across the SC stages, all involved processes can be conducted either more centralized or decentralized. A concentration of decision-making power within one partner throughout the SC refers to a high level of centralization, whereas the dispersion of decision-making powers indicates a low degree of centralization [3].

In former times, the tendencies towards either centralization or decentralization alternated. According to Arnold [4], preferences in regard to centralized or decentralized processes can be compared to a pendulum, which swings constantly towards full centralization or full decentralization. Nowadays, the trend shifts towards a hybrid approach, which can be described as a combination of centralization and decentralization [5].

Problem Statement and Objective

Especially MNEs need to implement a reasonable centralization strategy depending on the specific business type in order to improve the overall organizational performance. Due to rapidly changing organizational environments, company-intern processes and managerial decisions should be frequently re-evaluated. In order to maintain a high organizational performance, the Doka GmbH, an international company active in the formwork business, is currently re-evaluating their applied centralized supply strategy. The aim of this Master's Thesis is to provide decision support for the evaluation process. It is going to analyze the centralized supply management (CSM)- process and clarify, in terms of total transportation cost minimization, which degree of centralization is promising. In detail, the current sourcing process is going to be re-evaluated and different scenarios of supply networks are compared. In addition, this Master's Thesis provides a guide for central supply planners in regard to which sourcing strategy should be preferred in terms of cost minimization and clarify whether to stick to the current, centralized system of sourcing or whether to include decentralized sourcing as well in the daily sourcing business.

This problem statement leads to the following research question:
In terms of total transportation costs minimization, should the supply network be designed centralized (i.e. with the DC as central material buffer and the CSM as a central sourcing department) or decentralized (i.e. direct delivery from one branch to another including the sourcing responsibility directly within the branch)?

First of all, literature research is conducted to evaluate alternative supply chain concepts. In detail, especially the application of lateral transshipments, inventory pooling and warehouse consolidation are discussed concerning their application in a centralized and decentralized context and advantages and disadvantages are analyzed. Moreover, the literature research provides a solid base for argumentation in favor or against either centralization or decentralization. Furthermore, the problem setting is formulated as a linear model and implemented in the optimization software FICO® Xpress.

The Master’s Thesis is organized as follows. First of all, Chapter 2 presents the Doka GmbH and the current sourcing and warehousing system more in detail. In Chapter 3, a literature research is conducted in order to receive a broad overview on the theoretic background of centralization and decentralization and to point out advantages and disadvantages of either approaches. Chapter 4 focusses on the implementation of the problem statement into the linear programming program FICO® Xpress. Chapter 5 displays the results of the problem implementation. The results are discussed in Chapter 6, followed by the conclusion and remarks on future research and limitations in Chapter 7 and 8.

2. Doka

Doka is an international company with headquarter in Amstetten, Lower Austria. The enterprise is active in the formwork business and delivers solutions in the field of high rise, tunnels, bridges, residential and commercial high-rise constructions, power plants as well as civil engineering. Their product portfolio encompasses system components, wall formwork, floor formwork, climbing formwork, load-bearing tower systems as well as safety systems. Doka's business consists of the following business types: rental, buyback as well as sales of new and used material. Doka has more than 160 branches in over 70 countries worldwide, which function as independent sales and logistics intermediaries. Currently, there are two production facilities and five distribution centers (DCs). The goods are delivered to the customers either from other branches with overstock, the DCs or directly from the Doka Production (DPR) Site in Amstetten. Accordingly, Doka distinguishes the following flow of goods:

- Supply via interbranch material exchange (i.e. within one country in case there is more than one branch)
- Supply via intercompany material exchange (i.e. worldwide)
- Supply via the corresponding DC of the supply circle
- Supply from DPR
- Supply from external suppliers

In this respect, branches have the following possibilities of sourcing:

➢ Intercompany delivery, i.e. from one branch to another (either directly or with the DC as cross-docking station)
➢ Direct delivery from the DC
➢ Direct delivery from the DPR or external suppliers via the DC to the branches

In order to optimize the total Supply Chain Management (SCM)-costs, CSM with centralized sourcing was introduced. Prior to this, decentralized sourcing was performed with focus on direct deliveries and only with a hub instead of a DC. However, the system was changed recently to centralized sourcing including the integration of DCs in the sourcing activities as well as the implementation of a new SCM-tool. In this respect, Doka aims to balance shortages and overstocks in a more efficient and coordinated way.

2.1. Status Quo

2.1.1. Doka's Sourcing Process

The sourcing process is performed as follows: the SCM-tool continuously balances demand signals and supply streams, as illustrated in the following Table 1:

Demand Signals	Supply Streams
1. Unconsumed Consensus Demand (FC) ▪ Statistical Forecast ▪ S&OP Forecast ▪ Override (manual)	1. On-Hand Inventory ▪ Main yard
2. Customer Demand ▪ Quotations (material reservation) ▪ Sales Orders	2. Scheduled Receipts ▪ Reconditioning stock ▪ Stock on transit ▪ Planned returns
3. Safety Stock	3. Purchase Orders ▪ DC ▪ IC ▪ DPR/Purchase

Table 1: Overview Demand Signals and Supply Streams [6]

Demand signals consist of unconsumed consensus demand (forecasted demand minus already consumed demand), actual customer demand as well as safety stock settings. The supply streams consist of on-hand inventory (stored in the main yard), scheduled receipts, as the returns on the first sight stock, reconditioning stock, stock on transit and planned returns, as well as open purchase orders. If the demand signals are higher than the supply streams, the SCM-tool creates a planned order. Afterwards, supply planners examine the proposed delivery quantities and determine the source of goods. In general, as already mentioned, there are three possibilities of sourcing: either from any other branch, from the corresponding DC or directly from the DPR. Doka has developed a prioritizing scheme, which functions as a guideline for supply planners to decide from where to source. Regarding intercompany sourcing, the origin of goods is decided intuitively. In most of the cases, supply planners do not perform exact cost calculations; they only evaluate what seems to be more reasonable in this specific case. This also depends on the quantity of goods requested and on the availability levels in other branches. If the material is not available in any other branch, the supply planners source either from the DC or from the DPR.

2.1.2. Doka's Distribution Network

Besides the centralized purchasing process, the warehousing as well as the transportation network are operated centrally. Currently, the majority of the material is stored in the respective DCs, while branches keep as on-hand stock defined safety stocks as well as material for unconsumed consensus demand. Unsatisfied customer demand is fulfilled by shipments either from the DC or from other branches. In this respect, both, direct shipments from the DC but also lateral transshipments (LTs) within the same echelon are permitted. Nevertheless, currently LTs and intercompany-exchange of material is only applied if a full truckload (FTL) can be organized or if there is an urgent request. All other deliveries, i.e. regular shipments or less than truckload (LTL) shipments, are originating in the DC. Occurring overstocks can be redelivered to the DC and stored there until further request.

Figure 1 illustrates the current sourcing and distribution network.

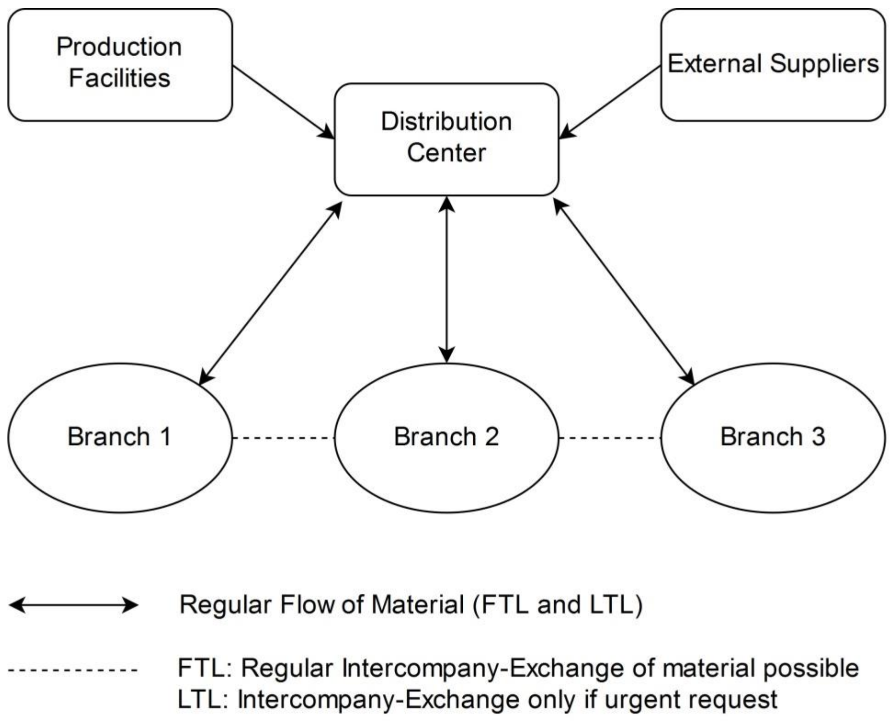

Figure 1: Current Sourcing System (own illustration)

2.1.3. Evaluation

The current centralized sourcing and inventory strategy entails two major cost drivers: the DC as well as the CSM-department. Firstly, the DC is integrated in almost all transportation processes, either as a source for direct delivery, as a buffer support for overstock material or as a hub / cross-docking station for intercompany material exchange. In this respect, shipments from the DC can take advantage of collective transports and respectively cost savings in terms of transportation costs. Branches are also able to deliver overstocks back to the DC in order to decrease local inventory holding costs. Nevertheless, due to this centralized system, LTs might not be used effectively since only in few cases the material is shipped directly from one branch to another. In most of the cases, LTs are only applied if a high total weight needs to be shipped directly or in terms of emergency shipments in order to fulfil urgent customer demand. The second cost driver is the CSM-department. The main function is the efficient utilization of available material and the securing of supply streams for the branches. However, due to increased decision-making levels, the centralized department implicates certain inflexibility. In addition to this, another important aspect is the optimization of inventory usage. Since a major part of Doka’s business is rental business, which is conducted with used material, already available material could be used more efficiently with decentralized sourcing while avoiding the production of unnecessary new material in the DPR.

Therefore, it is evaluated whether the focus should be put again on decentralized sourcing, as illustrated in Figure 2, or whether the centralized system should be sustained, as represented by Figure 1.

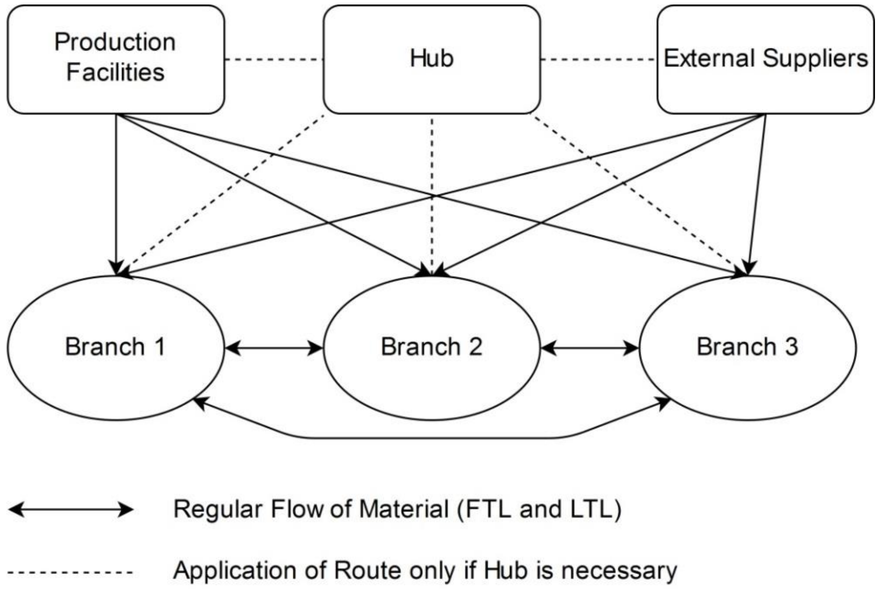

Figure 2: Evaluated Sourcing System (own illustration)

The main difference between Figure 1 and Figure 2 is the incorporation of the DC as a central location in terms of warehousing and transportation. As illustrated in Figure 1, the main inventory is stored at the DC and most of the deliveries originate at the DC. The branches only have inventory in the amount of predefined safety stocks. Overstock material is delivered mainly back to the DC. In contrast, Figure 2 represents a decentralized supply network, in which the main deliveries are conducted in-between branches or directly from the DPR or external suppliers to the branches. In this case, the DC is replaced by a simple hub or a cross-docking station, with the main function of bundling deliveries in order to save transportation costs. Since there is no major inventory storage location in Figure 2, the inventory levels of the branch sites are higher.

3. Literature Research

Due to increasing worldwide competition for MNEs, organizational structures need to be prepared for potential risks, demand uncertainties and global competitors. In this respect, organizations have to adapt their corporate strategies to occurring global challenges by creating more efficient organizational structures and minimize costs at the same time. When re-evaluating a current supply and logistics system in terms of logistics cost minimization, drivers influencing the SC costs need to be analyzed. The scope of integrated logistics management and the interactions of different logistics processes are presented in Figure 3.

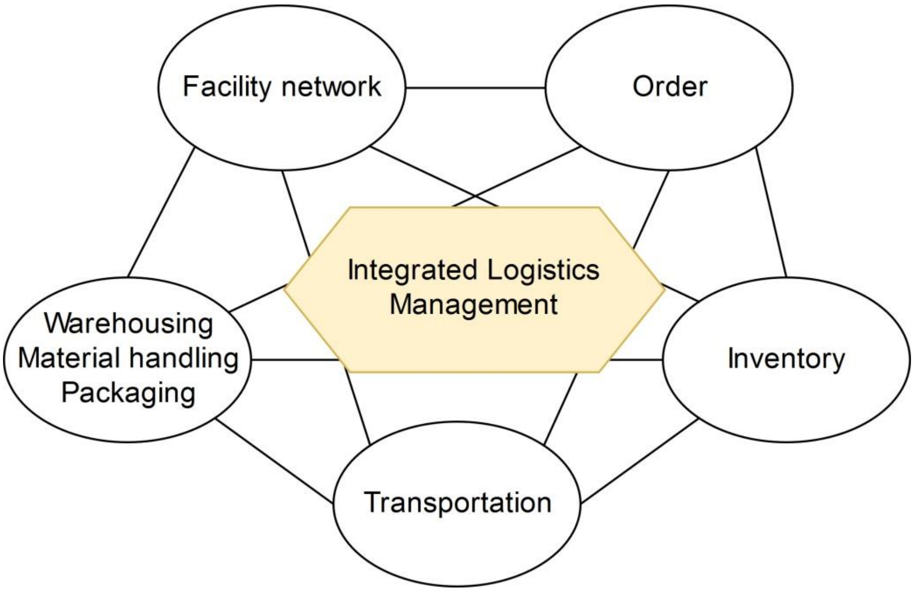

Figure 3: Five Functions of Logistical Work (modified illustration from [7])

In this respect, according to the traditional cost logistics model, logistics costs are composed of order processing costs, inventory costs, transportation costs, warehousing costs as well as facility costs [7]. In the following, a set of alternative approaches of organizational processes in conjunction with centralization or decentralization are presented, which are able to contribute to a more efficient supply network and consequently to minimized logistics costs. In detail, alternative concepts in regard to order processing and procurement, inventory holding as well as transportation are elaborated. Afterwards, those alternatives are merged and discussed regarding their success potential when applied in a centralized or decentralized context. In the end, advantages and disadvantages of either approach are analyzed.

3.1. Procurement and Order Processing

Procurement can be regarded as the first interface to the outside-world of the organizational environment. Therefore, when designing efficient procurement processes, not only the internal organization but also the intersection with partners along the SC need to harmonize. Since procurement has many points of commonality with external partners, the collaboration with partners along the SC has an impact on the overall company's performance. In the following, both, the design of supplier relationship networks and internal purchasing processes are elaborated.

Supplier relationship management in terms of purchasing was researched thoroughly by Spekman et al. [8], Canella et al. [9], and Juha and Pentti [10]. According to Spekman et al. [8], "closely knit supply chains tend to be partnerships in which sourcing cuts across company boundaries with a focus on reducing costs, improving quality, and, ultimately, increasing shareholder value." In order to build up and manage collaborations efficiently along the SC, the creation of an information network both upstream and downstream is important [9]. In this respect, sourcing processes benefit from sharing information extracted at a single point in the SC with trading partners, which supports the sustainment of strategic sourcing advantages [8]. This exchange of information is facilitated through modern information technologies and can encompass all various data, as for example customer surveys, sales forecasts, orders, transportation information up to inventory levels [9]. With aid of this data, suppliers are able to reduce perceived risks for the organization in the buying process by adapting their market activities more effectively to the organization's requirements [10]. In this regard, competitive advantages can be generated by a reasonable supplier relationship management. Spekman et al. [8] have elaborated a 10-steps scheme for more effective supplier management and sourcing. They focus on a strong integration of suppliers in the SC and they underline again the importance of information sharing. Moreover, they emphasize the creation of an effective partnership network in order to achieve alignment, which can be accomplished by the development of trust and the utilization of commodity teams for example. According to them, essential values are exchange of information, trust and confidence that partners are not engaging in self-serving behavior leading to detriment of other members of the SC. In this regard, they suggest handing over a certain degree of responsibility to the suppliers and focusing at the same time on global sourcing while rationalizing the supply base.

Furthermore, in order to be able to establish a solid purchasing organization, not only the connections to external partners but also internal processes need to fit. Since the exchange of information is a crucial success factor in this regard, internal processes should focus on the design of an efficient information exchange network. As already mentioned, improvements in information technologies have facilitated the exchange of data and augmented the efficiency of organizations. In this regard, global enterprises can take advantage by sharing and monitoring data throughout the whole SC, ranging from latest forecast values, actual demand data and current stock levels up to production or transportation capacities and bottlenecks. Consequently, companies are able to share information regarding inventory, delivery status as well as collaborative production planning and scheduling in real time along the SC and take appropriate measures [9]. Nevertheless, also if information technologies have facilitated the storage of data, they cannot influence the origin of data. Although demand can be forecasted in a more precise way due to easier monitoring of previous data, demand uncertainties will remain. According to Meissner and Senicheva [11], demand uncertainty is the major reason for an imbalance between actual customer demand and a supplier's available stock. Although enterprises distribute their inventories across multiple regions according to previous sales patterns, unpredictable fluctuations might lead to overstock or stock-out situations [11]. In this respect, perceived risk and uncertainties entail significant influence on the company's structure [10]. In order to counteract these demand uncertainties, data quality is a crucial issue. It is important to keep data up to date in order to cope with both sides of demand uncertainties, i.e. either with larger demand quantities as expected or with less demand. One possibility of counteraction would be for example cancelling already placed orders if less demand occurs or organizing more flexible transports for larger demand situations. In this respect, the organizational design needs to be structured appropriately in order to be able to face global challenges, uncertainties and occurring risks along the SC. Therefore, all processes along the SC need to be geared to each other, ranging from purchasing processes to production planning, inventory storage up to transportation logistics.

According to Tchokogué, Nollet and Gobeil [1], a company's success is determined by the assimilation of company strategy and supply strategy as well as by a strategic design of the supply function since "it facilitates or hinders the contribution that supply can make to a company's business performance". In this respect, the purchasing strategies need to be aligned with the corporate strategies and adapted to the global environment, the MNC is operating in.

Odhiambo and Odari [12] stated that organizations need to formulate and implement effective purchasing strategies in order to maintain an effective and efficient purchasing function which is appropriate to support the enterprise globally in increasing competitive business environments. Accordingly, enterprises need to be aware of potential occurring risks, create an appropriate risk management but also adapt internal processes to the business environment. Juha and Pentti [10] displayed in their research that in most of the cases, “failures in purchasing activities are caused by an organization’s failure to integrate the purchasing function with its operation functions”, which might result in output discontinuity, deprivation of profits as well as minor performance in competition. In order to avoid those scenarios, an overall goal of MNCs is therefore the achievement of a global purchasing synergy. In this respect, the organizational structure plays an important role when designing a supply structure. Enterprises with successful sourcing strategies typically perceive sourcing as a key capability which is closely related to a company’s strategy but also takes into consideration linked processes and people [8]. Furthermore, the design of the SC network needs not only to fit to the corporate strategy but also to the global conditions, the company is operating in. In this respect, an enterprise operating merely in Europe might need to design their SC network differently than a globally active corporation. The sourcing strategy should focus on a maximization of supply contribution to the overall company performance [13]. Accordingly, when designing a supply organizational structure, not only the overall organizational structure needs to be taken into consideration, but also the advantages and disadvantages of an either centralized or decentralized supply structure [13].

Regarding the sourcing process, enterprises can either implement a centralized, a decentralized or a hybrid structure. Depending on the business type and on the distinct challenges of the business, each organization needs to select a particular, appropriate structure; hereby the advantages and disadvantages of either approach need to be considered [13]. According to the contingency theory, an organizational structure directed towards a higher degree of centralization and formalization including clearly defined rules for decision-making is more effective in a stable environment due to the facilitation of planning, coordinating and controlling of activities [10]. In contrast, enterprises which are operating in more uncertain environments trend towards implementing a less formalized sourcing process and a higher involvement of lower hierarchical levels in the purchasing decision process [10]. However, since organizational environments evolve over time, the tendencies of organizations towards either centralization or decentralization might change. “Like ebb and flow, the pendulum of centralization swings periodically towards the option full centralization or full decentralization.” [4]

Sticking too long to either one of the structures might lead to conflicts. Whereas a high degree of centralization may lead to a certain inflexibility including too much bureaucracy and rigid rules, decentralization may result in higher sourcing costs as well as chaotic conditions [1].

Furthermore, the decision about the degree of centralization in the purchasing structure is also influenced by the division of responsibilities throughout the SC [14]. Even in the same industry, different approaches are used and various degrees of centralization preferred. One example for this is the supply structure of the retailers Walmart and Carrefour in China [15]. Carrefour pursues a decentralized supply structure, in which neither a centralized distribution and logistics network, nor central warehouses or DCs are used. Suppliers are responsible for the direct delivery to the stores and for the storage of the products, since only a minor part of the inventory is held directly at the stores. Furthermore, each store manager handles purchasing individually. In contrast, Walmart has implemented a centralized supply structure with highly centralized operations done in Global Procurement Centers and centralized inventory and transportation network. It can be concluded, that Walmart has set its focus more on the logistics part, whereas Carrefour focuses on the purchasing part of the SC. This example illustrates that there is no unique or perfect solution. As a consequence, every organization needs to find its individual preference for the degree of centralization, depending on various influence factors such as the industry, the organizational environment, already existing organizational structures, etc. However, the different benefits and drawbacks of each structure need to be taken into consideration.

3.2. Distribution Network Design – Inventory Management and Transportation

According to Chopra [16], the term distribution encompasses all “the steps taken to move and store a product from the supplier stage to a customer stage in the supply chain”. In this respect, the distribution network comprises inventory management, storage, warehouse management as well as physical distribution and transportation. Due to constantly changing requirements and respectively a certain fast-paced nature of those processes, decisions are often made on a cost or transit time basis [17]. Moreover, in consequence of the strong correlation of those areas, strategy adaptions in one area have reciprocal influence on the other areas. Although those processes are not core activities of most of the companies, its financial implications have direct influence on the efficiency of an organization [18]. In this regard, the distribution network has a direct effect on the total profitability of an enterprise due to the direct impact on the SC costs and on customer experience [16].

It is important to find an appropriate distribution network design in order to increase the cost effectiveness of the entire SC. Therefore, an efficient supply network – aligned to the company's core business and environment – needs to be designed [19]. In this respect, also the distribution network needs to be assimilated to the overall organizational structure and the environment, the company is operating in.

3.2.1. Transportation

A major issue in the distribution network design is the determination of a transportation policy, which is strongly related to the respective inventory strategy. A transportation strategy should encompass policies regarding transportation modes (such as rail, truck, air, ship), type of carriages (such as common, contract, private), size of shipments, shipment frequency as well as the allocation of loads to vehicles [17]. According to Matthews and Hendrickson [18], faster freight methods as for example truck or air transportation result directly in both, reduced inventory levels in transit, but also decreased inventory levels in general. Consequently, a more flexible supply network can lead to lower production quantities. Flexibility can be achieved by implementing a supply network which permits LTs.

Lateral Transshipments

"Traditionally, the design of inventory system is hierarchical, assuming material flow from the upper echelon to the lower, i.e. from supplier to retailer." [20]. By integrating stock movements within the same echelon the performance of the whole inventory system can be improved [20]. More precisely, LTs are able to balance disequilibria between actual customer demand and available inventory in diverse locations across the company, while there is an inability of replenishment from the central warehouse [11]. In this regard, total inventory of the SC and lead times can be reduced by fulfilling material by the same echelon level instead of a higher level [21]. Figure 4 represents an example supply network with incorporated LTs.

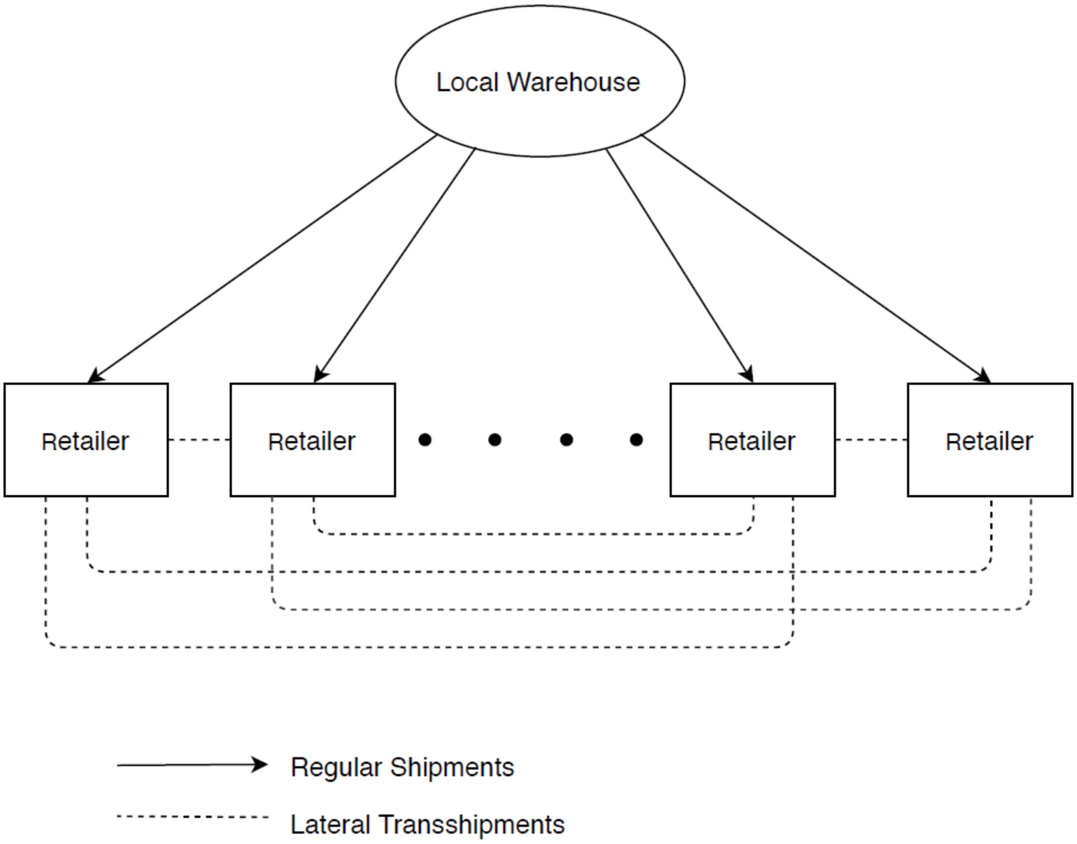

Figure 4: Supply Network including Lateral Transshipments (own illustration)

Accordingly, in order to optimize stock levels, horizontal material flow can be integrated and inventory can be pooled and reallocated within the same echelon. LTs are especially often observed in the retail industry; nevertheless, they are also common in the automotive and machine tool industry and in spare parts management [20, 22]. In the latter area, LTs are especially important since spare parts are in most of the cases slow-moving and expensive items; therefore, the transportation network needs to be designed in a way to be able to respond quickly to infrequent demand [11]. In this regard, LTs are able to provide service improvements as well as cost reductions in comparison to a no-transshipment network.

Based on the timing of the shipments, transshipments are split up into emergency lateral transshipments (ELT) and preventive lateral transshipments (PLT), as illustrated in Figure 5:

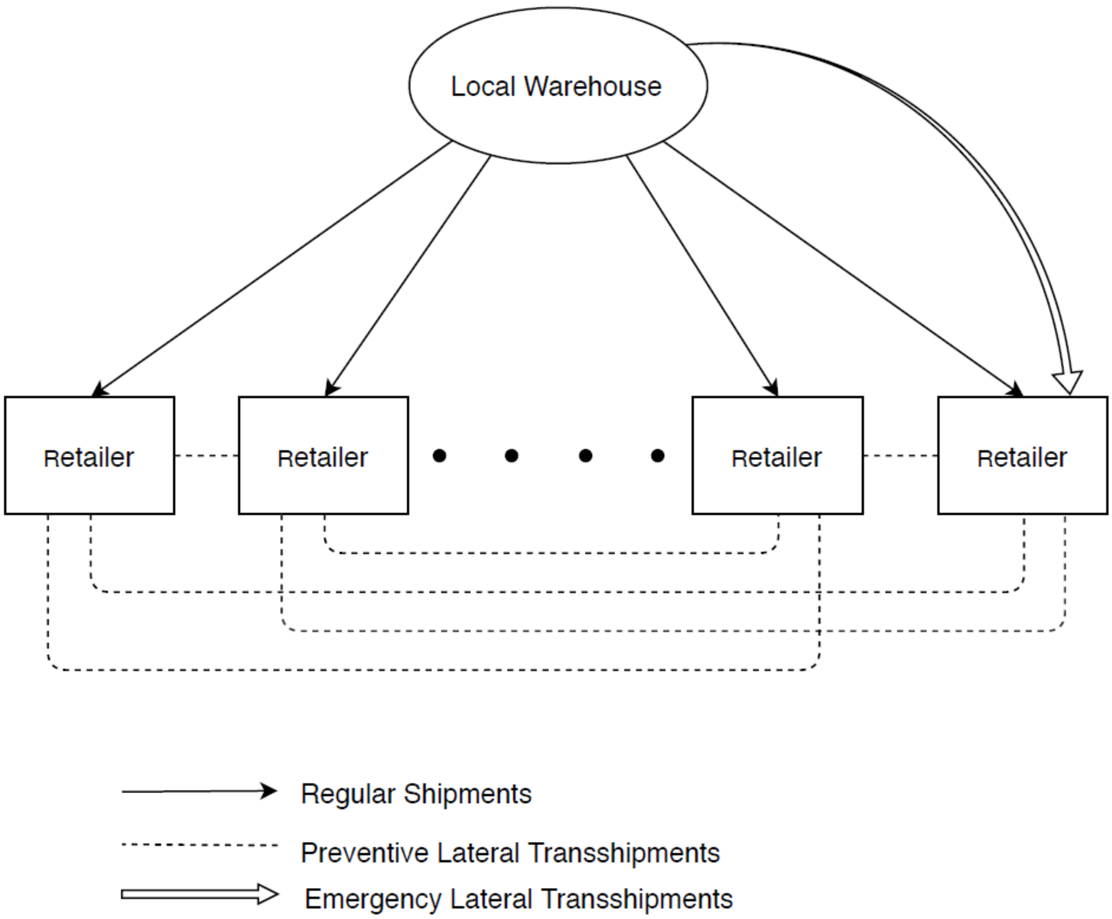

Figure 5: Transportation Network including Transshipments (modified illustration from [20])

ELTs refer to shipments, which are conducted if customer demand cannot be fulfilled with the available stock on-site or if stock-outs occur [20]. In order to avoid customer dissatisfaction and consequently a loss of sales for the company, shortages are often covered by ELTs either from the supplier or from other locations available [11]. ELTs tend to have relatively high transportation and handling costs since the aim is a fast response to customer demand and hence a reduction of customer-waiting time and therefore, faster transportation modes are chosen [22].

PLTs, in contrast, can be regarded as a preventive measure in order to balance inventories as soon as disequilibria are observed. Feng, Wu, Fung, & Jia [22] have conducted extensive research in this area. According to their studies, PLTs are often applied if inventory imbalances are anticipated since they contribute to sensible inventory redistribution. They are performed in advance to stock-outs, before customer demands are fully realized [20]. Nevertheless, PLTs need to consider the "interrelationship between transshipment quantity and uncertain residual demand" and therefore, the conduction is more complicated [20].

PLTs depend strongly on demand forecasts since the shipments are conducted before the full realization of customer demand. In this respect, PLTs are able to proactively counteract stock-outs and balance inventory levels. Demand uncertainty in turn might lead to deterioration of the system performance and to ineffective use of inventory [22].

In order to take advantage of both, ELTs and PLTs, an intense network of information needs to be built up. Especially information about inventory levels and customer demand need to be exchanged with partners along the SC regularly. Nevertheless, this strong dependence on reliable information about current inventory levels within the SC has constituted the largest challenge for the application of this strategy [11]. However, the increase in opportunities for exchanging information provided by developments in the information technology has facilitated communication along the SC and facilitated the access to current data [20].

LTs are able to improve effectively customer service levels and they provide a competitive advantage in contrast to a scenario without any LTs. According to Feng, Fung, & Wu [20], this is valid for both types of LTs, since, although PLTs strongly depend on demand forecasts, they are able to generate substantial benefits in contrast to a no transshipment case. As mentioned beforehand, this is especially important for companies with strong dependence on providing material in a timely manner, such as spare parts or after-sales service [20].

Furthermore, when analyzing the occurring costs of LTs, the situation is parted. On the one hand, total costs can be reduced by taking advantage of rebalancing company-wide stock levels and improving customer service at the same time [22]. In this respect, LTs contribute to a more flexible and responsive inventory network [22]. On the other hand, LTs, and especially ELTs, display higher administration, handling and transportation cost for redistributing the material [20]. Consequently, total profit might be decreased by LTs; however, this needs to be assessed for every specific organization on their own [22].

3.2.2. Inventory Management

Another important aspect in the design of a distribution network is inventory management. Inventory management encompasses all the different components including incoming deliveries, rotating stock, as well as finished goods [18]. Accordingly, especially the definition of inventory levels and the location of storage are important. In this respect, inventory strategies should incorporate decisions regarding "total inventory level in the system, location of inventories, and levels of cycle stock at various locations" [17]. As a consequence, inventory management directly affects the transportation policies as well as the warehouse strategy and vice versa. These policies again are depending on the level of uncertainty the company is facing.

A very unpredictable customer demand leads to high inventory levels in order to offer customers product availability in a timely manner and respectively high inventory holding costs [23]. This is especially crucial for companies with high importance on the after sales service since it is very difficult to implement an effective inventory management for the after sales business while keeping low levels of inventory [23]. Low levels of inventory in turn might lead to shortages and to an inability to fulfil customer demand.

Inventory Pooling

Inventory pooling describes the mutual usage of inventory stocks. The implementation of inventory pooling is closely linked to LTs since both policies require the exchange of material within the same echelon. Nevertheless, when incorporating inventory pooling, a few more factors need to be considered.

Paterson et al. [24] have conducted research in the area of inventory pooling and especially regarding regulations of inventory pooling. In order to keep up an effective inventory pooling system, clear regulations need to be established. According to them, not only the redistribution moment needs to be defined but also the disposable transshipment quantities of supplying branches. Therefore, when determining a pooling policy, it also needs to be defined whether complete pooling or partial pooling is applied. The difference of both terms is the level of available stock of the transshipping location. In a complete pooling scenario, all of the stock is shared, whereas partial pooling considers future demand of the transshipping location, for which some part of the inventory is held back [24]. The results of either complete or partial pooling depend largely on the organizational system.

Hereby, the outcome is especially influenced by the cost structure, the possibilities of setup as well as the industry and environment the company is operating in [24]. Enterprises with dependence on spare parts business often apply complete pooling since transshipment costs are typically lower than holding or backordering costs [24]. Paterson et al. [24] have shown that in some cases, significant cost savings can be generated by the use of ELTs since lower inventory levels are needed directly at the locations. Nevertheless, complete pooling is not always necessarily the best option for every transshipping system. According to their research, partial pooling is able to exceed the performance of complete pooling. However, partial pooling requires a higher level of control and managerial optimization input since decisions on the reserved stock level for future demand need to be made.

Besides the degree of pooling, also the moment of redistribution needs to be considered and predefined. An approach with dynamical determination of the redistribution moment has advantages in regard to flexibility; nevertheless the implementation might provide some difficulties [24]. However, due to the flexible nature of dynamic redistribution policies, the total performance can be improved and cost savings can be generated. In this respect, dynamic approaches are able to compensate demand uncertainties more flexibly and inventory levels can be used more efficiently [25]. In detail, research has shown that dynamic approaches are able to outperform static approaches with cost savings up to 30 percent [24].

Furthermore, appropriate stock levels depending on the forecasted demand need to be defined. According to Archibald, Sassen & Thomas [26], the definition of an order-up-to level is crucial for profit optimization. It was displayed that inventory levels determine threshold times, so that a subsidiary should only oblige a LT request “if the time until the next ordering opportunity is less than the threshold time” [24].

3.2.3. Facilities and Warehouses

When designing a supply network, also the design of the physical distribution network needs to be taken into consideration. The role of the warehouse receives increasing importance and the determination of a reasonable warehousing strategy is able to determine the efficiency of the whole SC [27]. Cost savings as well as speed, flexibility and quality improvements can be gained by choosing the right supply base [28]. Furthermore, an organization can take advantage by economies of scale (EOS) in respect to transportation or shipping costs; therefore, the best locations for warehouses or stocking points have to be determined [29].

When distribution networks are designed from the scratch, it is common to first decide for a certain network structure, which is in most of the cases predetermined due to geographical or organizational reasons [30]. In this regard, the location and quantity of warehouses and facilities, the warehouse capacity load ratio, the division of customer demand to particular warehouses as well as the allocation of specific warehouses to certain production plants need to be determined [17]. Based on this network structure, other decisions such as inventory policies can be taken [30]. Especially the number of facilities has a distinct influence on the warehousing costs. According to Chopra [16], total logistics costs first decrease by increasing number of facilities until a certain point, at which they increase again. This total logistics function is displayed in the following Figure 6:

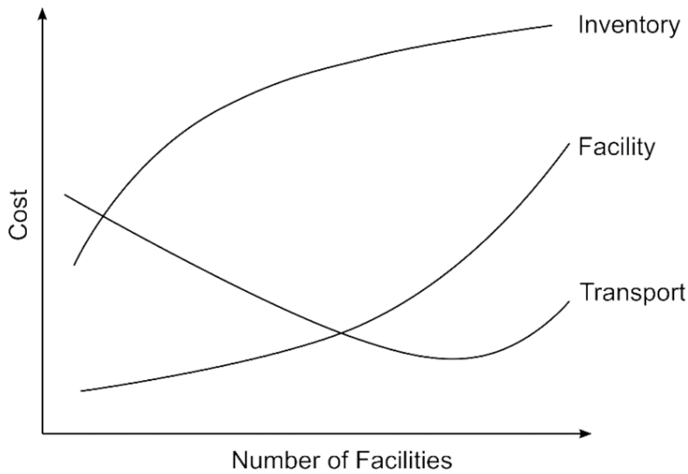

Figure 6: Relationship between Number of Facilities and Logistics Costs (modified illustration from [16])

Accordingly, while minimizing total logistics costs, the quantity of warehouses that minimize total costs should be established [16].

Furthermore, also the response time varies with increasing number of facilities and should be taken into consideration. Chopra [16] also researched the relation of the response time with the amount of facilities. The trend of those parameters is displayed in Figure 7.

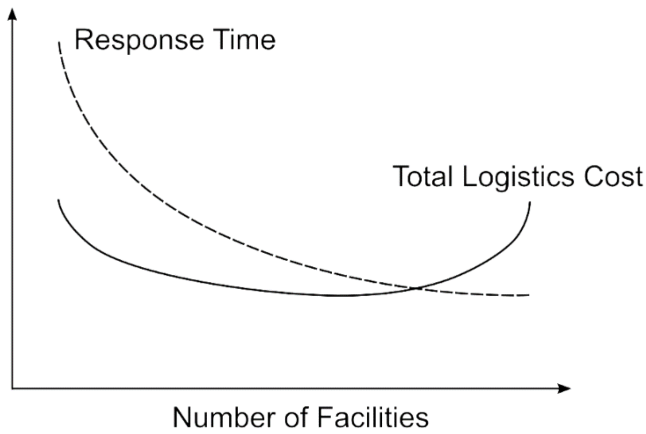

Figure 7: Variation in Logistics Cost and Response Time with Number of Facilities (modified illustration from [16])

It is shown that with increasing number of facilities, the response time decreases. Nevertheless, it needs to be taken into consideration that the total logistics cost increase again after a certain amount of facilities. Thus, if an enterprise strives to achieve an optimal customer response time, the number of facilities has to be increased beyond the optimal logistical costs point [16]. However, further facilities should only be added beyond the cost-minimizing point if an augmentation in revenues is highly probable due to increased responsiveness achieved by the supplementary warehouses [16].

Warehouse Consolidation

In order to increase the efficiency of a physical distribution network, a warehouse consolidation strategy can be implemented. According to Melachrinoudis & Min [27], a consolidation strategy entails the consolidation of smaller warehouses into fewer lager facilities and promotes a more effective capacity utilization and a higher throughput. In this respect, warehousing costs can be reduced due to savings in regard to inventory holding, warehouse handling costs and shipping costs and by a lower quantity of facilities and aggregated inventory storage. Moreover, EOS can be exploited due to transportation consolidation and consequently larger volume shipments [27]. In addition to this, warehousing consolidation benefits reduces material handling costs due to bulk storage and aggregated picking [27]. Furthermore, administrative costs can be decreased by lower coordination efforts in regard to warehouse management [27]. Nevertheless, warehouse consolidation may also implicate some drawbacks. Lead-time may be increased and customer service levels may be corrupted [27]. Fewer facilities might increase the distances to the customers. In this regard, in order to compensate increased distances, more direct shipments might be necessary [27].

Hub-and-Spoke Network

A similar approach to warehouse consolidation is the implementation of a hub-and-spoke distribution network. This system is characterized by the establishment of several hubs, through which bundled flows of goods are shipped. This aggregation of flows leads to EOS and accordingly to cost savings [31, 32]. A well-established hub-and-spoke distribution network does not increase the total distance and time travelled in comparison to a direct shipment to its destination [31]. However, if not implemented properly, this distribution system may lead to higher shipping times and consequently a negative impact on the service performance [31]. Furthermore, “a mismatch between the arrival rate of shipments and processing rate of hub resources may cause queues to build” which may decrease the customer service performance further [31].

It can be concluded, the mentioned alternative approaches of distribution network strategies in regard to transportation, inventory and warehousing policies should be taken into consideration in order to select the most appropriate strategy for the organization. Each of the centralization strategies, i.e. centralized, decentralized or hybrid, can either be incorporated including those alternative approaches of collaboration or not. In this respect, it has to be distinguished between the degree of centralization regarding the management style and the degree of collaboration. As an example, centralized supply management can also be implemented including collaboration such as lateral transshipments or inventory pooling without being a hybrid approach due to the different division of responsibilities.

3.3. Centralization Strategies

The concept of coordination of activities throughout the SC has emerged in the 1980s and became wide-spread since then due to opportunities for saving costs, increasing customer service levels or generating competitive advantages for all parties involved in the SC [32]. Synergy – received by collaboration – is assumed to entail competitive advantages by sharing know-how and resources, coordinating strategies, and pooling negotiation power [33]. Centralization and coordination of different organizational functions is regarded to be an important progress of professionalizing various organizational processes throughout the SC [33]. According to Glock and Hochrein [34], there are in general two different approaches used in order to measure the degree of centralization in terms of decision-making.

In detail, the first approach focusses on the concentration of decision-making within a single organizational unit, whereas the second one focusses on the position of the decision-making authority within the organizational hierarchy [34]. In this respect, the degree of hierarchy levels and authority is also an indication for the degree of centralization of an organizational structure [35].

3.3.1. Centralized Procurement

A centralized supply structure can be divided into centralized procurement and centralized distribution network design. Both approaches are closely related but could also be applied separately.

Procurement is regarded more and more as a key element in SC management and a trend towards a centralized, more integrated function within the organization's strategy is visible [35]. The level of centralization of a purchasing unit can be defined as the degree of division of authorities, responsibilities and power within a purchasing department or organization. By definition, centralized sourcing is an organizational structure based on close cooperation, characterized by the establishment of a central authority with the responsibility for inventory control activities of the whole organization [32]. In most of organizations with centralized supply strategy, a central sourcing department, often referred to as buying center, is established, which is situated either directly in the company's headquarter or at some regional or divisional level [35]. This central department is in charge for inventory replenishment for frictionless operations by considering available information in regard to demand or expenses [32]. It has the ultimate authority and the main task of this buying unit is to scrutinize, adjust and consolidate orders placed from other units across the company [12]. In this regard, in order to implement a centralized supply network, the organizational structure as well as the hierarchical division of authority needs to be adapted. Various organizational design elements, such as control structures, positions, departments, or communication channels need to be implemented in order to adjust to the different requirements of the sourcing situation [34].

The dimension of those central purchasing departments has often been used as criteria for measuring the quality in the sourcing process. According to Glock & Hochrein [34], the size of the central purchasing department has direct influence on the quality of the purchasing process. According to them, a larger scale buying center leads to higher quality in the sourcing process and reduces uncertainty as well as the perceived risk in sourcing.

The variable degree of involvement of the buying center can “be subdivided into the variables lateral involvement and vertical involvement and also includes the size or extensity of the buying center” [34]. In detail, lateral involvement refers to the quantity of separate departments or divisions involved in the sourcing process, whereas vertical involvement refers to the number of hierarchical levels integrated in the process [34]. Uncertainty can be reduced by advanced exchange of information, which can be ensured by an increased number of departments [34]. Consequently, purchasing decisions with a higher level of uncertainty and risk require more lateral involvement, i.e. a higher number of divisions involved in the sourcing process. In contrast, organizations confronted regularly with complex and difficult sourcing decisions need a higher degree of vertical involvement [34]. In conjunction with vertical involvement and more levels of decision-making, it becomes obvious that purchasing managers have a substantial influence on the buying process and play an important role in the purchasing process. Nevertheless, due to the increased amount of hierarchical levels, a fluent flow of processes has to be ensured by well-established communication channels. In this respect, also the extent of application of various communication channels in the sourcing process can be regarded as an indicator of involvement [34]. According to Glock and Hochrein [34], the influence of members on buying decisions is facilitated by a higher number of communication channels. A high number of communication channels is especially relevant in centralized and little formalized environments [34].

Advantages of centralized sourcing are mainly derived by synergy benefits. Synergy can be defined as an organization’s common goal to produce collectively higher combined returns on resources by taking advantage of interrelationships between business units [35]. In this respect, competitive advantages can be generated by the collaboration of different business units in terms of know-how, resources, strategy coordination or combined negotiation power [35]. Moreover, increasingly complex product portfolios and rapid innovations even require a higher level of collaboration [9]. Collaboration is facilitated by increased information availability and exchange as well as changed relationships with suppliers and business partners along the SC [9]. According to Trautmann, Bals & Hartmann [5], purchasing synergy benefits created by purchasing centralization can be divided into three categories: economies of scale (EOS), economies of information (EOI) and learning, and economies of process (EOP). First of all, EOS and thus lower unit costs are generated by taking advantage of standardization of categories and volume bundling as well as quantity discounts [35]. Furthermore, due to the higher purchasing quantities, enterprises receive more attention and better service from suppliers [13, 36].

Secondly, EOI and learning refer to benefits received by sharing knowledge and skills, new technologies, members of the organization as well as common applications [33]. EOI also refer to benefits received by specialization and categorization, which proves to be more efficient since the purchasing experts are responsible only for a certain area on which they can focus on [35]. In this respect, in-depth know-how of markets globally can be acquired and this knowledge can be bundled in one department [35]. Due to the bundling of knowledge within one department, company-wide requirements can be consolidated in a better way and global supply shortages might be predicted earlier. Necessary resources might be secured by looking for alternative resources due to the time advantage [35]. In this respect, an organization might be able to respond more effectively to rapidly changing business environments and take advantages by sourcing globally [35]. Sourcing can be planned more effectively and a better control and evaluation of the system can be ensured [13]. According to McCue & Pitzer [36], the development of purchasing expertise is the heart of a centralized purchasing system, which makes sourcing more efficient and profitable and ensures the integrity of the system.

Thirdly, EOP can be generated by the implementation of common processes and a mutual way of working throughout the purchasing system [35]. In regard to administrative work, total workload can be reduced and duplicated work can be spared; thus, purchasing organizational expenses can be decreased [35]. Especially with increasing scope of purchasing, centralized sourcing is able to simplify the buying process and decrease the overall sourcing effort [13]. In this respect, processes are facilitated and total costs are decreased. Moreover, it is expected that it is possible to reduce costs also in other areas of the company, as for example accounts payable [37].

Summarizing, purchasing synergy benefits can be categorized into EOS, which focusses mainly on low prices through bundling, EOI, which are generated by personnel which can focus full-time on sourcing and develop therefore specific knowledge, and EOP, which is referring to savings in regard to reductions of overlapping work and processes [35]. Nevertheless it has to be mentioned that all these benefits are “all potentially attainable through centralization, but most likely they do not all materialize at the same time and equally fast for the organization and for individual units” [35]. The following Figure 8 illustrates the marginal benefits, which can be generated by committing a certain number of business units to the centralized system:

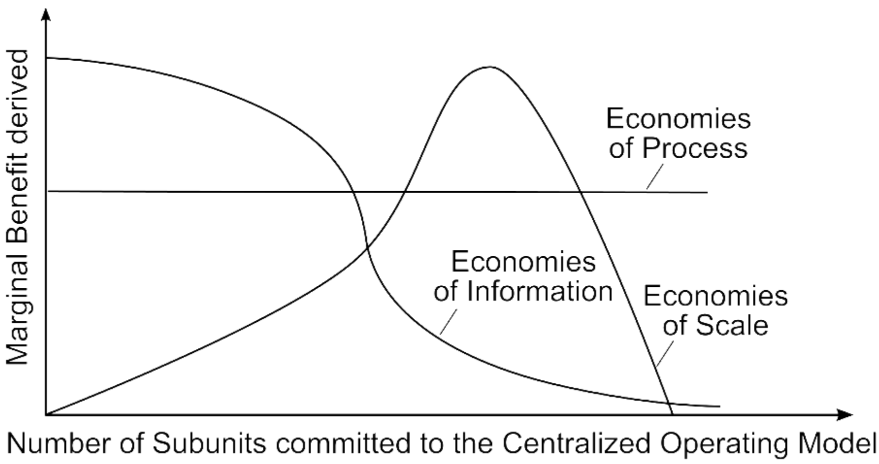

Figure 8: Marginal Benefits Derived from Increased Commitment to the Centralized Operating Model (modified illustration from [35])

Consequently, Figure 8 displays that the three curves of the different economies receive different marginal benefits with increasing number of units committed to the centralized system. Regarding this figure, however, it has to be mentioned that the aim is not to rank the different economies according to their marginal benefits derived. First of all, it is shown that marginal benefits derived from EOIs decrease with increasing number of subunits committed to a centralized model. Reasons therefore are that benefits derived from the categories of EOI, as proposed by Faes et al. [33], i.e. application of new technologies, recording of supplier information or creating standardized negotiation strategies, can already be received by a low level of units committed to the centralized system. Accordingly, those marginal benefits decrease in relation with increasing number of centralized subunits. Furthermore, regarding marginal benefits derived from EOP, it is shown that those benefits remain constant with increasing number of additional units committed. According to Karjalainen [35], this can be explained by the fact that with each unit joining common processes, one unit less is operating in parallel processes and therefore, there is a cost saving in equal processes. In contrast, EOS are realized by creating higher purchasing volumes. In this regard, marginal benefits derived by EOS increase with growing number of units committed. Due to this fact, larger volumes can be negotiated and maintained more effectively. Nevertheless, after a certain number of units committed to centrally negotiated contracts marginal benefits are decreasing. In this regard, if the largest volume for a maximum of discounts from the suppliers is reached, other units committed have no influence anymore. Consequently, marginal benefits from EOS then quickly decrease until they reach zero additional benefits.

When establishing a centralized purchasing structure, also the disadvantages of this system should be taken into consideration. First of all, a centralized buying structure might limit an organization's flexibility to respond quickly to market fluctuations. Walmart has encountered similar conflicts in the Chinese market, since Walmart's centralized purchasing system has proven to be too rigid and therefore not capable to respond immediately and effectively to market changes in the unstable Chinese market [15]. Thus, centralized processes might be rigid and decisions might be taken in a very slow and inefficient way since the central department has no direct relationship to the end-customer [35]. This inflexibility might also be influenced by the fact that there is only one central department which is in charge of controlling the sourcing process. Since this department is implemented in addition to the current personnel, excessive overhead costs should be taken into consideration as well [38].

In contrast to decentralized purchasing, where every division is responsible for their own purchases, centralized structure might also encounter difficulties in respect to an entire control of processes. A centralized system implies less user control and less responsiveness to decentralized needs since there is a higher distance to the departments with actual need for resources [12]. Due to this distance, a lack of information about those local needs might become a critical issue as well; therefore, the maintenance of an elaborated information exchange system is a crucial requirement for a centralized system [39]. Otherwise, this lack of entire control of processes might lead to issues in regard to attitudinal problems [35]. One example therefore might be maverick buying, i.e. autonomous purchasing by departments without inclusion of the procurement department, hence procurement beyond standardized purchasing processes.

Furthermore, another disadvantage might arise due to the standardization of processes in centralized purchasing systems. On the one hand, standardization leads to a routine performance of processes, which in turn, leads to a reduction in variability and to a lower uncertainty in the whole sourcing process [34]. On the other hand, standardization leads to a limitation of the organization to process information due to more hierarchical levels and an aggravated exchange of information [2]. In this respect, only in environments with low information processing requirements, standardization should be applied as a design instrument [34].

Moreover, another disadvantage of centralized purchasing and mutual buying might result from the high purchasing quantities. Suppliers might be overburdened by the total required purchasing volume and not able to fulfil the requirements [35]. In this respect, this topic should also be taken into consideration before implementing a centralized supply structure and agreements with suppliers should be arranged beforehand.

Finally, it has to be mentioned that the success of a centralized supply network depends heavily on the general implementation of the centralized processes in the organizational structure. An important issue besides a frictionless organizational implementation is the conviction of the business unit managers of the new system. Reasons for resistance against a centralized purchasing system might result from a reluctance to terminate existing supplier relationships or differing product and/or service specifications [35]. Especially in the introduction phase, cost savings and improvements need to be demonstrated in order to avoid resistance from purchasing managers [35]. Nevertheless, as more and more business units are going to cooperate, benefits are going to be derived automatically through a stronger negotiating position and the processes will be less questioned [35].

3.3.2. Centralized Distribution Network Design

A centralized distribution network design is characterized by a centralized management of transportation, inventory as well as facilities. A main feature is the establishment of central warehouses or DCs. In this regard, central warehouses or DCs are integrated in the distribution process in order to fulfil the total occurring demand of all subsidiaries [40]. Instead of intercompany stock exchange, demands are mainly covered by deliveries from the central warehouse.

In general, centralized inventory management is able to reduce costs in two ways: firstly, by decreasing safety stock levels, and secondly, by realizing EOS [41]. In this regard, centralized stock keeping may lead to lower warehouse inventory levels, less production, lower costs and lower environmental impact due to a reduction of shipments [18]. In detail, due to a central supply of material and a frictionless provision of material, local safety stocks can be reduced. Accordingly, centralized inventory management and lower safety stocks lead to less production of unused inventory and existing inventory can be used more efficiently [18]. Those savings can even be increased if inventory pooling is incorporated in addition to the centralized supply system [41].

Consequently, inventory pooling is able to lead to an increased part availability and hence to a further reduction of total stock levels [23]. Even better results can be generated if ELTs from the central warehouse are permitted [24]. Furthermore, by incorporating a centralized inventory and distribution system including inventory pooling, demands can be balanced more efficiently and the variability of demands can be reduced by “compensating the underestimated demand of one store with the overestimated demand of another store” [40]. However, it should be ensured that inventories are fairly allocated between the subsidiaries so that no subsidiary has an incentive to operate their own warehouses [40]. In this respect, it has to be ensured that uncertain demand can be satisfied by stock kept in central warehouses or by physically combining and sharing inventories [41]. Moreover, inventory can be utilized even more efficiently by taking advantage of substitutable products or by delaying the point of differentiation of a basic product, so that a common product can be stored [41].

Furthermore, shipments can be bundled and therefore, fewer shipments are necessary which reduces costs and has incidentally also a positive impact on the environment. In detail, EOS can be obtained due to reduced fixed costs in regard to transportation or stock keeping costs [41]. In addition to this, centralized distribution network design leads to risk-pooling and consequently to the exploitation of EOS [40]. In this regard, centralized inventory management is able to reduce total inventory costs by minimizing overall SC inventory expenditures and by reduced inventory handling and warehousing costs [18, 43]. With regard to transportation costs, opinions extracted from literature divaricate. On the one hand, according to literature, inventory centralization might increase transportation costs. Centralized inventory management implicates a trade-off between inventory and transportation costs [40]. In this respect, additional transportation costs might be increased since distribution is only conducted by the central warehouse and there is no direct distribution from local stores anymore [40]. Matthews and Hendrickson [18] came to the same conclusion and outlined that centralized inventory management is able to reduce the total amount of inventory as well as warehousing costs while increasing transportation costs. Especially the integration of ELTs might increase total transportation costs in order to avoid repair delays while waiting for deliveries [18]. On the other hand, it is stated that transportation costs might decrease since enterprises can take advantage of shipment pooling and resulting EOS in transportation [41]. Less transportation in turn would also lead to lower environmental emissions, which can also be stated as positive side-effect of centralized distribution [18].

Another advantage of centralized distribution management is the augmentation of flexibility and efficiency. Chuang, Donegan, Ganon, & Wei [15] conducted research about inventory systems of retailers and illustrated that Walmart's success in its home market is determined by their adaptable centralized distribution and cross-docking systems. According to Mr. Lee, Walmart China's SC director, centralized distribution leads to efficient and fewer deliveries while avoiding unnecessary inventory storage [15]. This underlines the possible efficiency of a centralized inventory system and shows that success might be determined by a thoughtful inventory strategy. Further advantages of centralization in regard to inventory management are decreased uncertainty and thus reduced costs and better service levels as well as a more reasonable utilization of resources in terms of production and transportation [32]. Nevertheless, it turned out that it is complicated to find an optimal policy for distribution systems due to stochastic and time-varying demand [32]. Research has shown that the extent of profits obtained by centralized inventory management is influenced by factors such as the correlation between demands or the variability in demand [41].

Nevertheless, an important issue to define in centralized inventory management is overstock regulations. According to Matthews and Hendrickson [18], the following components need to be considered in regard to remaining non-excess inventory in non-major locations: "(1) the benefits associated with reduced inventory management expenses at non-major locations, (2) the costs of moving the remaining inventory from non-major back to major locations, and (3) the costs of increased inventory handling expenses at major locations". In this respect, a potential relocation of material needs to be well-considered in advance including the influence on the receiving location. Therefore, individual overstock management needs to be incorporated in an organizational strategy, adjusted to the individual company's situation.

In Table 2, advantages and disadvantages of centralized supply management are presented.

Advantages	Disadvantages
• Synergy benefits by collaboration in terms of know-how, resources, strategy coordination, combined negotiation power	• Limited organizational flexibility due to rigid buying structure to respond quickly to market fluctuations
• Economies of scale	• Control of processes – less user control
• Economies of information and learning	• Less responsiveness to decentralized needs
• Economies of process	• Lack of information about local needs
• Respond more effectively to rapidly changing business environments	• Distance to customers
• Global sourcing strategies	• Limitation of organization to process information
• Lower warehouse inventory levels, less production, lower costs and lower environmental impact	• Overburden of suppliers by total required purchasing volume
• Reduced inventory costs	• Resistance against implementation of centralized purchasing system of business units managers
• Decreased safety stock levels	

Table 2: Advantages and Disadvantages of Centralized Supply Management (own illustration)

3.4. Decentralization Strategies

3.4.1. Decentralized Procurement

Besides a centralized organizational purchasing structure, enterprises can also adopt a decentralized system. This decentralized structure is characterized by decentralized purchasing, which is conducted either by independent departments or by individual plant or division managers [35]. Whereas a centralized structure is reasonable if several organizational units have similar product requirements, a decentralized structure is especially applied in organizations with individual units, which produce unique or distinctly different products [2]. Hence, it can be said that the major difference between a centralized and decentralized purchasing structure lies in the global product structure and on similarities within global units. Thus, the organizational purchasing structure needs to be adapted to the company-specific requirements and to product-related specifications.

In general, a decentralized procurement strategy is able to ameliorate customer and supplier relationships. More precisely, advantages are generated due to the close distance of the purchasing manager to the origin of requirements. Especially in regard to customer relationship management, an enterprise can benefit from providing problem-solving competences close to the source of problems [33]. In detail, enterprises are able to provide better customer service and improve service level performance, which might increase customer satisfaction and lead to a higher reputation. In addition to this, speed of operation is distinctively higher in comparison to slower processes of a centralized structure [13]. However, a decentralized purchasing structure does not only entail benefits on the demand side, but also on the supply side. More precisely, a decentralized approach promotes the use of local sources in a more effective way [13]. Whereas centralized sourcing might encounter problems in regard to cultural differences and local market conditions, local purchasing might benefit from cultural knowledge of purchasing managers [33]. In addition to this, relationships with local suppliers are ameliorated. In order to receive best service from external suppliers, the maintenance of a close relationship is a crucial factor. Decentralization is able to strengthen the relationship with local suppliers since there is a closer distance and more direct communication between the place of requirement and the source of supply [33]. However, it has to be mentioned that close cooperation with suppliers and the use of local information can also be utilized within a centralized approach; nevertheless, the costs might be distinctly higher [42].

Secondly, another benefit of a decentralized structure is the possibility to reduce costs. Total costs of ownership can be managed and monitored by individual units managers in a better way and lower costs can be generated by locating the decision-making closer to the local manager [43]. In this regard, a decentralized structure focuses on cost containment in each unit and on controlling total costs [33]. Furthermore, a decentralized structure is able to decrease overhead costs by avoiding a centralized purchasing department. Nevertheless, according to a study conducted by Johnson & Leenders [13] decentralization does not guarantee lower costs. In detail, the aim of their study was to investigate the reasons of enterprises for major structural changes of their supply processes and different implementation approaches. The study comprised ten large companies with recent major changes in their supply organizations in terms of moving from one of the main approaches, i.e. centralization, decentralization or hybrid, to one of the other forms. Several companies participating in this study applied a decentralized organizational design in order to decrease total costs [13]. More precisely, decentralization was incorporated in order to initiate a downsizing operation and in consequence, to reduce head-count costs [13].

Nevertheless, according to this study, although the aim of several companies was downsizing, “the research did not find any evidence that downsizing implied a shift toward either centralization or decentralization” [13].

Drawbacks of a decentralized structure might be caused by the dispersion of purchasing competences throughout the company. First of all, this dispersion of competences leads to difficult communication between business units. Furthermore, due to the splitting of competences, it might be the case that too much focus is put on local sources and better supply possibilities are ignored [43]. In this respect, it was observed that business unit managers usually have their focus on the operational point of view whereas the strategic focus might be neglected [43]. Accordingly it can be said that business unit managers have a different perspective and might not take into account entire organizational processes and strategies. Consequently, corporate strategies may differ from business unit preferences and the attainment of an effective global sourcing strategy and achievements might not be possible [34, 44].

3.4.2. Decentralized Distribution Network Design

A decentralized distribution network is characterized by individual management of each stocking point [24]. In a decentralized system, each site manager is responsible for a pre-defined set of processes and decisions for the respective site [44]. Depending on the specific organizational structure, responsibilities of the site managers differ. In most of the cases, the sites are in charge for the replenishment of their stock-levels and for the organization of the shipments. In this respect, requested goods are ordered individually by the subsidiaries and delivered directly to the sites without any central department [40]. In order to avoid any mismatch between headquarter and individual sites or any incentive for misalignment, clear corporate rules need to be established [44]. These rules should not only clearly define responsibilities and processes but also encompass detailed regulations as for example about sharing quantities [44]. The determination of how much to share is a critical issue in decentralized systems. Especially if all the subsidiaries are independent, they are focusing on their own customer demand and success. According to Paterson et al. [24], no additional profits can be generated if retailers can decide about the sharing quantities. This might be particularly the case in partial pooling, since it might lead to the circumstance that no overstock is redistributed between the retailers.

Furthermore, the success of a decentralized distribution system depends on the diversity of demand sources and respectively on the variety of the product portfolio. Çömez-Dolgan & Tanyeri [41] illustrate that the difference between the demand sources stands in a direct relation to inventory costs. They show “that as the [positive] correlation between the different demand sources decreases, the reduction in inventory costs increases” [41]. In this respect, more inventory costs can be saved if there is less difference between demand sources.

Comparable with the centralized system, the best results in terms of cost reduction can be generated if resources are shared and pooling is integrated into the system [24]. Inventory pooling on the same echelon level leads to lower inventory levels and costs while reaching the requested customer service levels [45]. Also the research model of Slikker et al. [46] proves that cooperation leads in general to a higher total profit. These results show that collaboration and respectively transshipments and centralized purchasing also implicate benefits for a decentralized distribution system [24]. However, it needs to be taken into consideration that the approach of Slikker et al. [46] does not include transshipment costs.

Table 3 summarizes the respective advantages and disadvantages of a decentralized supply strategies.

Advantages	Disadvantages
• Problem-solving competences close to the source of problems	• Dispersion of purchasing competences
• Better customer service and improved service levels performance	• Decision about sharing quantities should not be made by local managers
• Higher customer satisfaction and higher reputation	• Neglecting total organizational costs by only optimizing local performance and local inventory cost minimization
• Speed of operation	• Difficult communication between business units
• Reduction of total costs and overhead costs	• Limited functional advancement possibilities
• Use of local sources	• Corporate strategies may differ from business unit preferences
• Strengthened relationship with local suppliers	

Table 3: Advantages and Disadvantages of Decentralized Supply Management (own illustration)

3.5. Hybrid Strategy

3.5.1. Procurement in a Hybrid Organization

The last approach in terms of organizational procurement design is a hybrid strategy, which is a combination of a centralized and a decentralized organization. In this respect, the basic principle of the hybrid approach is to link the centralized and decentralized design. A hybrid organization is able to avoid the "trade-off between efficiency/control by centralization, versus flexibility/service level by decentralization", by merging features of both, centralization as well as decentralization [28]. In this regard, the hybrid structure is able to support organizations in order to manage the trade-off most effectively and maximize profits by global sourcing at the same time [2]. Accordingly, a balance between the better service levels and greater flexibility of a decentralized purchasing system and the scale effects of a centralized purchasing system has to be found [34]. In detail, especially the combination of the two sources of competitive advantage, location-specific advantages and company-specific competences is of major importance [5]. The first one refers to the extracting of advantages by utilizing local supply, labor markets, local know-how or new technologies, the second one refers to benefits extracted by the existence of global synergies such as mutual cross-national requirements [5]. Nevertheless, in order to take advantage by any of the two mentioned ones, the global purchasing strategy needs to be incorporated in the organizational design and part of the global strategy [5].

According to Leenders & Johnson [43] even a tendency towards the hybrid approach is observed. They conducted a study with ten companies and observed major structural changes over the time-frame of more than ten years. Out of the ten enterprises, 15 major structural changes in the supply strategy were noticed. As illustrated in Figure 9, in total nine organizational changes were conducted towards centralization, of which five changes in the direction of a hybrid approach. In contrast, six structural changes were heading towards decentralization, including three towards an hybrid approach.

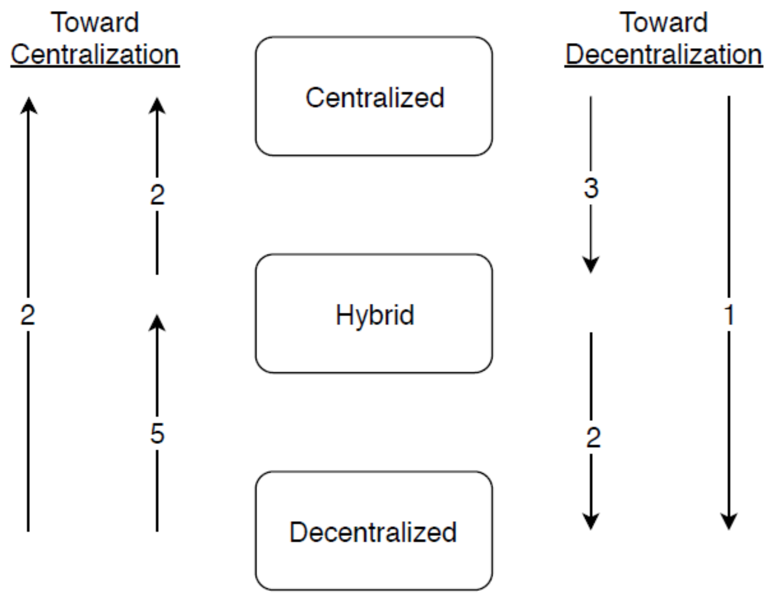

Figure 9: Major Changes in Supply Organization Structure between Centralized, Hybrid and Decentralized Modes (modified illustration from [43])

In detail, the main characteristic of a hybrid purchasing organization is the differentiation of practices according to some criteria [35, p. 88]. One possibility of differentiation would be according to product categories. In this respect, certain product categories are sourced by the central purchasing department, whereas other categories are ordered directly from the local business unit. Accordingly, a division of tasks is implemented in the organization in order to take advantage of the special expertise of each department or division [5].

Consequently, product categorization is an important procedure in order to benefit from EOS. Therefore, bundling decisions are a crucial issue in every hybrid organization. "It has been argued that raw materials are more appropriate for bundling initiatives, while specialized components should be rather sourced locally" [5]. In general, standardized product categories and bought-in goods can be bundled efficiently; therefore, they are especially suitable for cross-national integration and centralized purchasing respectively [5].

Nevertheless, the product categorization also poses one of the key challenges of the hybrid organizational purchasing structure. It is important to differentiate product portfolios, determine the ones with synergy potential and find an appropriate degree of integration across geographical units [2]. It needs to be differentiated between product groups that are purchased directly at the sites, and those, which are purchased under the authority of a central purchasing department [5].

In this respect, the difficulty does not arise from the coordination itself, but more from the identification of the categories in which the specific policy is applied [33]. When performing the categorization, the three types of economies, i.e. global efficiency and EOS, national responsiveness and EOI and worldwide learning and EOP should be taken into account, which increase the complexity of categorization [5]. Nevertheless, since those three dimensions are crucial factors for gaining global competitive advantage, they can be regarded as a structuring and evaluating tool of global buying synergies [5].

In addition to this, another challenge arises from the balance of the two forces of global purchasing: global integration and local responsiveness [5]. Although organizations with a hybrid purchasing structure are able to combine the trade-off of centralized and decentralized structure, it is still difficult to maximize profits of global sourcing at the same time [2]. Accordingly, in order to be able to compete globally, it is necessary to adapt the organizational structure to the increasing complex environments and company-specific prerequisites [5].

3.5.2. Distribution Network Design in a Hybrid Organization

Concepts such as inventory pooling and lateral transshipments can be applied in hybrid organizations as well. Since the hybrid approach is a combination of the centralized and decentralized system, responsibilities are divided. Accordingly, for example, central inventory strategies are defined by the headquarter, whereas local managers are allowed to determine safety stock levels or are responsible for the organization of transports. As in the hybrid purchasing organization, clear regulations need to be established. Consequently, hybrid organizations imply increased coordination effort while taking advantage from local knowledge combined with expertise from a central department.

Table 4 displays advantages and disadvantages of a hybrid approach of supply management.

Advantages	Disadvantages
• Combination of location-specific advantages and company-specific competences	• Product categorization
• Utilizing local supply, labor markets, local know-how	• Adaption of organizational structure
• Mutual cross-national requirements	• Coordination effort
• Minimization of trade-off between centralized and decentralized structure	
• Maximizing profits by global sourcing	

Table 4: Advantages and Disadvantages of Hybrid Approach of Supply Management (own illustration)

4. Model Framework

The underlying problem setting can be classified as a transportation problem. According to Nahmias & Olsen [47], the aim of this class of mathematical model is the optimization of transports scheduling for the flow of material from production sites either to DCs or to customers. In this respect, the “optimal flow paths and the amounts to be shipped on those paths to minimize the total costs of all shipments” should be assessed [47]. Transportation problems have been approached by several heuristics and linear programming procedures. Heuristics are characterized by the application of decision tree procedures and iterative approaches [48]. In contrast, linear programs apply complex mathematical procedures in order to find an optimal solution [48]. Vanderkam, Wiersma and King [48] have compared the application of heuristic algorithms vs. linear programs. According to them, heuristics are characterized by a simple implementation and the delivery of fast solutions. Nevertheless, heuristics cannot guarantee optimal solutions and do not inform users about potential suboptimality of the solution. Optimal solutions especially for larger scale problems can be found more efficiently by the application of linear programming [47]. With aid of this programming method, a wide range of optimization problems with millions of variables can be solved easily [47]. In detail, this technique was designed in order to solve different real-life problems such as distribution and logistics problems, production planning, inventory control or personnel scheduling [47]. A linear programming problem requires a linear function, which should either be minimized or maximized, including n real variables, which are subject to m constraints [47]. Since the problem setting of the Doka GmbH is related to transportation planning and distribution network designing, it can be classified as a transportation problem. Due to the scale of the problem setting and the amount of decision variables and constraints respectively, the solution finding process with heuristics would implicate excessive efforts and it might not be possible to determine an optimal solution with aid of heuristics. Therefore, it was decided to choose linear programming as mathematical technique in order to be able to detect an optimal solution and decrease computational efforts.

In the further process, this linear model should be implemented into the optimization software program FICO® Xpress. Taking into account the demand signals and overstock situation leading to possible supply streams of the selected branches, the program should provide as outcome the solution, from where to source while minimizing total costs. At a later stage, additional constraints should be added in order to establish recommendations regarding prioritizing rules and sourcing strategies.

4.1. Notation

In the following, the required sets, indices, parameters and variables for the linear program are presented.

4.1.1. Input Data

n … number of sites with supply

m … number of sites with demand

p … number of products

I … set of sites with supply and overstock material, $i \epsilon \{1, \dots, n\}$,

J … set of sites with demand, $j \epsilon \{1, \dots, m\}$

P … set of products, $p \epsilon \{1, \dots, z\}$

D_{jp} … demand of branch j of product p

S_{ip} … supply of branch i of product p

W_p … weight of product p *(in kg)*

E_{ij} … distance of branch i to branch j *(in km)*

B_{ij} … transportation costs per km from branch i to j *(per km FTL)*

X_{ij} … surcharge if truckload is LTL

Q … ranges; set of possibilities regarding the fill rate, taking into account the differing transportation costs in regard to the fill rate, $q \epsilon \{1, \dots, 17\}$

L_q^o … upper limit of fill rate, $|Q|$ possibilities

L_q^u … lower limit of fill rate, $|Q|$ possibilities

A_q …charge depending on the ranges of the fill rate

V … large value (for calculatory reasons), $V = 100$

K … capacity truck *(in kg)*, $K = 22{,}000\ kg$

4.1.2. Decision Variables

s_{ijp} … transported units of product p from branch i to branch j (decision variable)

b_{ijq} … binary decision variable, defining the corresponding range q by taking into consideration the applicable fill rate for the shipped products from i to j

4.2. Calculation of Transportation Costs

The transportation costs are calculated by taking into consideration the total transportation costs per distance as well as the respective fill rate of the truck per distance. In this regard, T_{ij} represents the FTL transportation costs from branch *i* to branch *j* , while F_{ij} constitutes the total fill rate per connection used. For the calculation of F_{ij} also the total capacity of one truck has to be considered. According to information from Doka, the maximum capacity of a truckload should be estimated to 22,000 kg, which is assumed the average loading capacity. The total transportation costs, which incorporate the fill rate as well, are represented by C_{ij}. C_{ij} is calculated by multiplying the fill rate F_{ij} with the transportation costs per distance FTL T_{ij}.

$$T_{ij} = E_{ij} * B_{ij} \qquad \forall\, i \in \{1, \dots, n\}, j \in \{1, \dots, m\}$$

$$F_{ij} = \frac{\sum_{p=1}^{z} s_{ijp} * W_p}{K} \qquad \forall\, i \in \{1, \dots, n\}, j \in \{1, \dots, m\}$$

$$C_{ij} = F_{ij} * T_{ij} \qquad \forall\, i \in \{1, \dots, n\}, j \in \{1, \dots, m\}$$

4.3. Calculation of Surcharges

In order to receive accurate results in terms of total transportation costs, ranges are defined. Experts from the logistical department of Doka suggested assuming for the calculations that the weight of possible transports ranges from 2 tons to 22 tons per truck. Since there is basically no possibility of transporting less than 2 tons or at least it is related to high organizational effort, a high surcharge for this range of 0 – 2 tons is applied in order to avoid this scenario. Furthermore, the assumption is made that from 18 tons on, the transportation costs of a FTL are applied. For calculatory reasons, also the range of not transporting anything at all is added, of course with no surcharge. Due to the fact that some branches might have more demand than one truckload, the set of ranges is extended in order to represent all possibilities. Nevertheless, from range 17 on, representing more than five truckloads, it is decided to apply no charge at all since freight forwarders would not charge any surplus anymore. Another aspect that needs to be mentioned is the possibility to circumvent surcharges. For example, a transport has the fill rate of 1.80. Since more than one truck is required, the model splits the load according to the cost minimizing scheme. The first possibility is to choose one full truck load and one truck with 0.8, which leads to a surcharge of 100 €. Another option, which is actually taken by the model since it minimizes the total costs, is to choose two trucks with 0.9 fill rate and no surcharge respectively.

The chosen ranges q and the respective lower limits L_q^u and upper limits L_q^o as well as the corresponding surcharges A_q are displayed in Table 5:

Ranges q	**Lower Limit** L_q^u	**Upper Limit** L_q^o	**Charge** A_q
1	0	0	0
2	0.00000003	0.09	10 000
3	0.091	0.82	100
4	0.821	1	0
5	1.01	1.09	10 000
6	1.091	1.82	100
7	1.821	2	0
8	2.01	2.09	10 000
9	2.091	2.82	100
10	2.82	3	0
11	3.01	3.09	10 000
12	3.091	3.82	100
13	3.82	4	0
14	4.01	4.09	10 000
15	4.091	4.82	100
16	4.82	5	0
17	5.01	100	0

Table 5: Overview Ranges, Lower and Upper Limits and Surcharges (own illustration)

In order to integrate the surcharge in the model as well, X_{ij} is introduced, which ensures that the surcharge A_q is only added to the costs if the corresponding fill rate is applicable. With aid of the binary decision variable b_{ijq}, only the applicable surcharge A_q is added.

$$X_{ij} = \sum_{q=1}^{17} b_{ijq} * A_q \qquad \forall\, i \in \{1, \ldots, n\}, j \in \{1, \ldots, m\}$$

4.4. Objective Function

Since the objective of the model is to minimize total costs, the function to be minimized consists of the entire amount of transportation costs plus contingent surcharges for LTL.

$$Z = \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} + X_{ij} \rightarrow min$$

4.5. Constraints

The following constraints (1) – (6) are incorporated in order to ensure a correct functioning of the model. After the mathematical notation, the constraints are explained and described in detail.

$D_{jp} - \sum_{i=1}^{n} s_{ijp} = 0$	$\forall\, j \in \{1, \dots, m\}, p \in \{1, \dots, z\}$	(1)
$\sum_{j=1}^{m} s_{ijp} \leq S_{ip}$	$\forall\, i \in \{1, \dots, n\}, p \in \{1, \dots, z\}$	(2)
$b_{ijq} * L_q^u \leq F_{ij}$	$\forall\, i \in \{1, \dots, n\}, j \in \{1, \dots, m\}, q \in \{1, \dots, 17\}$	(3)
$F_{ij} \leq L_q^o + V * (1 - b_{ijq})$	$\forall\, i \in \{1, \dots, n\}, j \in \{1, \dots, m\}, q \in \{1, \dots, 17\}$	(3)
$\sum_{q=1}^{17} b_{ijq} = 1$	$\forall\, i \in \{1, \dots, n\}, j \in \{1, \dots, m\}$	(4)
$s_{ijp} \in \mathbb{N}$	$\forall\, i \in \{1, \dots, n\}, j \in \{1, \dots, m\}, p \in \{1, \dots, z\}$	(5)
$b_{ijq} \in \{0,1\}$	$\forall\, i \in \{1, \dots, n\}, j \in \{1, \dots, m\}, q \in \{1, \dots, 17\}$	(6)

Constraints (1) and (2) ensure the fulfilment of the demand as well as the abidance to the material availabilities and supply sources. In this respect, constraint (1) secures that the demand of every product p of every branch j is fulfilled. In detail, this is ensured by setting the entire demand of every product p of branch j subtracted by all units, which are delivered from all branches i to the requesting branch j, equal to zero. In this way, the demand needs to be exactly fulfilled and neither excess units, nor a deficit of delivered units are allowed. Moreover, regarding the intercompany excess capacities, constraint (2) ensures that the supply is not exceeded. In this respect, the sum of all transported units of all products p from every branch i to every branch j has to be smaller or equal than the available supply of branch i of product p.

Constraints (3) and (4) are included for calculating the appropriate fill rate and the corresponding surcharge. Since the surcharge depends on the fill rate of the trucks, the truckload needs to be taken into consideration. As mentioned beforehand, it was decided to incorporate 17 different ranges for the different possibilities of surcharge, with each range responsible for a different range of tonnage and respectively a different surcharge. Constraint (3) limits each range by applying a certain lower limit L_q^u and an upper limit L_q^o. Together with constraint (4), it is ensured that exactly one of the 17 ranges is chosen. Therefore, the sum of b_{ijq} needs to be exactly 1, as presented in constraint (4).

Furthermore, constraints (5) and (6) are incorporated in the model in order to ensure the correct functioning of the decision variables. In this regard, constraint (5) ascertains that the transported units s_{ijp} are integer and positive. Constraint (6) deals with the decision variable b_{ijq} and makes sure that b_{ijq} is binary. This is especially important in the calculation of the fill rate for the selection of the appropriate ranges in order to consider the relevant surcharge.

4.6. Establishment of Scenarios

In order to evaluate the current sourcing system and compare it to different approaches, it is decided to establish three sub-models, which should be compared at a later stage. The first one focuses on a basic scenario without any restrictions. The second scenario represents the current sourcing system and prohibits intercompany material exchange except for FTL shipments. The last scenario describes a decentralized system, in which the DC is transformed into a cross-docking station, which should only be utilized if deliveries should be bundled in order to save transportation costs. In this regard, the focus is put on the intercompany exchange of material, disregarding the fill rate of the trucks.

4.6.1. Scenario 1 – Basic Scenario

The basic principle of the first scenario is the unrestricted transportation of material. Therefore, it is assumed that there is one basic warehouse in which overstock material can be stored. In this respect, the warehouse can also be regarded as a supply source, since the overstock material can be utilized in order to fulfil future demands. In addition to this, regular flow of material between the branches is permitted, disregarding the fill rate of the trucks. Due to the fact that material can also be stored at the warehouse, inbound deliveries can exceed outbound deliveries. The scheme is presented in Figure 10.

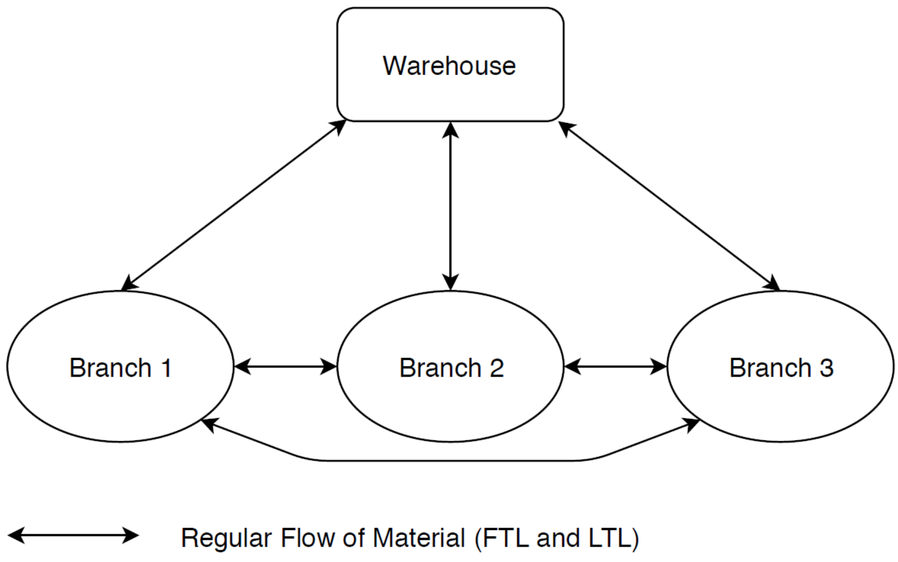

Figure 10: Illustration of Material Flow in Scenario 1 (own illustration)

4.6.2. Scenario 2 – Centralized Supply Management

The second scenario, as illustrated in Figure 11, is incorporated in order to illustrate the current sourcing situation of centralized supply management. In this scenario the main focus is put on the provision of material from the DC. Therefore, intercompany exchange of material is only permitted if a FTL can be organized or if it is explicitly reasonable. The difference to scenario 1 is the restriction regarding the FTL allowance of intercompany transportation. Inbound deliveries from the branches to the DC are allowed; however, there is no incentive provided in the model to perform overstock reduction and respectively, inbound deliveries.

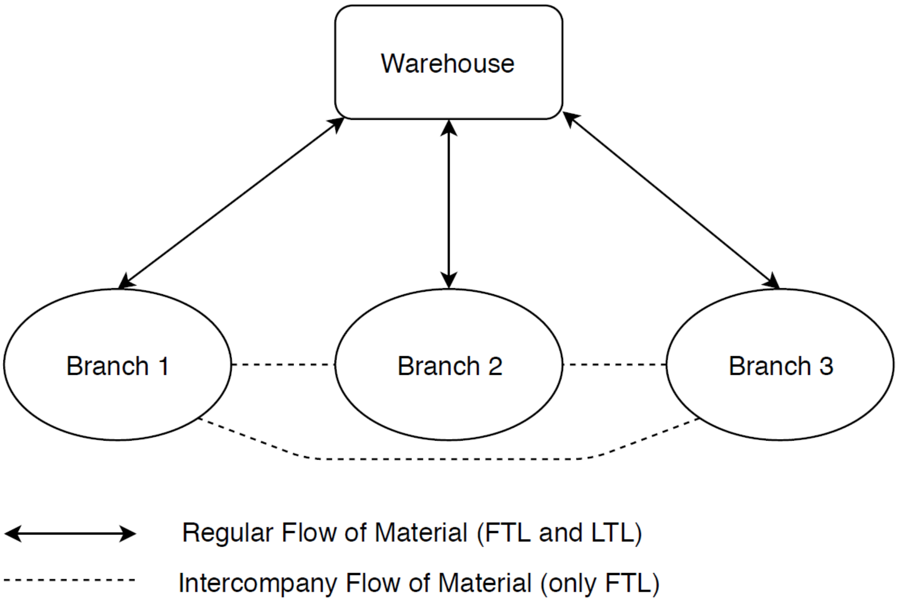

Figure 11: Illustration of Material Flow in Scenario 2 (own illustration)

Adaptations

In order to be able to compare the results of the different scenarios, the analyzed data remains the same. Nevertheless, in addition to constraints (1) - (6), some adaptations in the model are implemented. In order to be able to restrict LTL lateral shipments by applying a high charge on intercompany LTL transportations, another variable is incorporated. This variable ensures that the additional high charge is only applicable on intercompany shipments, but not for shipments originating in the DC. In this respect, the surcharge reduction variable d is integrated and defined as

$$d_j = \begin{cases} 9900 & J = (\text{"DC AM"}) \\ 0 & otherwise \end{cases} \qquad \forall\, j \in \{1, \dots, m\}$$

The variable d has the value of 9,900 if the supply-site is the DC. In all other cases, i.e. for all other supply-sites, the value is zero. With aid of this variable, the model is able to reduce the high charge of 10,000, which is initialized for the applicable LTL range from 0.091 to 0.82, by 9,900. In consequence, the regular surcharge for LTL shipments of 100 € is received for LTL deliveries from the DC. This variable is integrated in the calculation of the surcharge X_{ij} and the calculation of X_{ij} is changed to

$$X_{ij} = \sum_{q=1}^{17} b_{ijq} * A_q - d_j * (b_{ij3} + b_{ij6} + b_{ij9} + b_{ij12} + b_{ij15}) \qquad \forall\, i \in \{1, \dots, n\}, j \in \{1, \dots m\}.$$

Consequently, if a shipment from the DC is conducted to any other branch with LTL, the regular fee of 100 € is added to the total transportation costs. In the case of an intercompany shipment, the surcharge remains 10,000 € since there is no deduction of d. Summarizing, Table 6 displays an overview about the adapted ranges and applicable charges of scenario 2:

Ranges q	**Lower Limit** L_q^u	**Upper Limit** L_q^o	**Charge if IC** $\mathbf{A_q}$	**Charge if DC AM** $\mathbf{A_q}$
1	0.000	0.000	0	0
2	0.00000003	0.090	10 000	10 000
3	0.091	0.820	10 000	100
4	0.821	1.000	0	0
5	1.010	1.090	10 000	10 000
6	1.091	1.820	10 000	100
7	1.821	2.000	0	0
8	2.010	2.090	10 000	10 000
9	2.091	2.820	10 000	100
10	2.820	3.000	0	0
11	3.010	3.090	10 000	10 000
12	3.091	3.820	10 000	100
13	3.820	4.000	0	0
14	4.010	4.090	10 000	10 000
15	4.091	4.820	10 000	100
16	4.820	5.000	0	0
17	5.010	100.000	0	0

Table 6: Adapted Ranges for Scenario 2 (own illustration)

4.6.3. Scenario 3 – Decentralized Supply Management

The third scenario is designed in order to display the possibilities of a decentralized sourcing system and a decentralized distribution network. The central warehouse or DC is removed and replaced by a simple hub, which functions mainly as a cross-docking station, whose main purpose is the bundling of deliveries in order to save transportation costs. Consequently, the main focus is put on the intercompany fulfilment of demands. Figure 12 represents scenario 3.

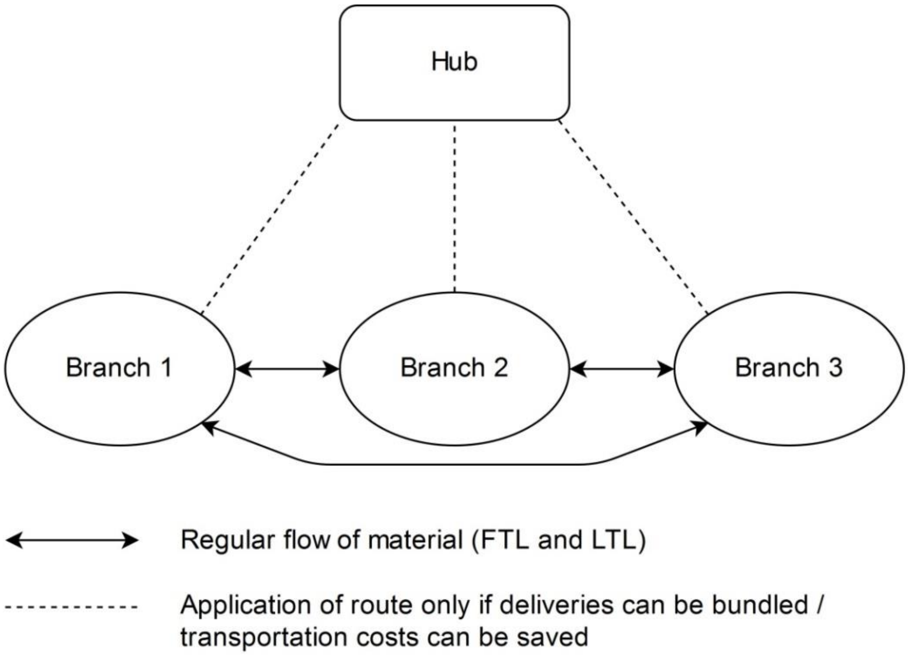

Figure 12: Illustration of Material Flow in Scenario 3 (own illustration)

Adaptations

In order to be able to implement this scenario, the DC as a never-ending supply-source is removed from the data. While constraints (1) – (6) are still valid, the model has to be modified in addition. In order to ensure that the hub is only used as a kind of cross-docking station to bundle deliveries, the constraint (7) is added, ensuring that the sum of all inbound deliveries needs to equal the sum of the outbound deliveries. This constraint secures that no overstock material is stored in the hub. In detail, the equality of inbound and outbound flows from and to the DC is ensured by equating the total amount of inbound deliveries of all products p from all branches i to the total amount of outbound deliveries from the DC to all receiving branches j. (7) is implemented as following:

$$\sum_{i=1}^{n} s_{iDCp} = \sum_{j=1}^{m} s_{DCjp} \qquad \forall\, p \in \{1, \dots, z\} \qquad (7)$$

Regarding the surcharges, it has to be mentioned that again the same ranges and surcharges are implemented as in scenario 1, i.e. regular charges for LTL and no charge for FTL.

4.7. Data Collection

After the establishment of the mathematical model, relevant data is collected. In this respect, especially data in regard to various accruing costs as well as data concerning the inventory and demand situation is raised. The data is provided either by internal and external logistical experts or by data specialists, who extract the data from the system. If no data can be extracted, appropriate assumptions are made by company experts.

First of all, the decision regarding the limitation of branches has to be made. It is decided to focus on selected branches in Central and Eastern Europe since the inclusion of all branches and all DCs worldwide would be on the one hand too complex and on the other hand not reasonable since intercompany exchange on the broad scale only makes sense via land transportation. Therefore, it is decided to focus on the branches, as illustrated in Figure 13. Due to the close distance of the DPR, the DC and the branch Amstetten, the red mark indicates those three locations.

Figure 13: Overview of Selected Branches (own illustration)

In order to receive a comprehensive insight into the demand situation, demand signals of 30 reference dates (RD) is collected. More precisely, the retrieved data per RD represents the aggregated demand for the upcoming four weeks. Although in reality, the transports of the goods are split over the next four weeks, the model assumes that the entire demand is delivered on one day. This explains the high total amount of trucks required. In detail, the data consist of the need quantity of every product available in the Doka system on the basis of pieces for the upcoming four weeks. However, in order to consider only relevant products, it is decided to triage the product portfolio in advance. Doka has in total about 16,000 products listed in the system, of which approximately 9,500 products can be regarded as the standard portfolio. Those 9,500 products are evaluated regarding their demand signals and those items with no demand signal are eliminated. After this step, roughly 750 to 850 articles, depending on the RD, remain in the product pool. In this regard, it is decided to focus on randomly chosen 700 products as representative sample per RD. On average, the demand consists of approximately 126,500 pieces with a median of approximately 128,700 pieces. The mean weight per RD is about 58,600 kg for the 700 products, which represents the sum of the weight of the products without taking the detailed demand of every product into consideration. Table 7 represents the demand and weight figures.

Average Demand (pcs.)	Median Demand (pcs.)	Min Demand (pcs.)	Max Demand (pcs.)	Average Weight (in kg)
126 578	128 713	105 745	140 325	58 631

Table 7: Overview Demand and Weight – Consolidated for all Reference Days (own illustration)

In order to be able to calculate the transportation costs, data regarding distances between the branches and transportation costs per km is gathered and processed. Since the SCM-tool also calculates with distances, it is decided to rely on this information. Regarding the data concerning transportation costs, experts from the logistical department provide the relevant data in consultation with a forwarding agency.

5. Results

As evaluation criteria, it is decided to focus first of all on the analysis of the total costs. In this respect, the three sub-models are compared in regard to the total occurring transportation costs including both, transportation costs and respective surcharges. Secondly, the transported weight per kilometer is analyzed. In detail, this evaluation displays the total truckload factor in relation to the total shipping distance which is interpreted as the efficiency of the conducted shipments. Thirdly, the fill rate is assessed. The fill rate represents the truckload factor per truck and respectively also the amount of trucks necessary per connection. Consequently, it is interpreted, how many trucks are conducted as LTs and how many trucks origin in the DC.

5.1. Results Scenario 1

First of all, scenario 1 displays in terms of total logistics costs results ranging from 171,924 € up to 329,714 €. The lowest total transportation costs on RD 12 can be explained by the low demand situation of this RD. In contrast, the highest value of RD 26 results from a high total weight of the products of the specific RD although the demand signals are still significantly below the average demand values of all RDs. The average total value accounts for 258,839 € and the median comes to 253,846 €. In detail, the values are presented in Figure 14.

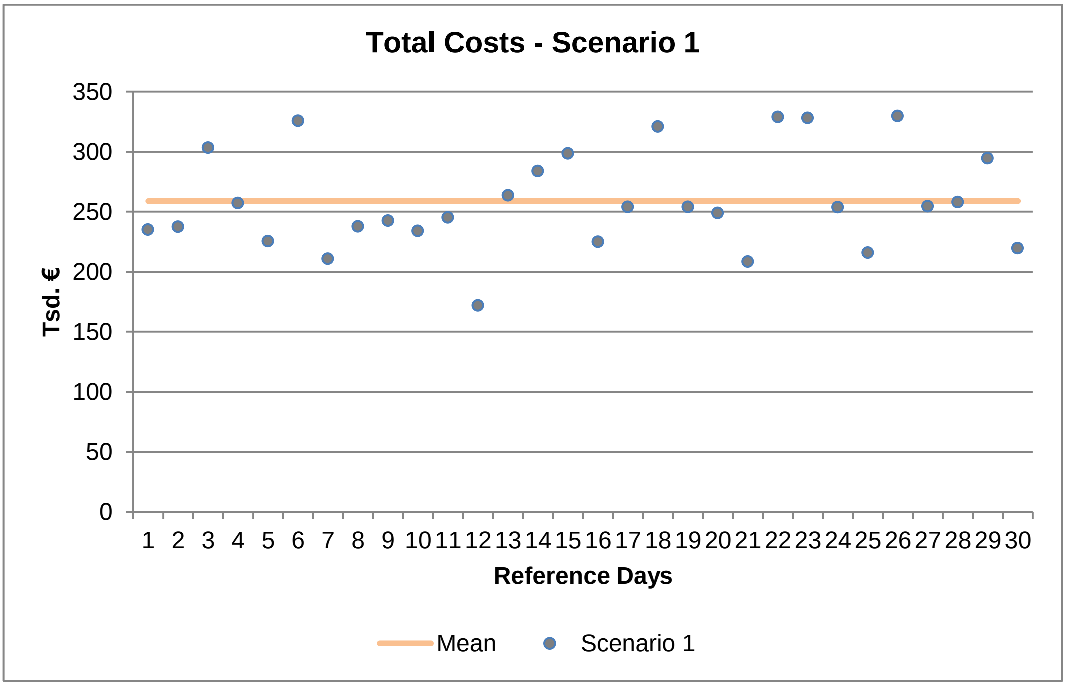

Figure 14: Total Costs, Scenario 1 (own illustration)

In order to compare the truckload factor, the total weight transported per RD is divided by the total distance. Scenario 1 displays a range from 120 kg/km to 197 kg/km and an average value of 158 kg/km transported. RD 12 achieves again the lowest value of 120 kg/km which can be explained by the low general demand situation and a high distribution of the respective supply sources. In contrast, the highest value of 197 kg/km is presented by RD 3, which results from significantly higher demand signals of this RD compared to the average demand signals. Furthermore, the total weight transported on this RD is obviously higher than on the other RDs. In detail, Figure 15 illustrates the distribution of the 30 RDs.

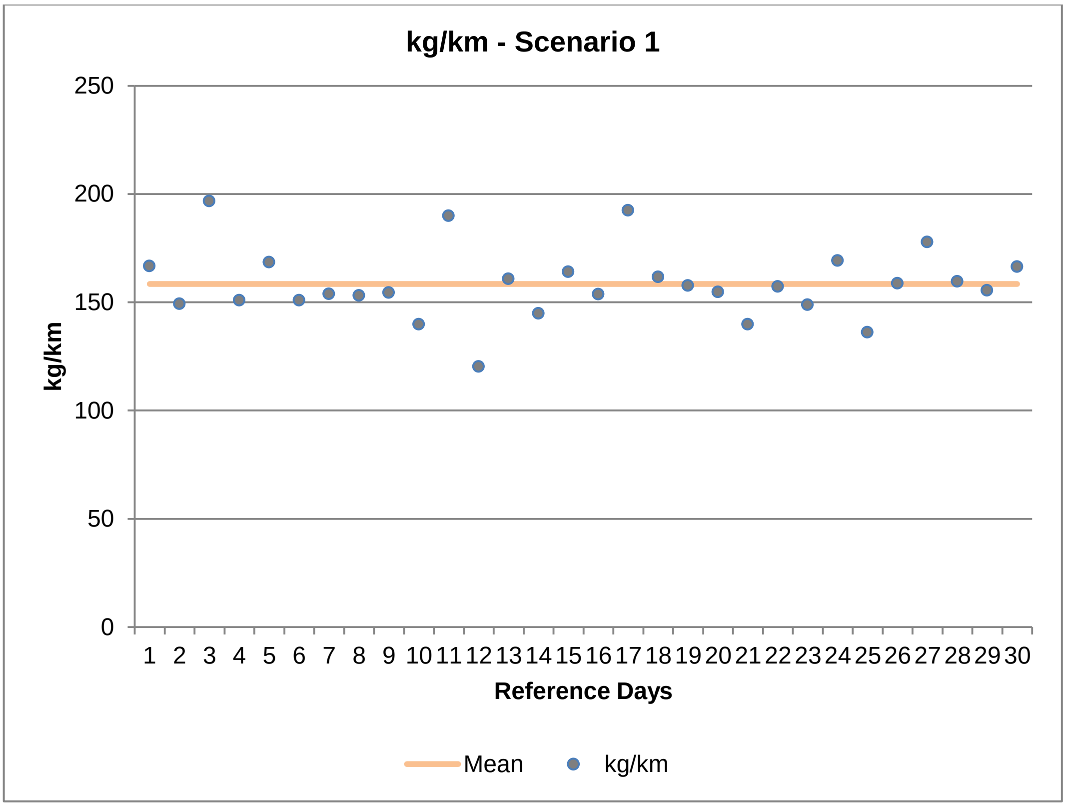

Figure 15: Transported Weight per Kilometer, Scenario 1 (own illustration)

Moreover, the fill rate is evaluated, which represents the truckload factor as well as the amount of truckloads required in order to fulfil the customer demand. The results regarding the fill rate are illustrated in Figure 16.

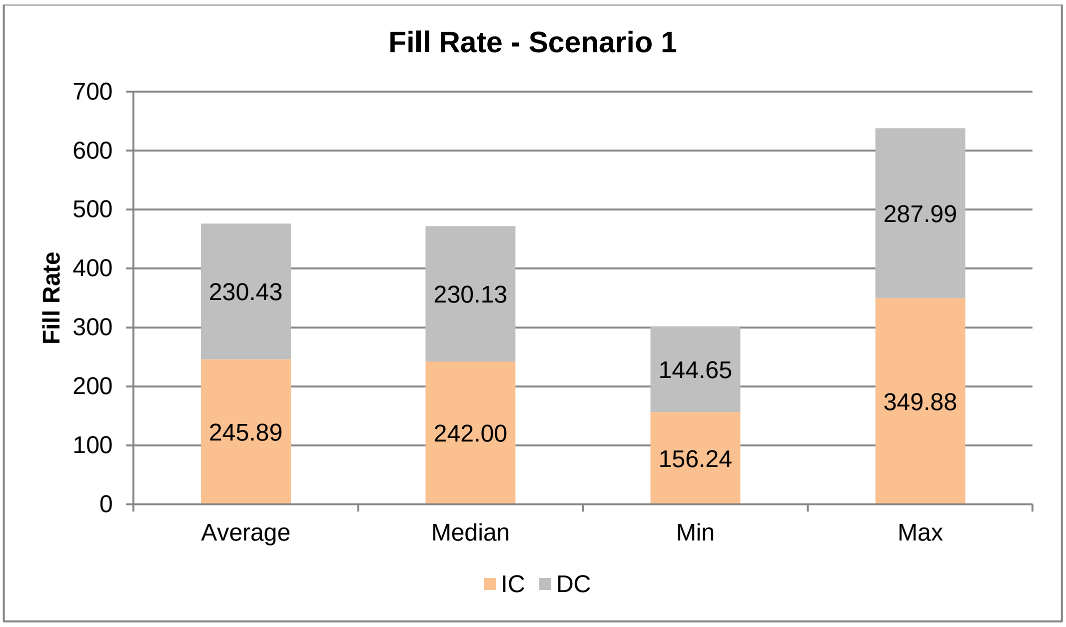

Figure 16: Fill Rate, Scenario 1 (own illustration)

In total, the aggregated fill rate amounts to 476.32, divided into 245.89 standing for the fill rate of intercompany shipments, and 230.43 for deliveries from the DC. The aggregated fill rate can be equalized to the lower bound of the amounts of trucks needed. In this regard, it displays that a minimum of 246 trucks are conducted as LTs and 230 trucks origin in the DC. The median of intercompany shipments comes to a minimum of 242.00, while the median of DC deliveries accounts for 230.13. In order to encompass the whole range of fill rates, also the minimum and maximum values are displayed. In this regard, the minimum value of fill rate for LTs is 156.24, the maximum 349.88. In contrast, the minimum value for DC deliveries amounts to 144.65, the maximum value to 287.99. These figures show that tendentially a higher amount of material is transported via LTs.

Furthermore, in this context, the amount of utilized connections is evaluated. It is shown that only 21 percent of connections used are originating in the DC. Consequently, 79 percent of connections are utilized for intercompany shipments. When comparing those results to the fill rate, it becomes obvious that the minimum of 246 shipments that are conducted between branches, account for 79 percent of total connections used, whereas the 230 trucks originating in the DC represent only 21 percent of connections. This implies that deliveries from the DC are more efficient since more trucks are utilized for less connections and this demonstrates that the trucks have a higher load factor.

5.2. Results Scenario 2

As in scenario 1, the total transportation costs, transported weight per distance, fill rate as well as the utilized connections are evaluated. The minimum total costs of scenario 2 are 174,963 € while the highest value are 332,985 €. These values are again recorded on RD 12 for the lowest and on RD 26 for the highest value. This is of course justified due to the same demand and supply signals as in scenario 1. The average total costs account for 262,360 €, while the median is situated at 256,717 €. The dispersion of total costs is displayed in Figure 17.

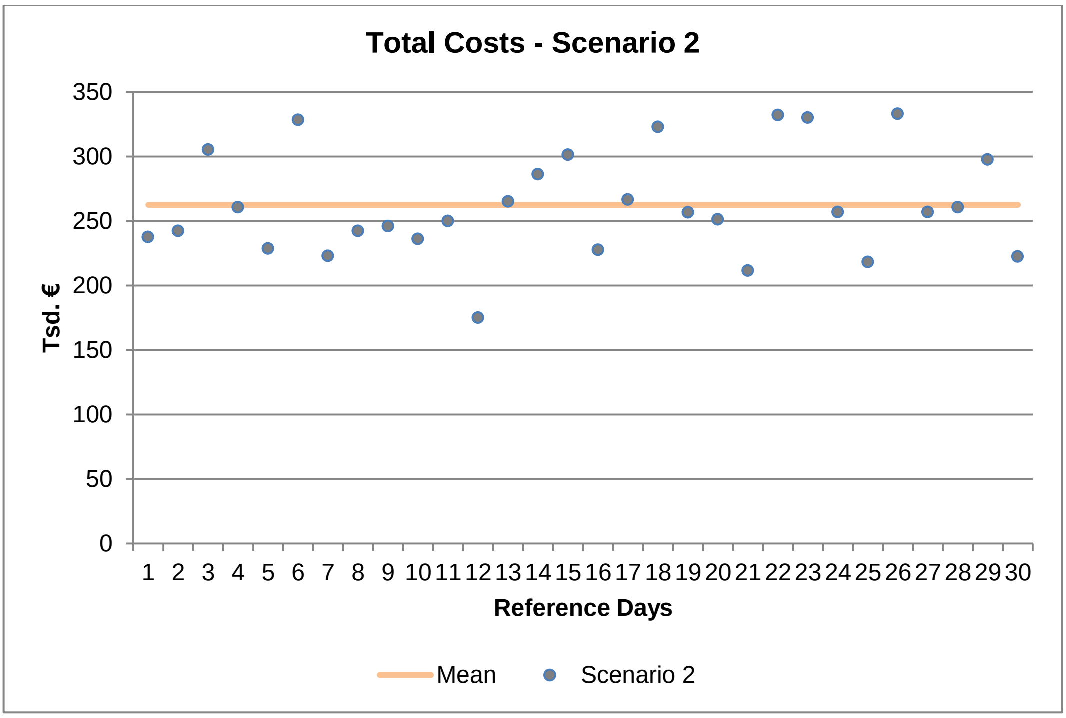

Figure 17: Total Costs, Scenario 2 (own illustration)

Secondly, the results regarding the transported weight per distance range from 117 kg/km up to 229 kg/km. Again, these figures are presented by RD 12 and RD 3 respectively. On average, 173 kg are transported per km and a median of 170 kg/km is achieved. The values for all RDs are displayed in the following Figure 18.

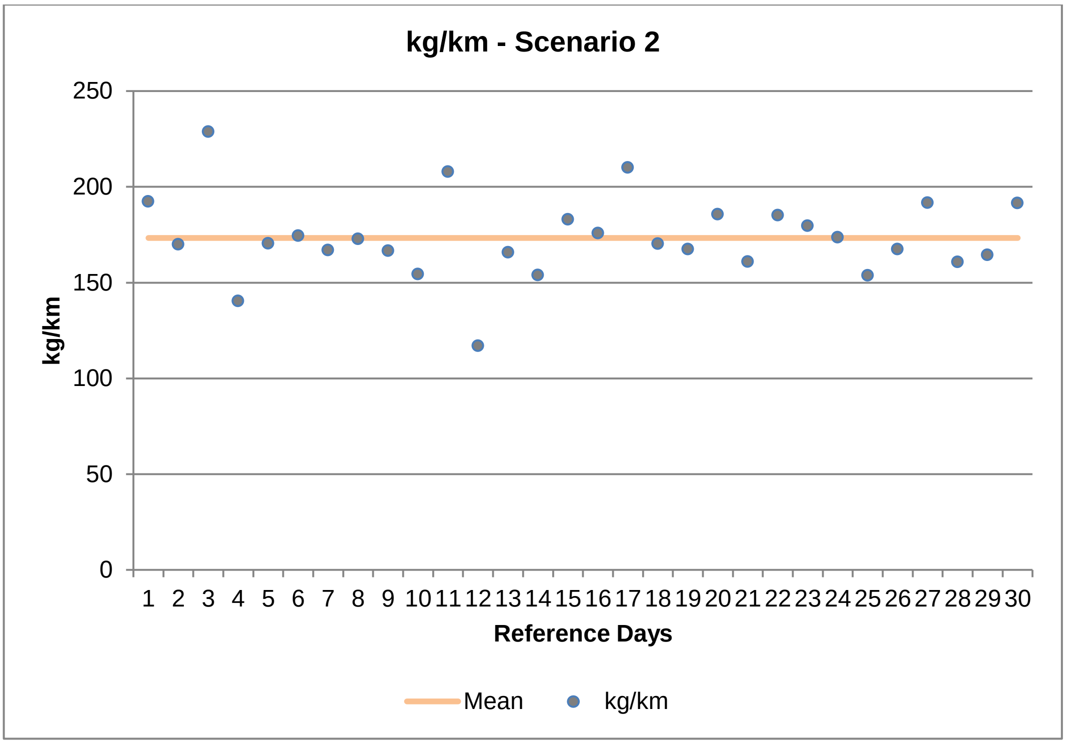

Figure 18: Transported Weight per Kilometer, Scenario 2 (own illustration)

Thirdly, scenario 2 displays a mean aggregated fill rate of 476.32, which is of course the same value for all three scenarios due to the same demand data. Nevertheless, the division of intercompany and direct deliveries varies for the three scenarios. In this scenario, the intercompany fill rate accounts for 236.68, which signifies that a minimum of 237 truckloads are conducted as LTs. The average minimum of trucks leaving the DC sums up to about 240 truckloads. In this respect, it can be said that the lower bound of trucks needed can be considered as equal in this scenario. The median of intercompany fill rate amounts to 232.52, while the median of DC deliveries comes to 239.21. Intercompany shipments range from about 150 fill rate up to 344, while direct deliveries from the DC range from 151 up to 296 approximately. Figure 19 illustrates the distribution of intercompany fill rates versus fill rates from direct deliveries of the DC.

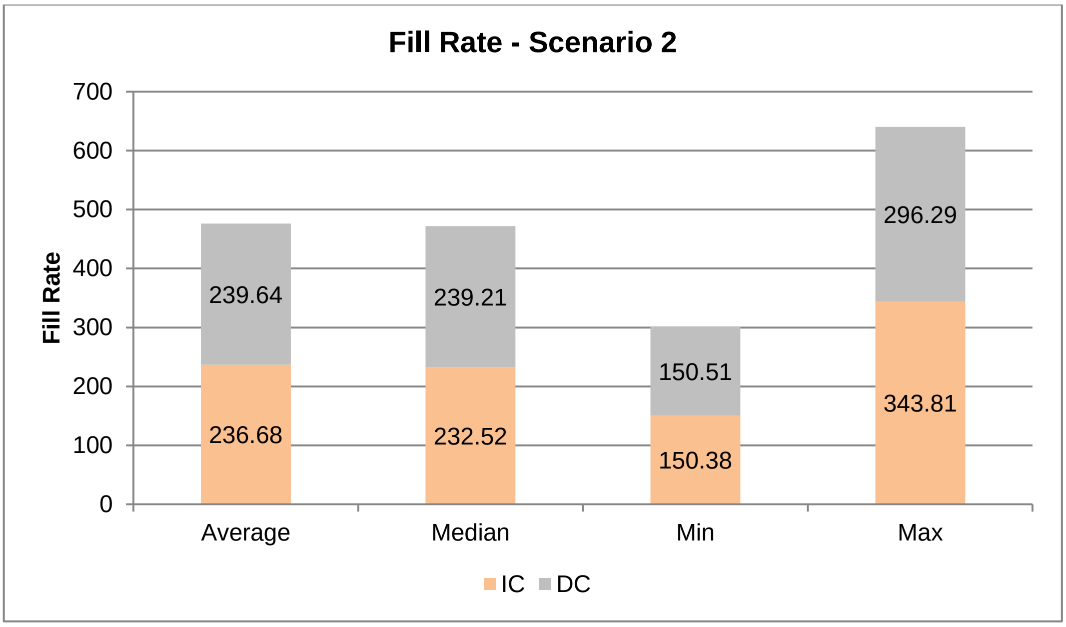

Figure 19: Fill Rate, Scenario 2 (own illustration)

Furthermore, a slight shift of the utilized connections in comparison to scenario 1 is observed. In this regard, the results of scenario 2 display that the average intercompany fill rate of 236.68 accounts for 76 percent of utilized connections between branches, whereas the mean fill rate of the DC of 239.64 is only responsible for 24 percent of utilized connections.

5.3. Results Scenario 3

First of all, when analyzing the results of scenario 3, the higher total logistics costs become obvious, as illustrated in Figure 20. These results display average total costs of 702,957 € and a median of 721,311 €. The minimum total costs account for 550,572 € while the maximum total costs come to 856,484 €. In contrast to scenario 1 and 2, the lowest value is generated in RD 2. Although RD 2 has higher demand signals than the average RDs and average weight values, the lowest total transportation costs are explained by the fact that the total transported weight of this day is significantly below average. In this respect, also less than average truckloads are required for this RD. In contrast, the highest value of 856,484 € is received on RD 7. The reason therefore is a significantly high demand situation.

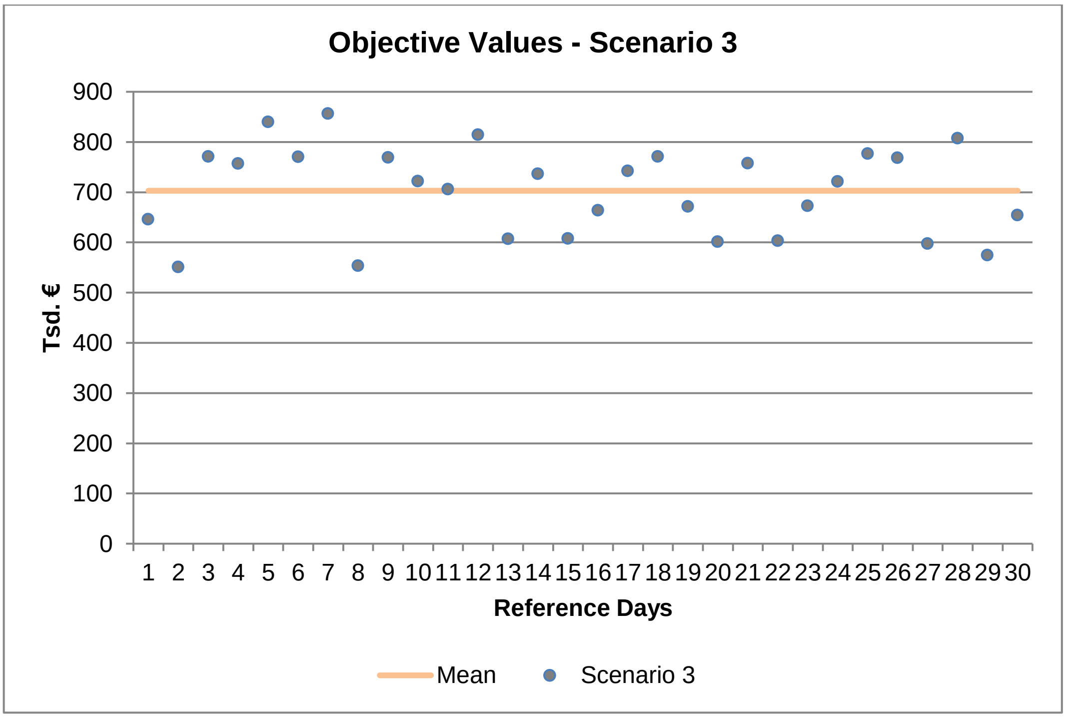

Figure 20: Total Costs, Scenario 3 (own illustration)

Secondly, also the transported weight per kilometer of scenario 3 displays significantly different results as the other two scenarios. Scenario 3 has an average transported weight of 30 kg/km and a median of 31 kg/km. The values range from 19 kg/km up to 37 kg/km. The values are illustrated in Figure 21.

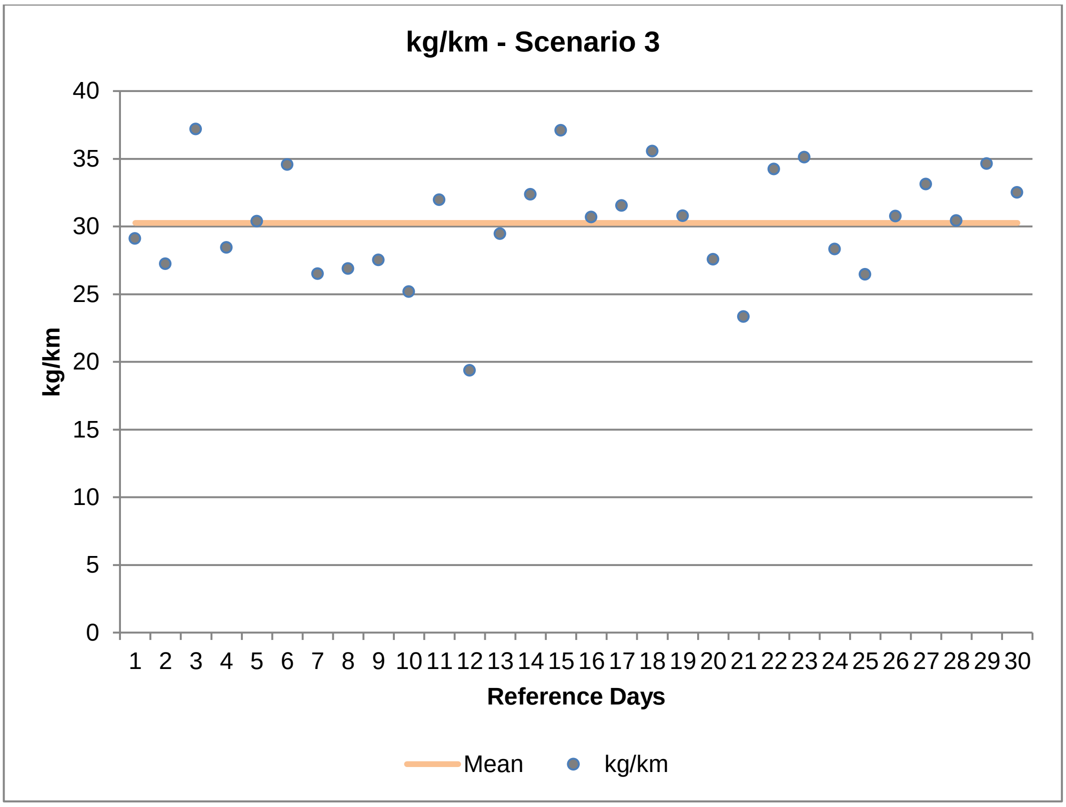

Figure 21: Transported Weight per Kilometer, Scenario 3 (own illustration)

Moreover, regarding the fill rate it has to be mentioned, the shipments are only conducted via intercompany shipments since there is no central warehouse or DC. Therefore, the average aggregated fill rate comes to 476.32, the median to 486.23. The minimum fill rate is 300.89, the maximum fill rate 579.78, which signifies a range from approximately 300 up to 580 truckloads in total. The lowest fill rate is received on RD 12 due to very low demand signals and low total weight of the product portfolio of this specific RD. In contrast, the highest value of at least 580 truckloads is observed at RD 3 due to high demand figures and additionally high total weight. The figures regarding the aggregated fill rate are displayed in Figure 22.

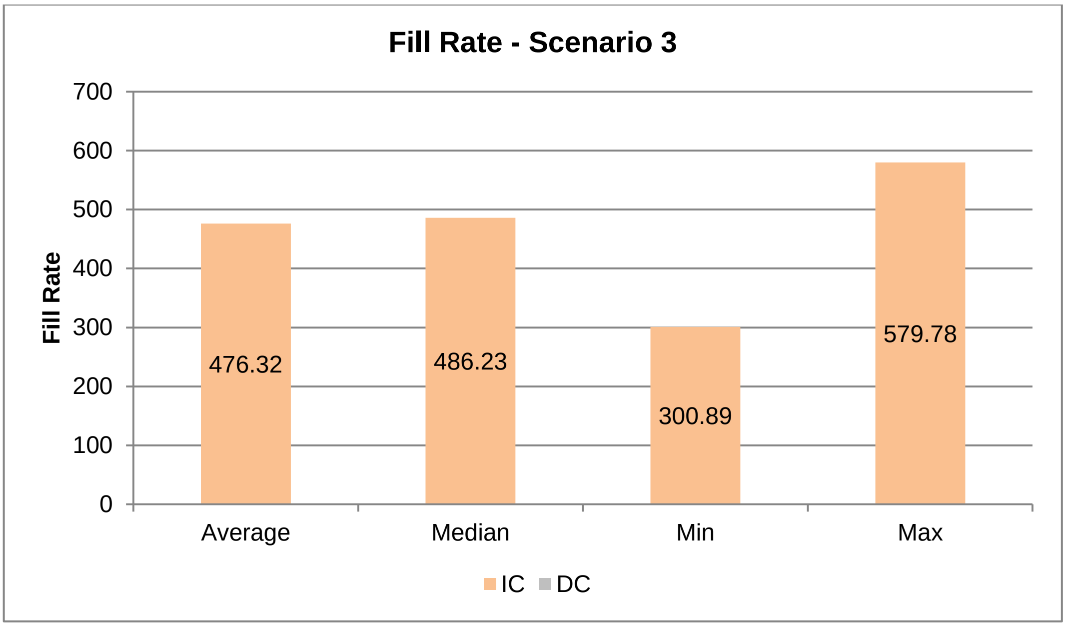

Figure 22: Fill Rate, Scenario 3 (own illustration)

5.4. Summary Results

When comparing the results, it becomes obvious that in regard to the total value, scenario 1 receives marginal better results than scenario 2. This can be explained by the fact that scenario 2 is a restricted version of scenario 1. In contrast, scenario 3 displays in comparison to the other two scenarios the highest values in all RDs. This is due to the fact that scenario 3 requires more shipments in order to fulfil the total customer demand. However, it needs to be mentioned that although scenarios 1 and 2 receive better results in regard to transportation costs, additional costs might arise in regard to overhead costs or increased complexity of processes. The comparison of total transportation costs is illustrated in Figure 23.

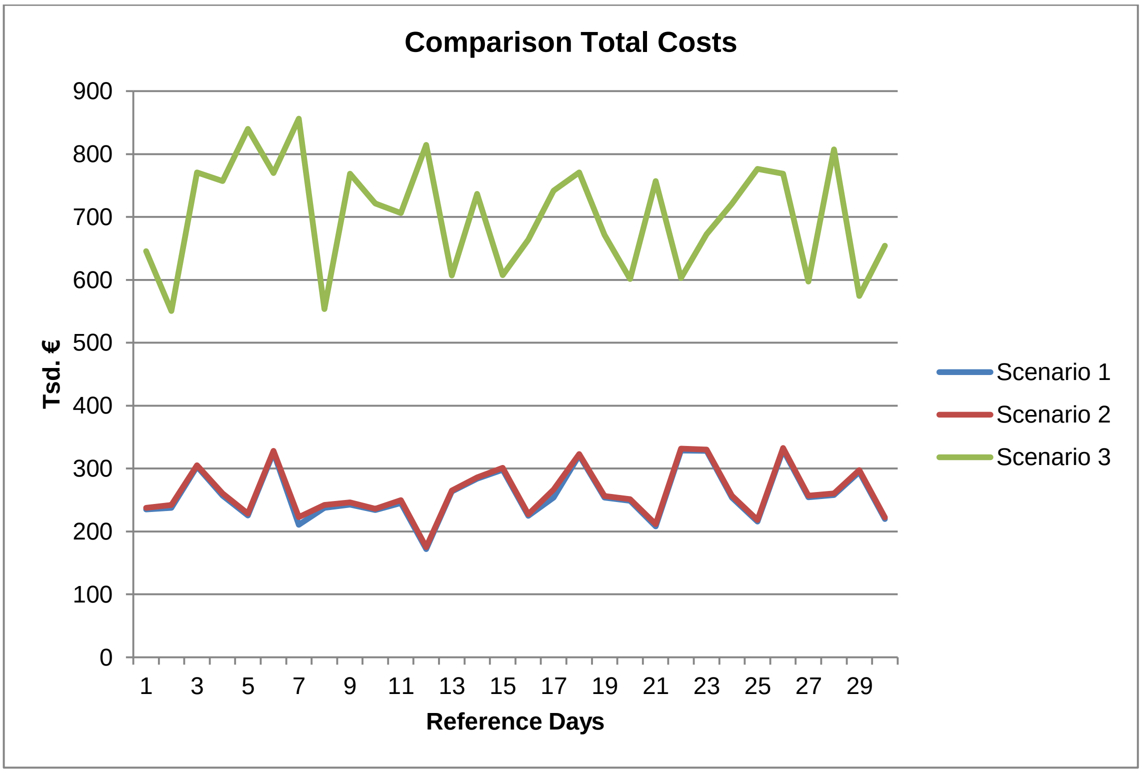

Figure 23: Comparison Objective Values, Scenarios 1-3 (own illustration)

Furthermore, a detailed analysis of the total costs is represented by Figure 24. It shows the marginal differences of scenario 1 and 2 and the significantly larger values of scenario 3.

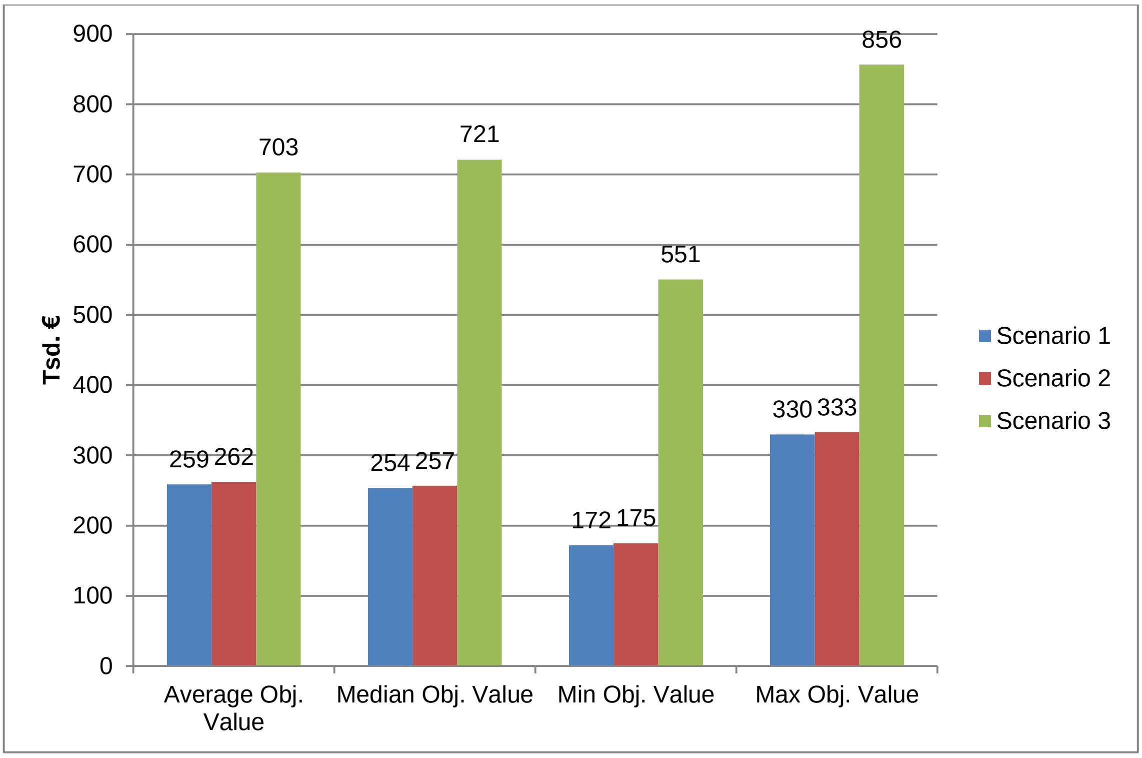

Figure 24: Detailed Comparison Objective Values, Scenarios 1-3 (own illustration)

The higher values of scenario 3 are explained by the higher amount of connections used in order to fulfil the customer demand, which is illustrated in Figure 25. As a result of the necessary higher amount of connections used, the trucks only carry a smaller weight. This is illustrated by the transported weight per kilometer. The comparison of the transported weight per kilometer is displayed in Figure 26.

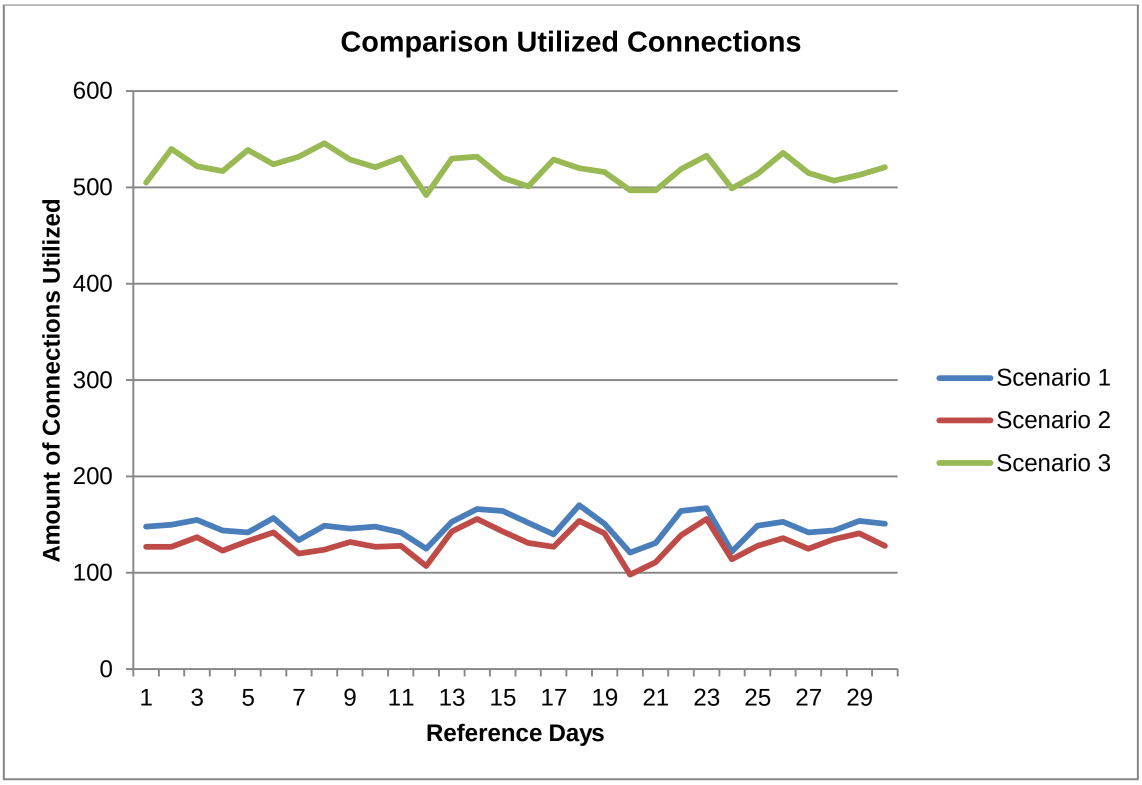

Figure 25: Comparison Utilized Connections, Scenarios 1-3 (own illustration)

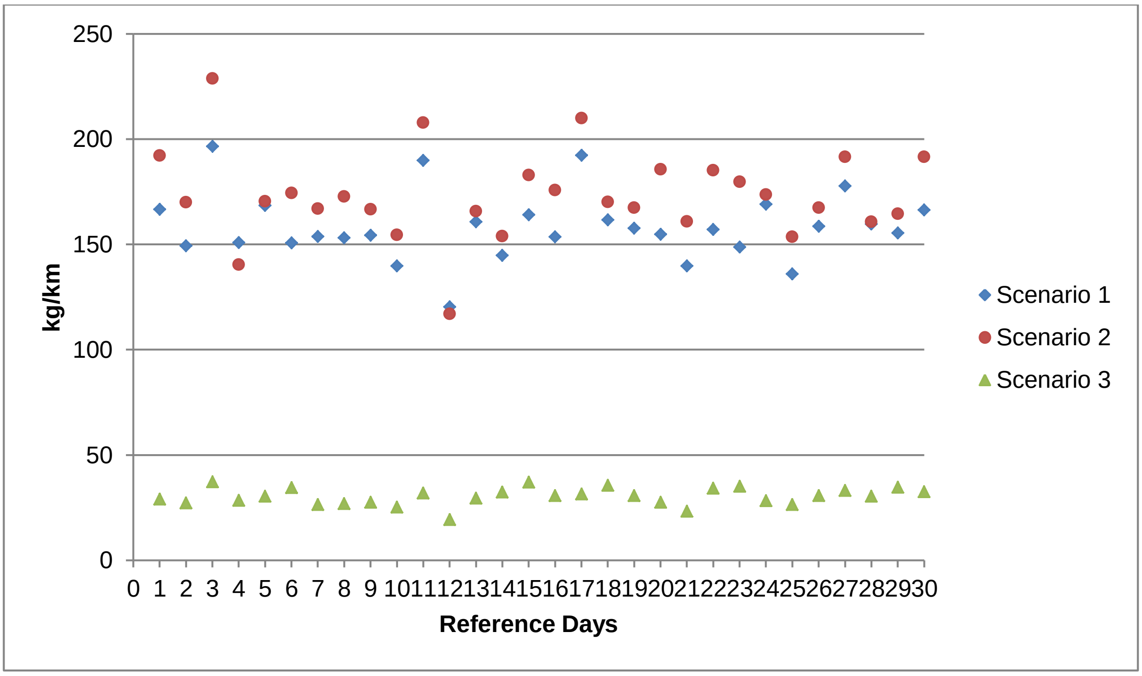

Figure 26: Comparison Transported Weight per Kilometer, Scenarios 1-3 (own illustration)

Shipments in scenario 3 carry on average five to six times less weight per truckload than shipments of scenario 1 or 2. This lower transported total weight is explained by the different allocation of supply across the branches. In this regard, a different allocation of supply might be able to lead to different results. Consequently, scenario 3 might receive lower total costs if supply is allocated close to the demand. Nevertheless, due to the fact that the figures of scenario 3 are in all RDs significantly higher compared to the other two scenarios, it can be concluded that also a different dispersion of supply would not lead to a reduction of shipments by approximately 70 to 80 percent.

In this respect, according to the chosen parameters, RDs and demand-situation, the mixed situation of scenario 1 receives slightly better results than scenario 2; nevertheless, due to merely marginal differences, the outcomes of scenarios 1 and 2 can be regarded as equal. Therefore, when deciding about either implementing a centralized or decentralized approach, the results show that the centralized approach displays lower costs, at least in regard to the evaluated costs. This can be explained by the central location of the DC, which ensures close distances and hence also lower transportation costs, which is the main criterion in this conducted research. In this respect, the location of supply and demand basically determines the success potential of a SC strategy and has high influence on the total costs. This outcome can also be underlined by the literature, which emphasizes the application of LTs and inventory pooling in addition to centralized sourcing and transportation. However, in addition to transportation costs, inventory holding costs need to be compared and also the costs of a CSM-department need to be analyzed.

Visualization Results

The following illustrations in Figure 27-30 display the entire flow of shipments across the branches consolidated for the RD 1 as example RD. Figure 27 highlights the strong flows originating from the DC towards the branches, but shows also the LTs.

Figure 27: Flow of Transports, Scenario 1 (own illustration)

Figure 28 shows the visualization of the shipments of scenario 2 of RD 1. It displays that this scenario has a strong focus on centralized deliveries. In addition to this, LTs are especially conducted if there is a larger distance to the DC as displayed for example in Romania and Bulgaria or in Poland and Baltic countries.

Figure 28: Flow of Transports, Scenario 2 (own illustration)

Figure 29 illustrates again the distribution of shipments between the branches of RD 1. It displays the high amount of shipments across the branches and the large distribution network.

Figure 29: Flow of Transports, Scenario 3 (own illustration)

6. Discussion

In this work, outcomes from literature research are merged with findings from the implementation of the linear model in the optimization software FICO® Xpress. The aim is the combination of those results in order to compare and rank the different centralization approaches. This ranking is conducted according to the cost efficiency potential of those approaches in terms of transportation costs and general advantages or disadvantages extracted from literature.

The outcomes of the literature research display different benefits and drawbacks for each of the three approaches. Centralized supply management has shown to generate advantages mainly derived from synergy benefits in terms of EOS, EOI and EOP. Corporate strategies can be established easier and consequently, also global sourcing strategies can be pursued more effectively. Moreover, due to central stock keeping, general inventory levels and safety stocks can be kept low which decreases total inventory holding costs. Nevertheless, due to rigid organizational structures, processes have proven to be more inflexible and thus, the organization cannot react quickly to market changes. Furthermore, as a result of the higher distance to the end customers, there is less responsiveness to their requirements and also a lack of information about those needs. Additionally, there might be a resistance against the implementation of a centralized system and it can be difficult to convince local business managers of the new approach. Finally, increased overhead costs for a CSM-department as well as costs for the operation of a DC have to be taken into consideration.

In contrast, according to the researched literature, decentralized supply management derives its main advantages by the close distance to the customers. As a consequence, customer service levels performance can be improved, which leads in turn to higher customer satisfaction and higher reputation. Furthermore, a decentralized approach benefits from extensive direct decision-making powers and associated flexibility and higher speed of operation. Additionally, overhead costs can be reduced by avoiding a centralized department or a DC. Moreover, local sources can be utilized more efficiently and the relationship to local suppliers is ameliorated. Nevertheless, due to the dispersion of purchasing competences, communication between business units is difficult. Furthermore, business unit preferences may differ from corporate strategies. In this respect, business unit managers may also optimize on their local performance while neglecting total organizational costs.

Finally, the hybrid approach has its main strength in the combination of location-specific advantages with company-specific competences. In this respect, the organization can derive benefits by local advantages such as local supply, labor markets or local know-how. Nevertheless, at the same time the organization can take advantage of mutual cross-national requirements and conduct global sourcing. Additionally, a mutual organizational strategy can be performed which poses no contradiction between local needs and organizational-wide policies. Nevertheless, a hybrid approach requires a certain adaptation of the organizational structure. In addition to this, if the enterprise decides to separate the competences regarding certain product categories, this categorization might be difficult.

In addition to these outcomes from literature research, the results from the implementation of the linear model were analyzed as well. The research and the comparison of the three scenarios have displayed a trend towards the maintenance of centralized features. In detail, scenario 1 showed slight better results than scenario 2. In this regard, also the commitment of LTL shipments can be recommended at least according to the extent of the conducted research. The combination of a centralized managed SC in combination with decentralized features such as inventory pooling and LTs shows advantages in terms of total transportation costs. When including the outcomes from the literature research, the implementation of a hybrid approach should be considered. As mentioned beforehand, a hybrid approach aims to combine the efficiency and control of a centralized supply management with the flexibility and increased service level of decentralized supply management [28]. In addition to the application of decentralized features, a hybrid approach is characterized by a division of responsibilities. In this respect, branches receive more responsibilities and are permitted to take their own decisions within a predefined scope. Regarding this mentioned scope, one possibility is the division of responsibilities based on different product categories [35].

The research has displayed that the intercompany exchange of material also with LTL shipments is promising. Therefore, this strategy should be incorporated in the daily sourcing business of both, the central supply management department and the branches. In this regard, a re-evaluation of the current prioritizing rules is recommended. According to the conducted research, intercompany exchange of material should be prioritized over deliveries from the DC due to various factors. First of all, especially in branches with larger distance to the DC, intercompany exchange should always be prioritized due to lower transportation costs, also for LTL shipments. Nevertheless, also if branches are located closer to the DC, LTs are reasonable due to the better utilization of inventory and probable lower transportation costs.

Secondly, overstocks can be balanced more equally and the exchange of excess material prevents overstock deliveries back to the DC. In this regard, not only transportation costs might be saved but also inventories can be used more efficiently and handling capacities of the DC can be optimized.

In the case of the current prioritizing system, as illustrated in scenario 2, with the main focus on deliveries from the DC and FTL intercompany shipments, higher costs may occur due to inefficient use of inventory and due to higher transportation distances. In this respect, centralization can only be recommended in combination with an intensive use of reasonable LTL shipments and consequently, inventory pooling. Furthermore, a complete decentralized approach as presented in scenario 3, including the closure of the DC and installation of a simple cross-docking station without any inventory keeping, cannot be recommended as well. The central warehouse has proven to be reasonable according to the conducted research at least in terms of transportation costs. In addition to this, a complete liquidation might not be possible due to limited inventory storage capacities of some branches. In this respect, some branches might not even be able to store the entire material for the upcoming customer demand within their own branch.

7. Conclusion

MNEs need to cope with worldwide increasing competition. Therefore, it is important, to develop organizational strategies in order to stay competitive and achieve global efficiency. In the case of the Doka GmbH, the organizational structure is strongly influenced by the significant importance of the rental business. This business type makes the implementation of a global supply strategy difficult. Nevertheless, especially in such a case, the incorporation of an elaborated supply management is important. Hereby, various factors need to be considered and defined. One major decision in this regard is the degree of centralization. Both centralized and decentralized supply strategies have its advantages and disadvantages. Nevertheless, the conducted research recommends a tendency towards a hybrid approach for the Doka GmbH, including a central supply management department and a DC, while incorporating and intensifying inventory pooling and LTs between branches. This direction should also be internalized by the supply planners and intercompany transports should be emphasized also in case of LTL shipments.

8. Limitations and Future Outlook

This Master's Thesis has some limitations which represent opportunities for future research. First of all, limitations in regard to the considered costs can be assumed as limitations. In the conducted research only transportation costs were considered. Future research might include inventory holding costs or inventory keeping limitations of the branches in their calculations. Another option might be the active promotion of milk-runs in the program in order to further optimize transportation costs. Furthermore, limitations arise in the area of the CSM-department. The conducted research does not incorporate any costs arising from this department. Therefore, one possibility for future research would be to include also CSM-department costs and costs arising directly in the branches in their models.

References

[1] A. Tchokogué, J. Nollet and K. Gobeil, “Supply structure:The pendulum in action,” *Journal of Purchasing & Supply Management,* vol. 17, no. 3, pp. 148-157, 2011.

[2] G. Trautmann, V. Turkulainen, E. Hartmann and L. Bals, “Integration in the Global Sourcing Organization - An Information Processing Perspective,” *Journal of Supply Chain Management,* vol. 45, no. 2, pp. 57-74, 2009.

[3] I. Giannoccaro, “Centralized vs. decentralized supply chains: The importance of decision maker's cognitive ability and resistance to change,” *Industrial Marketing Management,* vol. 73, pp. 59-69, 2018.

[4] U. Arnold, “Organization of global sourcing: ways towards an optimal degree of centralization,” *European Journal of Purchasing & Supply Management,* vol. 5, no. 3-4, pp. 167-174, 1999.

[5] G. Trautmann, L. Bals and E. Hartmann, “Global sourcing in integrated network structures: The case of hybrid purchasing organizations,” *Journal of International Management,* vol. 2, pp. 194-208, 2009.

[6] Doka, *Schulungsunterlagen,* Amstetten, 2019.

[7] E. Rabinovich, R. Windle, M. Dresner and T. Corsi, “Outsourcing of integrated logistics functions,” *International Journal of Physical Distribution & Logistics Management,* vol. 29, no. 6, pp. 353-374, 1999.

[8] R. E. Spekman, J. Kamau and J. Spear, “Towards more effective sourcing and supplier management,” *European Journal of Purchasing & Supply Management,* vol. 5, no. 2, pp. 103-116, 1999.

[9] S. Cannella, M. López-Campos, R. Domingueza, J. Ashayeric and P. A. Miranda, “A simulation model of a coordinated decentralized supply chain,” *International Transactions in Operational Research,* vol. 22, no. 4, pp. 735-756, 2015.

[10] M. Juha and J. Pentti, “Managing risks in organizational purchasing through adaptation of buying centre structure and the buying process,” *European Journal of Purchasing & Supply Management,* vol. 14, no. 4, p. 253–262, 2014.

[11] J. Meissner and O. V. Senicheva, “Approximate dynamic programming for lateral transshipment problems in multi-location inventory systems,” *European Journal of Operational Research,* vol. 265, no. 1, pp. 49-64, 2018.

[12] J. A. Odhiambo and S. Odari, “Effects of Centralised Purchasing on Organizational Efficiency: A Case Study of Florensis Kenya Limited,” *IOSR Journal of Business and Management,* vol. 11, pp. 68-78, 2016.

[13] P. F. Johnson and M. R. Leenders, “The Supply Organizational Structure Dilemma,” *The Journal of Supply Chain Management,* vol. 37, no. 3, pp. 4-11, 2001.

[14] F. Jia, R. Lamming, M. Sartor, G. Orzes and G. Nassimbeni, “International purchasing offices in China: A dynamic evolution model,” *International Business Review,* vol. 23, no. 3, pp. 580-593, 2014.

[15] M. Chuang, J. J. Donegan, M. W. Ganon and K. Wei, “Walmart and Carrefour experiences in China: resolving the structural paradox,” *Cross Cultural Management: An International Journal,* vol. 18, no. 4, pp. 443-463, 2011.

[16] S. Chopra, “Designing the distribution network in a supply chain,” *Transportation*

Research Part E: Logistics and Transportation Review, vol. 39, no. 2, pp. 123-140, 2003.

[17] V. Jayaraman, “Transportation, facility location and inventory issues in distribution network design,” *International Journal of Operations & Production Management,* vol. 18, no. 5, pp. 471-494, 1998.

[18] H. S. Matthews and C. T. Hendrickson, “The Economic and Environmental Implications of Centralized Stock Keeping,” *Journal of Industrial Ecology,* vol. 6, no. 2, pp. 71-81, 2008.

[19] H. Andersson, A. Hoff, M. Christiansen, G. Hasle and A. Løkketangen, “Industrial aspects and literature survey: Combined inventory management and routing,” *Computers & Operations Research,* vol. 37, no. 9, pp. 1515-1536, 2010.

[20] P. Feng, R. Y. Fung and F. Wu, “Preventive transshipment decisions in a multi-location inventory system with dynamic approach,” *Computers & Industrial Engineering,* vol. 104, pp. 1-8, 2017.

[21] J.-H. Kang and Y.-D. Kim, “Inventory control in a two-level supply chain with risk pooling effect,” *International Journal of Production Economics,* vol. 135, no. 1, pp. 116-124, 2012.

[22] P. Feng, F. Wu, R. Y. Fung and T. Jia, “Evaluation of two transshipment policies in a two-location decentralized inventory system under partial backordering,” *Transportation Research Part E: Logistics and Transportation Review,* vol. 118, pp. 207-224, 2018.

[23] B. Satır, S. Savasaneril and Y. Serin, “Pooling through lateral transshipments in service parts systems,” *European Journal of Operational Research,* vol. 220, no. 2, pp. 370-377, 2012.

[24] C. Paterson, G. Kiesmüller, R. Teunter and K. Glazebrook, “Inventory models with lateral transshipments: A review,” *European Journal of Operational Research,* vol. 210, no. 2, pp. 125-136, 2011.

[25] H. W. Bouma and R. H. Teunter, “The routed inventory pooling problem with three non-identical retailers,” *International Journal of Production Economics,* vol. 156, pp. 223-234, 2014.

[26] T. W. Archibald, S. A. E. Sassen and L. C. Thomas, “An Optimal Policy for a Two Depot Inventory Problem with Stock Transfer,” *Management Science,* vol. 43, no. 2, pp. 173-183, 1997.

[27] E. Melachrinoudis and H. Min, “Redesigning a warehouse network,” *European Journal of Operational Research,* vol. 176, no. 1, pp. 210-229, 2007.

[28] L. Bals, J. Laine and G. Mugurusi, “Evolving Purchasing and Supply Organizations: A contingency model for structural alternatives,” *Journal of Purchasing and Supply Management,* vol. 24, no. 1, pp. 41-58, 2018.

[29] A. Amiri, “Designing a distribution network in a supply chain system: Formulation and efficient solution procedure,” *European Journal of Operational Research,* vol. 171, no. 2, pp. 567-576, 2006.

[30] G. Van der Heide, P. Buijs, K. Roodbergen and I. Vis, “Dynamic shipments of inventories in shared warehouse and transportation networks,” *Transportation Research Part E: Logistics and Transportation Review,* vol. 118, pp. 240-257, 2018.

[31] R. Ishfaq and C. R. Sox, “Design of intermodal logistics networks with hub delays,” *European Journal of Operational Research,* vol. 220, no. 3, pp. 629-641, 2012.

[32] D. Çelebi, “Inventory control in a centralized distribution network using genetic algorithms: A case study,” *Computers & Industrial Engineering,* vol. 87, pp. 532-539, 2015.

[33] W. Faes, P. Matthyssens and K. Vandenbempt, “The Pursuit of Global Purchasing Synergy,” *Industrial Marketing Management,* vol. 29, no. 6, pp. 539-553, 2000.

[34] C. H. Glock and S. Hochrein, “Purchasing Organization and Design: A Literature Review,” *Business Research,* vol. 4, no. 2, pp. 149-191, 2011.

[35] K. Karjalainen, “Estimating the cost effects of purchasing centralization—Empirical evidence from framework agreements in the public sector,” *Journal of Purchasing and Supply Management,* vol. 17, no. 2, pp. 87-97, 2011.

[36] C. P. McCue and J. T. Pitzer, “Centralized vs. decentralized purchasing: current trends in governmental procurement practices,” *Journal of Public Budgeting, Accounting & Financial Management,* vol. 12, no. 3, pp. 400-420, 2000.

[37] P. F. Johnson, “The Pattern of Evolution in Public Sector Purchasing Consortia,” *International Journal of Logistics Research and Applications,* vol. 2, no. 1, pp. 57-73, 1999.

[38] P. Cousins, R. Lamming, B. Lawson and B. Squire, Strategic Supply Management - Principles, Theories and Practice, Essex, England: Prentice Hall, 2008.

[39] N. Dimitri, F. Dini and G. Piga, “When should procurement be centralized?,” in *Handbook of Procurement*, Cambridge , Cambridge University Press, 2006, pp. 47-81.

[40] D.-J. Lee and I.-J. Jeong, “Regression approximation for a partially centralized inventory system considering transportation costs,” *Computers and Industrial Engineering,* vol. 56, no. 4, pp. 1169-1176, 2009.

[41] N. Çömez-Dolgan and B. Tanyeri, “Inventory performance with pooling: Evidence from mergers and acquisitions,” *International Journal of Production Economics,* vol. 168, pp. 331-339, 2015.

[42] S. Vagstad, “Centralized vs. decentralized procurement: Does dispersed information call for decentralized decision-making?,” *International Journal of Industrial Organization,* vol. 18, no. 6, pp. 949-963, 2000.

[43] M. R. Leenders and P. F. Johnson, “Major Structural Changes in Supply Organizations,” in *Perspektiven des Supply Managements - Konzepte und Anwendungen*, Berlin Heidelberg New York, Springer, 2000, pp. 241-249.

[44] H. Lee and S. Whang, “Decentralized Multi-Echelon Supply Chains: Incentives and Information,” *Management Science,* vol. 45, no. 5, pp. 633-640, 1999.

[45] Y. Gao, Z. Niu and X. Wang, “Analysis on the effects of stock sharing on supply chain,” *Computers & Industrial Engineering,* vol. 60, no. 3, pp. 433-437, 2011.

[46] M. Slikker, J. Fransoo and M. Wouters, “Cooperation between multiple news-vendors with transshipments,” *European Journal of Operational Research,* vol. 167, no. 2, pp. 370-380, 2005.

[47] S. Nahmias and T. L. Olsen, Production and Operations Analysis, 7th edition ed., Long Grove, Illinois: Waveland Press Inc., 2015.

[48] R. Vanderkam, Y. Wiersma and D. King, "Heuristic algorithms vs. linear programs for designing efficient conservation reserve networks: Evaluation of solution optimality and processing time," *Biological Conversation,* no. 137, pp. 349-358, 2007.

[49] M. W. Horner and M. E. O'Kelly, "Embedding economies of scale concepts for hub network design," *Journal of Transport Geography,* vol. 9, no. 4, pp. 255-265, 2001.

[50] P. F. Johnson, A. Shafiq, A. Awaysheh and M. Leenders, "Supply organizations in North America: A 24 year perspective on roles and responsibilities 1987–2011," *Journal of Purchasing and Supply Management,* vol. 20, no. 2, pp. 130-141, 2014.

[51] Q. Duan and T. W. Liao, "Optimization of replenishment policies for decentralized and centralized capacitated supply chains under various demands," *International Journal of Production Economics,* vol. 142, no. 1, pp. 194-204, 2013.

[52] X. Yan and H. Zhao, "Decentralized Inventory Sharing with Asymmetric Information," *Operations Research,* vol. 59, no. 6, pp. 1528-1538, 2011.

[53] H. E. Fearon and M. R. Leenders, Purchasing's organizational roles and responsibilities, Tempe, Arizona: Center for Advanced Purchasing Studies, 1995.

[54] Y. Rong, L. V. Snyder and Y. Sun, "Inventory Sharing Under Decentralized Preventive Transshipments," *SSRN Electronic Journal,* pp. 1-47, 2009.

[55] A. J. Schmitt, L. V. Snyder and Z.-J. M. Shen, "Centralization versus Decentralization: Risk Pooling, Risk Diversification, and Supply Chain Disruptions," *Omega,* vol. 52, pp. 201-212, 2015.

Abstract

Due to rapidly changing organizational environments, company-intern processes and managerial decisions should be frequently re-evaluated. In order to maintain a high organizational performance, the Doka GmbH, an international company active in the formwork business, is re-evaluating their applied centralized supply strategy. The aim of this Master’s Thesis is to provide decision support for the evaluation process. Therefore, a literature research is conducted to evaluate alternative supply chain concepts. In detail, especially the application of lateral transshipments, inventory pooling and warehouse consolidation are discussed concerning their application in a centralized and decentralized context and advantages and disadvantages are analyzed. Furthermore, the problem setting is formulated as a linear model and implemented in the optimization software FICO® Xpress. Afterwards, the results are compared and different centralization approaches are ranked. This ranking is conducted according to the cost efficiency potential of those approaches in terms of transportation costs and general advantages or disadvantages extracted from literature. The outcomes display a trend towards the maintenance of centralized features. The combination of a centralized managed supply chain with decentralized features such as inventory pooling and lateral transshipments show advantages in terms of total transportation costs. The central warehouse proves to be reasonable at least in terms of transportation costs.

Kurzfassung

Firmen-interne Prozesse und Managemententscheidungen sollten aufgrund zunehmend unbeständigerer Organisationsumgebungen regelmäßig erneut evaluiert werden. Um eine leistungsstarke Organisationsperformance aufrechtzuerhalten, führt die Doka GmbH, ein internationales Unternehmen tätig im Betonschalungswesen, derzeit eine Re-Evaluierung ihrer angewandten zentralen Versorgungsstrategie durch. Diese Masterarbeit soll eine Entscheidungshilfe für diesen Evaluierungsprozess darstellen. Dafür wird zuerst eine Literaturrecherche durchgeführt, um verschiedene Supply Chain Strategien zu bewerten. Im Detail wird besonders die Verwendung lateraler Transshipments, gemeinsame Nutzung von Lagerständen sowie eine Zusammenlegung von Läger in Bezug auf deren Anwendung in einem zentralen und dezentralen Kontext diskutiert, sowie Vor- und Nachteile analysiert. Des Weiteren wird die Problemstellung als lineares Modell formuliert und in die Optimierungssoftware FICO® Xpress implementiert. Danach werden die Resultate verglichen und die verschiedenen Zentralisierungsansätze gereiht. Diese Reihung erfolgt anhand der Kosteneffizienz dieser Ansätze in Bezug auf Transportkosten sowie aufgrund der Vor- und Nachteile, die aus der Literaturrecherche herausgefunden wurden. Die Ergebnisse zeigen einen Trend in Richtung der Beibehaltung von zentralen Merkmalen auf. Die Kombination einer zentralen Supply Chain mit dezentralen Eigenschaften wie der gemeinsamen Nutzung von Lagerständen und lateralen Transshipments legen Vorzüge hinsichtlich Transportkosten dar. Außerdem wird bewiesen, dass das zentrale Lager durchaus sinnvoll hinsichtlich Transportkosten-Einsparungen ist.