Master's degree thesis

LOG950 Logistics

VMI implementation and effect in the wholesale industry. A case study of TOOLS Molde

Laura Jasene

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Preface and acknowledgements

This thesis is the final mandatory paper of two-year Master degree of Science in Logistics program, specialization in Supply Chain Management at Molde University College. These years have been both challenging and rewarding with new experiences and knowledge.

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Laura Jasene.
Molde, Norway.
May, 2014.

Summary

VMI is a widely used strategy of inventory control. Scientific research highlights numerous advantages experienced by VMI users. However just a few companies were able to achieve considerable improvement after implementing it.

Current scientific research is investigated in the field of VMI implementation and effect with the purpose to compare theory with processes performed in one of wholesaler companies TOOLS Molde.

In order to answer research questions, a descriptive-exploratory case study was conducted. Both quantitative and qualitative data collection and analysis methods have been used so that VMI effect would be defined as good as possible.

The findings indicate that VMI policy highly depends on customers' needs as it also is not necessarily difficult to implement neither requires high investments. Customers are willing to implement this strategy mainly because of its ability to simplify administration work. Meanwhile supplier is able to better meet customers' needs which later results in increase in sales.

Key words: *Vendor Managed Inventory, Business-to-Business, collaboration, Economic Order Quantity, Periodic replenishment.*

Contents

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List of abbreviations

VMI – Vendor Managed Inventory

B2B – Business to Business

IT – Information Technologies

ERP – Enterprise Resource Planning

EDI – Electronic Dara Interchange

ICT – Information and Communication Technology

SAP – Systems Applications and Products in Data Processing

PAR – Product Activity Record

EOQ – Economic Order Quantity

3PL – Third Party Logistics

1. Introduction

1.1 General introduction

In today's competitive world, where Just-in-Time, Lean and other efficiency programs are being heavily promoted, companies constantly search for new ways to save more. Inventory is probably the largest investment that, according to Stock and Lambert (2001, p. 188), may comprise up to 50 per cent of total assets for wholesalers and retailers. Being the largest tied-up asset, inventory is also the trickiest one to reduce. This is because stocks have a buffer function that enables continuous and uninterrupted production and performance of other necessary activities in the company. For wholesalers inventory is also important because it allows assuring required service levels to the customer. Many inventory control techniques have failed to keep balance between cost reduction and high service levels. Therefore companies tend not to take risks and usually keep stock quantities above the necessary level.

Collaboration among sellers and customers appeared to be a solution that might have been just right in terms of better satisfaction of customers' needs while keeping lower inventory levels. Vendor Managed Inventory (VMI) has been one of the most often applied collaboration forms in various markets all over the world. There have been success stories as well as failures which have raised a huge interest among scientists. As a consequence, a vast amount of research is found under this topic. It might even imply the thought that there is not so much left to analyze in this field. However each market, industry and even each company has its own special features that result in different VMI implementation techniques and positive (or negative) effects on its users. The case company TOOLS Molde is a supplier of industrial consumables. In accordance to its activities, the company can be placed under *Industrial Machinery and Equipment and Supplies Merchant Wholesalers* industry (NCAIS code 4238). The industry comprises operations primarily engaged in the merchant wholesale distribution of construction, mining, farm, garden, industrial, service establishment, and transportation machinery, equipment and supplies (NCAIS_2014).

1.2 Purpose of the thesis

In the literature VMI is usually analyzed from the perspective of a manufacturer that produces one type of goods. In other words, the object of research usually is one manufacturer, one product and one customer (Smaros et al., 2003). Therefore it has been important and at the same time interesting to investigate how a wholesaler, that has over 350 000 unique products in its catalog together with over 1000 customers a year, implements VMI to 10 of its customers each representing different industry. Important fact is that neither TOOLS Molde nor its VMI customers have ever tried to calculate financial benefit of VMI. In addition, even though VMI is considered as an advantageous strategy for supplier as much as for its customer, all VMI agreements were initiated by the customers only.

The purpose of this thesis is to analyze existing literature on VMI and compare it with the findings in this specific case company. In order to reach the goals of the thesis, certain research questions have been asked. For the purpose of comparison, the same questions were answered while analyzing the literature as well as in the process of investigating the case company:

RQ1: What are the main factors for successful VMI implementation?

RQ2: What changes in partnering companies does VMI lead to?

RQ3: What are the main characteristics of VMI agreement?

RQ4: What financial and non-financial benefits of VMI are experienced by both wholesaler and its customer?

1.3 Structure of the thesis

This thesis comprises 5 chapters: Introduction, Literature review, Methodology, Results and Analysis of the Case Company and Conclusions.

Introduction. The chapter briefly presents the importance of inventory management. The reader is also introduced to the purpose and research questions as well as structure of the study.

Literature review. The chapter explicitly analyzes current scientific research relevant to the study. The concept of VMI is investigated in addition to brief definition of Business-to-Business (B2B) markets as well as the importance of collaboration in today's competitive world.

Methodology. The chapter discusses about research design of the paper. Data sources as well as the main methods to analyze the data are described.

Results and analysis of the case company. The chapter presents the main characteristics of the case company and its customer base with the main interested laid on VMI customers. The reader is also introduced to the outcome of the questionnaire. The chapter is finished with the discussion about the main findings of this research.

Conclusions. In this chapter the results of comparison the literature with empirical findings are presented. The chapter also consists of proposal to future research in this field.

1.4 Limitations of the study

This study has a few limitations that are necessary to underline:

- First, VMI implementation and effect is analyzed in certain industry and certain company therefore application of results might differ while considering wholesalers operating in other industries.
- Second, the case company is a department of B&B TOOLS that operates in other Nordic countries as well. However, each department has its own unique customer base therefore shipbuilding industry that was mentioned in this thesis as the main one might be not so-well developed in other regions or countries.
- Third, this thesis analyzes only manual periodic replenishment form of VMI. Therefore some parts of this thesis might not be very helpful to the reader who investigates other VMI policies.
- Fourth, the financial benefits experienced by a potential VMI customer have been calculated using historical demand data from a particular period. Having in mind the variability of demand, the results might differ while analyzing different periods.

2. Literature review

For the purpose of this thesis the importance of collaboration in B2B markets was investigated. Special attention was given VMI as one of the collaboration forms. The chapter discusses about the main advantages of VMI, changes in the company influenced by VMI, the main VMI agreement dimensions as well as factors for successful VMI implementation.

2.1 Characteristics of B2B markets

Over the past three decades B2B markets have been of high interest in the scientific research (Dant and Brown, 2008). Saeed (2011) defines B2B marketing as a

'*practice of individuals or organizations, including commercial businesses, Government institutions, facilitating the sale and resell of their products/services to other organizations/institutions'.*

In the case company sales of industrial products are performed towards other businesses rather than private persons, therefore unique solutions and strategies are implemented to overcome the challenges. Authors highlight certain characteristics that characterize B2B markets.

1. *Product specificity*. In B2B markets goods are usually intermediate products that are used to produce the end-product or contribute to producing it (Eckles, 1990). Buying organizations prioritize excellence in product quality, technology, and engineering. Price here does not play a dominant role since buyers are ready to pay for goods that contribute to improvement of the end-product. Goods are purchased by technically educated personnel who are well aware of what requirements should the product comply with. Therefore advertisements, special offers, and other 'marketing tricks' rarely affect their buying behavior (Kotler, 2003; Eckles, 1990).

2. *Derived demand*. Eckles (1990) considers derived demand for industrial products as one of the most significant features of B2B markets. Derived demand means that demand for B2B products are dependent on demand for end-user goods, including the products that are components or are otherwise used for production of the end-product. Gross et al. (1993) notice that derived demand would not exit if the buying

company could not sell its own products. Therefore the supplier of industrial products must monitor buying patterns of the end-consumers and be prepared to adjust to changes (Kotler, 2003).

3. *Acceleration principle*. Derived demand might also cause acceleration effect which is characterized by high fluctuations of demand for industrial products in connection with small changes in demand for end-products. Kotler (2003) claims that in certain cases a rise of 10 percent in consumer demand might result in 200 percent rise in business demand. It might cause chaos inside supply chain if proper communication is absent among partners (Eckles, 1990).

4. *Inelastic demand*. This feature means that demand for industrial products does not correspond to price changes. Kotler (2003) notices that demand is especially inelastic for goods that represent a small percentage of total cost of the end-product. Eckles (1990) explains that producers will buy the same exact amount of industrial goods that is necessary for manufacturing the end-product, regardless the price. In the case of price growth producers are able to pass added costs to the end-customer.

5. *Order size*. Regardless the size of buying organizations, their purchase orders are usually large in number of units, money value, or both (Gross et al., 1993). However industrial goods cover a wide range of products, anything from a box of nails to machinery parts, thus orders might differ significantly in terms of their value while the cost of preparing an invoice is always the same. Different order size also affects transportation costs therefore sellers tend to apply different strategies to different customers using segmentation and prioritization the most profitable ones (Eckles, 1990).

6. *Buyer-seller relationship*. In B2B markets sellers interact with a relatively small amount of professional customers. Sellers seek to keep close relationships with customers in order to be able to meet their needs as good as possible. The goal here is to maintain long-term relationships where partners depend on each other and work together towards mutual benefits. Thus, buyer-seller relationships in B2B markets are characterized by collaboration, trust and loyalty (Gross et al., 1993).

2.2 Collaboration in supply chain

Scientific research highlights customer service as a priority in the supply chain management (Williams and Tokar, 2008). All actors in the supply chain are working

towards one goal - getting the right product to the right place at the right time. However researchers agree that high customer satisfaction usually leads to high expenditures.

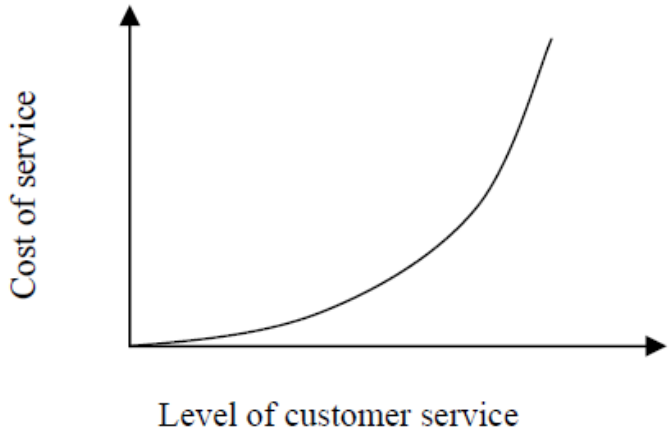

FIGURE 1 THE COST OF MAINTAINING CERTAIN CUSTOMER SERVICE LEVEL (CHRISTOPHER, 2011, P.44)

A steeply rising curve shows that the higher service levels are required, the higher are the expenditures that usually comprise the cost of surplus inventory that is needed for maintaining high service levels under conditions of uncertain demand.

According to Swatz et al. (2010) today's customer requires tailored services that are especially recognizable in logistics activities. In addition, Gronroos (1999) emphasizes that good quality and low price are simply not enough in competitive markets; customers expect well-handled deliveries, service and maintenance, customer-oriented complaints-handling routines as well as skilful and helpful personnel. Grant et al. (2006) define customer service as a

process which takes place between the buyer, seller and third party. The process results in a value added to the product or service exchanged. This value added in the exchange process might be short term as in a single transaction or longer term as in a contractual relationship.

However, Vargo and Lusch (2004) notice that the supplier cannot provide value-added service on its own; the customer is required to collaborate in the process of value creation. This leads to a change in focus from transaction exchange to relationship exchange which Gronroos (1999) describes as a source of competitive advantage.

Stank et al. (2001) claim that high customer service level might be also achieved by maintaining a close collaboration among partner companies. Bahinipati and Deshmukh (2011) define collaboration as a

'relationship in which the buyer and the supplier work together for a common objective by sharing information and resources to solve problems, improve products, and streamline inventory-related processes.'

Close supplier-customer relationships are believed to result not only in better service level but also in improved demand planning and, consequently, reduction in inventory levels. Collaboration success has been proved by numerous coordinated inventory management forms such as quick response, synchronized consumer response, continuous replenishment, efficient consumer response, rapid replenishment, collaborative planning, forecasting and replenishment and centralized inventory management (Disney and Towill, 2003).

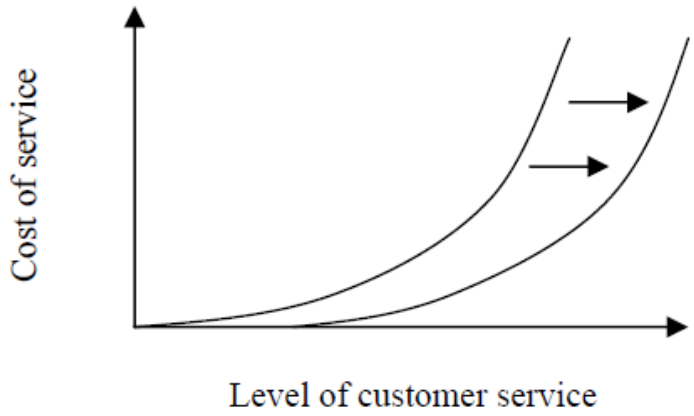

FIGURE 2. THE SHIFT IN THE COST OF SERVICE (CHRISTOPHER, 2011, P.46)

Christopher (2011) shows that high expenditures are no longer the only possibility to assure customer satisfaction. The right shift of the curve might be achieved by maintaining close relationships with customers. Collaboration speeds up the flow of information which allows reducing inventory costs or achieving higher customer satisfaction with the same inventory.

2.3 The concept of Vendor Managed Inventory

VMI is considered as *'one of the most widely discussed partnering initiatives for improving multi-firm supply chain efficiency'* (Waller et al., 1999).

Hines et al. (2000) define VMI as a

collaborative strategy between a customer and supplier to optimize the availability of products at minimal cost to the two companies. The supplier takes responsibility for the operational management of the inventory within a mutually agreed framework of performance targets which are constantly monitored and updated to create an environment of continuous improvement.

Researchers refer to the collaboration between Wal-Mart and Procter & Gamble as one of the first large-scale successful implementations of VMI. This partnership has contributed to significant benefits such as improved on-time deliveries while increasing inventory turns (Bichescu and Fry, 2009). Popularized in late 1980s this strategy has been widely adopted in various markets all around the world.

According to Marques et al. (2008) VMI is considered as a pull-oriented[1] strategy which allows reducing or even eliminating safety stock for certain products. Marques et al. (2012) define the main VMI features that show that this strategy has inherited pull logic:

- Replenishment is implemented after the product is consumed;
- Supplier determines replenishment quantity and time based on historical consumption;
- Forecasted consumption is not taken into consideration for making dispatch decision (but it is used for deciding on minimum and maximum levels).

[1] Push- and pull-oriented strategies were firstly used to define manufacturing processes in accordance to whether products were made-to-stock or made-to-order. Later, these concepts have been adapted to logistics and marketing where push strategy means that vendor orders products from supplier according to forecasted consumption of its customers while under pull strategy distribution is demand-driven (Klaas, 1998).

2.3.1 Benefits of VMI

Benefits of VMI are explicitly discussed in the current scientific literature. Authors usually distinguish different advantages experienced by each partner. As a rule partners in this relationship appear to be a manufacturer and a retailer. For the purposes of this thesis the parties of an agreement are named as a *wholesaler* and *its customer*.

Wholesaler benefits

1. Lower reliance on forecast.

Demand forecasting performed using only historical data has been the most common method for planning for a long time. Cachon and Fisher (2000) notice that wholesalers usually have no other choice but rely on orders historically placed by customers because they do not have accessibility to any other customer information. According to Smaros et. al (2003), such forecasting often reflects delayed and unreliable information about customer demand therefore using this data for planning would lead to inefficient capacity utilization, poor product availability, and high stock levels. Under VMI a wholesaler is able to observe on-going demand and make more precise replenishment decisions (Zammori et al., 2009).

2. Increase in revenue

In the case of VMI absence, a wholesaler is usually receives most orders at the beginning of the week or month. It might be difficult to meet the demand of all customers at the same time. Moreover a wholesaler has no ability to forecast random increases of demand. This results in lost sales and therefore lost revenue. Under VMI, a wholesaler can meet the demand more accurately and therefore sell more products (Zammori et al., 2009; Sui et al., 2010).

3. Acquisition of competitive advantage

By inventory centralization and ordering, the supplier gains strategic benefits over competitors (Bahinipati and Deshmukh, 2012). Gronroos (1999) notices that competitive advantage is achieved when customers' problems are being solved on a relational level rather than on a transactional one. By working together a wholesaler and its customer create unique product which is an outcome of their collaboration. It means that no competitor is able to offer the same "product" which results in loyalty from the

customer's side. According to Fawcett et al. (2010) strong relationships and sharing of sensitive information build new capabilities for both partners.

Customer benefits

1. Reduction of stock-out situations

Under VMI a wholesaler have a direct access to the information about customer's demand. More frequent inventory reviews and order intervals result in increased inventory visibility. A wholesaler can then forecast possible demand peaks which allows to assure that customer is never out of stock (Angulo et al., 2004; Groning and Holma, 2007; Kim and Park, 2010; Sui et al., 2010). This also leads to reduction of order modifications which occur in the conventional buyer-seller relationships when a buyer does not receive a full delivery (Zammori et al., 2009).

2. Purchasing process simplification

Probably the biggest benefit a customer gets from VMI is a purchasing process simplification. In a conventional buyer-seller relationship the same activities are performed by both supplier and its customer; only the customer performs its material requirement planning and supplier calls it distribution requirements planning (Holmstrom, 1998). Under VMI, a wholesaler becomes responsible for inventory replenishment therefore it is no longer necessary for a customer to plan and create purchase orders. Purchasing process simplification also reduces possibility of data entry errors which might occur more often when the same activity is done by two parties instead of one (Zammori et al., 2009).

Shared benefits

1. Reduction of costs

Firstly, a wholesaler is able to reduce transportation costs. Because of stable replenishment frequency a wholesaler can reduce number of trips, use fewer trucks or, at least, reduce number of trips with half-loaded trucks (Sui et al., 2010; Angulo et. al, 2004). Infrequent large orders force wholesalers keeping a surplus inventory so that high customer satisfaction would be maintained. In case of VMI implementation a wholesaler performs weekly replenishments which mitigate demand uncertainty. In that manner it is possible to plan inventory better which leads to reduction of tied-up capital (Waller et al., 1999; Zammori et al., 2009).

Meanwhile a customer experiences reduction in administration costs since excessive material requirement planning is done by the supplier. Customer does not need to place purchase orders, backorders or returns which reduce administration costs even more (Holmstrom, 1998).

2. Stock level reduction

In the conventional relationship both buyer and seller seek to optimize their inventory levels independently. However under uncertain demand both parties are forced to keep high levels of safety stocks (Holmstrom, 1998). Under VMI the wholesaler has access to inventory databases at the customer therefore it is able to coordinate both its own and customer's inventory levels from being excessive (Sui et al., 2010; Zammori et al., 2009). This also results in inventory turns (Angulo et al., 2004).

3. Improved service level

Heskett (1994) emphasizes the main factors that fall under the concept of customer service: delivery accuracy, delivery completeness, lead time and order placement flexibility. VMI is a strategy which, if successfully implemented, enables supplier improving customer service levels while balancing on minimum stock levels (Claassen et al., 2008).

4. Long-term relationship

In addition to above mentioned advantages, VMI is also an enabler of a long trustworthy relationship benefited by both wholesaler and its customer. In the long run wholesaler experiences customer's loyalty while customer receives a reliable partner who is able to ensure high service levels (Claassen et al., 2008; Angulo et al., 2004). Collaborating to manage inventory creates the platform for partners to solve arising issues together (Fawcet et al., 2010).

2.3.2 Success factors of VMI

Despite of numerous advantages of VMI, many companies have failed to implement this strategy successfully (Fawcett et al., 2010). In fact, just a few firms were able to achieve significant improvements (Frankel et al., 2002). Therefore a vast scientific research is done in order to determine the factors that lead to successful VMI implementation. Researchers agree that firstly, companies must understand the nature of VMI strategy before starting to implement it. Secondly, efficient information sharing

is considered as the main cause which makes VMI a successful strategy. Finally, VMI as any other relationship is not possible without trust between partners.

1. Understanding the concept of VMI

It is suggested that many of the problems related to supply chain collaboration arise because of lack of understanding of what collaboration actually is (Barratt, 2004). Collaborative inventory management requires preparation to manage behavioral, organizational, and technology systems (Fawcett et al., 2010). Implementation of any collaborative relationship is firstly a massive change both internally and externally. Holmstrom (1998) also agrees that the key to successful VMI implementation is cooperation between partners and common understanding of process and procedure. Guimaraes et al. (2013) notice that VMI contracts are not regulated by legal system. The agreement can be implemented between companies that trust each other and are willing to come into partnership which means that both parties are aware and agree on all the conditions so each one knows what to expect from the relationship.

2. Trust

According to Morgan and Hunt (1994) trust is the main key that causes and strengthens long-term relationships. Researchers have noticed that managers usually struggle at building trust. Laeequddin et al. (2010) reflect the situation most managers are in: '*We cannot improve what we cannot measure and we cannot build if we do not know where to start*'. Ganesan (1994) defines trust as a

'willingness to rely on an exchange partner in whom one has confidence. Two distinct components: objective credibility, belief that the other has the expertise to perform the job; and benevolence, belief that the other has motives beneficial to the target when new conditions arise for which a commitment was not made.'

According to Pohlen and Goldsby (2003) trust between the parties ensures that each will fulfill requirements that are necessary to make the relationship continue. Trust is the factor which gives a start to transition from satisfactory to close and reliable relationships. Jena et al. (2011) claim that communication is a crucial element in developing trust in the buyer-seller relationship. Informal means such as salesperson's visit to the customer may significantly improve the status of a relationship (Doney and Cannon, 1997).

3. Information sharing

Researchers highlight the importance of information to successful supply chain performance (Angulo et al., 2004). According to analysis done by Lee and Billington (1992) introducing sensitive information into decision making can lead to reduction of inventory levels as well as supply chain costs.

Huang et al. (2003) name the types of information that partners potentially agree to share in order to enhance relationship (table 1).

TABLE 1. TYPES OF SHARED INFORMATION (HUANG ET AL., 2003)

Category	**Type of information shared**
1. Product	Product structure
2. Process	Material lead time Lead time variance Order transfer lead time Process cost Quality Shipment Set-up cost
3. Inventory	Inventory level Holding cost Backlog cost Service level
4. Recourse	Capacity Capacity variance
5. Order	Demand Demand variance Order batch size Order due date Demand correlation
6. Planning	Demand forecast Order schedule Forecasting model Time fence

Parties of agreement decide how much and what type of information to be shared in accordance with each partner's position in supply chain as well as level of collaboration (Waller et al. 1999). Zhang (2008) proposes depth of information flow model which shows that type and amount of information shared depend on trust between partners, thus on relationship closeness (refer to Fig. 3).

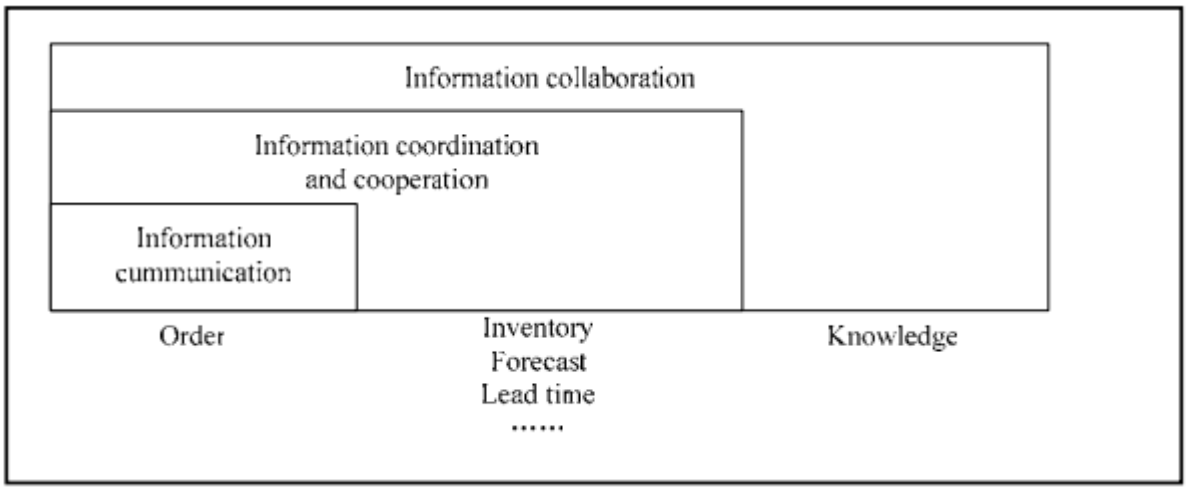

FIGURE 3. DEPTH OF INFORMATION FLOW (ZHANG, 2008)

The author describes three dimensions of information flow:

1. Information communication. This dimension refers to the least possible amount of information necessary to implement transaction between supplier and buyer.
2. Information coordination and cooperation. This dimension reflects the situation when supplier and customer are willing to come into a relationship which would assure a transparent and visible information flow. In this case much more information is shared, e.g. inventory levels, forecasts, lead times, etc.
3. Information collaboration. This dimension appears in collaborative initiatives such as VMI, where partners exchange information in order to create a shared knowledge about processes in supply chain and gain mutual benefits out of it.

Lee and Whang (2004) define three possible models of information sharing in accordance with storage of transferred information:

1. Information transfer model. This model is used when one partner has more power in a relationship and therefore maintains a database for decision making. Meanwhile the other partner only transfers the required information.
2. Third party model. In this case third party is involved in a relationship whose the main function is to collect and store data transferred from other parties.
3. Information Hub model. This model recalls third party model with the difference that there is no a physical third party in a relationship. In this case

data is stored in different locations in the Internet and it is reachable only by parties of the certain relationship.

Researchers also agree that in order to enhance collaboration the information must have certain characteristics such as accuracy, timeliness, completeness, ease of access and compatibility across users (Stank et al., 2001). These characteristics define the level of information quality.

Fawcett et al. (2010) notice that customers demand on-time deliveries however they fail to provide forecasts and other information necessary for inventory planning. According to Angulo et al. (2004) there are various reasons for insufficient information transfer: different incentives and performance measures between the seller and the buyer; confidentiality issues; trust; technology investment costs as well as antitrust regulations. The study conducted by Larson and Kulchitsky (2000) shows that only under close relationship sensitive information might be transferred.

2.3.3 Changes in the company influenced by VMI implementation

Any new process would certainly change everyday activities in the company. VMI implementation is not an exception. In fact, reluctance to change might be one of the most important causes of VMI failure. Scientific research distinguishes two main areas where adjustments are usually performed while introducing VMI: managerial capabilities and IT configuration.

Managerial changes. Under VMI the vendor acquires new obligation – to monitor and replenish inventory levels at customer's site. Appearance of a new process results in the creation of new job positions or, in other case, current employees gain more responsibilities. Bendoly and Jacobs (2005) suggest that a typical VMI team should consist of inventory analyst, EDI/IT specialist, and sales or account manager from supplier's side and purchasing manager EDI/IT specialist and logistics manager form customer's side. However, Chin et al. (2004) suggest that personnel representing different functions at different levels from both partnering companies should be included into VMI creation and implementation. In addition, supplier is recommended to set up a cross-functional team whose main purpose would be to monitor VMI process and propose potential improvements to it. Bendoly and Jacobs (2005) state that the ability to support, plan and execute both an general as well as individual VMI

collaborations are prerequisites for successful introduction and further implementation of the process. However, Waller et al. (1999) notice that responsible personnel often fail to define and prove the potential benefit of the process before it is introduced. Therefore Barratt and Oliveira (2001) highlight importance of collaborative introductory programmes that prevent internal resistance to change.

IT infrastructure. Waller et al. (1999) claim that successful VMI implementation often depends on computer platforms, communication technology and tracking systems. Software systems are helpful tools for decision making process in replenishment quantity and timing, safety stock levels, transportation routing and other processes. Simchi-Levi et al. (2000) also state that application of electronic data transfer systems considerably improves information quality and therefore is necessary for successful relationship. Authors define the main objectives in VMI:

- Providing information availability and visibility;
- Enabling a single point of contact for data;
- Allowing decisions based on total supply chain information;
- Enabling collaboration with supply chain partners.

The study conducted by Claassen et al. (2008) reveals that in all cases, the information was shared through some sort of ICT (Information and Communications Technology)-systems. For external buyer-supplier communication EDI (Electronic Data Interchange) linkages were used meanwhile for internal usage ERP (Enterprise Resource Planning) systems such as SAP were implemented as core ICT platforms for successful data collection and processing. Zammori et al. (2009) propose typical information sharing process via EDI during one inventory replenishment procedure:

1. The customer sends products activity record (PAR) on a daily basis to inform the supplier about any change in the inventory.
2. When the supplier receives PAR, he updates replenishment plan. In case the reorder point is reached for any product, the supplier creates purchase order and sends it to the customer.
3. When the supplier receives purchase order confirmation, relevant products are picked, packed and shipped to the customer. At the same time the supplier informs the customer that goods are shipped.

4. When the shipment is received the customer sends a receipt and informs the supplier about actual freight composition. The supplier then is able to compare received information with the purchase order and solve problems if any occur.

The authors agree that the above mentioned steps do not exactly define actual VMI situation because the customer is still included in the process. However, it is justifiable in the beginning of VMI relationship when the customer helps the supplier in the decision making process. Later on, the step of purchase order confirmation should disappear as the supplier is expected to take over inventory replenishment at full extent (Zammori et al., 2009).

Introduction and integration of EDI systems require huge investments in terms of both time and money. The level of EDI usage might also depend on characteristics of products that are to be replenished. Claassen et al. (2008) notice that in cases where VMI was applied for strategic products customers were willing to be fully integrated into replenishment process. Meanwhile the necessity for EDI integration between partners was low for replenishment of low cost commodities. Researchers also agree that even though advanced technological capabilities contribute to better VMI application, they are not a prerequisite for the process (Waller et al., 1999; Bendoly and Jacobs, 2005).

2.3.4 The design of VMI agreement

Over the years VMI strategy has been adopted in numerous industries which resulted in appearance of different VMI models and designs. The vendor and its customer have to reach an agreement on various details in order to make this relationship work out. Researchers have proposed different dimensions of agreement which they see as necessary ones for successful VMI implementation. Elvander et al. (2007) created a framework of possible VMI dimensions gathered from both theoretical sources and empirical analysis. Authors created four clusters were dimensions were placed in accordance to their similarities:

- Inventory-related dimensions
- Information-related dimensions
- Decision making-related dimensions

Inventory-related dimensions

1. *Inventory ownership*. Simchi-Levi et al. (2000) claim that agreement on this dimension is crucial to the success of any strategic collaboration effort, especially VMI. Originally, ownership is transferred to the customer as soon as goods are received and payment is placed. In this case it is considered that inventory is owned by the customer. Other type of inventory ownership is called consignment-inventory system. '*Consignment is a process of a supplier placing goods at a customer location without receiving payment until after the goods are used and sold* '(Williams, 2000). According to Emmet and Granville (2007) consignment is more beneficial for the customer because it lowers costs, reduces the risks of buying goods that will not be used and improves cash-flows. In addition, since the goods are owned by the vendor, he will be always concerned with optimizing inventory levels. Bichescu and Fry (2009) notice that consignment agreement reflects unequal power shares where the customer represents a more powerful party in the relationship.

2. *Inventory location.* The vendor and the customer should also agree where goods will be placed. According to Elvander et al. (2007) items can be located at the customer's production line or shop floor, at the customer's central warehouse, at the supplier's or thirds party's premises. Zammori et al. (2009) notice that both customer and vendor have certain responsibilities concerning inventory location. The customer assures that inventory will be stored in suitable conditions and will be separated from non-VMI items. Supplier obliges that goods are properly marked and packaged.

Information-related dimensions

1. *Demand visibility.* This dimension related to the type of information transferred. Vigtil (2007) has explicitly analyzed information exchange under VMI agreement. The author notices that different partnerships require the transfer of different data, however, the research suggests eight types of information: inventory levels, incoming orders, goods in transit, stock withdrawals, production schedules, sales data, forecasts, backorders and returns. Inventory levels are suggested as the most important information since the main activity performed under VMI is the replenishment of inventory. According to Angulo et al. (2004) demand visibility is a key success factor of VMI as it reduces amount of inaccurate information which then allows making better replenishment decisions.

2. *Access to information (IT configuration).* This dimension describes how the vendor gets necessary information. Elevander et al. (2007) mention three methods of information access: (1) visual examination, when the vendor comes to the customer's warehouse and physically checks inventory levels; (2) the vendor gets information via customer's ERP system; and (3) the customer sends data via Internet. The second alternative requires cooperation between vendor's and customer's ERP systems, which is usually time and investment consuming process to implement.

Decision making-related dimensions

1. Replenishment monitoring and ordering. This dimension refers to the means which are used by the vendor to monitor inventory levels and define replenishment frequency. There are three methods suggested: (1) inventory is continuously reviewed and replenished when needed; (2) inventory is reviewed periodically and replenished when needed; (3) inventory is reviewed periodically and replenished irrespective to inventory levels until it does not exceed defined maximum limits. The first two alternatives require IT system which warns the vendor about the next reorder point. The third alternative is performed in so-called manual VMI system when a vendor's representative visits the customer on defined frequencies, physically reviews inventory levels, and make orders for the next replenishment.

2. *Control limits.* This dimension shows how mush freedom the vendor owns while calculating the quantities of goods to be replenished. There are four possible scenarios in this case: the customer defines (1) both maximum and minimum levels, (2) only maximum levels, (3) only minimum levels, (4) no levels are defined. According to Williams (2000) definition of maximum or minimum limits should be a question of mutual agreement, especially under the consignment-inventory system. The reason is that the customer might be willing to keep high levels of inventory as a buffer to demand uncertainty which would result in high levels of tied-up capital for supplier. Claassen et al. (2008) claim that the customer tends to set tight min-max limits when it does not trust in the vendor's capabilities to replenish just-in-time. However, the tighter limits are, the less responsibility vendor has while making replenishment decisions which, in fact, is what VMI actually implies (Kaipia et al., 2002).

3. *Replenishment decision.* This dimension refers to the vendor's freedom to make decisions about quantity and frequency of replenishment. There are four possibilities suggested in the literature: (1) the customer confirms orders suggested by the vendor;

(2) the vendor has the right to decide either quantity or frequency; (3) the vendor is free to decide both quantity and frequency until the customer's demand is met; (4) the customer gives order proposals which can be changed under certain circumstances by the vendor. The first alternative is considered by Simchi-Levi et al. (2000) as being not a VMI solution because the vendor does not possess the right to make replenishment decisions on its own. However this method is possible in the transition period when traditional ordering system is being replaced by VMI.

3. Methodology

The chapter introduces the readers to methodological framework of this thesis. Research design is described together with the case study being the main research strategy. Data collection and analysis methods as well as research quality approaches are presented.

3.1 Research design

Saunders et al. (2012) define research as a process that people perform systematically in order to increase their knowledge. The word 'systematically' means that research is conducted using certain analysis methods and techniques rather than referring to one's beliefs or personal opinion (Ghauri and Gronhaug, 2010). In order to conduct a proper piece of analysis, composition of a research design is the first step. Research design is a framework that includes all techniques of data collection and analysis to be used in the research.

Saunders et al. (2012) present a 'research onion' which comprises 7 layers each representing a different part of a research design. Each part is necessary as it explains how research questions were approached in the thesis.

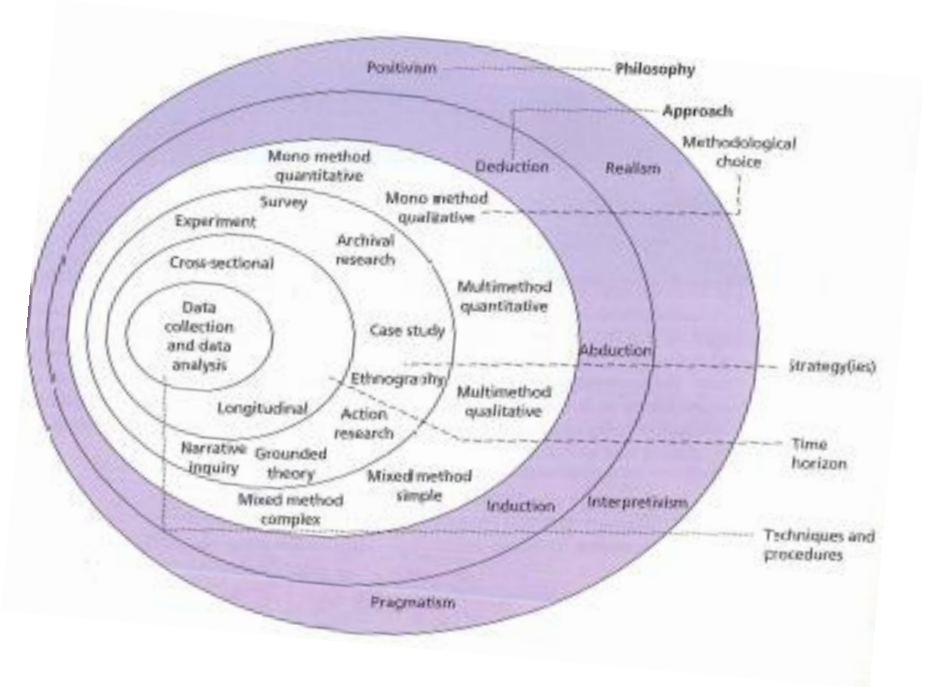

FIGURE 4. THE RESEARCH 'ONION' (SAUNDERS ET AL., 2012, PP.128)

3.1.1 Philosophy

The main philosophies mentioned in the 'research onion' are positivism, realism, interpretivism and pragmatism. This thesis is based on positivistic approach because of the following attributes of this philosophy (Robson, 2002; Saunders et al., 2012; Bryman and Bell, 2011):

- Objective knowledge is based on direct experience or observation.
- Data is collected with the purpose to search regularities and causal relationships.
- The purpose of theory is to generate hypotheses that can be tested empirically.
- Results of the research are mainly based on quantitative data that is derived by using strict rules and procedures.
- Research must be conducted in objective way.

Saunders et al. (2011) notice that in reality it is a difficult task to choose only one philosophical direction. It might be even more appropriate to look into research philosophy as a 'multidimensional set of continua' which is a mixture of several philosophies used.

3.1.2 Approach

There are three approaches to reasoning found in the literature: deductive, inductive and abductive. This thesis was elaborated by using a deductive approach to reasoning which is defined as '*a theory testing process which commences with an established theory or generalization, and seeks to see if the theory applies to specific instances*' (Hyde, 2000). Spens and Kovacs (2006) notice that the hypothetic-deductive model follows the path from a general law to a specific case, therefore a strong theoretical framework is needed beforehand studying processes in the case company.

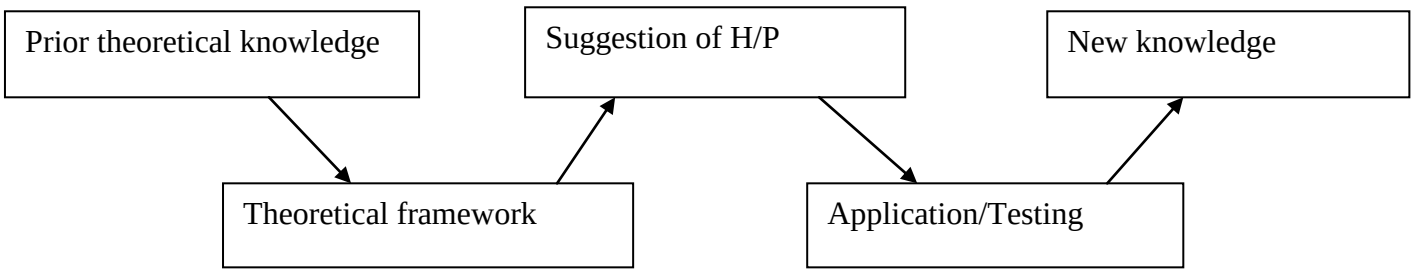

FIGURE 5. STEPS OF A DEDUCTIVE RESEARCH APPROACH (SPENS AND KOVACS, 2006)

In the figure 5 the steps of a deductive research approach implementation are shown:

1. Scientific literature in the relevant research field is analyzed;
2. General conclusions are derived from the literature in the form of general laws and presented as *ex ante* hypothesis and propositions (H/P);
3. A specific case is then analyzed in order to test the application of proposed H/P.
4. General conclusions are drawn based on confirmation or rejection of presented H/P in that certain case.

In the figure 6 it is shown how deductive approach to reasoning is applied in this study.

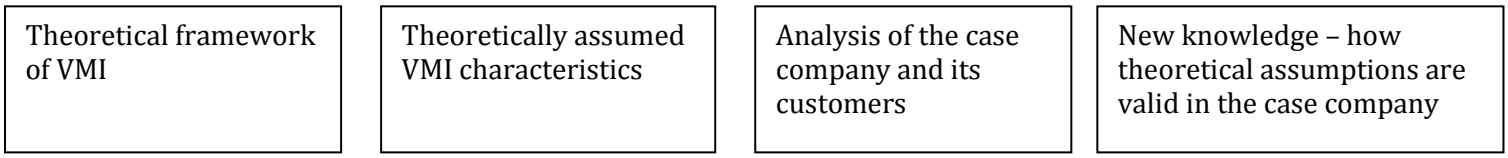

FIGURE 6. VISUALIZATION OF RESEARCH PROCESS IN THE STUDY

Step 1. Theoretical framework of VMI is analyzed.

Step 2. Clarification of VMI characteristics proposed in theory:

- Advantages;
- Requirements;
- Agreement designs.

Step 3. Analysis of VMI implementation among the case company and its customers.

Step 4. Comparison of theoretical and empirical views. It is concluded to what extent theoretically proposed VMI characteristics are applied in the case company.

3.1.3 Methodological choice

There are two research methods: qualitative and quantitative. The methods are distinguished in accordance with which – numerical (quantitative) or non-numerical (qualitative) – data collection and analysis methods are used. Research methods highly depend on the purpose of research however quite rarely a single method is applied. Saunder et al. (2011) give an example of a questionnaire. Being a quantitative data

collection method by its nature, a questionnaire becomes a mixed method in cases when respondents are required to express opinion while answering 'open' questions.

Analysis in this thesis was performed by means of mixed methods research using the approach of methodological triangulation technique which involves using more than one method to study a phenomenon. Methodological triangulation is a widely used method, mainly because of its numerous advantages: it provides confirmation on findings, gives comprehensiveness to data, increases validity of results and enhances understanding of the analyzed phenomenon (Bekhet, 2012).

The approach of *'across method'* of methodological triangulation has been applied which means that both qualitative and quantitative data collection techniques were combined in the study (Hussein, 2009):

- Qualitative data has been collected by means of literature review, interviews, observations and VMI contracts.
- Quantitative methods used in the study included numerical analysis of historical sales data and a questionnaire.

Bryman and Bell (2011) notice that the use of mixed method enables a more complete picture to be drawn about the investigated phenomenon.

3.1.4 Strategy

Research strategies include experiment, survey, archival research, case study, mixed methods research, ethnography, action research, grounded theory and narrative inquiry. A single case study is chosen to be the main research strategy in this thesis. Yin (2014) defines a case study as

'*an empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used.'*

Eisenhardt and Graebner (2007) notice that a case study is a suitable research strategy when one is seeking to get rich understanding about a research object in a real-life context. A VMI strategy is analyzed as a contemporary phenomenon in this study by investigating a wholesale company to reflect a real-life context in which VMI is implemented. In accordance to its purpose, this thesis is conducted by applying a descriptive-exploratory case study which is used when the author describes a

phenomenon in its real-time context (Yin, 2014). Descriptive research usually is a forerunner of an exploratory research because it is necessary to get a clear picture of a phenomenon before data collection process (Saunders et al., 2012). Therefore scientific research in the field of VMI was explicitly analyzed before it was explored how VMI is implemented in the specific industry.

3.1.5 Time horizon

There are two types of a time horizon of the study. Cross-sectional time horizon is otherwise called a 'snapshot' of an analyzed phenomenon while longitudinal time horizon is a 'diary' perspective of a research object when it is analyzed during a long period of time with a purpose to measure development and change.

Due to the time constraints of the study a cross-sectional time horizon is employed in this thesis. It has been analyzed how VMI is implemented and what effect this inventory control technique had at that particular time having no purpose to reflect how this strategy has changed during the years.

3.1.6 Techniques of data collection

The last part of a 'research onion' is research techniques that are applied in the process of data collection and analysis. There are various data collection techniques that are used in accordance with the purpose and type of research. In this thesis both primary and secondary data have been collected.

Primary data includes observation, interviews and a questionnaire.

Observation

Observation is a valuable tool to gather primary data while exploring how theoretical approaches are applied in real-life situations. The form of unstructured-non-participant observation was used during the study. This type of observation is applied when an observer tries to record participant behavior in detail. However, it does not intervene the action (Bryman and Bell, 2011).

During the process of writing this thesis the author had possibility to visit one VMI customer and observe the replenishment process. One non-VMI customer was also visited in order to experience how traditional ordering and replenishment is performed. The observation was a useful data collection technique that allowed comparing different inventory control methods in action.

Interviews

A research interview is a conversation between two or more people where the interviewer is a researcher and the interviewee is a professional who has experience in a certain field and therefore is able to answer purposeful questions in that way contributing to the research (Saunders et al., 2012). The form of semi structured interviews were chosen in this thesis implying that the researcher had prepared a set of questions however more questions were risen reacting to interviewer's responses. One VMI and one non-VMI customer were interviewed (see Appendix B and C). Certain questions were a reflection of observations performed beforehand. Interviews were conducted with the purpose to get a better understanding as well as explore causal links of participant behavior.

Number of unstructured interviews was conducted with the manager in TOOLS Molde in order to discuss about research questions and get the best knowledge about VMI implementation and effect in this specific company and its customers.

The questionnaire

A questionnaire is a data collection method in which a certain number of persons are given the same set of questions. Questionnaire is considered as a time and money saving data collection method which is often preferred by the respondents because of its convenience (Bryman and Bell, 2011). A questionnaire was prepared by using the Internet platform GoogleDocs which enabled the researcher receiving the answers right away (see Appendix D). There were both 'open' and 'closed' questions which allowed gathering personal opinions on the subject. The questionnaire was sent to 9 managers working in the companies where VMI technique was applied. Response rate is 44,4% (4 companies have responded).

Secondary data comprised research articles and books, historical sales data of TOOLS Molde and VMI contracts.

Research articles and books

Since the purpose of thesis is to compare existing scientific research on VMI with VMI implementation in the specific company, literature review has been a necessary part for this study. The research was conducted mainly by investigating scientific articles that were explored using the search engines Proquest and ScienceDirect. To complete the research, books on inventory management have been also analyzed.

Sales data

Historical sales data has been reachable via company's IRP system Penguin. This type of secondary data was used in performing the analysis of customer base, ordering frequency and quantity as well as product price. Sales data have also revealed the information about undelivered and incompletely delivered orders that allowed calculating service level for different products and customers. The period of analysis was 20.11.2012 – 31.10.2013 however for some part of analysis longer periods have been investigated.

VMI contracts

A VMI contract was a useful source of information while investigating terms and conditions of an agreement when the customer decides to transfer responsibility of inventory control to its vendor. Agreement dimensions found in the literature were compared with the existing contract. It was investigated how partners agree on inventory ownership, location, product quantity and replenishment frequency as well as consequences of contract breach. The analysis also revealed which other conditions have been also agreed on however not included in the contract.

3.1.7 Procedures of data analysis

One of the most important questions under inventory management is 'how much to order?' The certain quantity is to be calculated in order to minimize total costs (TC) while satisfying the needs of inventory user. Four theoretical approaches have been used in the analysis:

- Economic order quantity (EOQ)
- Moving from EOQ (sensitivity of EOQ)
- Coordinated replenishment
- Periodic-Review, Order-Up-To Level (R, S) Inventory Control System.

TABLE 2. VARIABLES USED IN THE ANALYSIS

Variable		Explanation
Order quantity	Q_i	The amount of units ordered during one inventory replenishment.
Demand	d_i	The number of units to be consumed during a certain period of time.
Unit cost	v_i	The unit purchase price charged by suppliers of the product.
Order handling cost	A_i	The cost of placing an order which might consist of employee working time for making and order, paying an invoice, quality checking as well as the cost of using relevant devices (such as computer, phone), etc.
Inventory holding cost (%)	I	The percentage of inventory value depending on taxes, employee costs, depreciation, etc.
Inventory holding cost	h_i	The cost of holding one item in stock for a given period of time.
Ordering frequency	N_i	The number of orders placed during a year
Total costs	TC_i	Annual costs incurred while buying the product and holding it in the inventory
Variable costs	VC_i	Order handling costs plus inventory holding costs
Reorder point	R	Time between two orders
Lead time	L	Time between ordering and arrival
Standard deviation	σ	Demand variation from the mean
Service level	$P(k)$	Probability of meeting the demand
Safety factor	k	Number of standard deviations from the mean corresponding to the selected service level
Safety stock	SS	Minimum amount of product necessary to meet the demand
Target stock level	S	Maximum amount of product in the stock

3.1.7.1 Economic order quantity

EOQ equation is considered as the most important element in the analysis of inventory control which defines the relationship between demand, order size and associated costs (Waters, 2003). The purpose of analysis is minimization of total costs that consist of three elements:

$$Total\ Cost = Purchase\ Cost\ (1) + Order\ Handling\ Cost(2) + Inventory\ Holding\ Cost(3)$$

$$(1) Purchase\ cost\ component = unit\ cost * the\ number\ of\ units\ demanded = v_i * d_i$$

$$(2) Order\ handling\ cost\ component$$

$$= \frac{reorder\ cost * the\ number\ of\ units\ demanded}{the\ number\ of\ units\ ordered} = \frac{A * d_i}{Q_i}$$

$$(3) Inventory\ holding\ cost = \ Inventory\ holding\ cost * averge\ stock\ level$$

$$= h_i * \frac{Q_i}{2}$$

We get the following formula:

$$TC_i = d_i * v_i + \frac{A * d_i}{Q_i} + \frac{h_i * Q_i}{2}$$

The minimum value of TC can be found be differentiating TC from quantity ordered (Q) and set it equal to zero (Waters, 2003):

$$\frac{d(TC_i)}{d(Q_i)} = -\frac{A_i * d_i}{Q_i^2} + \frac{h_i}{2} = 0$$

From the formula we can find optimal order quantity, known as Harris-Wilson Formula or Economic Order Quantity (EOQ) which is usually named as Q_0^*:

$$Q_{0(i)}^* = \sqrt{\frac{2 * A_i * d_i}{h_i}}$$

In order to use this calculation, certain assumptions should be met (Tersine, 1994):

1. A single item is considered, it does not interact with other items (there are no combined orders).
2. The demand is known, constant and continuous.
3. The lead time is known and constant.
4. The entire lot size is added to inventory at the same time.
5. There is enough storage space, capacity and capital to manage the estimated quantity.
6. All costs are known and do not vary.

7. Since the demand and lead time are constant, no shortages are allowed.

Having known the optimal quantity we can also find the annual number of orders, N_i:

$$N_i = \frac{d_i}{Q_i^*}$$

In case when high cost commodity is analyzed, EOQ results in frequent orders of small quantities which allows saving high inventory holding costs. However a low cost item is to be ordered rarely in large quantities in order to save order handling costs.

Limitations of *economic order quantity* model (Waters, 2003):

- Probably the biggest limitation of the model is the unrealistic assumptions. Demand and costs tend to vary over time therefore the calculations of the model might contain significant errors.
- The outcome of the model usually lead to rarely ordered large-size batches which is often seen as a problem from a customer's point of view. Large quantities require excessive storage capacity and results in too much capital tied up in stocks.

3.1.7.2 Sensitivity of Economic Order Quantity

The limitations of EOQ reinforce certain adjustments to the model. It is wise to move from EOQ in order to see how costs are sensitive to changes of quantity ordered.

First to be mentioned, we are going to analyze not total costs but only the costs that change with regard to changes of quantity ordered, in other words, variable costs (VC).

$$Total\ Cost = Fixed\ Cost + Variable\ Cost$$

$$TC = d_i * v_i + VC$$

$$VC = \frac{A * d_i}{Q_i} + \frac{h_i * Q_i}{2}$$

By substituting Q_0 into the formula we get optimal variable cost VC_0:

$$VC_{0(i)} = A * d_i * \sqrt{\frac{h_i}{2 * A_i * d_i}} + \frac{h_i}{2} * \sqrt{\frac{2 * A_i * d_i}{h_i}} = \sqrt{\frac{A * h_i * d_i}{2}} + \sqrt{\frac{A * h_i * d_i}{2}}$$

$$VC_{0(i)} = \sqrt{2 * A * h_i * d_i}$$

Other ways to calculate variable costs come from the observation that at Q_0 the order handling cost component equals the inventory holding cost component, therefore:

$$VC_{0(i)} = \frac{2 * A * d_i}{Q_{0(i)}}$$

$$VC_{0(i)} = h_i * Q_{0(i)}$$

In order to analyze sensitivity of variable costs we need to take a ratio of optimal variable costs,VC_0, which incurs when economic order quantity Q_0 is ordered with the variable costs VC of ordering any other quantity, Q.

$$\frac{VC_i}{VC_{0(i)}} = \frac{h_i * d_i}{Q_i * VC_{0(i)}} + \frac{h_i * Q_i}{2 * VC_{0(i)}}$$

Substituting VC_0 into the right-hand side of the above formula, we get:

$$\frac{VC_i}{VC_{0(i)}} = \frac{A_i * d_i * Q_{0(i)}}{Q_i * 2 * A_i * d_i} + \frac{h_i * Q_i}{2 * h_i * Q_{0(i)}}$$

Which leads to:

$$\frac{VC_i}{VC_{0(i)}} = \frac{1}{2} * \left(\frac{Q_{0(i)}}{Q_i} + \frac{Q_i}{Q_{0(i)}}\right)$$

Since VC_0 is the lowest possible value, this equation can only take values greater than one.

3.1.7.3 Coordinated replenishment

In the search of suitable quantity to be ordered coordinated replenishment method might also be used. In this case products are combined in one group, so-called family. Products that belong to the family are always ordered together with other family members. In case of coordinated replenishment variable costs correspond to:

$$VC(Q_i) = \frac{d_i * A}{Q_i} + \frac{1}{2} * \sum_{i=1}^{n} Q_i * v_i * I\,, \quad i = 1, \dots, n$$

From the equation we can find the optimal quantity Q_i^*:

$$Q_i^* = d_i * \sqrt{\frac{2 * A}{I * \sum_{i=1}^{5} v_i * d_i}}$$

By substituting Q_i^* into $VC(Q_i)$ equation, we can obtain optimal variable cost:

$$VC_0(Q_0^*) = \sqrt{2 * A * \sum_{i=1}^{n} d_i * v_i * I}$$

The number of orders N can be then calculated in two ways.

(1) By dividing annual demand of the product by the optimal ordered quantity:

$$N = \frac{d_i}{Q_i^*}$$

The number of orders should be the same for each family product since, as it was mentioned, products of the same family are always delivered together.

(2) By dividing total annual cost by the cost of one order:

$$N = \frac{\sum_{i=1}^{n} d_i * v_i}{VC_0(Q_0^*)}$$

Both equations give the same results therefore more convenient formula is to be used.

3.1.7.4 Periodic-review, order-up-to level (R, S) inventory control system

Periodic-review inventory control system is an approach of ordering when we order a varying amount of products at regular intervals. This method is suitable under uncertain demand conditions because in each period different quantity might be ordered (Waters, 2003). In addition, there is always a possibility to adjust safety stock as well as target stock levels in reaction of changing demand. VMI is a periodic-review system in the case company therefore this method has been used in the analysis.

First, we need to calculate safety stock:

$$SS_i = k * \delta_i * \sqrt{R + L}$$

Then, we can find target stock level:

$$S_i = d_{R+L} + SS_i$$

Variable costs correspond to:

$$VC_i = \frac{1}{2} * d_R * v_i * I + k * \delta_{R+L} * v_i * I$$

In order to apply (R,S) model we need to assume that demand is Normally distributed. The demand distribution of some analyzed products is Weibull shaped meanwhile others have Exponentially distributed demand. For the purpose of the thesis we refer to Central Limit Theorem which states that *'the mean of a random sample, drawn from a population with any probability distribution, will be approximately normally distributed, given a large enough sample size'* (Newbold et al., 2013, p. 254). 'Large enough' usually refers to a sample size which is greater than 30 (Johnson and Bhattacharyya, 2011, p. 276).

3.1.7.5 Service level

Service level can be measured in several ways (Waters, 2003):

- Percentage of orders completely satisfied from stock;
- Percentage of units demanded that are delivered from stock;
- Percentage of units that are delivered on time;
- Percentage of time there is stock available;
- Percentage of stock-cycles without shortages;
- Percentage of item-months there is stock available.

Service level that defines the percentage of units demanded that are delivered from stock is the most widely used method therefore it has also been employed in the thesis.

$$P = 1 - \frac{Number\ of\ units\ not\ delivered\ directly\ from\ shelf}{Annual\ demand}$$

Service level is a target, usually set by a customer, which defines the probability of meeting the demand directly from stock, or alternatively, maximum acceptable probability of situations when demand is not met from stock (Waters, 2003). For suppliers service level is closely related to safety stock with the meaning that higher service levels require higher safety stock levels.

3.2 Research quality

In order the research to be acknowledged as a proper piece of analysis, it must comply with quality criteria: validity (construct and external) and reliability. The criteria are described as follows (Yin, 2014):

- Construct validity – correct operational measures to gauge the concept have been used.
- External validity – the findings of analysis might be generalized. In other words, the results are valid outside the specific case study.
- Reliability – the repetition of the same methods of data collection and analysis would arrive to the same results.

Certain measures have been taken in order to assure that the research meets quality criteria (see table 3).

TABLE 3. MEASURES TO ASSURE QUALITY OF THE RESEARCH (ADAPTED FROM YIN, 2014, PP.45)

Criteria	Measures	Phase of research
Construct validity	• Multiple sources of evidence have been used. • Key informant have reviewed the case study	Data collection Composition
External validity	• Theory on relevant field has been explicitly analyzed and used.	Research design
Reliability	• Detailed description of methods of data collection and analysis used	Research design, data analysis

4. The Case study

The case study is conducted in order to compare theoretical framework with practical implementation of VMI. One of the departments of B&B TOOLS Group is chosen to be as a focal company for the study. The chapter contains five parts. Firstly, the company and its functions are described. Secondly, customer base analysis is conducted and presented. Moreover, current VMI approaches are being analyzed in addition to research of potential inclusion of a new customer to this strategy. The chapter is finished with the discussion where the main findings from the literature as well as the focal company are compared.

4.1 Description of the case company[2]

In 1906 two Swedish engineers, Arvid Bergman and Fritz Beving, founded the company with a purpose to introduce technical agency to Sweden. Today B&B TOOLS GROUP identifies itself as the largest supplier for the industrial and construction sectors in Northern Europe.

Products

Products and services offered by TOOLS are divided into three segments:

- Industrial consumables - tools, machinery, personal protective equipment, fastening elements and workplace equipment.
- Industrial components - bearings, seals, transmission and automation.
- Related services - logistics solutions, inventory optimization and more efficient maintenance planning. In addition, the company has service workshops in various parts of the Nordic region for the service of electric motors, gears, soldering equipment, electric hand tools, etc.

The Group has four business areas each specializing in different product segment. In the chart below one can see that all business areas contribute to sales quite equally with the biggest share taken by Luna and Skydda.

[2] The information about the company is taken from B&B TOOLS Annual Report, 2012/2013.

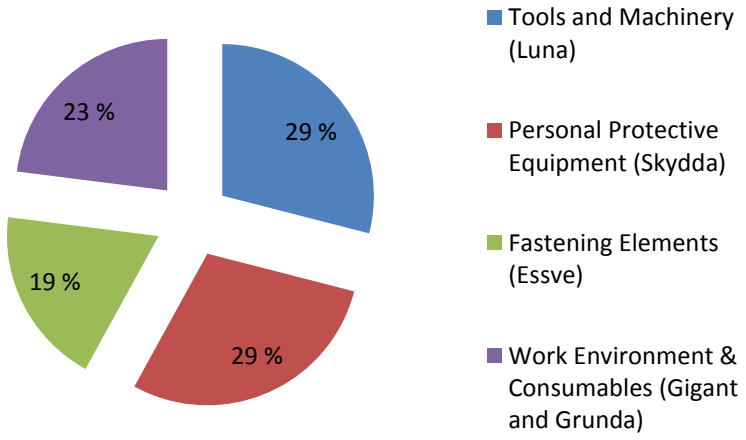

FIGURE 7. SALES BY BUSINESS AREA (B&B_TOOLS_2013)

Customers

B&B TOOLS' customers operate in all industrial areas such as offshore, construction, civil engineering, property maintenance, public administration, and defense sectors. In the chart below one can see a division of customers in accordance to the sectors they represent.

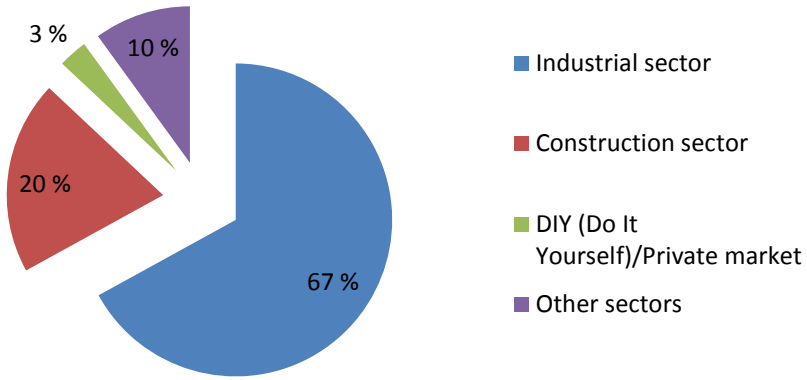

FIGURE 8. SALES BY CUSTOMER SEGMENT (B&B_TOOLS_2013)

Market channels

The Group uses three market channels to reach the end-user:

1. TOOLS. The products and services are provided by TOOLS stores and online catalog. Sales, marketing and expert support is provided by TOOLS employees.

2. Resellers. Sales, marketing and expert support is provided by independent resellers which operate outside industrial sector.
3. Exports. The Group also conducts business outside the Nordic region which is done in two ways:
    - The Business Areas have some sales operations of their own in ten countries, with most of the revenue generated in the Baltic States and Poland.
    - In twenty additional countries, independent distributors sell one or more of the Business Areas' proprietary product brands in the specifically defined market.

Countries of operation

TOOLS mainly operates in Sweden, Norway and Finland. The chart shows sales activity in each country.

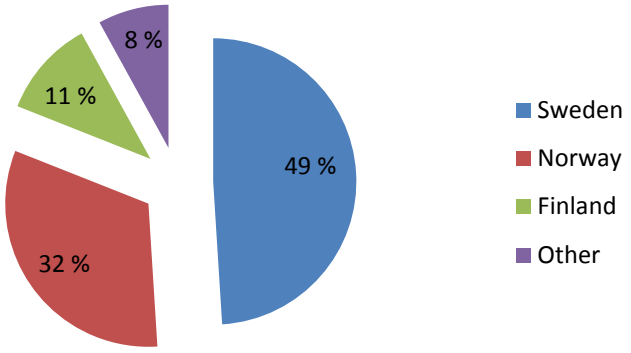

FIGURE 9. SALES BY GEOGRAPHIC MARKET (B&B_TOOLS_2013)

TOOLS is active in more than 200 locations and has approximately 2,700 employees. The operations are divided into sales areas. Each sales area has its own sales team, which is responsible for establishing close relationships with all main customers in that specific sales area. Each sales area also includes a number of TOOLS stores.

The market in Norway currently accounts for approximately 32 percent of the Group's total revenue. Industries such as offshore and the construction sector are highly significant in the Norwegian market for industrial consumables and industrial components. In recent years, the Norwegian market has been positively impacted by

continued investments in such areas as offshore industry, as well as infrastructure programmes in Norway. Major competitors include Tess, Würth, Proffpartner and Albert E Olsen.

B&B TOOLS Group has 60 departments in Norway. One of the departments is TOOLS Molde which is responsible for sales operations in Møre og Romsdal region. This department will be a central figure of the study.

4.2 Services offered in the case company

The vision of B&B TOOLS Group is '*to be the best choice for customers by making their everyday operations easier, safer and more profitable*'. The company agrees that it is very difficult to maintain sustainable cost advantage under today's competitive market conditions. Therefore they see the ability to create value for customers as the main factor which allows distinguishing themselves from competitors.

TOOLS offers a wide range of solutions in accordance to customers' needs. The services cover different areas such as works at heights, construction, storage and operations, personal safety and security, workplace safety and product delivery solutions. The company also arranges courses in the above mentioned fields. The company also offers various storage and delivery related services so that customers never run out of stock. Different solutions lead to reduction of tied-up capital as well as simplification of ordering process:

- Assortment optimization. This service basically begins with review of current stock analysis and is finalized by proposal for relevant changes.
- Online purchasing. Customers have a possibility to order products online by using TOOLS e-catalog. It is required to become a registered user so that TOOLS receive all the necessary information about the order into their system. In that way the ordering process is simplified since customers do not need to create purchase orders.
- TCO (Total Cost Ownership). This solution involves minimizing the handling cost for industrial components. The service includes optimization of data storage and maintenance systems, ordering and billing procedures.
- Two-bins-system. This system is usually used for small and cheap products that are stored in two bins. When the first bin is empty, it is sent back to TOOLS

for replenishment. Meanwhile products are continuously being taken from the second bin. The system assures that the customer never experiences a stock-out situation.

- VMI. This solution is also mainly used for relatively small items (though not necessarily) because TOOLS places a cabin in which agreed type and quantity of products are being stored. Replenishment is managed by TOOLS but customer has also a possibility to order products if there is a need.
- TOOLS containers. Containers are being used in the cases when there is a need for a temporary storage facility, e.g., at a construction site, onboard of a ship, on a floating platform, etc.

4.3 Analysis of customer base in TOOLS Molde

In the period of 20.11.2012 – 31.10.2013 TOOLS Molde had 1254 customers. The customers vary in size, industry they operate in, contribution to the revenue of TOOLS Molde and other factors. In order to reveal the most valuable customers, ABC analysis is conducted.

TABLE 4. ABC ANALYSIS OF TOOLS MOLDE CUSTOMERS

GROUP	% OF REVENUE	% OF CUSTOMERS	NUMBER OF CUSTOMERS
A	80%	3%	34
B	15%	16%	197
C	5%	81%	1023

As it was expected the distribution of customers corresponds to Pareto law which states that roughly 80% of all effects can be explained by 20% of the causes (Chatterjee, 1998). In this situation the numbers are even more impressive – only 3% of customers in TOOLS Molde contributed to 80% of company's revenue. Group A customers are the most important ones therefore they are being further analyzed.

As it has been already mentioned, there is a derived demand for industrial consumables. Therefore it is necessary to develop a deep insight into industries the customer companies operate in.

The primary analysis has shown that the customers differ from each other in accordance to the field of their specialization. However, for the purpose of the research 5 main categories of industries were distinguished:

- *Shipbuilding industry* – companies that build ships, manufacture certain parts of ships, create design or produce interior of ships.
- *Construction industry* – companies that build houses or other buildings or specialize in manufacturing certain parts of buildings (such as balconies, stairs, etc.)
- *Metallurgy industry* – companies that produce metals or specialize in metal scrap.
- *Oil and energy industry* – companies that produce oil drilling equipment, offshore constructions, safety elements or obtain oil.
- *Other industries*. Customers that were placed under this category are the companies that are unique by the nature of their operation and therefore could not be categorized together with others:

➢ Production of plastic
➢ Production of fish food
➢ Production of heating equipment
➢ Production of cranes and lifting equipment
➢ Production of dairy products

In the chart below one can see the percentage distribution of industries that are represented by major customers.

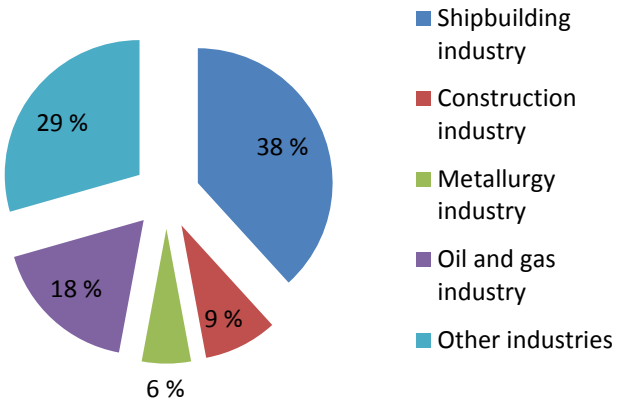

FIGURE 10. DISTRIBUTION OF INDUSTRIES IN WHICH MAJOR CUSTOMERS OPERATE (ESTIMATED BY THE AUTHOR USING HISTORICAL SALES DATA)

The biggest part of customers (38%) represents shipbuilding industry. This is no surprise since shipbuilding is one of the biggest industry branches in Møre og Romsdal region. The second biggest part (29%) is characterized under the category 'Other

industries'. This fact shows that TOOLS Molde has a heterogeneous customer base. Oil and energy industry takes the third place with 18% of the customers representing this branch. Construction and metallurgy industries represent accordingly 9% and 6% of Group A customers in TOOLS Molde. Does it mean that companies from shipbuilding industry are the most important customers to TOOLS Molde? Further and deeper analysis is necessary to be conducted in order to answer this question.

The industries represented by most companies do not necessarily lead to the biggest profitability to TOOLS Molde. Big companies might be small customers to TOOLS Molde and vice versa. Since companies differ in their purchasing power, the analysis is done in order to reveal which industries contribute to TOOLS Molde revenue the most.

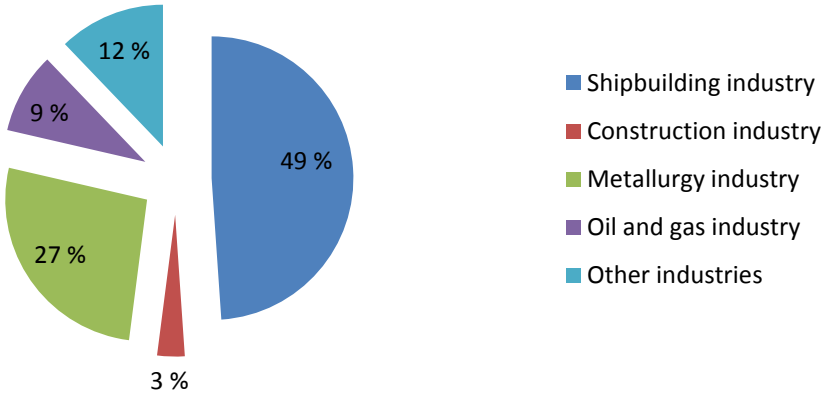

FIGURE 11. DISTRIBUTION OF INDUSTRIES ACCORDING TO REVENUE OF TOOLS MOLDE (ESTIMATED BY THE AUTHOR USING HISTORICAL SALES DATA)

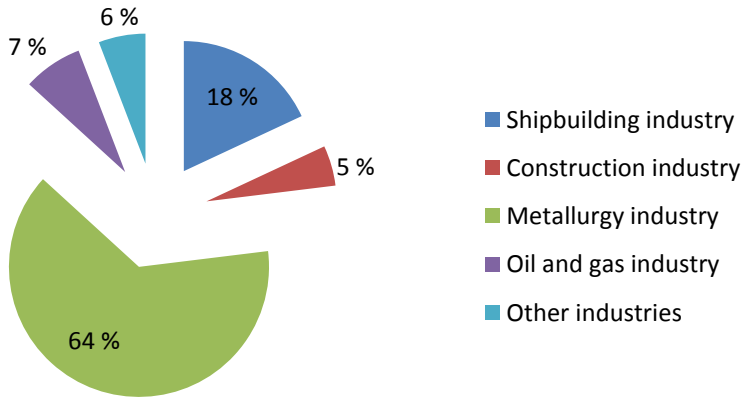

FIGURE 12. AVERAGE CONTRIBUTION TO REVENUE OF TOOLS MOLDE PER COMPANY IN EACH INDUSTRY (ESTIMATED BY THE AUTHOR USING HISTORICAL SALES DATA)

The figure 11 shows that shipbuilding industry is the most profitable segment which can be explained by the number of companies representing it. Metallurgy industry which comprises only 6% of the customers, significantly contributes to the revenue of TOOLS Molde. This can be noticed even better from the figure 12 which shows the extent of contribution by a company in each industry. Contribution to revenue from other industries is distributed quite evenly therefore will not be analyzed further.

To be concluded that the biggest part of TOOLS Molde customers operate in shipbuilding industry and all together they make the biggest contribution to revenue. However, analysis of each separate customer revealed that metallurgy industry is also a very important segment.

4.4 Analysis of current VMI customers in TOOLS Molde

Today TOOLS Molde have 10 VMI customers. The main characteristics of the customers are defined in the table below.

TABLE 5. CHARACTERISTICS OF VMI CUSTOMERS IN TOOLS MOLDE

Customer/ Characteristics	**Industry**	**Revenue (NOK)[3]**	**Rank[4]**	**Years as a Customer**	**Years as a VMI customer**	**No. of unique products under VMI**
Company_1	Metallurgy	14 417 113	1	3	3	2795
Company_2	Shipbuilding	3 659 695	5	>5	>5	186
Company_3	Offshore installations	2 846 125	6	>5	2	98
Company_4	Shipbuilding	2 721 378	8	>5	<1	430
Company_5	Machinery/Equipment	1 453 514	10	>5	4	806
Company_6	Plastic production	1 216 024	13	3	3	623
Company_7	Fish food production	969 882	16	>5	4	342
Company_8	White minerals	864 765	17	>5	1	220
Company_9	Oil and energy	716 840	19	>5	4	15
Company_10	Machinery/Equipment	712 968	20	>5	4	76

[3] The column 'Revenue' refers to customer's contribution to TOOLS Molde revenue (01.11.2012-25.10.2013)
[4] The column 'Rank' defines customer's importance in accordance to profitability to TOOLS Molde

Industry

The table shows that VMI customers in TOOLS Molde differ in accordance to the area of operation. As it is expected half of customers represent shipbuilding, oil and energy and fishing industries, which are the most developed ones in Norway as well as in Møre og Romsdal region itself. However, in overall TOOLS Molde has a heterogeneous VMI customer base which results in different VMI designs implemented in order to satisfy each customer equally.

Rank according to revenue

Recall that A Group of customer base in TOOLS Molde consists of 34 customers. The table shows that all VMI customers belong to A Group as they take from 1st to 20th place according to contribution to TOOLS Molde revenue. All these customers may be defined as strategic ones for TOOLS Molde, and VMI is a possibility to come into closer relationships with them.

Years as a (VMI) customer

The table 5 reveals that TOOLS Molde has more than 5 years of experience in working with the majority of its VMI customers. Analysis might also suggest that before VMI implementation customers tended to maintain arms-length relationships for some period of time in order to check reliability of the wholesaler. This assumption goes together with theoretical framework that suggests mutual trust as one of the main determinants for beginning of partnership, such as VMI.

Number of unique products under VMI agreement

Analysis shows that there is no minimum, maximum or average number of items required for typical VMI solution as the number of VMI items varies from 15 at Company_9 to 2795 at Company_1. Such a variety greatly depends on customer's specialization field which causes the difference in demands for certain products offered by TOOLS. It is also worth mentioning that the products customers chose to place under VMI agreement are not necessarily ordered from TOOLS Molde before. The analysis of one of the most recent VMI customer Company_4 revealed that 77% of products placed under VMI agreement have been previously ordered 5 or fewer times out of which 23%

have never been bought by Company_4. This fact implies that implementation of VMI has been a beneficial strategy for TOOLS Molde as it resulted in increase in sales.

4.5 The design of VMI agreement

Referring to the dimensions proposed by Elvander et al. (2003), the agreements between TOOLS Molde and its VMI customers have been analyzed (refer to the figure 13 in p. 46).

Inventory ownership. This is the only dimension that has been applied differently to different customers. It is not surprising since the ownership of inventory decides upon which partner will have tied-up capital. Therefore the ownership often is the object of discussion between partners. From the figure we see that 4 customers agreed to own the inventory which means that they pay for all inventory replenished by TOOLS Molde. Meanwhile other 6 customers do not have to pay for the very first replenishment which makes that quantity owned by TOOLS Molde. However, in case a customer wants to terminate the contract, it must pay for the whole inventory that has been delivered.

Inventory location. Inventory is stored in convenient places, usually near the production line or in the storage room. Inventory location also depends on the size of the company and number of products placed under the agreement. In case the company is very big, inventory is stored in several places that contain different types of products in accordance with the operation performed in that certain place. The products might be located on the shelves together with other stocks, placed in separate compartments or in special cabins delivered by TOOLS right after the VMI contract is signed.

Demand visibility. The main hindrance to a better VMI implementation probably is that customers do not forecast their demand for industrial products. It makes difficult for TOOLS plan their own inventory more accurately. The customers claim that it is very difficult to foresee the consumption change of this certain type of products. Therefore, while deciding on quantities to be delivered, TOOLS uses only information about demand from previous years. However, the customers are willing to warn TOOLS before major demand changes. In addition, companies that operate on project basis are used to announce about the amount of work they are going to have in the beginning of each year.

Access to information. Even though today's VMI is mostly imaged as IT based solution, in this case manual VMI is implemented for all customers. It means that

information about stock levels are accessed only when the representative of TOOLS comes to the customer and visually examines the inventory change. However the information might also be received by phone in case, as it was mentioned, some unexpected increase in consumption occurs.

Inventory replenishment and ordering. Visual examination of inventory levels implies that inventory is ordered and replenished only at certain amounts of time. This type is called periodic replenishment. In this case TOOLS agree on a certain day of the week when replenishment should be performed. All 10 customers have decided that the optimal period between two orders is one week.

Control limits. In the literature the limits are usually defined as minimum and maximum quantities to be stored in stock. However it is not entirely correct to use these terms in this case. Usually minimum limit is the level that can be crossed only in critical occasions. In this case minimum level is the quantity that should satisfy demand until the next replenishment. Maximum limits are also not strictly determined. The quantity highly depends on the box size. Therefore it is always discretion of a TOOLS representative to decide whether the quantity will exceed maximum limit or it will be to some extent lower.

Replenishment decision. Replenishment frequency and quantity limits are already decided before the agreement is signed. The quantities are usually calculated by TOOLS representative and are given to the customer for approval. When replenishment is performed, the representative decides personally on the amount to be ordered, as it has already been said. It is also worth mentioning that quantity limits are not constant and after some time from VMI introduction they are recalculated if necessary. This is a usual practice bearing in mind unpredictable nature of demand for industrial products.

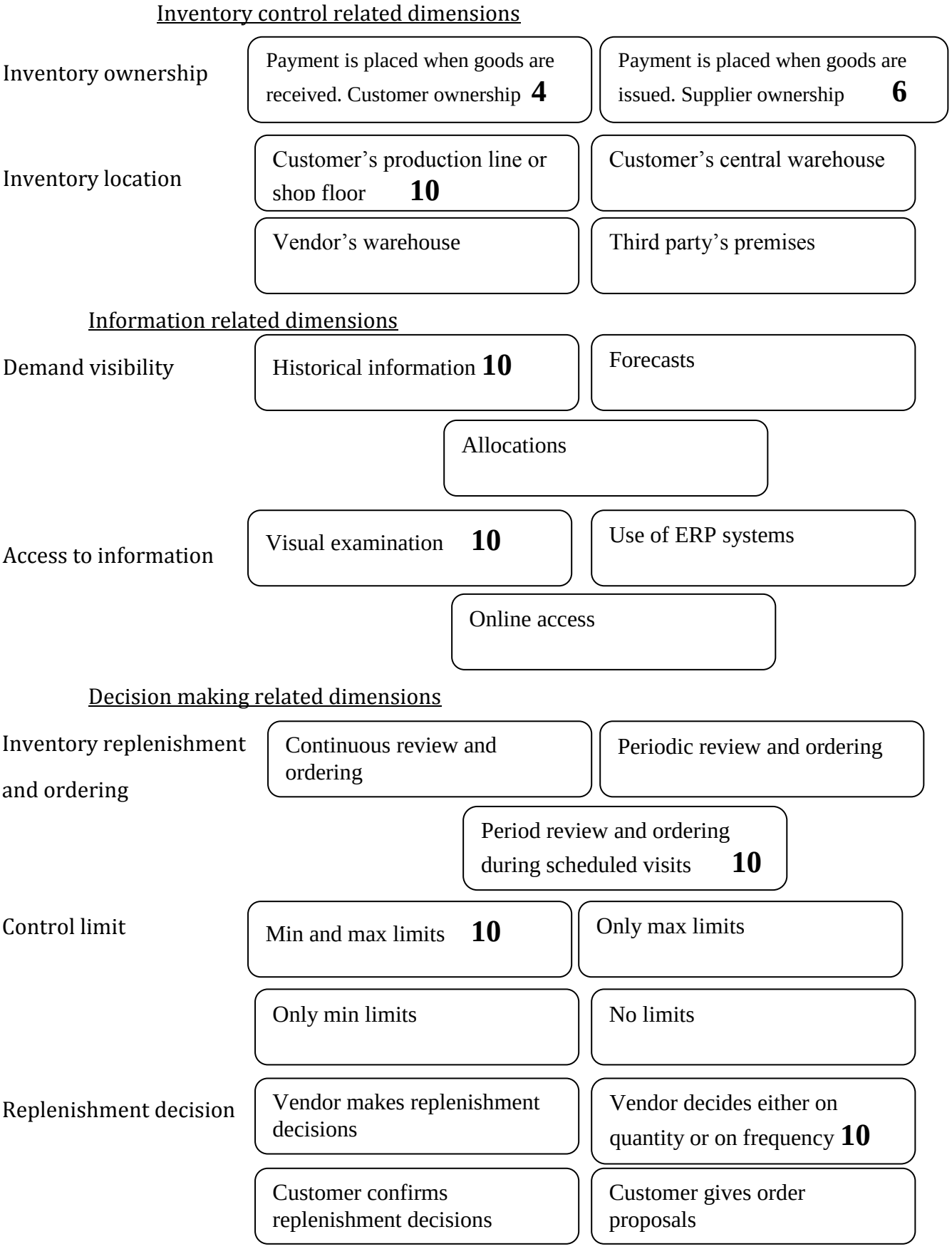

FIGURE 13. DIMENSIONS OF VMI AGREEMENT AMONG TOOLS MOLDE AND ITS CUSTOMERS (DESIGN ADOPTED BY THE AUTHOR FROM ELVANDER ET AL., 2007)

4.6 Traditional distribution model vs. VMI process in TOOLS Molde

Usually products offered in TOOLS Molde are ordered by phone and delivered by using Third-Party-Logistics (3PL) services. This process is defined as a traditional distribution model in this study. The model is further compared with VMI solution.

Traditional distribution model

The process consists of the following steps (see Appendix A):

1. TOOLS Molde receives a request for certain products from a customer.
2. If requested amount is present in the warehouse, products are picked, packed and sent to a customer the same day.
3. If request amount of products is absent in the warehouse, other departments of TOOLS in Norway are contacted. In this case it might take longer until products reach the customer.
4. If requested amount of products is absent in other TOOLS departments as well, only the available part of products is sent to the customer. The other part is usually not being reordered, therefore it is considered as a lost sale.

Traditional distribution model is based on transactional relationship which might cause problems for both parties. A customer does not share more data than it is needed to perform a transaction. Not having essential information about customer's future demand TOOLS Molde faces difficulties while planning its own inventory levels. This situation often leads to two opposite problems: stock-outs or exceed stock levels. In addition to that, some customers place orders frequently (every 1-2 days) which results in high transportation expenditures for TOOLS Molde.

VMI process

Steps of VMI procedure:

1. By signing the VMI contract partners agree on the amount and type of products as well as minimum and maximum levels to be replenished.
2. TOOLS Molde representative visits a costumer once a week. He then replenishes products requested from the previous week and checks which products should be ordered for the next week.

3. If required products are on stock in the warehouse, they are picked, packed and prepared for the next week's replenishment.
4. If products are not available, the requested amount is ordered from TOOLS Molde suppliers.
5. When products come from a supplier, they are stored in a short-term storage place until the agreed day of replenishment comes.

Absence of required amount of products in the warehouse is not a problem in this case because reorder point is 7 days. The lead time for most of the products is also 7 days which allows meeting customer's demand in time. The products, which have longer lead time, are planned to be always on stock in the warehouse in Molde. In this way the percentage of lost sales is reduced significantly.

The outcome of analysis does not however mean that VMI is always a better alternative in comparison with the traditional distribution model. Distribution decision highly depends on specificity of a customer's company, characteristics of products and demand variability.

4.7 VMI as an inventory control strategy from customers' point of view

In this section findings of the questionnaire as well as the interview with non-VMI customer are discussed. The findings reveal how customers choose products and suppliers for VMI agreement as well as what they see are the main factors for successful VMI implementation.

Customers that have answered the questions belong to different industries (aluminum production, fish food production, offshore installations and inspection, machinery production, white minerals) which show the variety of TOOLS' customer base.

Further the main points of customers' opinion are discussed.

Advantages of VMI. All customers highlight two main benefits experienced after VMI implementation. These are reduction of administrative costs as well as reduction of stock-out situations. VMI products are relatively inexpensive while order handling cost is independent from product price and therefore equal for all products. Thus, VMI is a highly beneficial strategy for those customers that have high order handling costs which

are reduced since ordering procedure is eliminated for VMI products. Customers are only obliged to execute the payment once a month.

Reduction of stock-out situations are benefited by both customer and supplier. The customer is able to perform uninterrupted production and other activities while the supplier is able to assure higher service levels which results in increase in revenue.

Characteristics of VMI products. All customers agree that VMI is the most advantageous strategy for products that have high ordering frequency and relatively low value (from 1 to 3 in 1-5 scale) as well as short lead time. However, one customer noticed that VMI has been implemented for critical products that are of high importance for production. It shows that VMI might be successfully implemented for different purposes.

Requirements for VMI supplier. 75% of respondents value product quality and flexibility while choosing VMI supplier. 50% of customers also pay attention to product price. The findings show that different customers raise different requirements. However, they all choose TOOLS Molde which proves to be able meeting all sorts of needs. 2 respondents would use other suppliers in case the VMI-supplier cannot deliver the right quantity in certain unexpected situations.

The main factors for successful VMI implementation. All respondents agree that the crucial factor for successful cooperation is continuing dialog among partners. 50% of customers state that demand planning also plays an important role bearing in mind variable consumption rates of VMI products. One respondent highlights the importance of engaged employees while implementing this strategy. In addition, one customer states that the usage of advanced IT systems results in successful VMI implementation.

Changes in the company caused by VMI implementation. 50% of respondents say that VMI has not resulted in major changes in the company while other half of customers agrees that the role of employees has slightly been adjusted since they no longer have the necessity to check stock levels of VMI products. Instead, the employees are required to keep a close contact with VMI-supplier.

All customers finish the questionnaire by emphasizing that VMI has been a successful strategy that has led to satisfactory results so far.

4.8 Introduction of a new customer into VMI agreement

VMI benefits suggested by scientific research as well as successful VMI implementation for current TOOLS Molde customers lead to the proposal that more strategic customers should be suggested VMI as a partnership initiative. The analysis of a potential VMI customer has also been used as a tool for determining financial benefit of VMI. In the process of customer base analysis one customer has been picked as an example for VMI implementation.

4.8.1 Description of the company[5]

Company_X is a major global shipbuilder, constructing offshore and specialized vessels used in the offshore oil and gas exploration & production and oil services industries. The company has five departments in Norway. One department located in Møre og Romsdal region is a TOOLS Molde customer and thus, was chosen to be analyzed in the context of VMI agreement.

There are several reasons for this choice (period of analysis 01.11.2012-25.10.2013):

1. The company is the second largest customer in TOOLS Molde. (The largest customer is already under VMI agreement).

2. The company operates in shipbuilding industry which is represented by the biggest part of A Group customers.

3. Service level for this company was 89.5% last year which is considered as being insufficient and unsatisfactory.

4. The company places orders approximately every 1.14 days which causes high transportation and order handling costs for TOOLS Molde. High order frequency is also considered as one of the necessary factors for successful VMI implementation.

5. Products are ordered in different quantities which forces TOOLS Molde to keep high stock levels in order to satisfy the demand. VMI is assumed to mitigate demand peaks and lows in that way minimizing stock levels and improving service levels.

A shipbuilding company differs from other typical manufacturers. It operates on the project basis each having its own budget and inventory. The company receives

[5] Information about the company is taken from its webpage which is not present in the reference list due to confidentiality constraints.

different number of projects each year therefore the amount of products ordered from TOOLS Molde varies from one year to another. The type and quantity of products required depends also on the stage the project is at in that moment. TOOLS Molde is one of the suppliers of Company_X that is integrated in the ordering system Bits&Pieces which is an Internet-based platform. This solution simplifies ordering process for Company_X as well as reduces the possibility of human error that might otherwise occur when products are ordered by phone or email. The system also enables the user to resend the same order to the secondary supplier in case the main one does not have relevant type or quantity of products. However the company has not implemented any solution that would define optimal quantity and frequency of products ordered. Current replenishment is a day-to-day activity performed by an employee who checks stock levels each morning and orders relevant quantity. No demand planning or forecasting is conducted for industrial products.

4.8.2 Analysis of the products ordered from TOOLS Molde

Company_X has ordered 949 unique products from TOOLS. The products were ordered in different frequencies and quantities.

TABLE 6. PRODUCT ORDERING FREQUENCY

Times ordered	Number of products
1-5	702
6-19	221
20-61	26

Analysis shows that most products were ordered 5 or fewer times during the period of 12 months. The causes for that are different for each product. Some products were used only in special occasions, others were ordered from other suppliers. In the figure below we can see the percentage of ordering frequency.

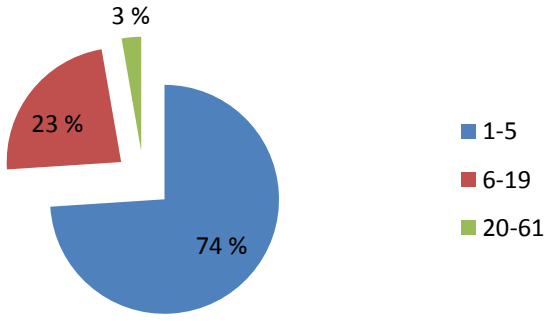

FIGURE 14. PRODUCT ORDERING FREQUENCY (TIMES PER YEAR)

Products that are chosen to be under VMI agreement are usually characterized by high ordering frequency as well as relatively low unit cost. According to historical sales data, 26 products (3% of all products ordered in 12 months) might be suitable for VMI. This is a relatively small number, however the outcome of analysis of current VMI customers has revealed that there is no defined minimum number of suitable products required for VMI implementation. Furthermore, after experiencing benefit from VMI, the customer might decide to place more products ordered from other suppliers under the agreement.

With regard to this thesis the five most frequently ordered products have been picked for further analysis.

TABLE 7. ANNUAL ORDERING CHARACTERISTICS OF SELECTED PRODUCTS

Product	Demand (units)	Number of orders	Service level
Product 1	24800	61	96,7%
Product 2	40000	73	89%
Product 3	770	56	84%
Product 4	6200	55	96,4%
Product 5	6000	53	95%

From the table 7 we can see that all five products were ordered more than once a week. Bearing in mind the information that the company has a four-week holiday break during summer, we can make a conclusion that products are ordered at high frequencies during working period. Frequent ordering results in high order handling costs that might on some occasions even overweight the cost of products ordered.

Service level is also a factor worth investigating. It is an element which customers pay big attention to while considering supplier's reliability. From the table we see that service level varies from one product to other. While some products were delivered with almost 97% accuracy, service level of other products is as low as 84% which is regarded as unsatisfactory. Low service level results in lost sales therefore the supplier is also concerned about maintaining service level as high as possible.

In the Appendix E one can also find variability of order quantity and frequency of product 4 as an example. The results reveal that the demand of products is not constant

during a year as both quantity of ordered products and number of orders vary each month. The reason for that might be both insufficient planning or/and the nature of operations. Being in current position, TOOLS Molde has no information about stock levels or future consumption patterns. This is the reason TOOLS Molde is unable to plan its own inventory which is followed by necessity to keep high stock levels so that required service level would be maintained.

The results have shown that current replenishment and ordering system might be costly and inconvenient for both customer and supplier. Theoretical approaches are further implemented in order to investigate which ordering behavior might be more efficient in comparison with the current one.

4.8.3 Findings of inventory control models

Different inventory control models were calculated in order to investigate the efficiency of current ordering behavior and analyze possible benefits in case VMI was implemented.

TABLE 8. VALUES OF RELEVANT VARIABLES

Product	d_i (units)	v_i (NOK)	$\bar{d}(R+L)$	σ_i
Product 1	24800	19,88	954	725
Product 2	40000	8,67	1538	1070
Product 3	770	79,28	30	18,8
Product 4	6200	4,04	238	105
Product 5	6000	4,85	230	107
A (NOK)	1000[6]			
I	20%[7]			
R	1 week			
L	1 week			
$P(k)$	0,99[8]			
k	2,23			

Economic Order Quantity

EOQ estimates optimal quantity per order which mainly depends on product cost and order handling cost. In this case we have low-cost commodities meanwhile order

[6] One order might contain many different products. Having in mind that order handling cost does not depend on the number of products per order, it is assumed that one product equals one order.

[7] The company does not have estimated the percentage of inventory holding costs therefore in accordance with the literature the value of 20% was chosen for the analysis.

[8] It was decided to choose P(k) = 0,99 since one of the purposes of VMI is to improve service levels.

handling costs are high. Therefore there is no surprise that the equation suggests ordering products in rare occasions (1,6-7 times per year) but in large quantities (see the table 9 below).

TABLE 9. RESULTS OF EOQ

Product	$Q^*_{0(i)}$ (units)	N (times per year)	$VC_{0(i)}$ (NOK)
Product 1	3532	7	14043
Product 2	6792	6	11777
Product 3	312	2,5	4941
Product 4	3917	1,6	3165
Product 5	3517	1,7	3412

Please remember that inventory costs were not given. This is because the company holds unique stock needed for each project. Yet, inventory holding costs play an important role in estimating both order quantity and variable costs. Thus, the chosen value of 20% in inventory holding costs is compared to values of 10%, 15% and 25% (see figure 16).

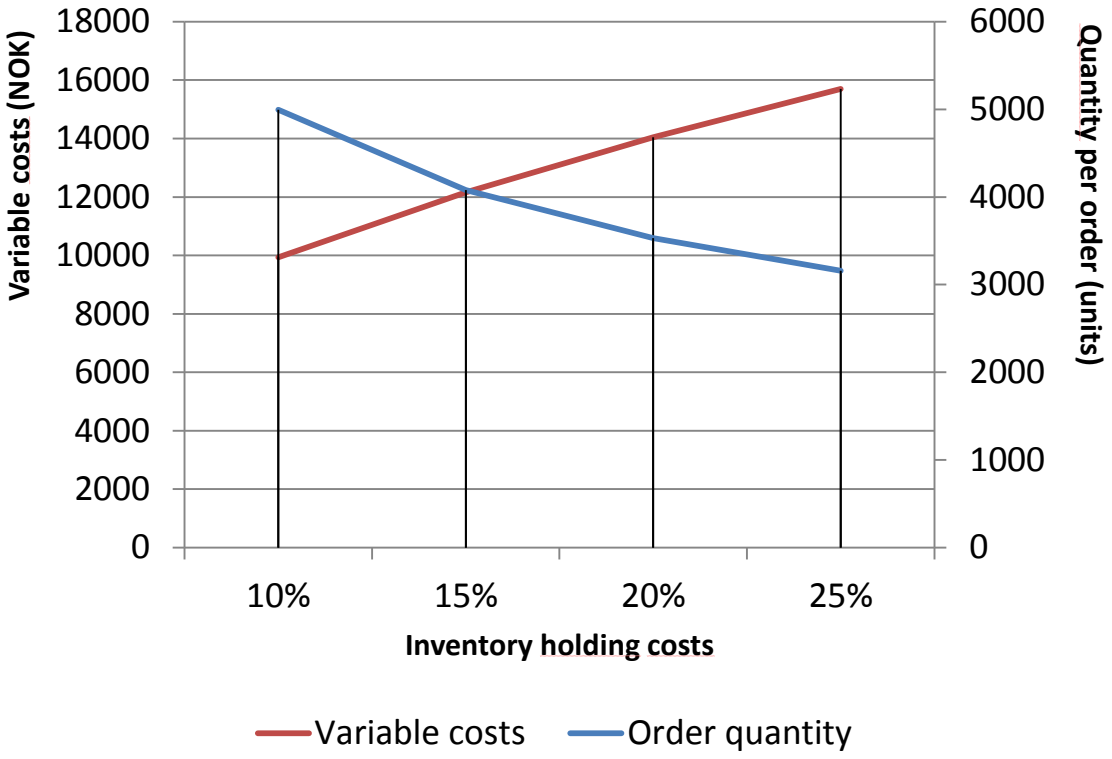

FIGURE 15. IMPACT OF INVENTORY HOLDING COSTS ON VARIABLE COSTS

As it was expected, increase in inventory holding costs leads to increase in variable costs while product quantity per order is being reduced. However, the change in these three elements is far from equal. If we take an example when inventory holding costs increase by 15% (from 10% to 25%), we get 36,8% decrease in product quantity per order and 58,1% increase in variable costs. It implies that inventory holding costs is an important part of variable costs therefore it is not advised to maintain high stock levels when inventory holding costs are high, even in the case when products are rather cheap. Since percentage change is equal for all products, product 1 was taken as an example in order to show exact values (see table 10).

TABLE 10. IMPACT OF CHANGE IN INVENVENTORY HOLDING COSTS (PRODUCT 1)

Inventory holding costs	Order quantity (units)	Variable costs (NOK)
10%	4995	9930
15%	4078	12 162
20%	3532	14 043
25%	3159	15 701

Moving from EOQ

Storage space might constrain having the quantities as large as they were estimated by using EOQ equation. In addition, it might be difficult to foresee consumption rate a few months in advance under unpredictable demand conditions. Therefore optimal quantity was reduced by 5%, 15% and 25% in order to investigate how costs were changing (see figure 16 below).

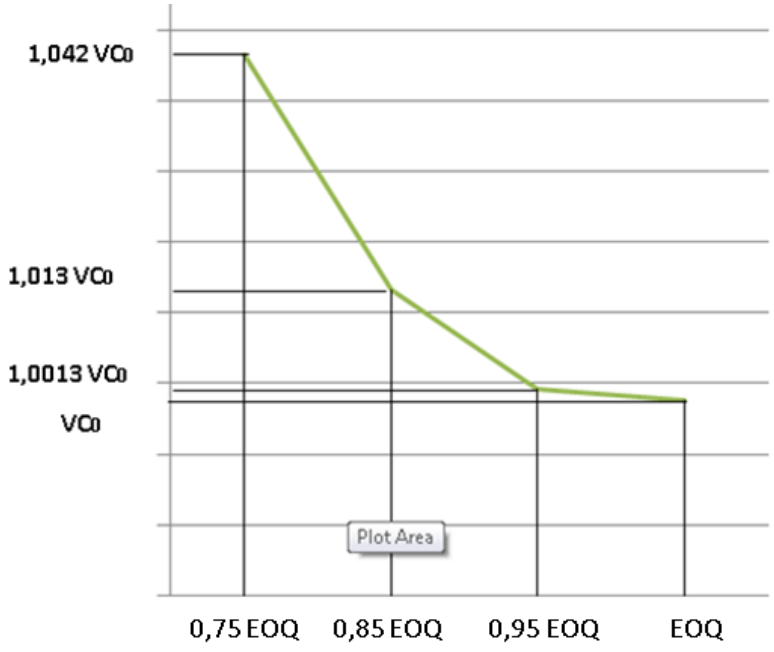

FIGURE 16. DEPENDANCE OF VARIABLE COSTS ON PRODUCT QUANTITY PER ORDER

In the figure 17 we see that variable costs are not sensitive to product quantity per order changes as if we move from EOQ by 25%, the variable costs will increase only 4,1%.

Exact values of product 2 are given in the table 11 in order to show, how variable costs are changing in connection with changes in the order quantity.

TABLE 11. COMPARISON OF VARIABLE COSTS AND QUANTITIES (PRODUCT 2)

	Q_i (units)	VC_i (NOK)	$\%\ change\ in\ VC_{0(i)}$
EOQ	6792	11 777	0%
-5% EOQ	6452	11 792	+0,13%
-15% EOQ	5773	11 933	+1,3%
-25% EOQ	5094	12 268	+4,2%
Current quantity: -89% EOQ	769	52 675	+447%

In the table 11 one can also see how the existing product quantity per order is far from suggested one by EOQ equation. It is revealed that current quantity causes more than 4 times bigger variable costs in comparison with EOQ. In other words, if EOQ was implemented, the company would save 78% of its present variable costs.

Coordinated replenishment

As it has already been mentioned, in this case selected products are merged into one family in order to perform coordinated replenishment of those products. This method was used to investigate the optimal product quantities per order as well as ordering frequencies as if all products were ordered at the same time. We get the following results (see table 12):

TABLE 12. RESULTS OF COORDINATED REPLENISHMENT

Product	Q_i^* (units)	N
Product 1	2538	10
Product 2	4093	
Product 3	79	
Product 4	634	
Product 5	614	

The results show that products should be ordered approximately 10 times a year which causes smaller product quantities per order in comparison with EOQ.

Comparison of the models

In the analysis three models were investigated: EOQ, moving from EOQ and coordinated replenishment. In order to compare these models with current situation the variable costs of ordering all five products were calculated. The results are the following:

TABLE 13. COMPARISON OF THE MODELS

The model	VC (NOK)	N	Savings
No model (current situation)	298 271	53 – 61	0%
EOQ	37 338	1,7 – 8	87,5%
-25% from EOQ	40 726	2 – 10,5	87%
Coordinated replenishment	19 545	7,77	93,5%

The outcome of analysis reveals the inefficiency of current ordering behavior as each of the proposed models reduces present variable costs in approximately 90%. EOQ is expected to cause the biggest cost reduction however high order handling costs result in coordinated replenishment being the best policy. In addition, this model simplifies planning and ordering process since all products are ordered and delivered at once. It is worth mentioning that while using coordinated replenishment policy, order handling costs might be bigger in comparison with other models where the products are ordered separately from each other. However, in order to be able to make calculations 1000 NOK is chosen to be as a constant order handling cost despite the number of products on one order.

Despite of the advantages all models were calculated based on number of assumptions and approximations that might lead to not as good results in reality. Furthermore, the models resulted in relatively low ordering frequency which is 6 to 10 times lower than present situation and therefore is unacceptable for the company. Having said that, we can make two conclusions:

(1) Proposed models are not suitable for the company because of high demand uncertainty as well as storage constraints. Yet, the models have revealed that current ordering behavior leads to high expenses and therefore should be adjusted.

(2) Given the above mentioned, VMI is assumed to be the right solution as it results in frequent replenishments along with low variable costs.

VMI

TOOLS Molde has implemented periodic VMI policy which means that stock levels at customer's site are checked and order is placed once a week on a selected day. It implies the fact that reorder point and lead time are seven days each. The customer together with the supplier agrees on safety stock which should absorb demand uncertainty. In addition, upper stock levels are decided so that TOOLS representative is able to calculate product quantity for the next order. Having said that, the most suitable theoretical approach for VMI implementation is *Periodic-review, order-up-to level (R, S) inventory control system.*

The results of the model are given in the table 14.

TABLE 14. THE RESULTS OF (R,S) INVENTORY CONTROL SYSTEM

Product	SS_i	S_i
Product 1	2263	3217
Product 2	3341	4879
Product 3	59	89
Product 4	328	566
Product 5	334	564

Even though there is a possibility to buy one unit of each product, it is much more usual to order a box containing a certain amount of units. The results were adjusted in order to reflect real situation as much as possible.

TABLE 15. ADJUSTED RESULTS OF (R,S) INVENTORY CONTROL SYSTEM

Product	Amount in the box	SS_i(adjusted)	S_i(adjusted)	VC_i
Product 1	10 units	2270	3220	9998,05
Product 2	25 units	3350	4880	6345,25
Product 3	10 units	60	90	1215,02
Product 4	10 units	330	570	318,76
Product 5	10 units	340	570	382,67

It is worth mentioning that under VMI agreement the payment for all VMI products is paid once a month which means that the company experience order handling costs only 12 times a year. Thus, annual variable costs of ordering all five products are 30 259,74 NOK which is **89.9%** lower than current costs. Recalling the table 13, we see that it is cheaper to use coordinated replenishment model in comparison with VMI. However price is not the main factor in the decision making process. Currently the products are ordered approximately twice a week therefore 8 orders a year is too drastic strategy for the company. Meanwhile a weekly

replenishment is considered as a suitable solution. In addition, the results comply with 99% service level which implies loyalty from the customer's side and reliability from the supplier's side.

Service level of 99% requires high stock levels and therefore contributes to an increase in variable costs. Therefore it is useful to investigate at what extent variable costs and safety stocks change in case service level is adjusted to 98% and 97%.

TABLE 16. CHANGE IN SERVICE LEVEL IMPACT ON SAFETY STOCK

	Product 1	Product 2	Product 3	Product 4	Product 5
SS_i (99%)	2270	3350	60	330	340
SS_i (98%)	2090	3100	60	310	310
SS_i (97%)	1910	2825	50	280	290

Table 16 reveals that in case service level is reduced by 1%, safety stock is 1,08% lower. Meanwhile if we reduce service level by 2%, safety stock will be reduced by 1,19%.

TABLE 17.CHANGE IN SERVICE LEVEL IMPACT ON VARIABLE COSTS

	VC
99%	30 259,74 NOK
98%	29 544,95 NOK
97%	28 843,53 NOK

From the table 17 we can find out that change in service level by 1% causes change in variable costs by 1,02%. If we reduce service level by 2%, variable costs will be reduced by 1,05%.

As we see, variable costs as well as amount of safety stock have low-value sensitivity to changes in service level. Therefore it is a customer's choice to decide whether service level or costs should be prioritized.

4.9 Discussion

This section analyzes the findings in accordance to the research questions proposed in the beginning of this paper. In addition, the reviewed literature is compared with VMI implementation in the case company with the purpose to explore contradictions and/or similarities.

TOOLS Molde is a supplier of industrial consumables, the majority of which are low-cost commodities (C category in ABC terms). The consumers of such products either do not implement a separate inventory control model or require a simple and

convenient strategy. Therefore the concept of VMI analyzed in this thesis appears to be easy to implement and does not require major investments or changes at a customer's site. ERP or other IT systems are not used to monitor consumption rate since inventory levels are examined physically while visiting the customer once a week. Trust and long-term partnership mentioned in the literature as being essential factors for successful VMI implementation are considered as being not as important by TOOLS Molde customers. They tend to pay more attention to supplier flexibility and product quality which again might be explained by non-strategic nature of products being ordered. The only factor equally evaluated by scientists and VMI customers is information sharing. The findings of a questionnaire revealed that customers value continuing dialog with the supplier which is seen as the main prerequisite to success under unpredictable demand conditions. Customers tend to warn the supplier prior unplanned changes of consumption. In case altered demand levels stay for a longer time, partners may agree to adjust minimum and maximum inventory levels in order to keep them as optimal as possible.

As for VMI agreement itself, the main parts of it follow the ones proposed in the literature. However the agreement signed between TOOLS Molde and its customers has a more general form, mainly defining inventory ownership, location and responsible employees. Other important dimensions such as minimum and maximum levels are certainly decided upon however, not included in the contract. This is mainly because the levels tend to change over time as well as it is unreasonable to discuss every product in the contract.

The literature suggests number of advantages to be experienced by both partners because of VMI implementation. Some of the benefits are of non-financial nature therefore cannot be easily expressed in a quantitative manner. Moreover, some economic benefits have also been difficult to calculate because of variety of many other influential factors. In any case, it can be concluded that most benefits suggested in the literature are reflected in this case study.

Lower reliance on the forecast. Being a wholesaler, TOOLS Molde is not able to forecast its own inventory independently from forecasts conducted by its customers. The problem is that the majority of customers do not perform forecasting themselves.

Having no visibility on customers' demand, TOOLS experience difficulties while coping with volatile ordering frequencies and quantities. Meanwhile, under VMI agreement TOOLS has ability to periodically monitor changes in customer consumption. In addition, having the agreement signed, the customers also tend to communicate more often and share more information.

Increase in revenue. The analysis of the most recent VMI customer revealed that before VMI implementation 23% of VMI products have not been ordered from TOOLS Molde. In addition, most of other products placed under VMI agreement have been ordered only 5 or fewer times. It means that VMI is an advantageous strategy for TOOLS Molde as a supplier since it results in sales of more products. Moreover VMI assures better service levels that also contribute in increase in revenue.

Acquisition of competitive advantage. This advantage is mainly experienced by vendors that supply strategic products and usually there are few of them in the market. In this case, VMI does not require big investments or have other hindrances that would not allow terminate the agreement at any time. In addition, even though VMI agreement is signed, it might occur that the customers contact other suppliers as well. Therefore it might be concluded that this advantage is not significant in this thesis.

Reduction of stock-out situations. Better demand visibility contributes to better planning and therefore results in fewer stock-out situations. This fact is also visible from the questionnaire that showed that reduction of stock-out situations is considered as one of the advantages of VMI experienced by customers.

Simplification of purchasing process. This advantage was mentioned by all customers that responded to the questionnaire. It was also named as the main reason for VMI implementation. This strategy transfers responsibility for managing low-cost products to the supplier which allows customers spending saved time on more important products.

Reduction of costs. From customers' point of view, this advantage was explicitly analyzed in the section describing introduction of a new customer into VMI agreement. The analysis showed that VMI is especially beneficial strategy for customers that have high order handling costs. The final result was 89,9% lower costs comparing VMI with the current situation in the company.

From suppliers' point of view, there might be a reduction in transportation costs. Nevertheless, they are difficult to estimate because they depend on product

measurements and weight, distance to the customer, tariffs of 3PL company and other factors. However, the reduction in cost might still be assumed because in case VMI is implemented, products are delivered by supplier owned transport which is considered as costing zero for delivering VMI products.

Stock level reduction. From customer's point of view, stock levels are to be reduced because while implementing VMI TOOLS employees review and recalculate present stock levels in order to make them as optimal as possible.

From supplier's point of view, better visibility of customers' demand allowing performing better inventory planning of its own inventory.

Service level improvement. The calculations have showed that while implementing VMI, there is a possibility to decide upon desired service level in accordance to safety stock placed. In case the customer is willing to have higher safety stocks, the service level might be as high as 99%.

Long-term relationship. Surprisingly enough, the questionnaire have revealed that customers do not prioritize close partnership or long-term relationship as prerequisites for implementing VMI. Described in the literature as a mutual advantage, it is much more benefited by supplier who receives a relatively long-term customer by implementing VMI.

5. Conclusion

This chapter briefly presents the main findings of the research as well as proposes directions for further research.

5.1. General conclusion

In this thesis, the author analyzed VMI as one of several inventory control strategies. The existing scientific research was reviewed in order to investigate the process of VMI implementation and the main factors that lead to benefits for the supplier and its customer. To make this thesis more practical the analysis of a real-world company from a wholesale industry was conducted.

The outcome of analysis revealed that there are some contradictions while comparing literature with the case company. Literature claims that VMI is a complex strategy that requires trust among partners, advanced IT systems and leads to major managerial changes. This is followed by the fact that only a few companies have succeeded to get significant benefits from this strategy. However, the findings revealed that VMI concept cannot be generalized for all industries as it highly depends on the specificity of the field the supplier and its customers operate in. Product characteristics are also an influential factor that determines the policy of VMI implemented.

The case company TOOLS Molde implements a VMI periodic replenishment policy that is benefited by its users mainly because of simplification and reduction of administrative work. In addition, the analysis has shown that this strategy also significantly contributes to reduction of variable costs and improvement of service level. Meanwhile TOOLS Molde as a supplier acquires a long-term customer that results in better demand visibility and, consequently, increase in sales.

5.2. Further research

- This thesis comprises a single case study which makes it limited to one specific supplier and few of its customers. In addition, TOOLS Molde is one of B&B TOOLS Group departments therefore the analysis has been conducted only in the area TOOLS Molde operates in. Having said that, the first suggestion for further research is to investigate other B&B TOOLS Group departments in terms of VMI implementation and the effect in these.

- This thesis investigates one company as a possible VMI customer of TOOLS Molde. Proposed economic benefit of VMI might encourage the company to implement this strategy of inventory control. In that case, second suggestion for further research would be to analyze VMI implementation from its very beginning in that company and compare the results with the theoretical findings of this research.
- This thesis investigates the company operating in specific industry that is Industrial Machinery and Equipment and Supplies Merchant Wholesalers. The third suggestion for further research therefore is to investigate other wholesale industries and compare the results in order to find out whether VMI implementation process and effect is similar to all wholesalers.

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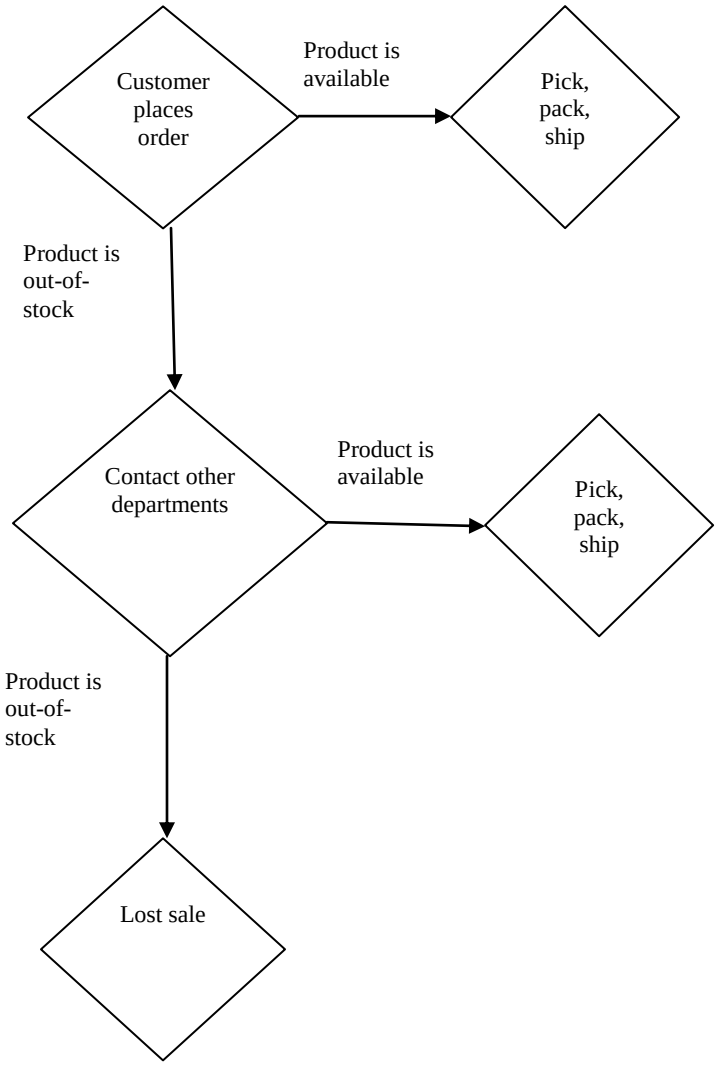
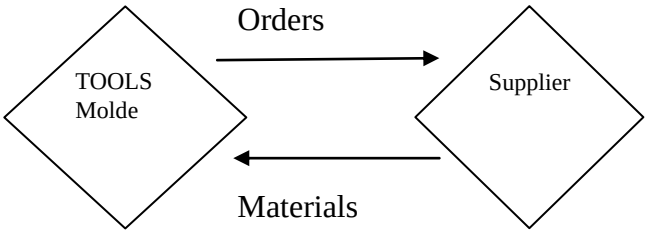
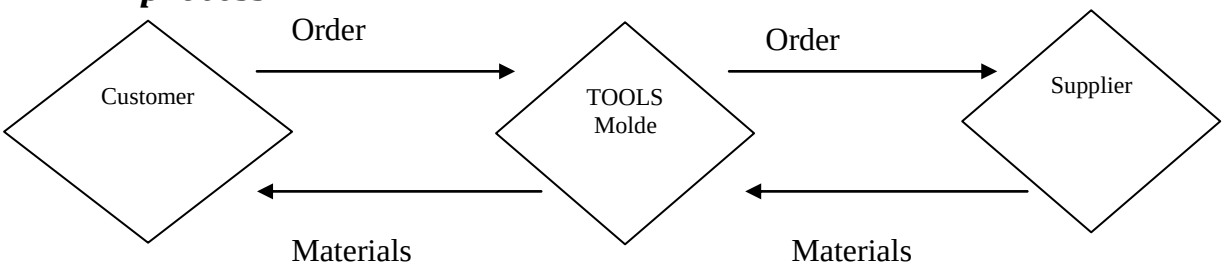
Appendix A

Traditional distribution model





VMI process



Appendix B

Interview with one of VMI customers.

VMI:

1. Hva er årsaken til at bedriften ønsker å bruke VMI?
2. Hva slags fordeler får Deres bedrift ved å bruke VMI?
3. Har Dere gjort noen kostnadsberegning for bruk av VMI?
4. Hvilke kriterier setter dere for VMI produkt? F.eks frekvens, viktighet, andre grunner?
5. På hvilket grunnlag settes min/maks nivå?
6. Gjøres det tilpasninger av min/maks nivå utifra etterspørsel/forbruk? I så fall hvor ofte?
7. Er bedriften fornøyd med dagens VMI?
8. Hva kan forbedres?

Andre produkter:

1. Hvordan bestiller dere andre industrielle forbruksvarer? Er det ansatte som har ansvar for kontroll og bestilling av varer?
2. Har dere flere leverandører av samme typer varer?
3. Utfører dere etterspørselsprognoser etter industielle forbruksvarer?
4. Er det mulig å forutsi økning i etterspørsel etter varer på grunn av økning i produksjon?
5. Er det variasjon i forbruk gjennomåret? Angi måneder med høyt/lavt forbruk.

Appendix C

Interview with one of non-VMI customers.

1. Could you describe ordering process? How could you explain variability of industrial product consumption each month?
2. Do you plan consumption for industrial products?
3. Can you predict variation in consumption of industrial products (e.g. in accordance with seasonality, project stage, etc.)?
4. Do you have many suppliers for the same products?
5. What requirements must suppliers comply with? How do you pick a supplier for certain product?
6. What service level do you require from your suppliers? How do you calculate service level?
7. Most of the products were ordered only 5 or fewer times during the period of 12 months. Could you give the main reasons?
8. What is your inventory holding cost?
9. What is your order cost?
10. Do you have any agreement with your suppliers in terms of delivery or inventory planning (such as Vendor Managed Inventory)? If not, have you considered this possibility?

Appendix D

Undersøkelse for VMI-kundene av TOOLS Molde

Hei! Jeg heter Laura Jasene. Jeg er Masterstudent ved Høyskolen i Molde. Jeg skriver Masteroppgave om VMI-innføring og effekt for kundene av TOOLS Molde. Derfor vil jeg gjerne stille dere noen spørsmål angående VMI i Deres bedrift. Undersøkelse er kort, den tar cirka 10 minutter å gjennomføre. Det er kun 9 kunder som blir undersøkt, derfor vil alle svar satt stor pris på. (Du kan avgi flere svar per spørsmål).
På forhånd takk!

Hva er bedriftens hovedindustri?

Kan dere nevne hovedtyper av VMI produkter i Deres Bedrift?

Hva slags fordeler får Deres bedrift ved å bruke VMI?

- ☐ Reduserte administrative kostnader
- ☐ Reduserte lagerbeholdningene
- ☐ Reduserte hendelser av lagermangel
- ☐ Etablering av troverdig forhold med leverandør
- ☐ Other:

Hvilke kriterium var det viktigste når dere valgte ut VMI-produktene?

- ☐ Bestillingsfrekvens
- ☐ Viktighet
- ☐ Verdi
- ☐ Ledetid
- ☐ Other:

For hvert av kriterium ovenfor, merk av hvilket alternativ som passer best for VMI-produkt.

	1	2	3	4	5	
Lav frekvens	○	○	○	○	○	Høy frekvens

	1	2	3	4	5	
Ikke kritisk produkt	○	○	○	○	○	Kritisk produkt

	1	2	3	4	5	
Lav verdi	○	○	○	○	○	Høy verdi

	1	2	3	4	5	
Kort ledetid	○	○	○	○	○	Lang ledetid

Planlegger dere å inkludere flere produkter i VMI-kontrakt?

- ○ Ja
- ○ Nei

Hvilke kriterier setter dere for VMI-leverandør?

- ☐ Pris
- ☐ Kvalitet
- ☐ Fleksibilitet i leveringstid og kvantitet
- ☐ Langvarig forhold før VMI
- ☐ Other:

Hva er det viktigste for en vellyket implementering av VMI?

- ☐ Planlegging av etterspørsel etter VMI-produkter
- ☐ Kontinuerlig dialog mellom kunde og leverandør etter VMI-kontrakt blir signert
- ☐ Avanserte informasjonsteknologi
- ☐ Engasjerte ansatte

Bestiller dere VMI-produkter fra alternative leverandører?

- ○ Ja
- ○ Nei

Dersom svaret er JA, kan dere forklare, på hvilke betingelser andre leverandører blir kontaktet

Hva slags forandringer måtte gjøres på grunn av innføring av VMI?

- ☐ Implementering av ny informasjonsteknologi
- ☐ Nye plikter til ansatte
- ☐ Opplæring av ansatte
- ☐ Ingen store forandringer foregikk
- ☐ Other:

Er bedriften fornøyd med dagens VMI? Hva kan forbedres?

Appendix E

Ordering variability of product 4

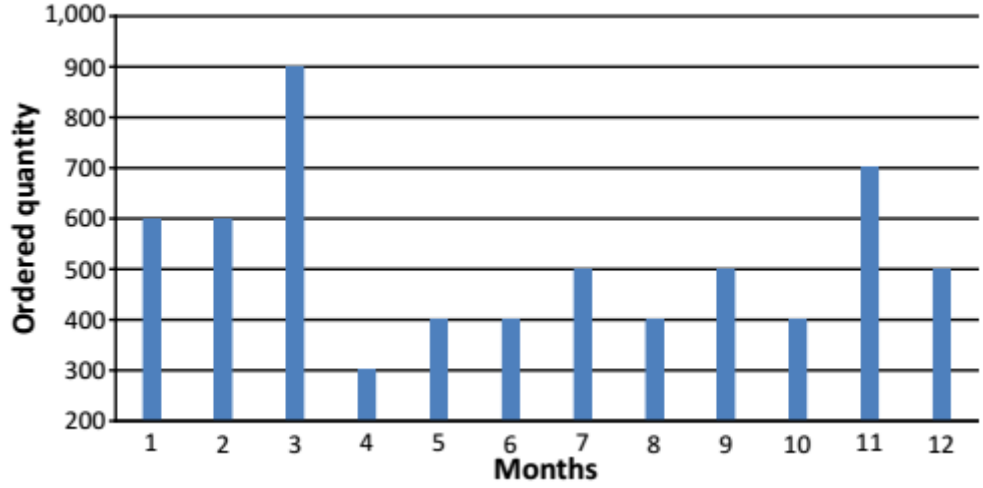


FIGURE 17. VARIABILITY OF MONTHLY DEMAND

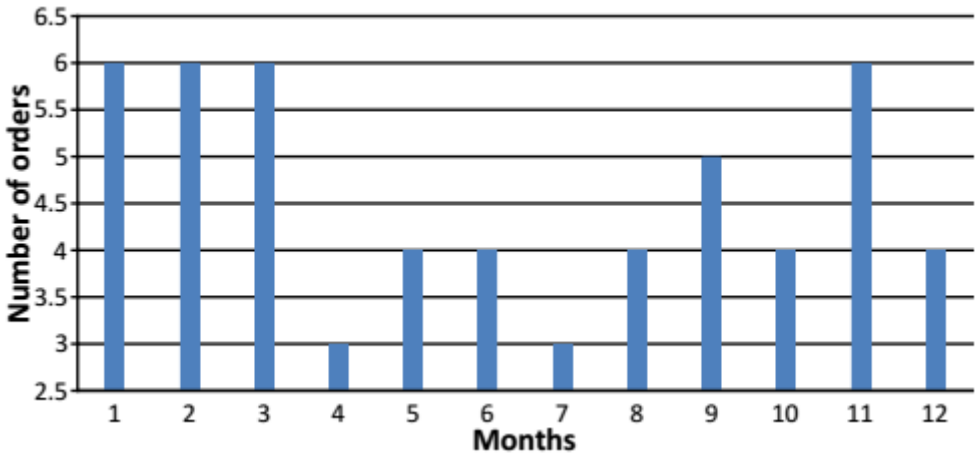


FIGURE 18. VARIABILITY OF MONTHLY ORDERING FREQUENCY