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Factors of distribution network design: evidence from Russian market

Master's Thesis by 2nd year student
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Concentration – International Logistics and Supply Chain Management

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ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

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АННОТАЦИЯ

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Название магистерской диссертации	Факторы дизайна систем дистрибуции: результаты исследования российского рынка
Факультет	Высшая Школа Менеджмента
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Год	2016
Научный руководитель	Константин Викторович Кротов
Описание цели, задач и основных результатов	Целью данного исследования является выявление и описание влияния факторов, определяющих решения о выборе определенного типа системы дистрибуции для производителей, реализующих свою продукцию в различных регионах России. На основе проведенного обзора литературы были выявлены четыре группы потенциально значимых факторов и была предложена классификация, состоящая из четырех типов систем дистрибуции. Для дальнейшего исследования был применен множественный кейс метод. Были описаны и проанализированы факторы, влияющие на выбор типа системы дистрибуции, для четырех производственных компаний с различными типами систем дистрибуции, оперирующих на территории России. В итоге были выявлены и описаны четыре группы факторов, влияющих на решения о выборе системы дистрибуции: время реакции на спрос, эффективность прямых поставок, эффективность комбинированных поставок, складские издержки и контроль над продуктом. На основе данных факторов были разработаны рекомендации для компаний по выбору типа системы дистрибуции.
Ключевые слова	Управление цепями поставок, физическая дистрибуция, дизайн сетей дистрибуции, факторы дизайна сетей дистрибуции

ABSTRACT

Master Student's Name	Polina Yatsyshina
Master Thesis Title	Factors of distribution network design: evidence from Russian market
Faculty	Graduate School of Management
Main field of study	International logistics and supply chain management
Year	2016
Academic Advisor's Name	Konstantin V. Krotov
Description of the goal, tasks and main results	This research aimed to reveal factors that influence distribution network decisions and describe their influence on selection of particular distribution network type of goods producers with demand fragmented across Russia. Based on the conducted literature review four groups of potentially relevant factors were identified and a classification of four distribution network types was proposed. For further analysis, multiple case study method was chosen. Factors of distribution network decisions of four companies with production facilities and customers in various regions of Russia but with different distribution network types were described and analyzed. As for findings, five categories of interdependent factors, which impact distribution network decisions were revealed and discussed: response time, direct shipment efficiency, transshipment efficiency, holding costs and control over the product. Finally, based on the five categories of factors, a framework of distribution network type selection process was proposed.
Keywords	Supply chain management, physical distribution, distribution network design, factors of distribution network design

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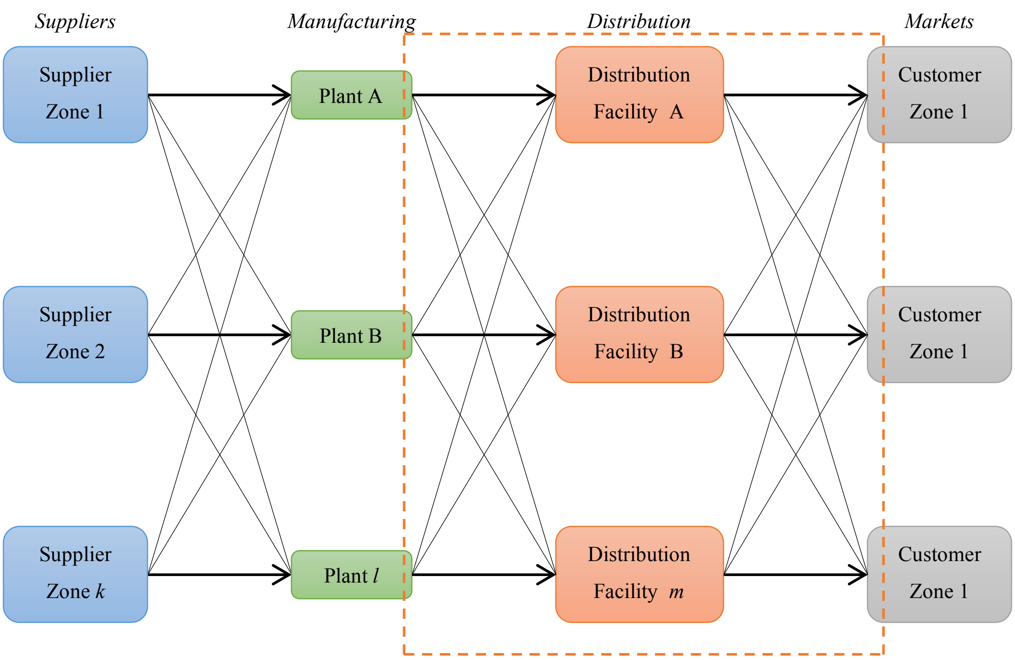
Introduction

Rapidly changing environment, time-based competition, decreased product life cycle and greater customer expectations have significantly changed the way companies operate. The pressure on supply chains has surged dramatically. As a result, many companies started to recognize strategic role of supply chain management as it influences directly not only costs, but also customer satisfaction. Thereby, supply chain management has become a crucial source of competitive advantage.

Supply chain network design is concerned with physical configuration of facilities: number, locations, allocations, capacities of production and distribution facilities. Distribution (see figure 1), in turn, is an important part of supply chain network design. It is responsible for a huge share of total logistics costs, only inventory costs generally account for up to 30% of total logistics costs (Pedersen et al, 2012). Another important role of distribution is supplying the customers with desired products at the right place and at the right time, at a minimum possible cost. Thus, distribution directly impacts customer satisfaction.

Figure 1. Role of distribution in supply chain



Selecting an appropriate physical distribution network structure is an important managerial decision as it directly influences supply chain costs and customer service in terms of response time and product availability. One of the strategic decisions that have to be made refers to selection of appropriate type of physical distribution network: number of echelons and types of facilities in distribution network. Most of academic research in this field refers to mathematical modeling, thus it mostly takes into account cost factors ignoring the impact of decisions on customer service.

This particular research on the contrary aims to examine various factors including service requirements and demand features as well as their influence on selection of appropriate type of physical distribution network. Particularly, it focuses on companies with production facilities and demand fragmented across Russia. The problem of distribution network reconfiguration is particularly relevant for Russian market due to worsening economic situation, which leads to increased competition from both cost and service perspectives. Moreover, such decisions become even more complex in the context of unbalanced fragmented demand in various regions, huge distances and long transportation lead times.

The **goal** of this master thesis can be defined the following way:

To reveal the factors that influence distribution network decisions and describe their influence on selection of particular distribution network type of goods producers with demand fragmented across Russia

In order to reach this goal, the following **objectives** were set:

1) Analyze existing theoretical approaches to distribution network design and factors that have an impact on distribution network decisions
2) Provide a classification of physical distribution network types
3) Justify selected research design and collect data for a multiple case study method
4) Identify factors that influence distribution network decisions of goods producers with demand fragmented across Russia
5) Describe the influence of these factors on distribution network decisions
6) Develop recommendations that would facilitate selection of appropriate type of distribution network for companies with demand fragmented across Russia

This research addresses a particular research gap. Firstly, based on the literature review no comprehensive classification addressing physical distribution network configuration was identified. Secondly, the influence of various factors, which affect distribution network decisions, has been currently studied from a relatively broad perspective of centralization versus decentralization. This master thesis aims to reveal the influence of various factors on selection of particular distribution network type.

As for the main direction of research, two **research questions** were identified:

(Q1) Which types of physical distribution networks can be identified?

(Q2) What are the factors and how do these factors influence selection of particular distribution network type of goods producers with demand fragmented across Russia?

The structure of this master thesis follows the mentioned above objectives. In the first chapter theoretical approaches to distribution network design are discussed: the definition and role of distribution network design, decision making approaches, design options and factors affecting decisions in this field. The second chapter is dedicated to methodology and data collection. In order to examine distribution network decisions from various perspectives, the multiple case study method was selected as it allows to identify linkages between variables and causal understanding. Four companies with production facilities, widespread customer base in various regions of Russia and different approaches to physical distribution network configuration were selected. Their motives for choosing particular approach were analyzed in the third chapter of this master thesis. As a result, five categories of factors that impact distribution network decisions were identified and their influence was discussed. The analysis is followed by proposed practical recommendations that aim to facilitate selection of appropriate type of distribution network.

1. Distribution network design

The discipline of supply chain management has been receiving growing attention recently from both academics and practitioners. Stock and Boyer define supply chain management as “the management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction” (2009, p. 706).

Distribution network in turn is an important part of supply chain and can be defined as a network of storage facilities, transportation system and interrelated arrangement of people, which aims to transfer final goods from producers to customers, typically retailers (Ballou, 2001). Distribution network design concerns with the structure of distribution network: determining the number of echelons in supply chain and for each echelon number, type, size and location of facilities, where the finished goods are stores on the way to consumers (Ambrosino & Scutella, 2005). Distribution network design choices are influences by various factors such as product features or demand features (Mangiaracina et al, 2015). The main goal of distribution network design is optimizing flow of goods mainly through producer network, from points of production to the demand points, which are mainly distributors such as wholesalers or retailers (Ambrosino & Scutella, 2005).

Distribution network design choices contribute significantly to supply chain performance both in terms of costs and consumers service level. An effective distribution network design can lead to significant decrease in logistics costs while increasing, or at least maintaining the service level (Ballou, 2001). Distribution network configuration is also closely related with marketing channel theories, where its role is described as closing the gap between manufactures and consumers regarding time, geography, quantity and variety of products (Abrahamsson, 1993; Baker, 2007). Thus, it can be considered as one of key drivers for companies’ performance (Mangiaracina et al, 2015).

Two major areas of research can be identified in the field of distribution network design:

- Optimization of flows of goods within an existing distribution network
- Improvement of existing network, which deals with selection of an optimal configuration of facilities – minimizing total distribution costs while meeting the required service level

1.1. Decision making approaches to distribution network design

Decisions on distribution network design concern with a wide range of questions: selecting an appropriate number of echelons in supply chain; locations and capacities of facilities; logistics activities that would be performed at these facilities; their allocation to specific product groups as well as transport and transshipment decisions (Mourits & Evers, 1995). Such decisions are interdependent, which makes the selection of a proper distribution network configuration an extremely complicated task. Decisions on distribution networks involve strategic decisions, which influence tactical and operational decisions (Crainic & Laporte, 1997). Mourits and Everts refer to decision making regarding distribution network configuration as to a highly complex trade-off between multiple cost elements combined with an evaluation of a wide range of non-quantifiable factors (1995).

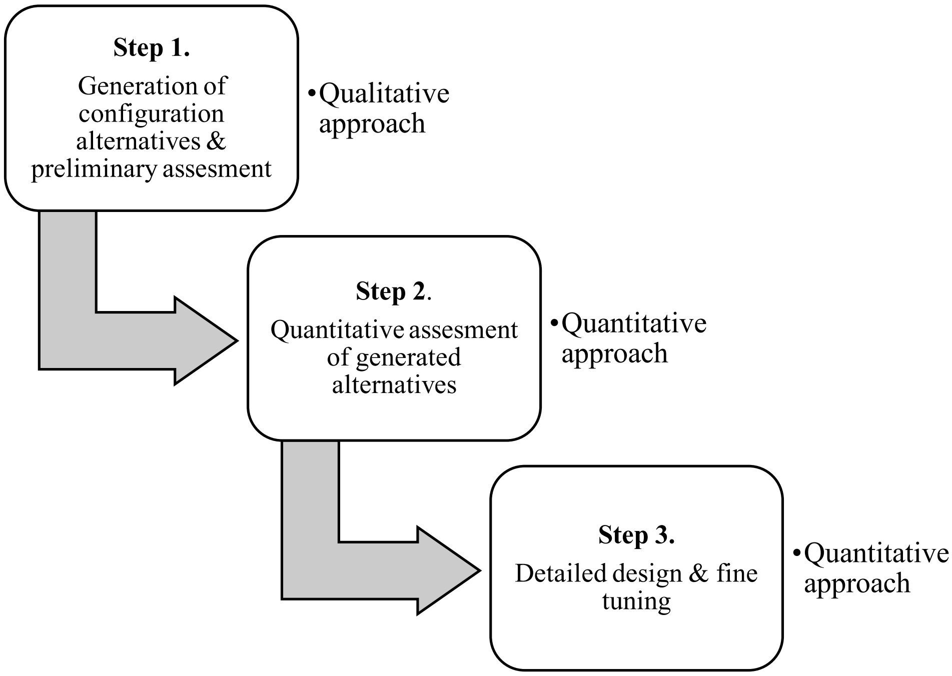
Considering a broad perspective of decision making in supply chain, Wanke and Zinn claim that there are three strategic level decisions in supply chain management regarding issues of market uncertainties, customer service and cost management (2004):

- *Make-to-order vs make-to-stock supply chain strategies* refer to manufacturing postponement concept (Hilletofth, 2012). Postponement aims at retaining the goods in neutral state as long as possible, thus moving the differentiation decisions to the latest possible point (Bowersox et al, 1996). Companies may delay delivery, packaging, assembling, production, sourcing or even product design as shown in appendix 1
- *Push vs pull inventory deployment logic* – according to Ballou under push decisions products movements are driven by planning and forecasting while under pull decisions products movements are driven by actual demand (1992).
- *Inventory centralization vs decentralization* decisions belong to the field of distribution network design and are further discussed in more detail

Within the paradigm of lean vs agile supply chain the approaches to inventory and hence distribution network design vary significantly. In lean supply chain inventory is considered as one of seven "wastes" and has to be reduced as much as possible (Womak & Jones, 1996). Agile supply chain is associated with few echelon distribution network so that companies are able to rapidly respond to changes in demand (van Hoek et al, 2001). Baker, however, claims that in reality importance of inventories is huge as it plays a role of buffer in supply chains and it is hard to eliminate the need for inventory (2007).

Decisions in the field of distribution network design can be split into at least three crucial steps: generation of configuration alternatives and their preliminary assessment; quantitative assessment of selected alternatives followed by detailed design and fine tuning, as shown in the figure 2 (Mangiaracina et al, 2015). The first step is dedicated to identifying possible distribution network configurations and selecting several alternatives for further analysis. For this step qualitative approach is usually applied. The next two steps involve quantitative analysis, which targets selection of best specific distribution network design.

Figure 2. Three steps of decision making in distribution network design



Source: (Mangiaracina et al, 2015)

Mourits and Evers proposed an approach to designing distribution networks, which consists of four consequent stages (1995):

1. *Arrangement stage*, during which number and locations of facilities are determined
2. *Deployment stage,* during which the optimal distribution of inventory among selected facilities is found
3. *Flow stage,* during which required levels of safety stock, batch sized and order frequencies are determined
4. *Operations stage,* during which operational procedure such as order placement, delivery algorithms are developed

The most widespread approach in the literature towards determining a number of warehouses in the supply chain as well as their location and routing is mathematical modeling (Bhatnagar et al, 2003). More than 85% of publications in the field of distribution network design refer to quantitative approach, in particular mathematical modeling (Mangiaracina et al, 2015). The goal of mathematical modeling is deterring the number and location of warehouses, which minimizes the total cost structure or maximizes total profit function under particular set of constraints. The first basic models were developed in 1960s, however, the most rapid development of mathematical modeling started after the year 2000 (Sebastian & Sternberg, 2015). The rise of mathematical modeling can be explained by developing computer science, which allows conducting complex calculations; and by globalization and constantly growing demand of business for optimization of cost structure.

The simplified approach to this issue is the transportation problem, which considers the case when actors of the network are already established (Costantino et al, 2013).

According to a recent literature review on distribution network design, more than 90% of mathematical models in this field can be attributed to single objective function models (Mangiaracina et al, 2015). Authors of this literature review claim that such models have an obvious shortcoming: they don't account conflicts between different objectives. For instance, total costs reduction in many cases would drive companies to select centralized distribution systems, while customers' service level requirements may push towards decentralization.

Several authors tried to approach this shortcoming by introducing multi-objective models which consider two objectives function simultaneously in an attempt to find the best trade-off between costs minimization and service maximization. For instance, Melachrinoudis proposed a multi-objective model, which targets total costs minimization combined with service level maximization measured by customers' demand coverage (2005).

An important drawback of mathematical models as tools for strategic decision making in the area of distribution network design is their reliance on various assumptions, which are not met in reality. Such assumptions might include single commodity consideration, unlimited facilities capacity, single sourcing assumptions and others.

Another constraint of mathematical modelling in distribution network design is that it is difficult to apply such models to real world cases due to large data requirements.

It is also worth mentioning that decisions regarding the optimal number of echelons in distribution network are considered only in few conceptual qualitative papers, which would be discussed further, while in quantitative models the number of echelons is considered as a constraint (Mangiaracina et al, 2015).

All in all, distribution network design is an extremely complex issue as it is influenced by a wide range of controversial factors. Most of research, which is conducted within this topic involves mathematical modelling. According to a recent literature review conducted by Mangiaracina et al, only in 11 out of 126 papers on distribution network design qualitative factors has been considered (2015). The major limitation of such approach is that is mostly doesn't take into account qualitative factors. This fact doesn't allow managers to rely solely on mathematical modeling in distribution network decision making.

1.2. Design options for a distribution network

1.2.1. Types of facilities

When discussing various options in distribution networks design it is important to distinguish different types of facilities, that can be present in distribution network. Basically, distribution facilities can be split into two large categories: warehouses and transshipment facilities. The major difference between warehouses and transshipment facilities is their role is supply chain. The major role of warehouses is inventory holding, thus acting as a buffer against demand uncertainty, which is important when producer's lead time exceeds consumer's lead time (Pedersen et al, 2012). On the contrary, transshipment facilities act as "switching yards" rather than as "holding yards" (Drucker, 1992).

Warehouses play a crucial role in distribution networks, however, warehousing may perform various functions. Frazelle provides the following classification of warehouse roles (2002):

- *Finished goods warehouses*, which aim at balancing and buffering variation between production and demand. Often such warehouses are located near production facilities and are characterized by a flow of full palettes in and out.
- *Distribution warehouses and distribution centers,* which accumulate various products from one or several producers for collective shipping of combined orders for customers. Such warehouses are often located central to customer base and perform shipping to customers on regular bases, for instance, weekly or monthly.
- *Local warehouses,* proximately located to customers to provide rapid response to demand. Often small quantities of goods are picked for same day delivery.

Another important role of warehouses has been receiving more and more popularity recently refers to more value added activities. *Postmanufacturing warehouses* are used for product customization, transformation and other value added operations. Product postponement is the major example, which leads to ability to react faster to consumer demand, decreasing complexity of manufacturing facilities, decrease in lost sales and total amount of inventory in supply chain (Cavinato, 2010).

The concept of transshipment, also referred to in the literature as cross-docking or just-in-time distribution is a relatively new distribution technique, which has proven its efficiency for some companies (Cóccola et al, 2013). Several types of transshipment facilities can be identified:

- Initially, the the term *transshipment facility* referred to a facility, which is used to change transport modem for example from large line-haul vehicles to smaller trucks (Baker, 2007).

- A *cross-dock* is a transshipment facility, where incoming goods are sorted, sometimes consolidated with other goods, and within few hours shipped further to customers, for instance retailers, without intermediate storage or order picking (Ghiani et al, 2004). Cross-docking allows to decrease inventory holding costs significantly, as goods spend very limited time in the facility.
- *Product-fulfillment centers*, which respond directly to final customers' orders. This kind of facilities is particularly widely used by online retailers (Frazelle, 2002).
- *Other facilities* such as returned goods depots, installation or repair depots (Baker, 2007).

1.2.2. Number of echelons

Number of echelons is another crucial characteristic of distribution network design. The decisions regarding the number of echelons are usually discussed in qualitative context, while it is usually perceived as a constraint in quantitative papers (Mangiaracina et al, 2015).

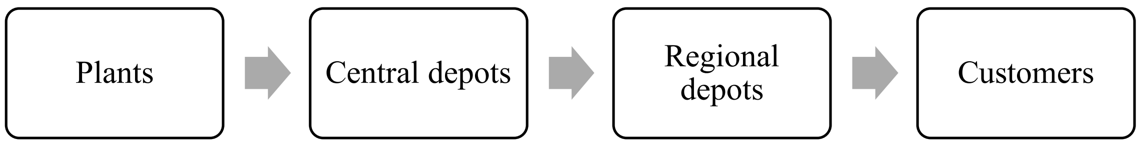
Ambrosino and Scutella in their work consider three types of distribution networks: two echelon distribution network and two types of three echelon distribution network depending on the characteristics of demand (2005).

The authors identify the following types of facilities in a distribution system:

1. Plants
2. Central depots
3. Transit points
4. Regional depots
5. Customers (demand points)

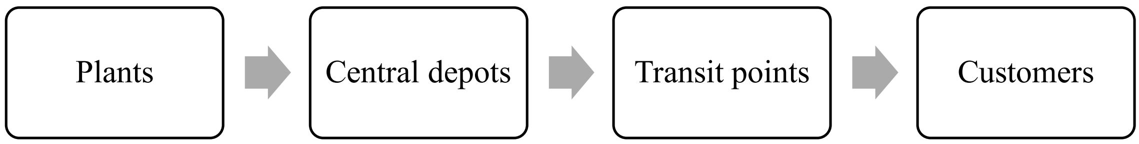
According to Ambrosino and Scutella there are three major configurations of distribution network for the mentioned above types of nodes. The first configuration consists of routes between plants and central depots, central depots and regional depots, regional depots and customers as shown in the figure 3.

Figure 3. Three echelon distribution network according to Ambrosino and Scutella, type 1



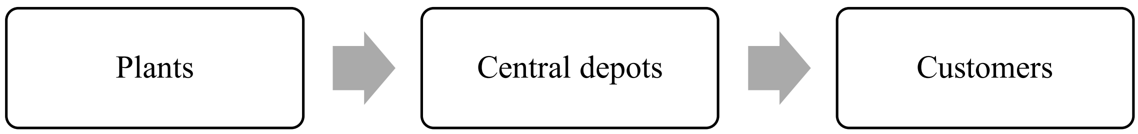
The second type of distribution network (see figure 4) is similar to the first one except for the fact that regional depots are substituted for transit points. The difference is that transit points do not keep inventories. Instead transit points receive goods and immediately resend them to customers. This means that the service level for the second distribution network configuration is lower than for the first one.

Figure 4. Three echelon distribution network according to Ambrosino and Scutella, type 2



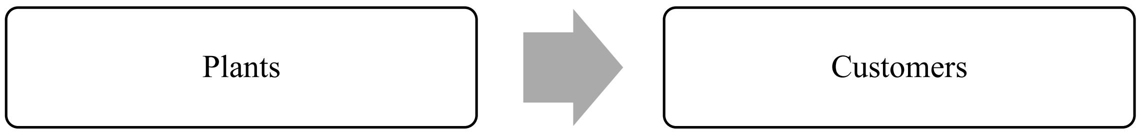
The third distribution network configuration (see figure 5) excludes transit depots and regional depots. In this two echelon distribution network clients are served directly via central depots. However, the authors mention that this type of distribution network is efficient only in case the clients are "big" enough to guarantee transportation full load.

Figure 5. Two echelon distribution network according to Ambrosino and Scutella



Cóccola also considers a single echelon distribution network when goods are shipped directly from manufactures to customers as shown in the figure 6 (2013).

Figure 6. Single echelon distribution network according to Cóccola



Chopra and Meindl provide analyze distribution network design options from two different perspectives (Chopra and Meindl, 2007):

- Whether the product is delivered directly to customer or picked up by a customer at a predetermined location
- Whether the products flows through intermediary

Based on this two decision options the authors provide the following classification of generic distribution strategies (Chopra and Meindl, 2007, p. 93):

1) *Retail storage with customer pickup* – inventories are stored locally and picked up by consumers in retail stores
2) *Manufacturer storage with direct shipping* – goods are shipped directly from producer to costumers bypassing intermediaries
3) *Manufacturer storage with direct shipping and in-transit* merge – goods are shipped to the consumer, however, on the way the shipping is consolidated with goods coming from other locations
4) *Distributor storage with package carrier delivery* – inventories are held by distributors in intermediate warehouses rather than by producers, package carriers are used for delivery of goods to final customers from intermediate facilities
5) *Distributor storage with last mile delivery* – in this case inventories are accumulated at distributors' facilities
6) *Manufacturer or distributor storage with pickup* – inventories are stored at manufacture's or distributor's warehouse and than shipped upon consumer's request from warehouse to pick-up points

1.3. Factors affecting distribution network design

There is a wide range of factors, that influence distribution network decisions of companies. Baker claims that there are multiple factors, which influence the "optimal" level of inventory for each company, hence, companies have to consider various perspectives when designing their supply chains and distribution networks in particularly (2007). Factors influencing distribution network design are not prioritized in the literature and overlap in content (Pedersen, 2012).

As is was described in the section 1.2 of this master thesis, two major types of facilities in distribution networks can be identified: "holding yards" and "switching yards". When describing the influence of different factors on distribution networks, most authors focus their attention on the specific issue of determining the appropriate number of "holding yards", in other words warehouses. Some authors, however, investigate more global issues. For instance, Baker proposes to start distribution network planning with asking the question if the inventory is needed at all for the company (2007). He claims that in markets with very short product life-cycle the products are being pushed directly to the market without holding any inventory and provides examples of fashion and high-technology markets.

Moreover, when discussing factors that affect distribution network design, authors mainly concern with centralization – decentralization choices. Hence, factors are analyzed with regards to optimal total number of facilities in distribution systems rather than particular design options.

All in all, distribution network design simultaneously deals with complex cost and service trade-off with both drivers for centralization and decentralization influencing managerial decisions (Pedersen, 2012).

In this section factors influencing the distribution network decisions, which are discussed in the literature, are grouped into four categories: product characteristics, cost factors, market uncertainties & customer needs and other factors.

1.3.1. Product characteristics

According to Fisher et al, all products can be divided into two broad categories: *functional* and *innovative products* (1997). Due to fundamental difference in these product types they require different supply chain and distribution strategies. Characteristics of both functional and innovative products are presented in table 1. Authors claim that efficient supply chain is preferable for functional products while responsive supply chain is preferable for innovative products. Lovell et all claim that efficient supply chain is associated with centralized distribution systems and responsive supply chain is associated with decentralized distribution system with higher inventory level (2005).

Table 1.

Functional vs. Innovative products

Product characteristics	Functional products	Innovative products
Cost of lost sales	Low	High
Risk of obsolescence	Low	High
Forecast accuracy	High	Low
Product variety	Low	High
Product life cycle	Long	Short

Source: (Fisher, 1997)

Physical attributes of the product can have a significant impact on distribution network design. For example, products with low shelf life or perishability require networks with minimum inventory level and faster transport modes (Lovell et al. 2005). Other physical attributes of products, which may pose constraints on distribution networks may include weight, volume, etc. (Bowersox et al, 1996).

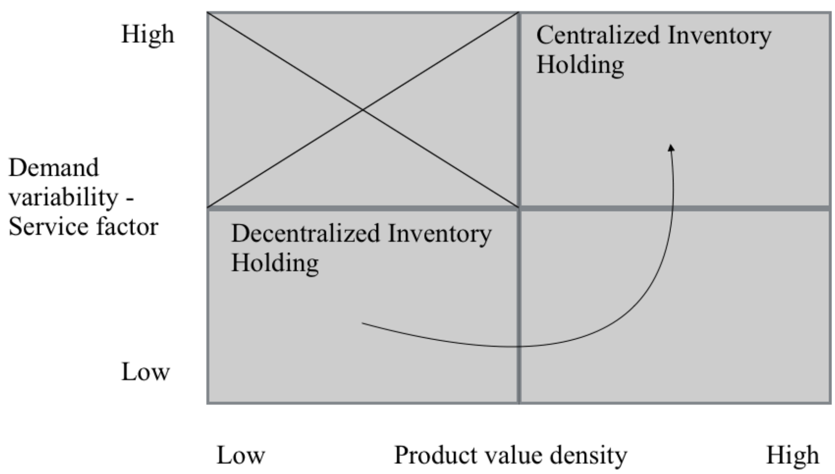
Langley et al claim that *product value* affects distribution strategy decisions. High degree of decentralization results in increased level of inventory (2009). High level of inventory, in turn, freezes capital and decreases the available amount of financial resources for the company, which is not a desirable situation. Consequently, high product value would push companies towards centralization.

Lovell et al suggest that *product value density* together with demand variability influence companies' distribution network centralization – decentralization decisions as shown in the figure 7 (2005). The authors determine product value density the following way:

$$Product\ value\ density = \frac{Product\ value\ (EUR)}{Chargeable\ weight\ (kg)}$$

Generally, increase in product value density leads to centralization of distribution network facilities. The same logic as for product value factor can be applied here.

Figure 7. Inventory centralization according to product value density and variability – service factor



Source: (Lovell et al, 2005)

Purchase size also affects warehousing strategy. In case consumers purchase in small quantities, transportation costs for long-distances of small lots is unreasonable strategy both in terms of costs and lead times. This drives companies to chose decentralized type of warehousing, as it allows to ship consolidated lots to warehouses and hence minimize the distance of small lots transportation with no negative effect on lead time (Langley, 2009).

1.3.2. Cost related factors

A common approach to distribution network decisions is a cost-based approach, which is concerned with general cost trade-offs (Langley at al, 2009).

Lowering inventory carrying costs is considered to be the major driver for centralization of distribution network (Abrahamsson, 1993; Croxton & Zinn, 2005). There are plenty of opinions in the literature on what are the components of inventory carrying costs. According to Waters, inventory carrying costs consist of chargers for storage space, losses due to damages, handling costs, administrative and insurance costs (1996). Gurmann and Schreiber viewed this category of costs as operating warehouse costs and warehouse maintenance costs (2013). Cavinato splits inventory carrying costs into capital investments, cost of capital, labor costs, variable costs and tracking costs (2010).

Despite existence of various opinions on the structure of inventory carrying costs, most researches mention two major subcategories of inventory carrying costs: cost of capital and storage and handling costs.

Capital costs – cost of capital tied-up in inventories act as a driver in favor of centralization of physical distribution network. Capital costs of holding inventory also referred to as frozen capital costs significantly contribute to the inventory holding costs and typically account for 8-15% of average inventory value (Cavinato et al, 2010). Basically, this category of costs represents the cost of money invested in inventory. In order to calculate the cost of capital, opportunity cost of capital of the company is usually applied. In case this value is not available, a competitive rate of marketable securities can be applied. Inventory investment cost of capital is calculated as cost of capital (a year rate) multiplied by the value of inventory and the duration the inventory is held.

Other factors in favor of reducing number of facilities in distribution network include reduced *warehouse operating costs*, reduced *learning costs* and reduced *fixed warehousing costs or facilities costs* (Croxton & Zinn, 2005). Facilities fixed costs, are the costs that can be eliminated or must be increased due to changes in the number of warehousing facilities in supply chain (La Londe & Lambert, 1977). Such costs to the high degree are fixed in nature. The major expense in this group of costs is the rent. In case the facility is owned by the company, it is recommended to include in calculations an equivalent of rent based on amortized investment cost over the lifetime of the facility (Daganzo, 2005). Apart from the rental rate, facilities fixed costs can be split into two categories: public utility payments and maintenance costs (Frazelle, 2002).

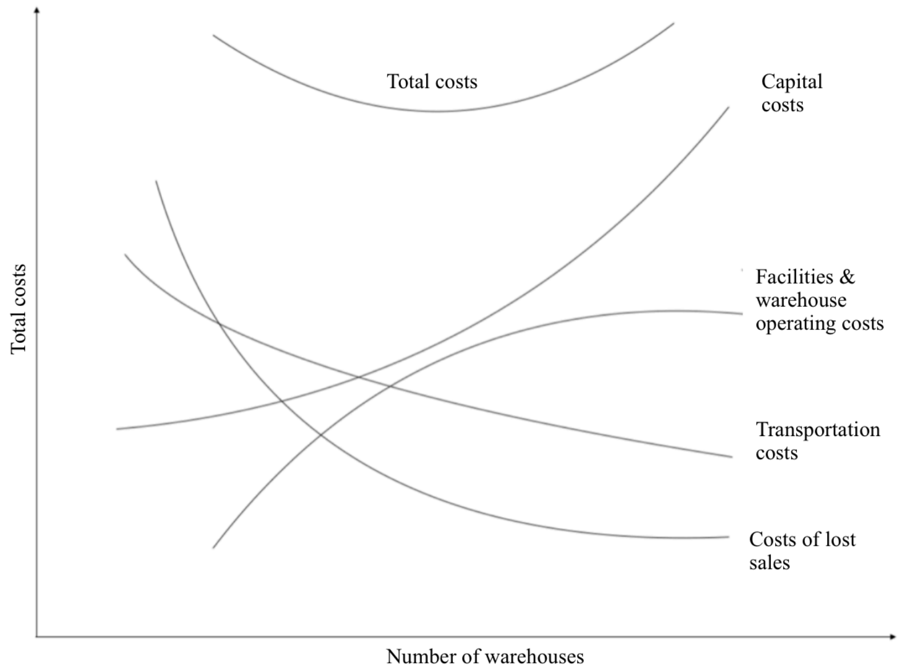
Warehouse operating costs consist of labor costs, administrative costs and public utility payments in case they can be linked to the amount of inventory carried (Kivinen & Lukka, 2004).

All in all, centralization of warehousing results in decreased level of inventory, which is mathematically confirmed by the square root law (Croxton & Zinn, 2005). Decreased level of inventory is associated with lower level of capital costs while warehouse operating costs also decrease as a result of centralization due to economies of scale.

On the contrary, increasing number of warehouses in the system generally results in decrease of *lost sales* thanks to a greater proximity to customers and decrease of *transportation costs* due to possible optimization of different transport modes usage (Das & Tyagi, 1997).

According to Langley et al, total cost function's non-linearity suggests that there is an optimal number of warehouses in the system, which results in minimization of costs related to warehousing and transportation as shown in the figure 8 (2009). The author considered warehousing costs as facilities costs together with warehouse operating costs. The inventory costs correspond to the capital costs.

Figure 8. Logistics Cost Related to Number of Warehouses



Source: (Langley at al, 2009).

1.3.3. Market uncertainties & customer needs

Previous research has shown that market uncertainties have a significant negative impact on supply chain performance (Bhatnagar et al, 2003). In order to develop both efficient and effective supply chain it is crucial to know and understand the constraints and possibilities of the market (Christopher and Towill, 2002).

Customer needs consist of various components. In this section those that influence distribution network strategies would be discussed. Market uncertainties which follow out customer needs would also be considered.

Chopra provides the following classification of customer needs that influence distribution strategies (2003):

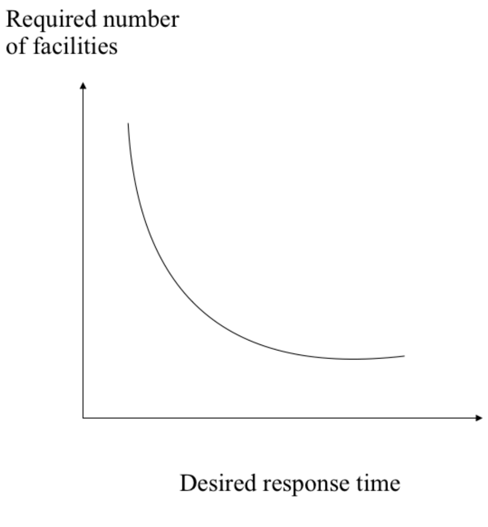
- *Response time* – number of days/time between order placement and the moment the customer receives the order, also referred to in the literature as *cycle time* (Mangiaracina et al, 2015)

- *Product variety* – number of different products or product configurations which are desired by customers
- *Product availability* – probability of having the product in stock when the customer places the order
- *Customer experience* – the ease of placing and receiving the orders
- *Order visibility* – the ability to trace the order from the moment of placement till receiving
- *Returnability* – the ease of returning unsatisfactory orders including the ability of the distribution network to handle such returns

Chopra claims that it may seem that customers require all of these dimensions to be on the highest level, however, in practice, the required levels vary (2003).

The author also suggests that the number of required distribution facilities increase with the decrease in available response time as demonstrated in the figure 9. Das and Tyagi as well suggest that decrease in available delivery time would drive companies to prefer decentralized distribution networks (1997).

Figure 9. Relationship between desired response time and number of facilities in distribution network



Source: (Chopra, 2003)

Changing consumer needs contribute a major part to market uncertainties in supply chain (Patil et al, 2013). Patil et al identify five sources of uncertainties in supply chain caused by varying consumer needs: *range of quantity required, lead time, variety of product required, number of channels through which product may be acquired and rate of innovation* (2013).

Range of quantity required or, *demand variability*, also referred to as throughput, *according* to Harrison and van Hoek, influences the inventory policy in terms of level of centralization of distribution network (2008).

Table 2.

Impact of consumer needs on demand uncertainty

Customer needs	**Demand uncertainty**
Range of quantity required increases	Increases as a wider range of quantity required leads to greater variances in demand
Lead time decreases	Increases as less time to react to order is available
Variety of product required increases	Increases as demand per product becomes more disaggregated
Number of channels through which product may be acquired	Increase as total demand becomes more disaggregated
Rate of innovation increases	Increases as new products tend to have a greater demand uncertainty

Source: (Patil et al, 2013)

Wanke and Zinn consider *inventory turnover* as a factor that influences centralization – decentralization decisions in distribution network design (2004). The authors have conducted an empirical study, which revealed a positive relationship between inventory turnover and centralization – decentralization. The faster the inventory turnover, the more likely the companies to decide in favor of decentralization of distribution network (Wanke & Zinn, 2004).

Level of competition or *product substitutability* also has a potential impact on decisions regarding distribution network design. Tough market conditions drive companies to increase level of customer service and reduce volume of lost sales. In this case decentralized system is indicated (Langley at al, 2009).

Bargaining power of buyers is also indicated in several articles as a relevant factor. It is argued that with an increase of bargaining power of customers, based on example of large multinational retailers, producers would tend to use more direct distribution networks with reduced number of echelons (Coe & Hess, 2005; Lozentz et al, 2007).

1.3.4. Other factors

As for other factors, *distance between nodes* affects the optimal number of facilities in a distribution network by several means: firstly, the distance is directly correlated with the response time and, secondly, it is connected with transportation costs function as increasing number of facilities in the distribution network may result in decrease of mean travel time, but at the same time result is a less efficient truck load (Lumsden et al, 1999; Chopra 2003).

Special warehousing needs such as control of temperature or humidity require substantial financial investments. Langley claims that in this companies would prefer centralized distribution networks as it will allow to reduce capital investments in equipment (2009).

Production characteristics can pose various limitations on distribution network design. For instance, production technologies determine whether the product can be possibly supplied within given response time, which refers to build-to-order supply chain, or inventories should be used as a buffer (Christopher & Towill, 2002).

Geographic environment can act as a constraint for distribution network design when, for example considering infrastructure availability (Lovell et al. 2005). *Commercial environment* factors may also push companies towards selecting particular distribution network design options. Such factors might include market characteristics, tax rates in various regions or countries; tariff and non-tariff barriers, currency exchange rate (Dicken, 2003).

All in all, plenty of factors can be found in the literature that potentially influence distribution network design decisions. However, there is no single factor that dominates the decision making. As Wanke and Zinn state, "no strategic decision should be made on the basis of the value of a single variable", it is important consider product, operational and demand data as well as other constraints (2004; P 477).

Table 3 summarizes the factors that impact distribution network decisions, which were revealed in the literature and discusses above.

Table 3.

Factors influencing distribution network decisions

Factor group	Factor
Product characteristics	Innovative vs functional products
	Physical attributes
	Product value
	Product value density
	Purchase size
Cost related factors	Facilities costs
	Warehouse operating costs
	Learning costs
	Capital costs
	Transportation costs
	Costs of lost sales
Market uncertainties & customer needs	Response time
	Product variety
	Product availability
	Customer experience
	Order visibility
	Returnability
	Throughput
	Number of channels through which the product may be acquired
	Rate of innovation
	Inventory turnover
	Level of competition
	Bargaining power of buyers
Other factors	Distance between nodes
	Special warehousing needs
	Production characteristics
	Geographic environment
	Commercial environment

To conclude, the first chapter of this master thesis was dedicated to the literature review of distribution network design and the factors that influence distribution network decisions. The chapter started with explanation of the role of distribution networks in supply chains and the importance of distribution network decisions for companies' performance. Afterwards the decision making approaches in distribution network design were considered. It was identified that the dominant part of research papers focuses on quantitative approaches to decision making. However, such approaches have significant limitations as they do not consider the impact of multiple qualitative factors, which also impact significantly distribution network design choices. After that a classification of distribution network facilities was provided and two major groups of facilities were identified: warehousing facilities and transshipment facilities. In the next step single, two and three echelon distribution network design options were discussed. We failed to identify a comprehensive classification of distribution network types since most of the research papers focus on mathematical modelling and perceive number of echelons and type of facilities as a constraint.

Finally, a review of factors influencing distribution network decisions was provided. The factors were grouped in four categories: product characteristics, cost related factors, market uncertainties & customer needs and other factors. The influence of these factors was mainly analyzed by researchers from the point of increasing or decreasing of facilities number in distribution network. Again, the influence of these factors on number or type of echelons is currently not examined to a very low extent.

All in all, based on the literature review, the following research gap has been identified:

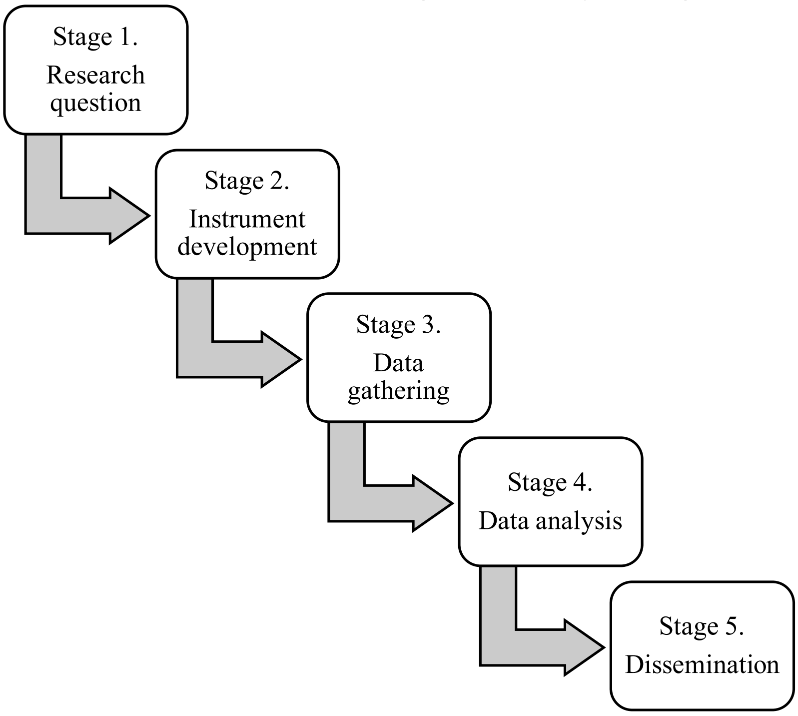
- There is a lack of classifications of distribution network types regarding number of echelons and types of facilities.
- Various factors that influence distribution network design decisions have been discussed in the literature. However, their impact on such decisions has been mostly considered from a very broad centralization – decentralization perceptive. From the existing literature it is still unclear what is the influence of these factors on selection of particular distribution network type.

2. Methodology and data collection

2.1. Research design

According to Stuart, research and dissemination process can be split into five critical stages, which is illustrated in figure 10 (2002). The authors state that this research process is also applicable for case study method.

Figure 10. The five stage research process model



Source: (Stuart et al., 2002)

During the first stage the research questions are to be defined. This particular research addresses the following research questions:

(Q1) Which types of warehouse networks can be identified?

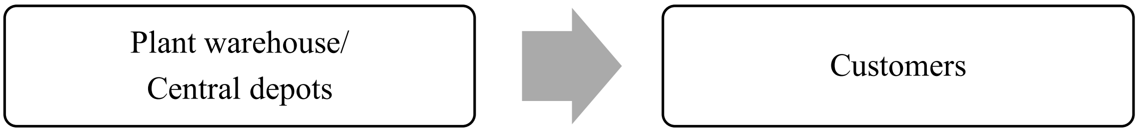
(Q2) What are the factors and how do these factors influence selection of distribution network type of goods producers with demand fragmented across Russia?

In order to provide configurations of distribution networks, firstly, a decision on considered nodes or, in other words, facilities should be made. For the purpose of this study the types of facilities identified by Ambrosino and Scutella and Cóccola et al (see chapter 1.3.) were selected. However, a slight modification was applied: in this research plants and central depots are considered as one node and are defined as "Plant warehouses/Central depots". For countries with large territories plant warehouses often perform the role of finished goods warehouses, from which goods are transferred to regional facilities; regional facilities in turn tend to play an increasingly important role of buffer between demand and supply in distribution systems (Пинар и др., 2011). Also, another echelon has been added, which is called the local depots. When distribution network is spread along huge distance, local warehoused are more likely to be present in it (Schönsleben, 2007). Local depots or warehouses, according to Frazelle, are located in proximity to customers in order to react rapidly to the demand (2002).

Based on the selected facilities types four types of distribution networks will be considered.

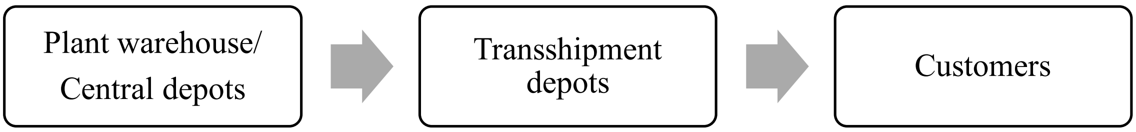
In the distribution network type 1, the goods are directly shipped to customers from the plant warehouse or central warehouse as presented in figure 11, which corresponds to the single echelon distribution network according to Cóccola (2013).

Figure 11. Distribution network type 1



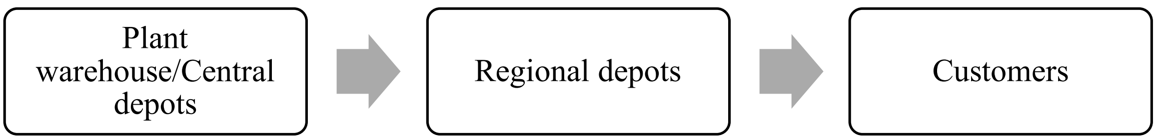
The second type of distribution network (see figure 12), which is considered in this research, is a two echelon network in which goods flow from the plants or central warehouses to customers via transshipment depots, which allows to decrease transportation costs. This type of distribution network is a variation of a three echelon distribution network type 2 according to Ambrosino and Scutella (2005).

Figure 12. Distribution network type 2



The third type of distribution network it is assumed that the goods are delivered from plants or central warehouses to regional depots, which perform the function of buffering the demand and supply sides, and than are transported to customers as shown in the figure 13. Ambrosino's and Scutella's three echelon distribution network type 1 was taken as a foundation 14 (2005).

Figure 13. Distribution network type 3

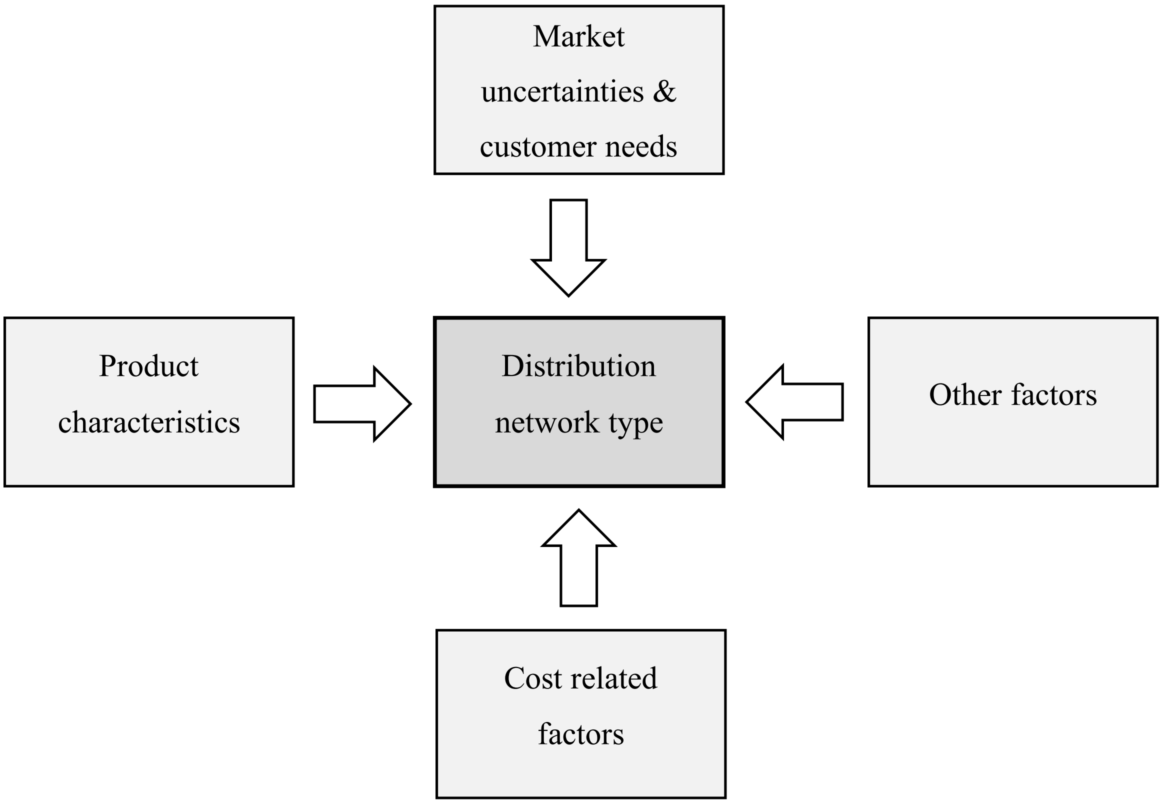


In distribution network type four goods from regional depots follow to local depots first and afterwards are transported to customers as shown in the figure 14.

Figure 14. Distribution network type 4

The second research question refers to the factors that influence the decisions on distribution network design. In the literature review in the first chapter of this master thesis four groups of factors, that potentially impact such decisions were identified: product characteristics; market uncertainties and customer needs; cost related factors and a broad category other factors. However, in previous research the impact of these factors was examined mostly from the point of centralization vs. decentralization of distribution facilities, while other aspects were ignored. Such aspects include, for instance, the degree of centralization or decentralization or the role of transshipment facilities in distribution network. This research attempts to address these gaps by investigating the impact of identified factors and, presumably, of other relevant factors on particular distribution network types selection as shown in the figure 15.

Figure 15. Research design



The nature of knowledge contribution of this research can be identified as mapping and relationship building, according to the classification proposed by Stuart et al (2002). One of the appropriate research methods for elaborating on this type of research questions is a multiple case study method, which was selected for this particular research. The approach is discussed in detail in the next section of this master thesis followed by data gathering description. Data analysis and dissemination refer to the third chapter of this work.

2.2. The multiple case study approach

A case study can be identified as "an empirical inquiry that investigates a contemporary phenomenon within its real life context" (Yin, 2003: 13). The popularity of applying case study method in the field of supply chain management has risen significantly recently (Kotzab et al, 2006). According to Yin case study method is an appropriate research method when complex, unstructured problems are being analyzed through mapping of major variables (2003).

The multiple case study method doesn't allow extrapolating conclusions on bigger samples, however, it allows to identify and describe critical variables of a phenomenon as well as to identify linkages between variables and causal understanding (Stuart et al., 2002). Thus, this method suits the research questions of this master thesis. Generally, when multiple case-study method is being applied, the analysis is performed on 4 to 15 cases (Cooper & Schindler, 2006).

One of possible sampling strategy for selecting cases for multi-site case study is selecting cases which provide examples of polar types of a phenomenon (Eisenhardt, 1989). For this research four companies representing different warehouse network types were selected. The criteria for cases selections were the following:

- Case companies should have final goods production facilities in Russia
- Case companies should sell their products in multiple regions of Russia
- Each identified warehouse network type should be present in the case analysis

Companies, which agreed to participate in this research, depending on their warehouse network type are presented in the table 4.

Table 4.

Case studies distribution depending on warehouse network type

Distribution network type	**Case company**
Distribution network type 1	LSR Stenovye
Distribution network type 2	Slotex
Distribution network type 3	Proctor & Gamble
Distribution network type 4	Palfinger

The four selected companies operate in various industries and have different profiles in terms of number of employees, country of origin and serve different types of customers. Table 5 introduces briefly the case profiles, while a more detailed information on case companies is provided in the third chapter of this mater thesis.

Table 5.

Characteristics of case companies

Company	Industry	Number of employees	Product range	Customers
LSR Stenovye	Construction materials	100-500 employees	Façade and paving clinker bricks	Dealers, retailers, construction companies
Slotex	Decorative components	201-500 employees	Laboratory plastics, decorative laminates, compact laminates; furniture fittings such as waterproof countertops, furniture facade paintings (decorative panels), decorative furniture boards and decoration materials	Manufactures, Dealers
Procter & Gamble Russia	FMCG	4000+ employees	70 + brands in two major categories: Homecare products: soap, washing powder, dishwashing, etc. Personal care products: grooming products, body wash, hair coloring, skin care, child care, etc.	Retailers, Distributors
Palfinger CIS	Engineering	2000+ employees	Loader cranes, Marine cranes, Hooklifts and skiploaders, Access Platforms, Railway systems, Auto cranes, Bridge inspection units, tail lifts, passenger lifts, truck mounted forklifts	Dealers

According to the selected research framework, the distribution network choices of case companies would be analyzed by examining the influence of factors derived from the literature review, which potentially impact such decisions.

The data analysis process for multiple case study method can be split into two categories: analyzing within case data and cross-case data (Eisenhardt, 1989). According to Eisenhardt, the cross-case analysis is typically performed either by selecting pairs of cases and listing similarities and differences between them or by selecting dimensions of research and comparing their meanings for different cases, searching for similarities and differences. The author claims that result of these forced comparisons can lead to a more sophisticated understanding of the problem. For this research the second method of cross-case analysis was selected as the dimensions of analysis are already selected.

2.3. Data collection

Both primary and secondary data was collected for the purpose of this research. The data required for this research is described in the table 6.

Table 6.

Data collection process

Required data	Purpose
Secondary data	
Companies' profiles	Selecting companies that suit the requirement of this research for further analysis and interviews
Product range	Understanding the physical attributes of the products, product value, diversity of product range, which influences distribution network decisions
Demand characteristics	Examining market dynamics, competition level, characteristics of customers that potentially shape distribution network
Primary data	
Distribution network characteristics	The description of existing distribution networks: number, types and location of facilities, connections between facilities, is required to determine the corresponding distribution network type
Influence of selected factors on distribution network decisions and relative their relative importance	To determine which factors are important and describe how exactly they influence distribution network decisions

The secondary data is especially important in the initial stage of research, when companies are selected for the case analysis. After the companies were selected and the companies agreed to participate in the research, data on activities of these companies, market and demand characteristics was acquired through secondary sources. The following secondary sources were used: companies' official websites, industry reports, articles, news.

The primary data was collected based on a series of in-depth interviews with companies' representatives. The research interview is an extremely important and probably the most widely used method for collection of qualitative data (Qu & Dumay, 2011). For the purpose of this research semi-structured interviews were selected. The interview guide, which which consists of pre-prepared questions, is provided in the appendix 2. Semi-structured interview is an effective method of data collection due to it's flexibility, as it allows to modify the questions and their order, capability of revealing important and commonly hidden factors as it allows interviewees to provide answers on their own terms (Qu & Dumay, 2011).

Distribution network design issues and the factors that led to selection of particular network configuration were discussed with representatives of logistics departments or business development departments of case companies. Information regarding sales and demand characteristics was discussed with sales representatives for two case companies. All in all, 6 in-person interviews were conducted. The information regarding the interviewees' positions is summarized in the table 7.

Table 7.

Semi-structured interviews

Case company	Interviewee's position
LSR Stenovye	1. Manager of business unit LSR Stenovye
Slotex	1. Head of logistics department 2. Head of corporate sales department of decorative board materials
Proctor & Gamble	1. Forward deployed inventory category leader
Palfinger	1. Corporate development manager 2. Strategic project manager

All in all, the second chapter of this master thesis is dedicated to methodology description. The answer to the first research question (Which types of physical distribution networks can be identified?) was provided based on the literature review and is covered in the research framework part. Four types of distribution network were suggested and discussed.

In order to answer the second research question (What are the factors and how do these factors influence selection of distribution network type of goods producers with demand fragmented across Russia?) the multiple case study method was selected. Such method is applicable, when the research aims at identifying and describing critical variables of a phenomenon and identifying linkages between variables (Stuart et al., 2002). Four companies were selected for the multiple case analysis and the research design and process of data collection were discussed.

3.Analysis and findings

The first stage of data analysis consisted of within case analysis. Four cases, which were four companies with different types of distribution network, were analyzed according to a list of 28 factors, which were identified in the literature review (see table 3). The description of the four cases is provided below. The within case analysis is followed by cross case analysis, discussion of findings, theoretical and managerial implications.

3.1. LSR Stenovye case

Company background

LSR Stenovye is a group of enterprises manufacturing wall materials, which is controlled by LSR Group. In this research, the distribution network of LSR Stenovye for two product types is analyzed: façade and paving clinker bricks, as these products are distributed in multiple regions of Russia: Northwestern, Central, Volga, North Caucasus, Urals regions and further. Clinker bricks are also exported to Kazakhstan.

The brick market has demonstrated moderate decrease of 5-7% in 2015, however, in 2016-2017 the situation may worsen due to surge of investments in new construction projects in Russia ("Импортозамещение добралось до клинкера", 2016). At the same time, clinker brick market is a perspective niche. First of all, the product itself gains more and more popularity in the construction market. Secondly, the demand on imported clinker bricks is switching towards more affordable products (40% decrease on imported bricks), which are produced locally ("Импортозамещение коснулось кирпича", 2016). All in all, current economic situation is favorable for LSR Stenovye, which is the only mass producer of clinker bricks in Russia ("Группа ЛСР объединяет кирпичные активы", 2016). According to market analyses conducted by LSR Stenovye, company's market share in Russian brick market accounts for 6%, while the market share in the clinker brick market is as high as 20-25%.

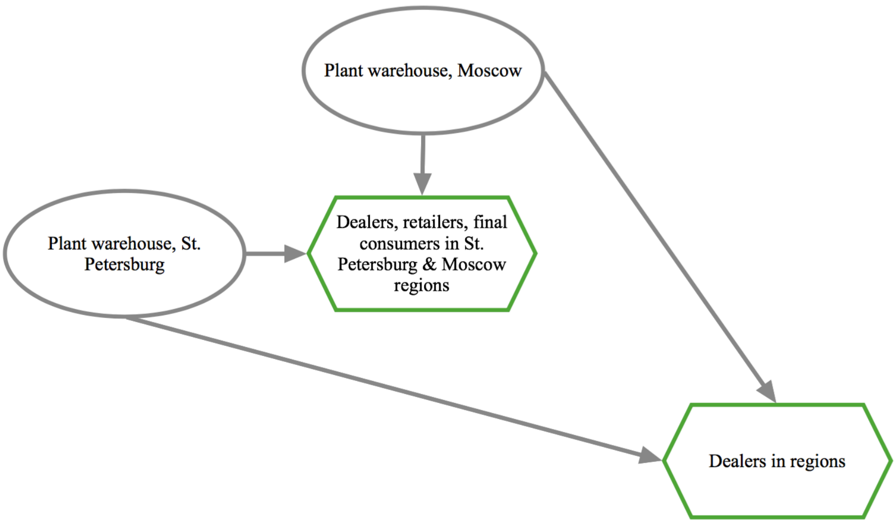
Traditionally, construction materials are produced and distributed regionally due to low product value density. However, there are very few producer of clinker bricks in Russia and especially high-quality clinker bricks. At the same time, the demand exists in all regions of Russia. This factor pushed LSR Stenovye to the decision to distribute its products throughout the country.

In St. Petersburg and Moscow regions LSR Stenovye works with various types of customers including dealers, retailers, construction companies and private consumers. However, the company prefers direct contracts to contracts with intermediaries. In other regions, products are sold via dealers which have better understanding of local markets peculiarities and required promotion activities. The company has set the target in regions to have one dealer for 500 000 citizens.

Distribution network description

Façade and paving clinker bricks are produced in two plants, which belong to the business unit LSR Stenovye. Pavlovsky Posad Brickyard is located in Pavlovsky Posad town, Moscow region. The plant is equipped with one production line of façade clinker bricks. The second production facility – Nikolsky Brickyard is located in St. Petersburg region, where all types of clinker bricks are produced. The finished goods warehouses are located on the territories of the production facilities. From the plant warehouses the clinker bricks are directly shipped to customers either by railroad or in trucks. The distribution network of LSR Stenovye for clinker bricks is shown in the figure 16.

Figure 16. Distribution network of LSR Stenovye



Influence of product characteristics on distribution network decisions

Clinker bricks are considered to occupy premium brick segment as their price exceeds the price of regular bricks at least 2-3 times. Nevertheless, as most of construction materials, which can be related to *functional products* group, the *product value density* is extremely low. Relatively low *product value* compared to heavy *weight* of bricks results in high share of transportation costs compared to product value, which can be as high as 30% for the case company. At the same time, the physical attributes of the product combined with the *purchase size* in most cases guarantee full load of transport. According to the manager of business unit LSR Stenovye, one fully loaded truck generally carries around 8000 brick, one fully loaded wagon carries around 20000-30000 bricks. At the same time, construction of even a small private house on average requires around 56000 bricks, while average order from regional dealer significantly exceeds these volumes. Hence, the practice of half-empty transportation is not common for the company.

Influence of market uncertainties and customer needs on distribution network decisions

The *response time* in the brick market is generally very high. According to the manager of business unit LSR Stenovye, final customers can foresee their demand for bricks at least a year in advance during the construction project planning stage. The response time for dealers exceeds the delivery time. However, the production cycle can be as high as several months, as the each of two plants have just one production line for clinker bricks, hence only one type of product can be produced by a plant at a period of time, while the *product variety* is relatively high – 20 SKU for façade and 7 SKU for paving clinker bricks. Due to this, the company is forced to hold large amount of safety stock – up to 7 months of sales before the summer season, but on average around 3-4 months of sales. This results in moderate *inventory turnover* value. *Product availability* at the time when order arrives is important, that is why such high amounts of safety stock are maintained. However, absence of required items does not lead to lost sales in many cases, as customers are often ready to wait due to described above reasons.

Bargaining power of buyers is relatively low compared to bargaining power of LSR Stenovye due to leading position of the company in its segment, especially since the *level of competition* has decreased as a result of depreciation of ruble. Nevertheless, *customer experience* is still important as better dealers' experience boosts sales for final consumers. Customer experience includes extensive use of IT. Dealers can track the availability of products in stock, reserve stocks, place orders online, track orders (*order visibility*).

The *volume of sales* is important when linked to physical attributes of the products. *Number of channels through which the product may be acquired* is not that crucial in this particular case, as each order corresponds to transport full load and there is no need in combining orders.

Rate of innovation and *returnability* were not reported as important determinants for distribution network decisions.

Influence of cost related factors on distribution network decisions

As it was discussed above, despite high transportation load factor, *transportation costs* are extremely high compared to product value for LSR Stenovye. Introducing new facilities to distribution network would also result is appearance of substantial *facilities and warehouse operating costs*. However, selecting a different distribution network type wouldn't lead to significant strategic benefits, according to the manager of business unit LSR Stenovye.

In order to decrease the *costs of lost sales* the company stocks large amounts of inventories. Large amounts of inventories are associated with high *capital costs*, however, low value of products partly compensates this factor.

All in all, in case of LSR Stenovye, cost factors are not the major determinants of distribution network design. This is not the case, when increased costs prevent the company from operating a more decentralized distribution network. Major reasons for that are long response time, fragility of the product and high transportation load factor.

Influence of other factors on distribution network decisions

Clinker bricks, as any other bricks do not require any *special warehousing needs*. However, the product is fragile and increased number of facilities in distribution system corresponds to increased level of product damage. According the manager of business unit LSR Stenovye, this is one of the major reasons why the company is not considering introducing any additional storage or transshipment facilities.

The production characteristics impact directly the inventories level, as it was discuses above, while geographic environment results in high transportation costs due to long distances between the production facilities and customers and not extremely efficient infrastructure. According to the company's representative, the commercial environment doesn't impact the distribution network design of LSR Stenovye.

3.2. Slotex case

Company background

The JSC Slotex is a producer of wide range of materials that are used in interior finishing including decorative coatings such as laboratory plastics, decorative laminates (CPL), compact laminates (HPL); furniture fittings such as waterproof countertops, furniture facade paintings (decorative panels), decorative furniture boards and decoration materials such as decorative wall panels, window-sill plates and demolition board (Production, n.d.).

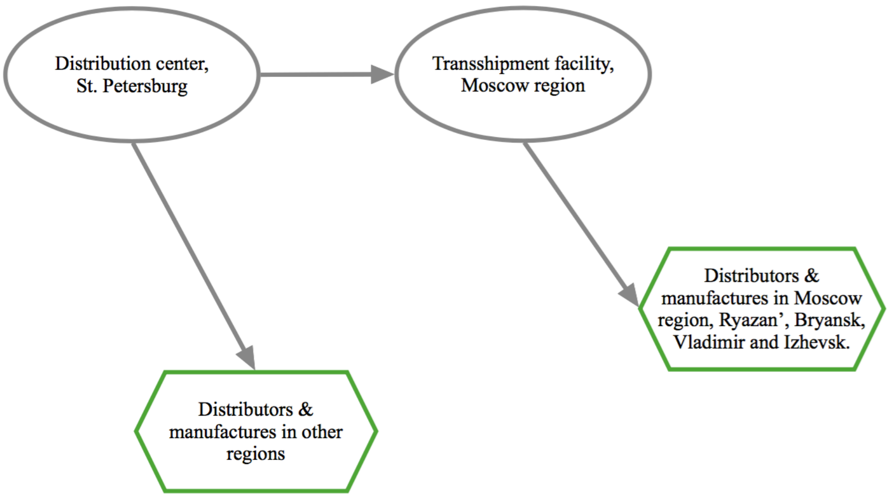
The demand for the furniture market in Russia was showing stable growth recently (Russian furniture market, n.d.). But due to the current economic situation, demand for furniture items has declined significantly (Bazenkova, 2015). According to the head of corporate sales department of decorative board materials of Slotex, demand in middle price segment has shown the most significant decline in growth rate. Producers even switch to lower price segments in order to load capacities. At the same time the demand in upper price segment is stable. As a result of ruble depreciation, many companies engage in import substitution. Companies with production facilities in Russia, especially niche players, even demonstrate growth in sales. However, all in all, the forecasts are not very optimistic.

The JSC Slotex agreed to participate in this research in order to provide first-hand information. The company has a broad distribution of points of sales, which are represented by partner companies in B2B sector – tabletop producers, furniture producers, front panels and façade manufactures and furniture distributors. A significant part of sales comes from selling materials for two biggest Russian tabletop producers, which are located in St. Petersburg region. In regions apart from St. Petersburg the company is selling finished goods. All in all, the company is presented in 64 regions of Russia.

Distribution network description

Slotex possesses two production facilities in St. Petersburg that perform different production stages. The finished goods are than delivered to the central depot – distribution center, which is also located in St. Petersburg. The distribution center performs storing, order preparation, packaging and shipping. The company is applying transshipment strategy for part of the regions: Moscow, Moscow region, Ryazan', Bryansk, Vladimir and Izhevsk. It's transshipment facility is located in Moscow region, in town Elektrostal. The goods are often transported by means of 10 or 20 ton trucks, depending on the demand volume. On a weekly basis the orders are delivered to the transshipment point and afterwards are picked up by or delivered to customers. For other regions direct shipping from distribution center is applied. The shipment can either be organized by Slotex or order picking strategy can be applied upon customer request. The distribution network of Slotex is represented graphically in the figure 17.

Figure 17. Distribution network of Slotex



Influence of product characteristics on distribution network decisions

Product characteristics are crucial determinants for distribution network design. *Physical attributes* together with *purchase size* play an important role in determining transportation efficiency. Slotex mostly uses trucks for transporting final goods to customers. A typical order fills much less than the full capacity of a 20 ton truck. Consequently, there is a clear benefit in consolidating shipments. *Product value* is also an important factor as it determines the cost of capital, which would be discussed further. At the same time the *product value density* is a more controversial factor, as it components (product value and weight) bend to opposite decisions (centralization vs decentralization). By most of characteristics, Slotex produces *functional products*, which requires an efficient distribution network. At the same time, *product variety* is high due to different decorative finishing options, which leads to decrease in forecast accuracy on SKU level and poses additional pressure on efficiency.

Influence of market uncertainties and customer needs on distribution network decisions

The most significant factor that influenced distribution network design of Slotex, according to the head of logistics department of the company, is the *response time*. The major final product of the company is tabletop panels. For the final consumer the purchase of tabletop from Slotex is connected with the purchase of customized kitchen. The average waiting time for a customized kitchen accounts for 40 days, according to head of corporate sales department of decorative board materials, which allows Slotex to perform make-to-order supply chain, as the production cycle doesn't exceed 14 days. Thus, *product availability* at the moment of purchase decision making is not that crucial for Slotex.

The high *product variety* also moves the company to centralization of distribution. Slotex offers more than 250 SKU due to a wide variety of decorative finishings. This fact makes the demand forecasting on SKU level imprecise. However, centralized distribution network and long lead time lead to relatively low level of inventories held and hence high *inventory turnover* rate (less than a weekly demand is maintained as safety stock). *Customer experience* in this framework refers to ease of placing and receiving the order by customers (Chopra, 2009). According to the head of corporate sales department of decorative board materials, initially the company put a lot of emphasis on this aspect and provided very flexible conditions to distributors. However, several years ago a decision to systemize this aspect of customer relationship management was made. Currently there is a limited number of options (customer pick-up or direct shipping included in the price of the products). *Order visibility*, *returnability* and *rate of innovation* are not considered as crucial service elements with regards to distribution network design.

The *number of channels through which the product may be acquired* is important in determining the efficiency of transshipment strategy together with the *throughput* level. The demand is much higher in Central region for the company both because of higher volume of sales and higher density of customers. Thus a constant flow of goods can be observed on the way to Moscow. In this case in is not reasonable for the company to deliver the goods individually to consumers, as there are potential economies that can be reached due to consolidation of deliveries. The role of demand volume is important in guaranteeing particular regularity of consolidated deliveries. The demand volume in Central region allows to ship consolidated orders in substantially loaded trucks every week, which together with favorable response time constraint and product characteristics moves the company towards the selection of transshipment distribution strategy for that region.

According to the head of corporate sales department of decorative board materials, Slotex is competing in middle-up price segment with importers of Italian and German tabletops and with few Russian companies. The *level of competition* is substantial, however, with depreciation of ruble Russian producers gained price advantages. The important point is that other producers also are prone to adopting centralized distribution networks, hence, there is no significant additional pressure towards decentralization from that perspective. The *bargaining power of buyers* is itself an important factor, but particularly for Slotex the power of dealers is moderate and do not lead to significant contradictions with the interests of the company.

Influence of cost related factors on distribution network decisions

Cost related factors also contributed significantly to the selection of existing distribution network type. Both interviewees admitted that with introduction of distribution network type 3, in which the finished goods are delivered from central warehouse to regional warehouses or even further, type 4 distribution network, in which local warehouses are introduced, the service level would increase. Thus, Slotex is tolerating particular level of *lost sales*. However, it would as well lead to significant increase in costs, which can result in decline in overall value proposition for consumers. The costs of opening new facilities in distribution network should be considered collectively. *Facilities costs,* which include investments required to open new facilities, discourage the company from moving to a more decentralized distribution network, especially during the crisis times, when cost of capital rises and demand falls. Moreover, Slotex is constantly diversifying its business, which increases the intra-firm competition for capital. The same logic is applied to *warehouse operating costs* and *costs of capital*. The latter plays a major role as investments in facilities and inventory freezes significant amount of capital. Learning costs also matter, as opening new facilities would require investments in personnel qualifications and would result in increased management complexity. However, they do not play a crucial role in decision making.

What really matters are *transportation costs*, as they represent a significant share of cost of goods. Even for close to full load trucks travelling to short-distance destinations the share of transportation costs in cost of goods reaches 3%.

Influence of other factors on distribution network decisions

As for other factors, *production characteristics* are crucial, as short production cycle compared to required response time allow the company to avoid holding inventory in intermediate facilities.

Geographic environment is significant in terms of large distances and, as a result, larger transportation costs. The quality of *commercial environment* for regions apart from Moscow and St. Petersburg turned out to be of a great importance for the company. Previously, the company had three regional warehouses, but it faced serious problems of maintaining *control over the product*: maintaining the desired quality of goods and costs control.

3.3. Procter & Gamble case

Company background

Proctor & Gamble has entered Russian market in 1991. The company operates in fast-moving consumer goods market, particularly in homecare (soap, washing powder, dishwashing, etc.) and personal care (grooming products, body wash, hair coloring, skin care, child care, etc.) categories. P&G identifies four major industry-based groups of products in which it competes: baby, feminine & family care; beauty; health and grooming; fabric and home care ("P&G Reorganizes Into Four Industry Groups Under New CEO", 2013).

Currently the company is present in the Russian market with more than 70 brands including Ariel, Tide, Pampers, Always, Head & Shoulders, Wella, Duracell, Gillette in various regions of Russia and is a market leader in ¾ product categories ("P&G в России", n.d.). According to company's representative, P&G operates more than 3000 SKUs in Russia. The head office of the company in Russia is located in Moscow. P&G also operates four branch offices in regions and three production facilities.

Russian market is extremely important for the company as it shows one of the highest growth rates among the markets, where P&G operates ("P&G в России", n.d.). However, according to Euromonitor International, though in 2015 the home care market still showed growth in value sales terms, due to strong depreciation of ruble there was no growth in absolute terms and customers started switching to economy segment (2016). The personal care market, on the other hand, showed strong growth in of 14,3% in 2014 in euro equivalent, however, switching to economy segment is also anticipated (MarketLine, 2015). In both home care and personal care markets, P&G has a strong dominant position with market shares of 27,8% and 11,4% respectively, which is nearly twice as much as it's closes competitors – Henkel and Unilever (MarketLine, 2015; Euromonitor International, 2016).

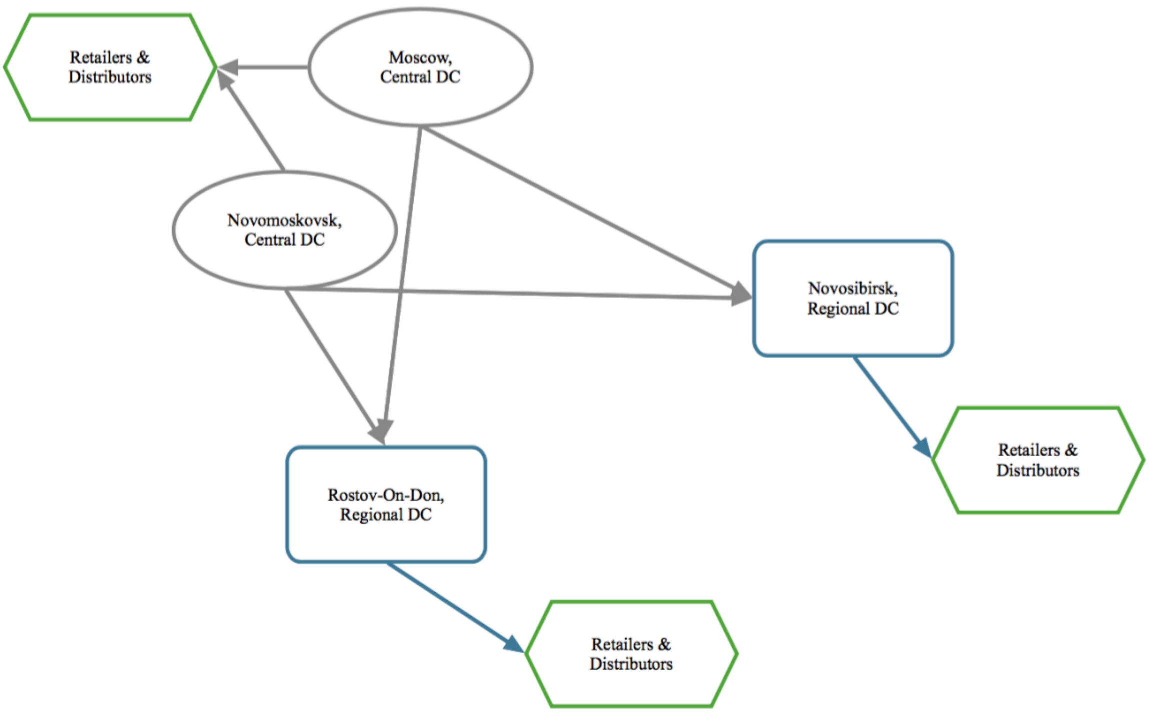
Distribution network description

Procter & Gamble operates three plants in Russia: in Novomoskovsk, Dzerzhinsk and St. Petersburg ("20 лет Procter & Gamble в России", 2011). In Novomoskowsk homecare products such as powders and detergents are produced as well as childcare products such as diapers

Pampers. The plant in Dzerzhinsk produces haircare products. In St. Petersburg the company produces goods under the brand Gillette (“Производство», n.d.).

Procter & Gamble possesses two central distribution centers. One is located in Novomoskovsk, where goods produced in corresponding plant are stored. The other one is located in Moscow, where imported goods (which account to approximately 50% of turnover, according to P&G’s logistics manager) and goods from St. Petersburg and Dzerzhinsk plants are accumulated. From these distribution centers the goods are either directly distributed to customers in the same region or are transferred to one of two regionals warehouses. Few remote destinations such as Vladivostok or Khabarovsk are also served directly from Moscow DC. The regional warehouses, from which goods are further transported to distributors or retailers, are located in Rostov-On-Don and in Novosibirsk. Figure 18 illustrates distribution network of Procter & Gamble in Russia.

Figure 18. Distribution network of Proctor & Gamble



Influence of product characteristics on distribution network decisions

Product characteristics always influence distribution network design. P&G produces rather *functional products*, which poses particular pressure on efficiency of distribution network. The *physical attributes* of products certainly have an impact of distribution network design. The company is producing a wide range of products with different volume and weight characteristics and is considering physical attributes as well as *product value* when designing the distribution network. For instance, the plant and distribution center in Novomoskovsk produce and store homecare and childcare products. This combination of product types was selected deliberately: homecare products such as powders weight a lot, while not requiring much space, while childcare products such as diapers require a lot of space, while being light. When transported together, the products allow to fully use the transportation capacity. Another example is the production of Gillette plant, which has a high *product value density*. The high product value density makes it expensive for distributors to purchase full loaded trucks from the plants. Thus, P&G decided to move the central warehouse of Gillette finished goods to Moscow, where expensive and light goods can be combined with cheaper products for consolidated shipping to customers.

The *purchase size* also matters for the company as it strives to eliminate major inefficiencies in distribution. P&G works directly only with those distributors and retail chains that order full loaded trucks of goods. In case the requested volume of goods is not high enough, the company suggests the distributor to order from larger intermediaries. Such policy implies that P&G should provide sufficiently diversified range of goods with varying characteristics in it's distribution centers.

Influence of market uncertainties and customer needs on distribution network decisions

The most significant factor, which influences distribution network decision for Procter & Gamble and for other FMCG companies, is *product availability*, or service level. The target service level of the company is 98%, which is now a "top priority of the company" according to interviewee. This means that P&G aims at satisfying 98% of consumer demand within the required response time. Currently, the service level accounts for 94%.

The *response time* is another crucial factor for P&G. the targeted response time for consumer orders is 48 hours, which is a standard response time for developed markets such as US and EU, according to P&G logistics manager. Such rapid response time is a result of extremely intense *competition* in FMCG market.

The targeted *response time* is almost met in regions where P&G's distribution centers are located and in neighbor regions, due to short delivery time. For distant demand points the delivery time can be as high as 30 days (for instance, railway delivery from Moscow DC to Vladivostok). Such long lead times require advanced forecasting procedures and tight collaboration with dealers and retailers in order to improve forecasts' accuracy. This is actually being implemented as P&G often performs forecasting activities for it's customers. The company is even sharing the costs of lost sales and excessive inventory holding with it's customers. In order to satisfy the regions within targeted response time, P&G has to develop a network of regional warehouses, as delivery time from central warehouses to distant regions by far exceeds 48 hours. According to the interviewee in P&G, the company is planning to expand its regional distribution network to the East, so that to be able to respond quickly to demand even in remote regions of Russia.

The *product variety* has an impact on distribution strategy as physical attributes and product value differ for different categories. However, broad product variety significantly increases the inventory carrying costs, as for each SKU required safety stock should be held in the warehouse. Currently, P&G carries more than 3000 SKU. In terms of *throughput*, the company can predict with high probability of 98% the demand for particular product category for a one-month horizon, but the demand accuracy on the level of SKU can be as low as 50%. The production lead times in P&G's plants are extremely low since the company introduced night shifts during which the products requested by customers, that are not in stock, are produced. This means that the company can produce the goods within less than 24 hours. Such production flexibility allows to decrease the inventory levels in central warehouses for products produced in Novomoskovsk and Dzerzhinsk (due to it's physical proximity to Moscow DC). On the other hand, regional warehouses have to stock more inventories as they respond slower to unpredictable changes in demand.

Customer experience is important, however, P&G provides higher service level for retailers compared to distributors. This can be explained by an extremely high *bargaining power* of retailers. According to logistics manager of P&G "P&G's products account for only 5% of retailers' turnover, while more than 50% of our sales come from retailers, and this share is constantly growing". Huge retailers like Magnit even have safety stocks reserves in the warehouse of P&G, which cannot be shipped to other companies. Moreover, one of the major reasons why P&G is planning to open new warehouses in more remote regions of Russia is the increasing presence of huge retailers in these regions. Hence, customer experience and bargaining power of buyers are crucial factors for distribution network decisions of P&G. On the other hand, distributors are highly dependent on the company. Most of them trade exclusively P&G's products and just recently the distributors received the rights to trade non-competing goods. *Number of channels through which the product may be acquired* plays a secondary role compared to the particular characteristics of the most important channel – retailers.

Returnability is an important service characteristic, however, it's impact on distribution network decisions is relatively low. *Order visibility* is important for the company and its customers, as P&G integrates it's ERP system with customers' and uses collaborative forecasting in order to decrease total inventory in supply chain and improve forecasting accuracy but it also doesn't impact directly the distribution network design.

The *inventory turnover* was not indicated by the interviewee as a factor, that influences distribution network design, but rather as a consequence. With more warehouses appearing in the system, inventory levels are increasing together with inventory turnover rate, but the service level is increasing as well. High *rate of innovation* fosters the companies to select responsive distribution networks. In case of P&G, the distribution network is designed for responsiveness but not because of innovativeness of the products, but due to market requirements.

Influence of cost related factors on distribution network decisions

Cost efficiency is extremely important for P&G, however, compared to target service level, cost factors play a secondary role in distribution network design. Thus, the most important cost factor is the *lost sales* factor. Other cost factors are analyzed in detail when particular alternatives are considered or during operational inventory and transportation routing planning, which correspond to the second and third stages of distribution network decisions according to Mangiaracina & Perego (2015).

Facilities costs and *learning costs* are considered when decisions about opening new facilities are made. For *warehouse operating costs* and *capital costs* P&G sets particular targets based on required service level. *Transportation costs* are also under strict control. The company operates with full loaded trucks. For customers it is also more efficient to follow the full-truck policy, as it allows to minimize the fixed costs per order. Thus, ordered goods typically can be divided in two categories: those that are needed urgently and "fillers" – the goods that would be needed in near future.

Influence of other factors on distribution network decisions

For particular types of goods, for instance aerosols*, special warehousing needs* are required. However, the investments needed to meet special requirements are minor compared with P&G's turnover, hence, this factor doesn't influence strategic distribution decisions.

On the other hand, *production characteristics* are crucial inputs to distribution network planning. Rapid production cycle allows keeping inventories in central warehouses, which are in proximity to plants on a moderate level. However, in order to be able to exploit the advantages of production characteristics, P&G has to place central warehouses close to the plants. *Geographic environment* and infrastructure influence the optimal routing decisions and particular location selections.

3.4. Palfinger case

Company background

Palfinger CIS (part of multinational company group with its headquarters in Salzburg, Austria) is the world's leading manufacturer of hydraulic lifting, loading and handling solutions ("Палфингер СНГ", n.d.). Palfinger globally operates in B2B segment providing companies of various industries the needed equipment.

In Russia Palfinger manufactures loaders, marine and auto cranes, hooklifts and skiploaders, access platforms, railway systems, bridge inspection units, tail and passenger lifts, as well as truck mounted forklifts. The final product for consumer is the car of specialized equipment, which is compiled of Palfinger's equipment and chassis by dealers. Palfinger CIS offers lifetime technical assistance for the sold equipment. Spare parts and components are sold via dealers (approximately 70 dealers in Russia) to end-users. Dealers are equipped with access to a large inventory of spare parts and experienced parts staff.

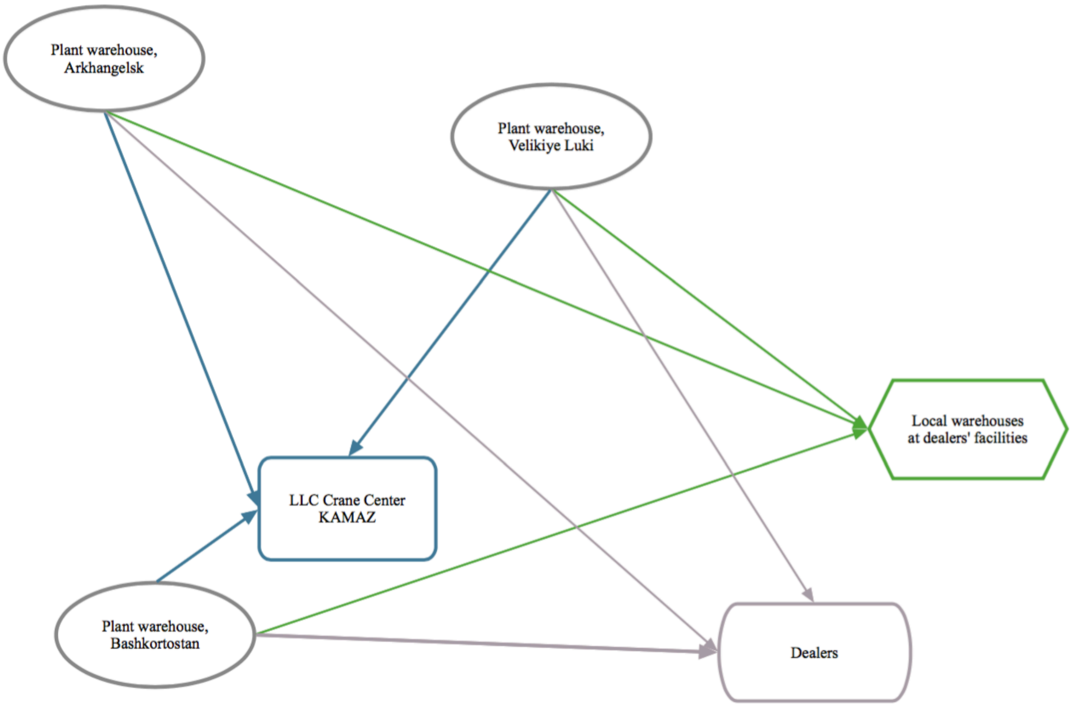
As for the market, BRIC countries are the focus of manufacturing plants for Palfinger ("Palfinger Integrated Annual report", 2013). Even though the investment climate in Russia has worsen from 2013 on and household consumption became sluggish the demand still remained above the average of the industrial nations. However, civil engineering and non-residential construction see pronounced deterioration in 2014 due to cuts in the federal fund's budget and delay of major projects from Russia's utilities industry ("Construction in Russia: ISIC 45", 2015). All in all, the market has seen a severe decline in 2015 - investments in construction industry and number of registered new trucks have decreased for 40% ("Palfinger Integrated Annual report", 2015). At the same time, Palfinger has gained significant competitive advantage as a result of localization of production and managed to even increase revenues in the shrinking market ("Palfinger Integrated Annual report", 2015).

Distribution network description

Palfinger has three major production facilities of finished goods in Russia. CJSC Podjomnie maschini - a plant located in Velikiye Luki Pskov region, is the central production facility, which produces manufactures loaders for timber industry as well as hooklifts and several other types of products. LLC SMZ in Arkhangelsk is the plant, which also produces loaders for timber industry. JSC Inman in Republic of Bashkortostan produces equipment for oil and gas industry. Another plant LLC Palfinger Kama Cylinders in Republic of Bashkortostan is a joint-venture with Kamaz, which produces spare parts for both companies. The final goods are stored in plant warehouses. The imported products are stored in a plant warehouse in Velikiye Luki.

From the three final goods production facilities the products are shipped either to dealers (130 dealers across Russia). or LLC Crane Center KAMAZ in Republic of Tatarstan. The latter is a dealer, which is another Palfinger's joint-venture with Kamaz. According to strategic development manager of Palfinger CIS, 40% of sales come from small construction and timber companies. In order to attract this type of consumers the company has guarantee local presence. It is important for the final consumer to see the physical product at the point of sale. At the same time, most of the dealers do not have financial resources to hold inventories of Palfinger's production. In order to guarantee local presence of it's products the company operates around 25 consignment warehouses at dealers' facilities. Palfinger rents the space and possesses the equipment, while the dealers are responsible for safekeeping of the equipment and sales. To summarize, Palfinger has 3 central plant warehouses in it's distribution network, from which the products are either shipped to local consignment warehouses, where they are stored, or directly shipped upon order. However, since the market conditions has become less favorable, the company is considering moving to a more centralized distribution system, which would also be discussed further. The current distribution network of Palfinger in Russia is represented in the figure 19.

Figure 19. Distribution network of Palfinger



Influence of product characteristics on distribution network decisions

The most important product characteristic, that impact the distribution network of Palfinger is the *product value*. An average value of the most popular product category, which is timber loader, is around 1 300 000 rub. High product value and *innovative nature of the product* also corresponds to high revenues at stake, which increases the importance of *cost of lost sales*. *Physical attributes* determine the transportation efficiency. For Palfinger, a full loaded 20-ton truck can carry from 6 to 10 pieces of equipment, and due to high *product value density*, the share of transportation costs compared to product value is low (on average 0,5 - 1%). However, the *purchase size* is not very high for Palfinger, which results in low full-load factor for direct shippig. On average, around 2000 units are sold per year, which is less that 200 units per month.

Influence of market uncertainties and customer needs on distribution network decisions

The response time again proved itself as a crucial factor for distribution network decisions. For large share of final consumers (around 40%), the response time is lower than the production and delivery time. Another important consideration is that despite extremely high bargaining power of Palfinger compared to *bargaining power* of dealers, most of the dealers do not have financial resources to ensure product stocks in their facilities. Low bargaining power of dealers is explained by the fact that Palfinger controls around 80% of it's Russian market (in 2014 Palfinger has acquired a major sake in the Podjomnie maschini plant located in Velikiye Luki, which was previously the main competitor).

However, in order to increase total sales, the *product availability* and also *product visibility* for the final consumer should be guaranteed. Palfinger's equipment is often critical and costly for small B2B consumer businesses, moreover, the purchase is done only once in several years, hence, the consumers are not huge experts in what they are purchasing. In this case local product visibility plays an important role facilitating the purchase. Thus, insuring high level of *customer experience* is rather important in terms of final consumer, than for dealers, who do not have strong bargaining position. High number of channels through which the product may be acquired together with the mentioned above factors pushes the company towards a decentralized distribution network design.

Volume of sales is important in determining the local warehouses locations. In case the sales are irregular and the demand potential is low, the company doesn't see ground for holding inventories locally.

High *product variety* tends to increase the overall inventory level. Palfinger has made a strategic choice to hold centralized safety stock at the central warehouses, while fast moving models are also held in local warehouses.

Returnability, *order visibility* as well as *rate of innovation* do not have a strong impact on distribution network design according to the company. Rate of innovation rather influences the production processes, while order visibility requirements influence IT procedures.

Currently Palfinger is considering restructuring it's distribution network. The company aims to decrease inventory by reducing it's local presence to a limited number of key cities. There are two major drivers behind that decision. Firstly, the *level of competition* for Palfinger has decreased since 2014 acquisition of major competitor. Secondly, the market conditions have worsened, *inventory turnover* has decreased, which in turn lead to increase in costs.

Influence of cost related factors on distribution network decisions

Until recent times, the top priority of Palfinger was ensuring proper presence of products in regions. Decentralized distribution system corresponds to high inventory and capital costs.

However, the *cost of lost sales* for high-marginal Palfinger products had a more important role for the company. Before the crisis, the company tolerated high *costs of capital*, which resulted from high level of inventories in the system (average level of inventory accounted for 450 units compared to 2000 units sold per year). However, when the demand dropped, average inventory increased up to 1000 units and the company started reconsidering it's distribution network design.

At the same time, due to specifics of chosen types of warehouses – consignment warehouses at dealers' facilities, the *facilities costs* and *warehouse operating costs* were kept at a minimum level. Most of these two types of costs corresponded to plant warehouses. *Learning costs* were not considered by the company as a factor, that determines distribution network design.

Transportation costs are also not considered as the most crucial factors for distribution network planning due to their low value compared to product value. Moreover, the company is following the ex works policy, when the dealers are responsible for transportation of the goods from the plant. According to the company, transportation was taken into account as a major factor only when the central warehouse for imported goods was selected.

Influence of other factors on distribution network decisions

Production characteristics have a strong impact on distribution network design. The production cycle for Palfinger is significant as it is together with delivery time much longer than response time for a large share of final consumers, which drives the company to the necessity of holding inventories in intermediate facilities. *Geographic environment* also is a relevant factor, as it influences transportation costs and delivery times. For instance, couple of years ago the company had one more warehouse in St. Petersburg for imported goods, but after the comparison of transportation costs and facilities costs, Palfinger decided to move the warehouse of imported goods to Velikiye Luki, where it had free storage space.

Changes in *commercial environment* have actually impacted the distribution network decisions significantly. The decrease of purchasing power of final consumers and the rise of prices for imported products drove the company toward more cost efficient distribution strategy considerations. Recently Palfinger has made a decision to go for a more centralized distribution network eliminating the number of local warehouses with inventories.

There are no *special warehousing needs* for Palfinger's products as the equipment is constructed to survive the harshest conditions, however, company's strategic development manager noted, that with implementation of decentralized distribution network Palfinger is losing *control over the product*. It is harder to guarantee proper quality at local than in central warehouses.

3.5. Cross-case comparison

The next step of analysis refers to cross-case analysis, which aims at exploring common patterns across cases. One possible tactic, which was selected for this research, is to select particular dimensions of research and compare their meanings for different cases, searching for similarities and differences (Eisenhardt, 1989).

The within case analysis was based on describing the influence 28 factors. The interviewees were asked to assess relative importance of these factors and explain in which way they influence distribution network decisions. The results of assessment of relative importance of these factors are provided in the appendix 3. Based on received results, the decision was made to exclude several factors from further consideration, as it was revealed, that these factors either do not influence distribution network decisions, or their influence is minor. The following factors were excluded based on the mentioned above logic: *order visibility, customer experience, returnability, rate of innovation, learning costs, special warehousing need, innovative vs functional products.*

Inventory turnover was eliminated as the respondents referred to it as a consequence of selecting particular distribution network design, rather than as a factor. *Distance between nodes* was also excluded from further consideration as influence of this factor is covered by another factor – *geographic environment.* Based on the same argument *product value density* was excepted, as it is reflected in product value and physical attributes factors and separately the factors carry more information. *Product availability* factor was also excluded as it is to large extent covered by the response time factor. Moreover, product availability in the analyzed context rather influences the amount of inventories in central facilities rather than selection of particular distribution network type.

At the same time, within case analysis revealed two relevant factors, which were not discussed in the first chapter of this master theses. The first factor can be named as *economic power of buyers*. This factor refers to the financial ability of buyers to stock inventories at their facilities in order to guarantee availability of products for further or final consumers.

The second factor is *control over the product*. This factor deals with ability of the company to maintain the required conditions of the product in regional and local facilities. The required conditions may include damage, impairment, loss, decrease in service level, etc.

Table 8 summarizes values of relevant factors of distribution network design for all cases. The discussion of influence of each factor on distribution network design is provided below.

Table 8

Cross-case comparison

Factor	*LSR Stenovye, DN type 1*	*Slotex, DN type 2*	*Proctor & Gamble, DN type 3*	*Palfinger, DN type 4*
Physical attributes	Low volume & weight	Moderate volume & high weight	Low volume & weight	High volume & weight
Product value	Low	Moderate	Low to Moderate	High
Purchase size	Big	Small	Big	Small
Facilities costs	High	Moderate	Moderate	Low
Warehouse operating costs	Moderate	Moderate	Moderate	Low
Capital costs	Moderate	Moderate	Low	High
Transportation costs	High compared to product value	High compared to product value	Moderate compared to product value	Low compared to product value
Costs of lost sales	Important	Important	Extremely important	Important
Response time	Exceeds delivery time, but in most cases lower than production & delivery time together	Exceeds production & delivery time	Lower than delivery time from central warehouses	Partly exceeds production & delivery time; partly is lower than delivery time from central or regional warehouses
Product variety	Moderate	High	Extremely high	Moderate – high
Bargaining power of buyers	Low	Moderate	Extremely high	Low
Economic power of buyers	Moderate	Moderate	Extremely high for retailers; low to moderate for distributors	Low
Throughput (volume of sales)	High	High for particular regions; low for others	High	Low

Number of channels through which the product may be acquired	High	High	High	High
Level of competition	Low	Moderate	High	Low
Production characteristics	≈1-4 months cycle	≈10-14 days cycle	Between few hours and 2 days cycle	≈1 month cycle
Geographic environment	Long distances ⇒ long lead times & high transportation costs; unequally developed infrastructure			
Commercial environment	Additional market opportunities	Additional pressure on efficiency but also additional market opportunities	Additional pressure on efficiency	Drives towards more centralized distribution network design
Control over the product	Discourages from decentralization	Discourages from decentralization	Maintained high in all regions	Loss of control tolerated previously

Physical attributes

The major *physical attributes*, that are relevant for distribution network design are volume and weight of products. The cross-case comparison shows that volume and weight alone don't determine the distribution network design. The same can be said about *purchase size.* It can be observed that companies with similar purchase size characteristics can select different distribution network types, for instance LSR Stenovye and Proctor & Gamble. At the same time, these factors together to large extent determine transportation efficiency.

An interesting observation concerns with the *product value factor*. According to the literature review, high product value pushes companies towards centralized distribution network design (Langley, 2009). However, in reviewed cases the opposite trend can be observed, as for companies with high product value the importance of lost sales grows. In order to avoid lost sales companies may go for more decentralized distribution network design and store products closer to customers despite high capital and facilities costs associated with such decisions.

Cost factors

The cost factors are often considered in the literature as major determinants of distribution network design. However, according to interviews of companies' representatives, who were actually involved in distribution network decisions, the cost factors are rather considered as constraints of increasing service level.

Facilities costs generally increase with the increase of the number of facilities in distribution network. However, as the cross-case comparison shows, their significance would vary for different companies. This can be explained by the fact that different types of facilities are associated with different levels of investments. For instance, Palfinger's distribution network consists of local consignment warehouses, which do not require investments in facilities. Volume of sales also influences the significance of facilities costs. The higher the turnover (Proctor & Gamble case), the less significant are investments in facilities. *Warehouse operating costs* unsurprisingly are strongly correlated with facilities costs. Moreover, according to the interviewees, large part of warehouse operating costs are also fixed in nature.

Capital costs increase with the increase of product value. According to literature review, high capital costs would push companies towards selecting centralized distribution network. In reality, Palfinger case shows, that companies may tolerate such costs in favor of providing high service level.

Transportation costs play a crucial role in distribution network type 2, which is basically built around economies of consolidation of orders. Distribution network type 3 also leads to optimization of transportation costs for the same reason. At the same time, distribution networks types 1 and 4 are associated with higher absolute transportation costs unless the transport full load factor is close to its maximum value. Another observation is that importance of transportation costs decreases with the increase of product value. In case transportation costs account for a small percent of product value, the companies may to some extent neglect optimizing transportation costs if the optimization is associated with managerial complexities.

The importance of *costs of lost sales* factor refers to subjective perceptions of management. The evaluation of this factor, according to interviewees is dependent on level of competition, product value and market volume. However, analysis of this factor alone between cases doesn't allow drawing any conclusions regarding distribution network decisions.

Market uncertainties and customer needs

According to this research, the major factor that shapes distribution network selection is the *response time* or the time the company has to supply the customer with the goods from the moment the customers makes the order. The response time should be considered in relative terms: compared to delivery time from production or central warehousing facility and to production cycle together with delivery time. In case if response time exceeds the production cycle and delivery time, the minimum level of inventories in distribution network is required, there is no need in establishing regional or local warehouses that store finished goods and the company would probably operate on make-to-order basis. This situation was demonstrated by the Slotex case. If the response time exceeds the delivery time from central warehousing facility but is less than production time together with delivery time, the amount of inventories in the distribution system would rise, but still there would be no need in regional or local warehouses, as the LSR Stenovye example shows. However, if the delivery from central facility exceeds than the response time from central facility, the companies have to introduce intermediate warehouses with finished goods. Regional warehouses are preferable when delivery time from regional facilities is less than the response time. However, when the response time from regional facilities is not short enough, the companies would be prone to establish local warehouses.

Product variety was high for all reviewed cases with different distribution network types, hence, no conclusion on the influence of this factor can be drawn apart from the fact that increased product variety leads to higher inventory costs, which is proven by the square root law (Croxton & Zinn, 2005).

The lower the *bargaining power of buyers*, the easier it is for the production companies to negotiate favorable conditions in terms of response time and hence, to decrease total inventory level. However, it is important to consider the fact that customers of production companies are often not the final consumers. Consequently, decreasing the service level for customers (for instance, dealers, distributors, retailers) may result in decrease of service level for final consumers, which would result in lost sales for producer. Therefore, it is also important to understand the *economic power of buyers*, whether the dealers/distributors/retailers are capable of holding the needed amount of inventories at their facilities in order to provide adequate service level for final consumers. Following this logic, Palfinger, which has a much stronger bargaining position compared to it's dealers, is still using highly decentralized distribution network.

Throughput or volume of sales alone doesn't allow drawing any conclusion on the optimal distribution network type. This factor becomes meaningful when analyzed together with other factors. *Number of channels through which the product may be acquired* was high for all case companies, thus separate influence of this factor again cannot be derived.

Level of competition compared across cases doesn't lead to any particular conclusion. For example, in both automobile and FMCG industry the level of competition is very high, however the companies are using very different distribution networks. What is important, according to interviewees, is the behavior of competitors. If competitors are offering lower lead times, it is a stimulus for companies to move towards a more decentralized distribution network type and to increase service level. In case competitors use efficient in terms of costs distribution network, the companies have to react either by optimizing their networks and decreasing the costs or by differentiating in terms of service level.

Other factors

Production characteristics are important in determining the level of inventories in the central facility. Short production cycle allows decreasing the level of inventories, while long production cycle leads to a higher level of safety stock required (Slotex vs. LSR Stenovye case). However, this factor doesn't impact further decisions on number of facilities.

Geographic environment is the same for all case companies. Long distances between cities and regions and inefficient transport infrastructure increase transportation lead time and transportation costs. This puts additional pressure on distribution network efficiency.

Commercial environment also impacts distribution network. Since the economic situation in Russia has worsen in two last years, the purchasing power of customers has decreased, while the costs for many components, especially foreign, and transport has risen. This pushes companies to select more efficient distribution strategies in terms of costs. For instance, Palfinger is considering switching from distribution network type 4 to distribution network type 3. On the other hand, for companies who mainly compete with imported products new opportunities in terms of growth arise.

Control over the product acts as a constraint for decentralization decisions. In case the company is not able to maintain the required conditions of the product in regional and local facilities due to regional, management or product specifics, it would be less prone to introduce additional warehousing facilities to it's distribution network.

3.6. Discussion

After conducting within-case analysis and cross-case analysis of the four cases by comparing the impact of various factors, which were identified in the first chapter, a conclusion can be made that these factors do not influence the decisions on distribution network design solely, rather they are interconnected and interdependent.

In the next step of analysis, based on the conducted comparison, the mentioned above factors were grouped into interdependent categories that commonly impact distribution network decisions. Four groups of such factors and one independent factor are proposed:

1. Response time
2. Direct shipment efficiency
3. Transshipment efficiency
4. Holding costs
5. Control over the product

Response time

The response time is a strategic decision of the company, which is shaped by the level of competition, commercial environment characteristics, importance of costs of lost sales and bargaining and economic power of buyers. All these factors determine how fast the company should react upon customers' orders in order to increase total sales.

Behavior of competitors and competition level shapes customers' expectations and drives companies either towards increasing service level or towards excelling cost efficiency depending on the selected market strategy. Generally, with the increase of competition the response time decreases. However, the industry standards may correspond to relatively long lead times, depending on the purchasing decision making patterns of final consumers. For instance, in the market of exclusive furniture long lead times are commonly practiced despite high level completion (Holweg & Pil, 2001). Thus, the level of competition should be analyzed together with industry benchmarks with regards to response time.

Commercial environment also influences the desired response time. The case analysis showed that the exchange rate fluctuations directly impact distribution network decisions. When the purchasing power of customers decrease, as it happened in the case of Russia due to depreciation of local currency, customers become prone to decide in favor of more affordable products and tolerate decrease in service level and, hence, the decrease in response time. Consequently, the cost based vs quality based nature of competition, which to large extent depends on the commercial environment, also influences the targeted service level.

The bargaining power of buyers is also important in determining the response time. In case customers have a strong bargaining position, as it can be observed in Proctor & Gamble case, companies have to react faster to the demand. When the bargaining position of customers is weak, producers are able to negotiate more favorable conditions. At the same time, an extremely low bargaining position of customers may also be a problem. When customers don't have enough financial capacity to accumulate products at their facilities for further sales to final consumers or other intermediaries, the producers may have to take on this responsibility in order to increase total sales of the product. The case of Palfinger illustrates this situation, when extremely low power of customers led to a selection of highly decentralized distribution network.

The importance of lost sales increases with the increase of either product value or volume of the market. When each sale contributes significantly to the company's revenue stream, the importance of losing one customer is significant. When the market volume is high, not meeting even a small percent of received orders is also associated with loosing significant revenue in absolute terms. Thus, the importance of lost sales would lead to decrease of response time, which was demonstrated by Procter & Gamble and Palfinger cases.

All in all, the response time is the main determinant of distribution network design. The selection of the response time impacts not only the distribution network design, but the value proposition to the final consumer, consequently it can be considered as a strategic managerial choice. Such decision can be made by benchmarking the behavior of competitors and considering the major market factors, which impact the required response time. Five such factors were analyzed in this research and their impact is summarized above in the table 9.

Table 9.

Influence of market factors on response time

	Response time	
	High	**Low**
Level of competition	Low	High
Commercial environment	Cost based competition	Quality based competition
Bargaining power of buyers	Low	High
Economic power of buyers	High	Low
Importance of lost sales	Low	High

In this framework the response time should be compared to delivery time from central and regional facilities. The response time which exceeds delivery time from central facility corresponds to distribution network types 1 and 2. In case the response time belongs to the interval between delivery time from central and regional facilities, the distribution network type 2 is preferable. The response time is lower than delivery from regional facilities acts as a motive for selection of distribution network type 4.

Direct shipment efficiency

The direct transportation efficiency factor aims at answering the following question: is it efficient for the company to ship the orders directly from the central facility to customers? The answer to this question depends on physical attributes of the products, purchase size, product value and geographic environment.

Volume and weigh characteristics of the products together with purchase size determine whether the shipments to customers correspond to transport full load. If the regular order size is close to transport full load, the direct transportation efficiency is observed.

In case the the regular order size is significantly less than the transport full load, the product value should be considered. If the product value is high compared to transportation costs, companies might decide to neglect the absence of transport full load, as the Palfinger case demonstrates. If the product value is relatively low compared to transportation costs, the direct transportation efficiency is not observed as in the Slotex case.

Geographic environment matters as it determines transportation costs. The longer the distances between producer and customers, the more expensive the transportation service is, the higher should be the value of transported products, which do not correspond to transport full load, to guarantee the direct sufficient transportation efficiency.

Distribution networks types 1 and 4 correspond to direct shipping from central facility to customers or local facilities. The absence of intermediate facilities leads to the conclusion, that direct shipping is efficient enough. In distribution network type 2 transshipment facilities are introduced to compensate the inefficiencies of direct shipping. In distribution network type 3 regional facilities might appear due to reasons both connected or unconnected with direct shipping inefficiencies.

Transshipment efficiency

The transshipment efficiency is important in case the direct transportation efficiency is lacking. The transshipment efficiency is determined by the direct transportation efficiency, number of channels through which the product may be acquired and throughput level.

The number of demand points together with volume and regularity of sales at these points should guarantee regular enough shipments to transshipment points with improved load factor within the required response time. In other words, the sales at demand points should be regular enough for the orders to be accumulated, shipped and delivered within the lead time requirements. The throughput should also be large enough for the created economies on shipment consolidation to cover the expenses of operating the transshipment facilities.

Transshipment efficiency is a crucial factor for the distribution network type 2. It can also be achieved in distribution network type 3 and result in transpiration costs decrease. However, this factor might be not the most important one for selecting distribution network with regional warehousing facilities.

Holding costs

Holding costs include all the costs, which are associated with holding inventories. The influence of cost factors on distribution network decisions is extensively covered in the literature. For this reason, in this master thesis the focus was rather switched towards qualitative factors, while cost factors are discussed on very general level.

The major groups of holding costs include facilities costs, warehouse operating costs and capital costs. Holding costs would typically increase with the increase of the number of facilities in the distribution network, as each additional facility is associated with increase of total inventory, higher level of investments and frozen capital.

Moreover, the level of holding costs would increase with the increase of product variety, as each additional product adds additional inventory to the system. On the other hand, the holding costs at central facilities would decrease with an increase of production flexibility, as it was illustrated by Slotex and Proctor and Gamble cases.

Holding costs act as major constraint towards selection of decentralized distribution network types. In the distribution network types 1 and 2, the holding costs are kept at the minimum level. In the first one, there is usually just one warehousing facility, where the finished products are stored, which corresponds to a production facility. In the second distribution network type the additional facilities do not perform inventory holding functions, thus adding transshipment facilities doesn’t increase significantly capital costs. Moreover, required facilities costs for transshipment facilities are much lower than for warehouses and distribution centers, which perform various activities. In distribution networks types 3 and 4 holding costs increase significantly due to mentioned above reasons.

Control over the product

The last proposed factor, which impacts distribution network decisions, is control over the product. As it was already discussed above, control over the product deals with ability of the company to maintain targeted service level and required conditions of the product in terms of damage, impairment, loss, decrease in service level, etc. with introduction of regional and/or local facilities to the distribution network.

Unfortunately, Russia is famous for lack of working discipline and low efficiency especially in the regions (“Менеджмент в России: в чем проблема?”, 2013). Introducing additional facilities to the distribution network requires particular managerial recourses and competences in dealing with these problems. Otherwise, the company might not be able to provide the targeted service level and product quality, which, in turn, may lead to reputation damage. In some cases, characteristics of products, for instance fragility, may also prevent the company from introducing intermediate facilities in distribution networks as it was demonstrated by LSR Stenovye case.

Control over the product acts as a constraint for decentralization decisions. The more facilities are introduced to the distribution network, the higher level of control capabilities is required. If the company is not able to maintain the required conditions of the product in regional and local facilities, it would be less prone to introduce additional facilities.

The five described factors and their values for the considered distribution network types are summarized in the table 10.

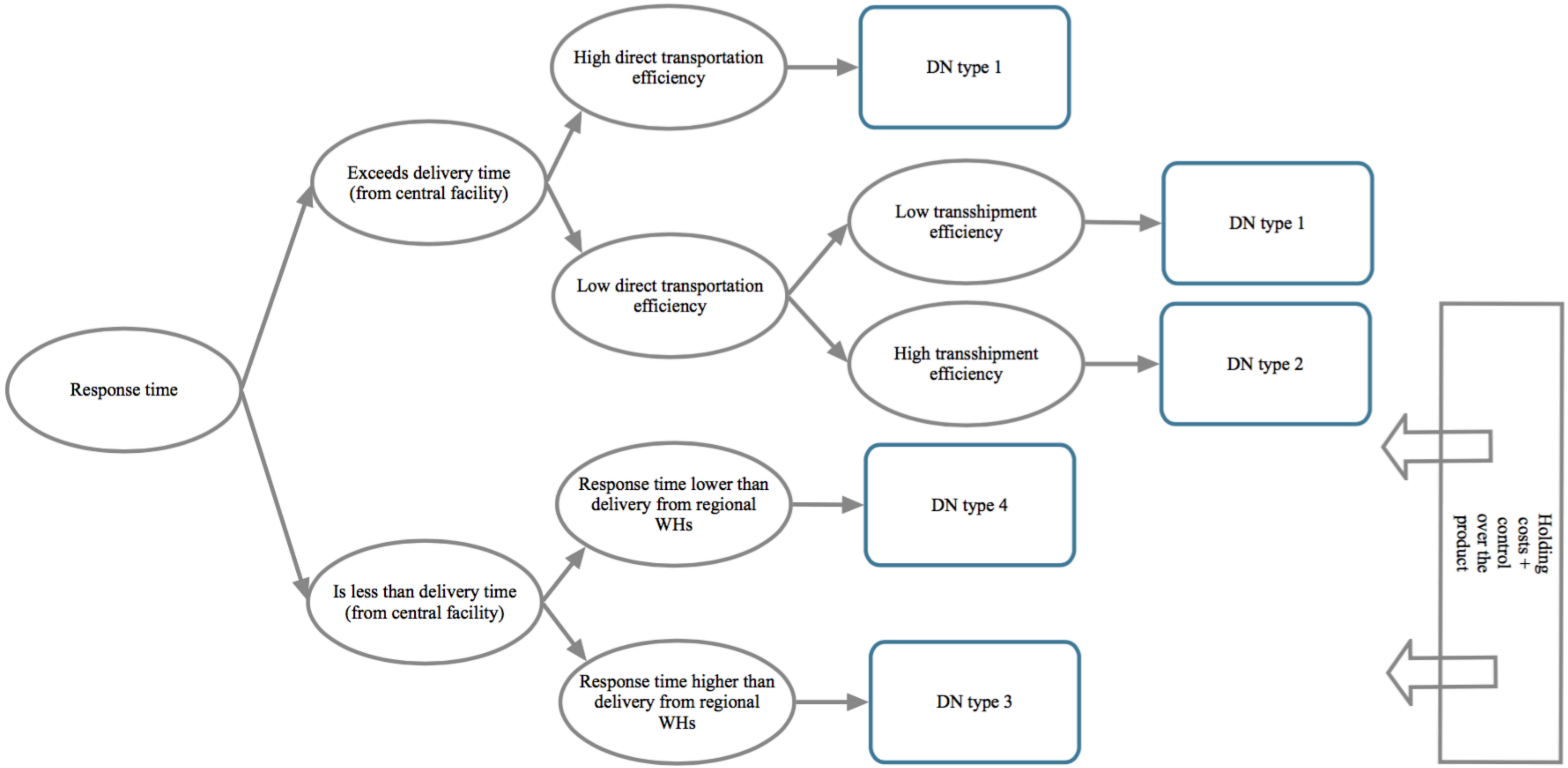
Table 10.

Factors influencing distribution network decisions

	DN type 1	*DN type 2*	*DN type 3*	*DN type 4*
Response time	Higher than delivery time from central facility	Higher than delivery time from central facility	Lower than delivery time from central facility, but higher than delivery time from regional facility	Lower than delivery time from regional facility
Direct transportation efficiency	High to moderate	Low	Can vary	High to moderate
Transshipment efficiency	-	High	Moderate to high	-
Holding costs	Low	Low to moderate	Moderate to high	High
Control over the product	Low level of control capabilities required	Moderate level of control capabilities required	High level of control capabilities required	Extremely high level of control capabilities required

Based on the conducted research and identified influence of response time, direct transportation efficiency, transshipment efficiency holding costs, the process of selection of suitable distribution network type can be depicted as a decision making tree as it is shown in the figure 20.

Figure 20. Distribution network selection process



At the first step, the targeted response time has to be determined based on strategic goals of the company shaped by subjective managerial evaluation of values and relative importance of the listed above response time factors. The targeted response time than should be compared to delivery time from the production facility or central warehousing facility. The determined value might be higher or lower than the delivery time to customers.

If the response time exceeds the delivery time, the direct transportation efficiency factor is to be considered. In case the transportation efficiency factor is high enough according to the management perceptions, the distribution network type one would be selected. If the transportation efficiency factor is not high enough, the transshipment efficiency factor is to be considered. High transshipment efficiency factor corresponds to distribution network type 2, where transshipment facilities are established. If transshipment efficiency is not achievable, the distribution network type 1 would be chosen, and other shipment strategies might be considered such as routing optimization or collaboration with other companies.

In the situation when response time is less than the delivery time, the company has to consider introducing intermediate facilities to it's distribution network. The first step is to consider introducing regional facilities. If the response time is still less than the delivery time from potential regional facilities, the distribution network type 4 is selected. If the response time is higher than delivery time from the regional facilities, there is no need in introducing the local facilities and distribution network type 3 is the choice. However, both distribution networks type 3 and 4 are associated with high holding costs and extensive cost analysis is required.

It is highly possible, that the cost and control factors may prevent companies from selecting the optimal distribution network in terms of service level. In case the costs, associated with the selected distribution network, are too high from the managerial perspective, a step back should be taken and the requirements to the response time are to be reconsidered. Moreover, the need to perform proper control over the product may also push the companies to reconsider selecting decentralized distribution network types.

Another possibility is to combine the various distribution network types within the company. The proposed analysis framework may be applied to product types, groups of regions or customer types as the reviewed factors can vary for product categories, different regions of the country as well as costumers' expectations and characteristics.

3.7. Theoretical and practical contribution

This research aimed to address a particular research gap. First of all, in the existing literature no classification of physical distribution network types was revealed, which would consider number of echelons and types of facilities. In order to address this research gap, a classification of distribution network types was proposed. The proposed classification (chapter 2.1) was based on distribution networks mentioned in the research papers of Ambrosino and Scutella, Cóccola, Chopra and Meindl (2005; 2007; 2013).

Another theoretical contribution refers to identification of five categories of factors that impact distribution network decisions. The following categories of factors that influence such decisions were identified: response time, direct shipment efficiency, transshipment efficiency, holding costs and control over the product. The categories of factors consist of groups of interdependent factors that collectively impact distribution network decisions. The revealed relationships within the group of factors as well as the impact of these factors on distribution network decision are described in the chapter 3.6 of this master thesis and can also be considered as theoretical contributions.

As for practical contributions, an instrument that aims to facilitate decision making in the area of selection of appropriate distribution network was proposed. The goal of the proposed instrument is to facilitate decision making process by systemizing decision making factors and providing overview of distribution network decisions from various perspectives. The proposed process of selection of distribution network type was described and consequent steps of this process were discussed in chapter 3.6. In order to select the appropriate distribution network type, the companies are to consider five mentioned above groups of factors.

Another implication is that different distribution network types might be used by single company. The market factors, demand peculiarities in particular regions, or demand characteristics for particular products may vary, thus the characteristics of input factors would differ, which can lead to different distribution network decision within one company.

The proposed framework can be useful for companies who are considering establishing production facilities in Russia and have to determine which physical distribution strategies would be appropriate. Also, the framework might be useful for companies, who are reconsidering their distribution network design. According to Ross, the need to reconsider distribution strategy might appear due to shifts in demand, required service level, supply, costs structure, demographics, transportation systems, expansion decisions, product diversification, increased cost pressure (2005). Due to recent shift in Russian economy, the research might be relevant for a wide variety of production companies.

3.8. Limitations

This research has several important limitations that have to be taken into account. First of all, due to the fact that this study was conducted based on data from companies, which have production facilities of final products in Russia, the recommendations are valid only for companies with the same characteristics. The companies share the same geographic environment, similar demand spread and similarities in the commercial environment. Also specific characteristics of products were such as perishability were not discussed, so there is room for further research in this field.

The case-study method itself is not free of limitations. One of limitations of qualitative research, which is also extrapolated on this study, is that the findings are lacking an agreed upon significance level (Pratt, 2009). Case study method is bottom-up approach and specifics of collected data may negatively impact the validity of results (Eisenhardt, 1989). Moreover, the method itself is not systematic to a large extent, which can distort conclusions (Yin, 2011).

Another important limitation refers to the subjective nature of qualitative data. While the distribution network type is identified based on objective physical characteristics of case companies' operations, the magnitude of influence of various considered factors is based on subjective opinion of interviewees. The opinion may be biased due to different managerial positions, knowledge, experience and personal attitudes of respondents. Unfortunately, only in two out of four case companies the interviews were conducted with more than one representative of the company. There is also a risk that the interviewees were not completely honest in their answers due to confidentiality issues.

At the same time, the case study method has a significant advantage over other methods as it allows identifying relevant factors of a phenomenon as well as linkages between these factors, which corresponds to the objectives of this study (Stuart et al., 2002). This qualitative research was aimed at getting a deeper understanding of distribution network factors. The selected research strategy lead to identification of particular patterns and connections between the reviewed factors and distribution network strategies.

To summarize, the final chapter of this master thesis was dedicated to multiple case analysis and discussion of findings. Firstly, the four cases corresponding to four distribution network types were described based on 28 potentially relevant factors. After conducting within case analysis, 11 factors were excluded from further consideration and two factors were added. The cross-case analysis was conducted in order to identify patterns and connections between the relevant factors and distribution network types. The factors were further grouped into 5 categories and relationships within these groups were discussed. Finally, based on the discussed findings, a framework that aims to facilitate decision making in the area of selection of appropriate distribution network was proposed.

Conclusion

The goal of this research was to reveal the factors that influence distribution network decisions and describe their influence on selection of particular distribution network type of goods producers with demand fragmented across Russia.

In order to reach this goal, the following objectives were set:

1) Analyze existing theoretical approaches to distribution network design and factors that have an impact on distribution network decisions
2) Provide a classification of physical distribution network types
3) Justify selected research design and collect data for a multiple case study method
4) Identify factors that influence distribution network decisions of goods producers with demand fragmented across Russia
5) Describe the influence of these factors on distribution network decisions
6) Develop recommendations that would facilitate selection of appropriate type of distribution network for companies with demand fragmented across Russia

The first objective was addressed in the first chapter, which was dedicated to the literature review of distribution network design and the factors that influence distribution network decisions. Two major groups of distribution network facilities were identified: warehousing facilities and transshipment facilities; as well as design options for distribution network design in terms of number of echelons were considered. Afterwards, a review of factors influencing distribution network decisions was provided. The discussed factors were grouped in four categories: product characteristics, cost related factors, market uncertainties & customer needs and other factors.

Based on the conducted literature review, the following research gap was identified. First of all, no comprehensive classification of distribution network types has been revealed, since most of the research papers focus on mathematical modelling where number of echelons and type of facilities are mostly perceived as constraints. Secondly, various factors that influence distribution network decisions were discussed in the literature, however, their impact on such decisions has been mostly considered from a very broad centralization – decentralization perceptive. The question, which is not widely discussed in the literature is what is the influence of these factors on selection of particular distribution network type. Taking into account that this research focuses on implications for goods producers with demand fragmented across Russia, in order to address the mentioned above research gap, the following research questions were identified:

(Q1) Which types of physical distribution networks can be identified?

(Q2) What are the factors and how do these factors influence selection of distribution network type of goods producers with demand fragmented across Russia?

The answer to the first research question, which also corresponds to the second objective of this master thesis, was provided based on the literature review. The following four distribution network types were proposed:

1) Single echelon distribution network, where the goods are directly shipped to customers from the plant warehouses or central depots
2) Two echelon distribution network, where consolidated orders are shipped from plant warehouses or central depots to the transshipment depots and than are distributed to customers
3) Two echelon distribution network, where the goods are delivered from plants or central depots to regional depots, which perform the function of buffering the demand and supply sides, and than are transported to customers
4) Two echelon distribution network, where the goods from plant warehouses or central depots are shipped to local warehouses, which are located in proximity to demand points, and afterwards are transported to customers

In order to answer the second research question, the multiple case study was selected as the most suitable method. The description and justification of research design is provided in the second chapter and answers the third objective of this master thesis. Multiple case study is a suitable research strategy since it aims at identifying and describing critical variables of a phenomenon and identifying linkages between variables (Stuart et al., 2002). Four case companies were selected for this study based on the following criteria:

- Case companies should have final goods production facilities in Russia
- Case companies should sell their products in multiple regions of Russia
- Each identified warehouse network type should be present in the case analysis

The required data was collected mostly through a series of in-depth interviews with representatives of the case companies, however, secondary data was also used.

As for the fourth and fifth objectives of the research, the cases were described based on 28 potentially relevant factors covered in corresponding literature. 11 factors were excluded from further consideration and two factors were added based on conducted within case analysis. The cross-case analysis was conducted in order to reveal the influence of relevant factors on distribution network decisions. It demonstrated, that the factors are interconnected and influence distribution network decisions collectively. The factors were grouped into five categories: response time, direct shipment efficiency, transshipment efficiency, holding costs and control over the product. The interconnections of factors within these categories were discusses as well as the influence of these categories on distribution network decisions.

The final objective was to propose practical recommendations that would facilitate selection of appropriate type of distribution network. For this purpose, a framework, which systemizes decision making factors, was proposed. The framework is based on analysis of the five categories of factors and is described as a set of consequent steps.

All in all, it can be concluded, that the objectives set within this master thesis have been met. The conclusions and recommendations are valid for companies with production facilities and customer base in Russia. The author believes, that the topic of distribution network design is especially relevant in the context of turbulent Russian market. Changing market conditions and increasing cost pressure require optimization of business processes in many fields including distribution network design.

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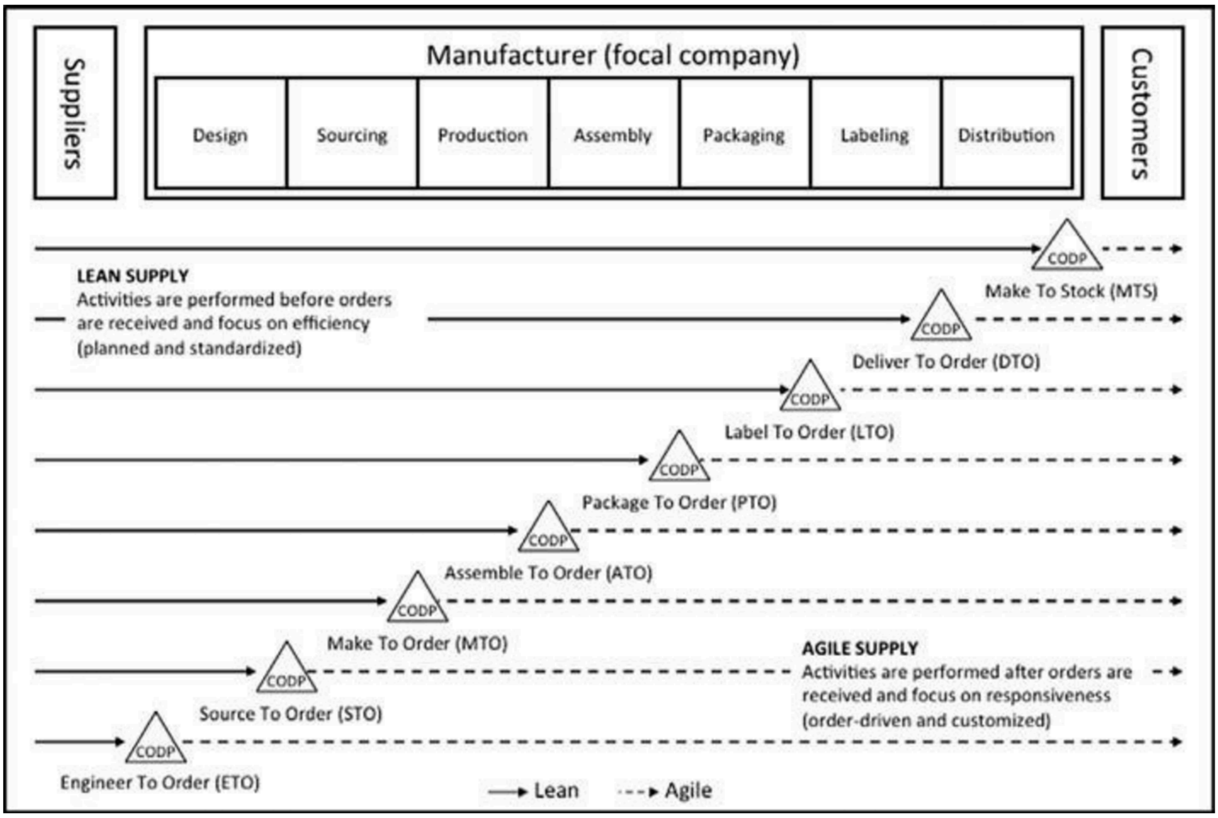
Appendices

Appendix 1: Different leagile supply chain approaches



Source: Hilletofth (2009)

Appendix 2: In depth interview questions

1) Which supply chain strategy is applied in your company? Does it depend on the product type?
    a. Make To Order
    b. Assemble To Order
    c. Package To Order
    d. Deliver To Order
    e. Make To Stock
2) Please, describe distribution network of final goods for your company in terms of:
    a. Number & Location of plants
    b. Number & Location of warehouses
        i. Central warehouse/s
        ii. Regional warehouses
        iii. Local warehouses
    c. Number & Location of customers

    Does it depend on the product type?
3) Do you use transshipment strategy? For which product types?
4) Please, describe decision making process with regards to distribution network configuration. How are decisions made:
    a. Qualitative assessment of alternatives
    b. Quantitative assessment of alternatives
    c. Qualitative and quantitative assessment of alternatives
5) Please, look at the table with factors, that potentially influence distribution network decisions. Based on your experience, evaluate the relative importance of these factors for your company, on a scale from 1 to 7, where 1 – the factor doesn't affect decisions at all and 7 – the factor was a top priority for distribution network decisions.

Factor	Impact of the factor on DN decisions, 1 to 7
Innovative (high margin, short life cycle, unpredictable demand) vs functional products (the opposite)	
Physical attributes (weight, volume)	
Product value	
Product value density (value/weight)	
Purchase size	
Facilities costs	
Warehouse operating costs	
Learning costs	
Capital costs	
Transportation costs	
Costs of lost sales	
Response time	
Product variety	
Product availability	
Customer experience	
Order visibility (ability to track the order)	
Returnability (ability to easily return the product)	
Throughput (volume of sales)	
Number of channels through which the product may be acquired	
Rate of innovation	
Inventory turnover	
Bargaining power of buyers	
Level of competition	
Distance between nodes	
Special warehousing needs	
Production characteristics	
Geographic environment	
Commercial environment	

6) Can you name any other factors that influenced selection of particular distribution network design by your company?
7) Which customers do you serve (plants/dealers/distributors/individuals/etc.)?

8) Which planning horizon What is the average forecast accuracy?
9) Does the response time (the time consumer is willing to wait for the product) exceed the delivery time from production facilities?
10) Does the response time (the time consumer is willing to wait for the product) exceed the production cycle and delivery time from production facilities?
11) Please, describe the demand for major product categories in terms of:
    a. Volume
    b. Variability
    c. Variety of products required by customers
12) Is it important for the final consumer to be able to see the product during purchase decision making?

Appendix 3: Relative importance of factors for case companies

Factor	*LSR Stenovye*	*Slotex*	*Palfinger*	*Proctor & Gamble*
Innovative vs functional products	4	3	2	3
Physical attributes	7	6	4	5
Product value	6	6	7	5
Product value density	6	4	5	5
Purchase size	7	6	3	6
Facilities costs	3	7	5	3
Warehouse operating costs	2	4	3	5
Learning costs	2	4	3	3
Capital costs	3	6	6	5
Transportation costs	7	7	5	5
Costs of lost sales	5	3	6	7
Response time	7	7	7	7
Product variety	5	5	4	5
Product availability	5	4	6	7
Customer experience	5	2	2	3
Order visibility	3	2	2	3
Returnability	1	1	2	3
Throughput (volume of sales)	7	7	3	5
Number of channels through which the product may be acquired	4	3	4	3
Rate of innovation	1	3	2	2
Inventory turnover	3	2	2	3
Bargaining power of buyers	4	5	5	7
Level of competition	6	5	5	7
Distance between nodes	5	3	5	5
Special warehousing needs	1	2	1	1
Production characteristics	6	7	6	7
Geographic environment	6	5	5	5
Commercial environment	6	6	5	3