Digital Transformation: Smart Supply Chains with Vendor Managed Inventory (VMI)

A Case Study for a medium sized Swedish healthcare company in VMI implementation

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Abstract

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Keywords:	*VMI, Supply Chain, VMI Implementation, VMI risk, Risk Management*
Background & Purpose:	Supply chain management (SCM) has become a hot topic in the current global competitive markets that drives many companies to explore, especially in inventory management. Vendor Managed Inventory (VMI) as an SCM method enables all participants in the supply chain to achieve rapid development and obtained huge benefits. Under the VMI model, manufacturers/distributors give the inventory management responsibility to the suppliers to increase the inventory efficiency. One Swedish healthcare company desire to increase the supply chain resilience and save supply chain cost, especially during the Covid-19 pandemic and would like to implement the VMI model with its supplier. The two research questions in this thesis are 1) How can a healthcare company in Sweden implement the VMI model with its vendor? and, 2) What risks are associated with implementing VMI with a vendor for a healthcare company in Sweden?
Method:	This thesis is a qualitative study focus on one single Swedish healthcare company. There are ten interviews conducted within the Swedish healthcare company and its vendor. The research strategy is to obtain data from literature reviews and interviews based on the two research questions and then compare the similarities and differences for analysis.

Results:	The implementation process of VMI has summarized in two steps. The first step is VMI preparation, which includes Choose Product Assortment, Supplier Selection, IT Foundation, VMI Project Team, Risk Analysis. The Second step is VMI implementation, which includes Sign VMI Contract, VMI Training and VMI Process Set Up.
	Based on theoretical and empirical data, the author developed a conceptional risk management model for VMI. Through analysis, the author identified 13 risk factors in five dimensions. In addition, a new dimension, Change Management, is added to the existing supply chain risk management model from Tang (2006). In this new conceptional model, the risk factors are supplier relationship, inventory control, lack of resources, supply network design, contract, which belongs to Supply Management. Product diversification, substitution bundling, and standardization belong to Product Management. IT system support belongs to Information Management. Lack of resources, keep frequent and large orders, more responsibility from marketing belong to Demand Management. Moreover, fear to change, long lead time for employees to learn a new system, and lack of knowledge about VMI belong to Change Management.

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1. Introduction

In the following section, the topic of vendor-managed inventory is presented. The introduction includes background, problem discussion, research questions, delimitations, and the disposition of the thesis.

I choose vendor managed inventory as my thesis topic because I saw how important to increase supply chain resilience for a healthcare company, who produces personal protective equipment to hospitals during the Covid-19 pandemic. China, as one of the largest suppliers of personal protective equipment, has exported goods by train to Europe, the United States and other places, with a longer delivery time. Vendor managed inventory system is a solution to reduce inventory and shorten delivery lead time, which takes into account the interests for both buyers and suppliers.

1.1 Background

In the current global competitive markets, supply chain management (SCM) has become a hot topic that drives many companies to explore this new management concept, especially in inventory management. The supply chain management is based on various information technologies to establish a strategic partnership between various participants to realize the flow of resources from raw material suppliers, manufacturers, distributors, and retailers to end-users, to achieve a multi-win goal process (Larson & Rogers, 1998). Companies manage their own inventory and pursue maximization interests in the traditional supply chain, having formulated own inventory goals and inventory control strategies. The goal of each player is to solve how to manage the production to satisfy its customers' demand, without concerning other players (Disney & Towill, 2003). This independent operation has led to a lack of communication, which inevitably leads to distortion of information and increases production lead time (Drakaki & Tzionas, 2019). As a result, the inventory demand information is gradually amplified from the downstream to the upstream of the supply chain, forming a bullwhip effect (Croson & Donohue, 2006). This has weakened the overall competitiveness of the supply chain.

Since Covid-19 started to spread worldwide, the demand for PPE products such as medical masks, protective clothing, and isolation gowns has soared, surpassing global production capacity (Asian Development Bank, 2020a). Demand has risen sharply, causing depletion of inventories, prices rising and increasing backorders. The personal protective equipment supply disruption is significant for medical staff. In order to respond effectively to outbreaks of infectious diseases, the health-care supply system should be designed to provide demand quickly and in time. As a new supply chain inventory management method, VMI discussed in this paper can help medical institutions and their suppliers cope with the increasing demand.

1.2 **Problem discussion**

The traditional concept is that inventory is an evil to manufacturer, in fact, in an environment of increasingly fierce supply chain competition, inventory is a necessary evil (Cuatrecasas-Arbós, Fortuny-Santos, Ruiz-de-Arbulo-López, & Vintró-Sanchez, 2015). In modern enterprise management, inventory is required by every company (Kontuš, 2014). Inventory can ensure timely delivery as far as possible according to the delivery time and production plan required by customers, which can effectively alleviate the contradiction between supply and demand (Oluwaseyi et al., 2017). However, companies that hold a certain amount of inventory have many problems in the production and operation process. For example, delayed delivery or cancellation of orders caused by unreliable suppliers, variations in customer demand, product quality issues, and lack of production capacity (Keskin, Melouk, & Meyer, 2010). In order to reduce the risks brought about by the above topics, companies need to reduce inventory holdings, thereby improving the company's ability to respond to changes in external demand and supply quickly (Tsay, 2001). Of course, excess inventory has the same bad impact on companies. Excessive inventory increases operating costs, warehouse costs, warehouse management costs, increases capital pressure, insurance, and taxes, thereby reducing corporate profits. Inventory resource management requires a high level of understanding of cost impacts and changes (Netessine & Fuqiang Zhang, 2005). Inventory management and inventory decision-making play a vital role in the entire process of supply chain management and even financial management (BOSE, 2006). Inventory decision-making is high-risk and far-reaching. It can be said that the competition of modern companies is the competition between the supply chain and even the competition between inventory management and inventory management (BOSE, 2006).

Traditional inventory management uses technical inventory control management methods such as economic order batches, order point reorders, safety stocks, maximum and minimum stocks, etc, to adapt to the modern supply chain environment (Lin, 2010; Prak, Teunter & Syntetos, 2017; Battini, Gunasekaran, Faccio, Persona & Sgarbossa, 2010). New production methods and inventory management methods such as Material Requirement Planning (MRP), MRPII, the concept of zero inventory, and just-in-time production (JIT) have successively implemented in past decades (Bielecki & Kumar, 1988; Monden, 2011; Mula et al., 2007). With the increasingly fierce market competition, the exploration and innovation of advanced inventory management ideas and models in the business world and academia have never stopped. In the 1980s, P&G and Wal-Mart tried a brand-new inventory management model—Vendor Managed Inventory (VMI). Relying on the new model, both parties have achieved rapid development and obtained huge benefits from it (Yu et al., 2009). Under the VMI model, distributors share the downstream user's demand plan, production plan, current inventory level, actual inventory consumption data according to the actual consumption and trend, and replenishment plan (Disney & Towill, 2003).

Researchers have identified many benefits about the VMI system, such as the participants will save cost and increase profit to get an economic scale in the supply process (Savaşaneril & Erkip, 2010). However, less discussion or research talking about the risk management of VMI system. For the vendor, when implementing VMI, they take responsibility on the inventory level. When the industry volume dropped, vendors have to hold the bag of material burden. The risk of inventory out of stock, overstock and transportation risks are transferred from distributor/retailer to vendor's shoulder (Wang & Yu, 2009).

Besides, a popular view is that VMI depends on significant volumes (Choudhary, Shankar, Tiwari & Purohit, 2016). Studies have shown that in order to reduce supply chain costs, VMI has the worst effect in the random demand model and the most substantial effect in the demand increase model (Choudhary, Shankar, Tiwari & Purohit, 2016). For distributors or legal manufacturers, if orders are not placed frequently with vendors, the VMI system may not run successfully. In addition, the realization of the VMI system relies on the trust between supply chain participants, and trust cannot be cultivated in a short time. This means that VMI may take some time to take effect (Ozpolat & Dresner, 2018). More importantly, VMI relies on process and information

technology support. It takes time to set up the IT system and also requires a professional team. Once a problem occurs, it may cause severe damage to VMI, cause a crisis of trust, and cause the supply chain to collapse (Fry, 2010). Furthermore, VMI system is widely used in the retail industry, but not in the healthcare industry. Wal-Mart and Procter & Gamble have already adopted VMI successfully in the past decades (Andel, 1996; Stalk et al., 1992). In this research, I focus more on a Swedish healthcare company to implement VMI, which can give some inputs to enrich the current theory.

There were several research gaps of the Vendor Managed Inventory topic when I did the literature review. One is that most of the research focused on the VMI system between the customer and the manufacturer, the downstream of the supply chain process. This study focuses on the VMI system between the supplier who only does the product workmanship for the manufacturer, a Swedish healthcare company. The other research gap is that more researchers described the benefit of the VMI system and how to implement VMI system and barely not mention the risk of VMI. In this study, I will focus on the risk and try to give some inputs for the management level for future evaluations. The last research gap relates to the supply chain risk. Change management is less discussed in the previous supply chain risk model, especially from the psychologic perspective. This thesis will explain the respondents' opinion towards VMI risk from a change management perspective.

1.3 Research questions

The thesis examines the VMI implementation between a Swedish healthcare company and its Chinese vendor as well as analysis the VMI risk for the Swedish healthcare company. The purpose of this study is to explore how to implement VMI with vendors through a single case study of The Swedish Healthcare Company, and what are the risks that need to be considered in implementing VMI, in order to help management team make decisions of whether implementing VMI. The two research questions are:

- How can a healthcare company in Sweden implement the VMI model with its vendor?
- What risks are associated with implementing VMI with a vendor for a healthcare company in Sweden?

1.4 Delimitations

What will be discussed is the VMI model between manufacturer/distributor and its vendor, not between manufacturer/distributor and its customers. The vendor here is a supplier who purchase raw materials and convert to a finished product, then and supplies it to the manufacturer to sell to the end customer. The vendor can own the product design and use own brand or use the legal manufacturers design. The manufacturer here means the company who own R&D department and design the own product specifications, artwork and find the vendor to do the workmanship. The distributor is the company who buy the product from vendor and then sell to end customer at retail prices. The report will introduce the traditional supply chain and the main purpose to mention the traditional supply chain is to compare with VMI model, and this thesis will not investigate further within traditional supply chain. Furthermore, the thesis will focus on unconsignment stock model within VMI, which means the stock is managed by the manufacturer /distributor and owned by the manufacturer/distributor (Tavakkoli-Moghaddam, Alinaghian, Mollaverdi-Esfahani & Parsa, 2016).

The empirical material was gathered through an interview with 9 employees representing a Swedish healthcare company and 1 employee of the Swedish healthcare company's supplier. Hence, this low respondent number limits the report's perspective on how this Swedish healthcare company's option towards VMI model and the implementation with its vendor in the future.

1.5 Disposition

In the below figure 1.1, I present a disposition with 6 chapters in my master thesis. Before writing the thesis, I explored the VMI subject by an initial discussion with the Swedish healthcare company to know their current situation and why they want to implement VMI with suppliers. In Chapter 1, I gave background information on VMI and formulated the research question. In Chapter 2, I review the literate to summary the key factors for VMI implementation and some VMI risks. In Chapter 3, the research methodology is described as a qualitative research strategy with a single case study approach. This approach allowed me to use different data (interviews, literature, and the Swedish healthcare company internal documents) to explore which factors can be applied and the VMI risks should be considered for the Swedish healthcare company management level.

Chapter 4 presents the empirical data from interviews with the Swedish healthcare company employee and its supplier. In Chapter 5, I develop an analysis to compare the literature review and the empirical data to address the research question with a summary in the end. I modify and update the risk management model based on my finding in previous chapters. Specifically, the model is added with the Change management dimension coming from the interview data. In Chapter 6, a conclusion is presented regarding the two research questions separately.

Figure 1.1: Research Disposition
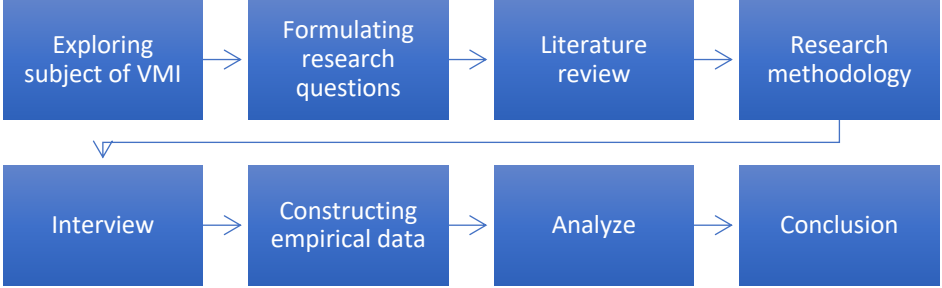
To better explain how to answer the research questions, Figure 1.2 shows that the research strategy is first to obtain data on the two research questions from literature reviews and interviews, and then compare the similarities and differences for analysis. Finally concluded suitable for The Swedish Healthcare Company.
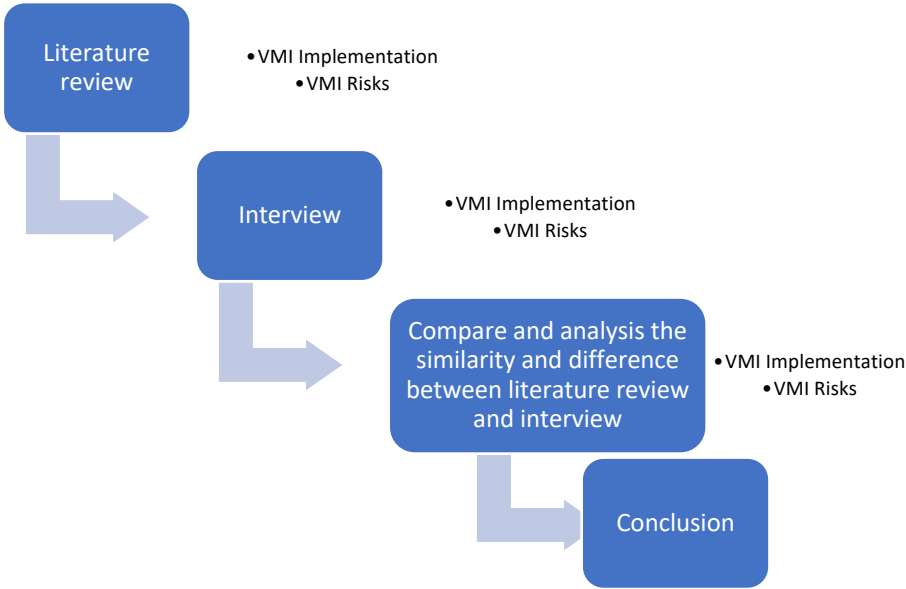
Figure 1.2: A brief strategy to answer the research question

2. Literature review

In the following section, I present a literature review relating to VMI concepts. The literature review consists of two parts. First part is a background information of VMI, including the current PPE business demand needs, supply chain digital trend and VMI definitions. The second part is structured on the research question, which are VMI implementation and VMI risks.
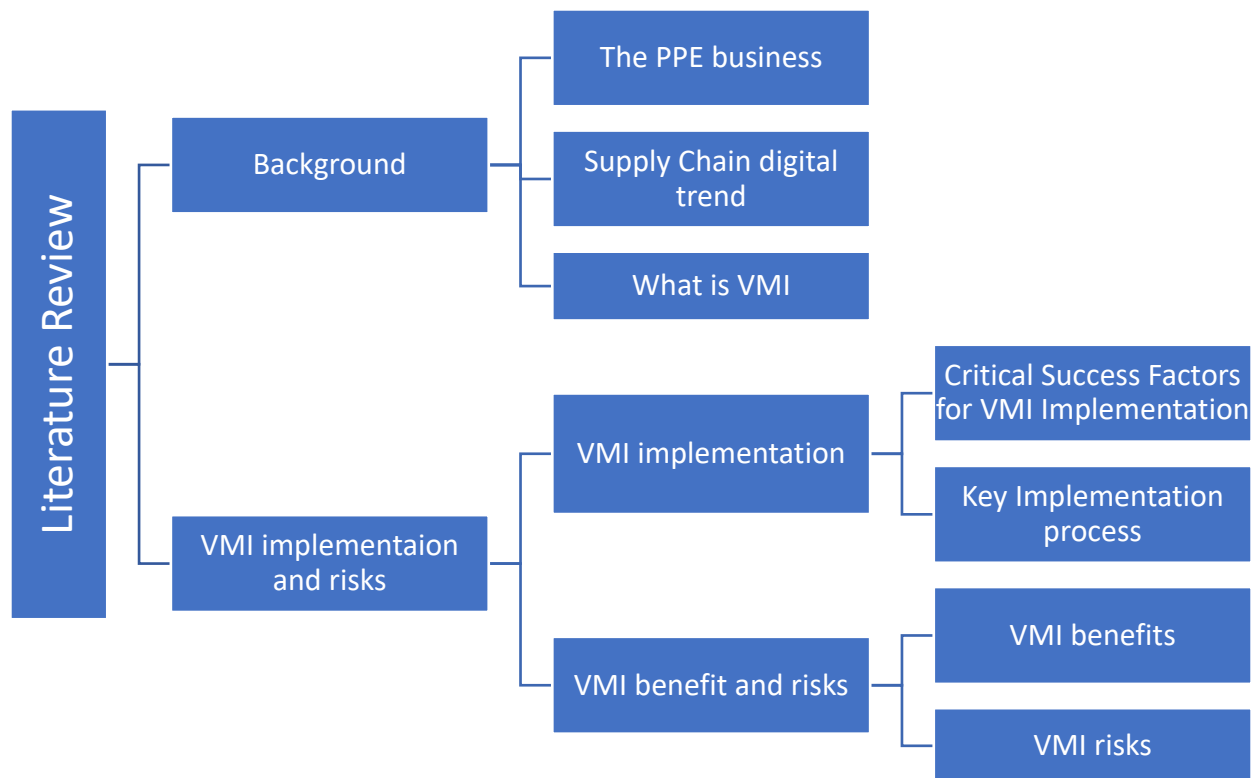
Figure 2.1: Literature review structure

2.1 The PPE business

In December 2019, a case of pneumonia was found in Wuhan, Hubei, China. On February 8, 2020, the State Council of China referred to the new type of coronavirus-infected pneumonia as a new type of coronavirus pneumonia, or new coronary pneumonia in short (Gong, 2020). By May XX, 2021, 160,813,869 confirmed new coronary pneumonitis cases globally and 3,339,002 cases of cumulative deaths (World Health Organization, 2021). According to Chinese regulation, the wards of patients with suspected or confirmed new coronary pneumonia should adopt contact isolation,

personal protective equipment such as droplet isolation and air isolation are required to wear. Personal protective equipment includes work caps, N95 masks, isolation gowns, protective clothing, gloves, goggles, protective masks, overshoes, boot covers, full-face breathing protective devices or positive pressure headgear, etc (World Health Organization, 2020). Personal protective equipment can prevent wearing contact with potentially infectious substances in the mouth, nose, eyes, hands, skin, etc. This is an important measure to reduce the risk of occupational exposure of medical staff.

Major PPE exporting countries such as China have responded to supplement supply, but the surge in foreign demand has triggered new concerns about product quality. At present, the global PPE market is in chaos. In addition to shortages, there are pirated and defective products. Many poor and fragile countries face uncertainty in obtaining imported personal protective equipment present and in the future (Bown, 2020). This is one reason why there is an urgent need to implement VMI system.

2.2 Supply chain digital trend

Supply chain is a complete system includes raw material suppliers, production factories/suppliers, distributors, and end customers together through downstream to upstream (Stevens, 1989). In the traditional supply chain model, all participants (sellers, distributors, manufacturers, raw material suppliers) need to control their own inventory levels to meet production and sales requirements (Disney & Towill, 2003). A classic problem that all participants in the traditional supply chain must solve is "how many production materials to meet customer needs.

Axsater (1985) stated in his research that the production/inventory control system controls inventory levels and production capacity. Inventory system is to convert incomplete information about the market to supplement production and raw materials. Under normal circumstances, supply chain participants adjust inventory levels through customer demand and order data, or use their experience and judgment to place orders from raw material suppliers in the supply chain (Axsater, 1985). The traditional supply chain structure has been developed because companies need to control their own assets, but the information transmitted has always been uneconomical (Axsater,

1985). The characteristic of the traditional supply chain is that supply chain participants only determines the production order based on the sales, inventory level or capacity of its own customers. They only have information about the needs of their direct customers, but no information about the needs of their end customers. This makes it impossible for suppliers to understand which products their customers have ordered, and which products customers have ordered to meet current customer needs (Kaipia et al., 2006). If the design is not correct, the lack of visibility into actual demand will cause supply chain problems.

In today's world healthcare industry, the three most typical and successful markets are North America, Europe and Japan (Chee, 2007). In North America, all industries have their industry associations, which these industry associations are combined into larger and more comprehensive industry associations according to their respective functions and characteristics. Everyone can share distribution resources and reduce costs. For example, the Canadian Pharmaceutical Wholesalers Association (CWDA), the organization is compelling. It provides a complete range of services for members, from channel sharing, the development of Electronic Data Interchange (EDI) data transmission format to preparing bar codes, and usage specifications (Moynihan, 1997). The widespread use of electronic data exchange in the pharmaceutical industry will achieve the expected cost savings, and manufacturers, sharing and medical service opportunities can start targeted changes and writing in the four areas of distribution, transportation, order management and inventory management. Jointly achieve efficiency improvement, cost reduction and profit increase (Glaser, DeBor & Stuntz, 2003).

2.3 What is VMI

In traditional ordering process, when the manufacturer receives the demand from the marketing department, it will first check the existing inventory. If the existing inventory is out of stock, they will place production orders with the supplier. Thus, the manufacturer at this time is in complete control of the order and maintains the level of inventory. (Disney & Towill, 2003). The biggest problem in the traditional ordering process is that it manufacturers and vendors are hard to minimize the inventory level (Savaşaneril & Erkip, 2010).
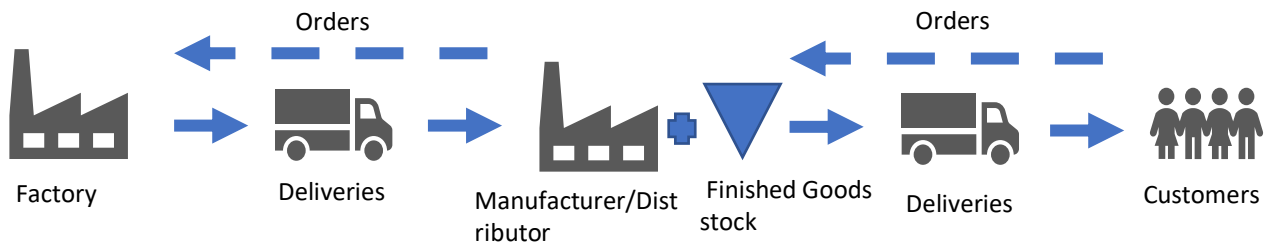
Figure 2.2: Traditional supply chain adapted from Stevens (1989)

Vendor-managed inventory (VMI) means suppliers have the visibility of demand and inventory level information from the customer and use this information to manage customer's inventory. It is a service provided by suppliers to customers and is also a collaborative process (Savaşaneril And Erkip, 2010). According to Disney & Towill (2003), suppliers are responsible for inventory management. In the VMI model, the supplier needs to monitor the customer's inventory level and formulate its own replenishment requirements and raw material purchase plans based on sales forecasts. Different from the traditional method, suppliers no longer accept customers' orders but instead determine the order quantity and shipping time by themselves through inventory levels (Waller et al., 1999; Danese, 2006). Disney and Towill (2003) believe that an essential fact about VMI is that information sharing between customers and suppliers. Supplier delivery plans are determined based on information shared by customers, including but not limited to data about sales forecasts, inventory levels.

Therefore, one of the basic requirements to implementation VMI successfully is information exchange between vendors and the manufacturers. Based on experience, companies use electronic data interchange (EDI) to exchange information and reduce data transmission time and errors (Lancioni et al., 2000). Figure 2.3 shows the VMI supply chain flow under the VMI model.

Figure 2.3: Supply Chain under VMI model inspired by Stevens (1989)
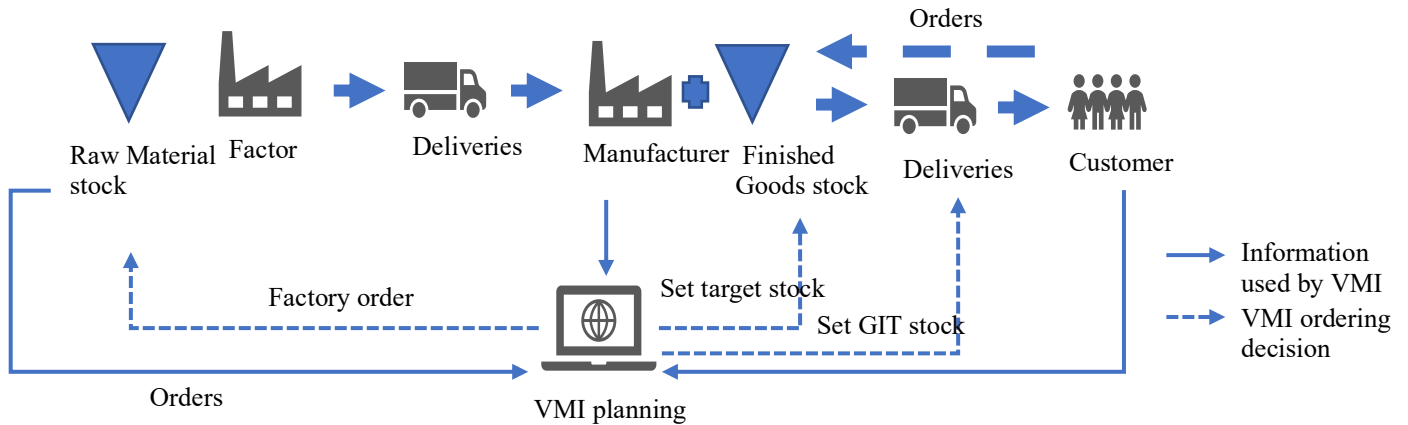
There are some assumptions in the VMI system. First, customers need to provide suppliers with sales forecasts, ending inventory level information, and end-customer demand information. Second, customers do not share information of unit inventory costs with manufacturers. There is no need to share product price information. Similarly, the supplier's cost information will not be shared with customers, these are confidentail information (Savaşaneril & Erkip, 2010).

Consignment stock and non consignment stock

There are two inventory management systems to choose for VMI mode. One is inventory owned by the customer, also known as consignment stock. The goods are in the customer (buyer), but the rights of the goods belong to the vendor, which is managed by the vendor (Valentini & Zavanella, 2003). The other is that the goods are in the customer's place, and the rights of the goods belong to the customer, but the vendor manages the inventory level and constantly makes up. This is called non consignment stock (Battini, 2010; Tavakkoli-Moghaddam, Alinaghian, Mollaverdi-Esfahani and Parsa, 2016).

2.4 VMI implementation

VMI implementation presents the critical success factors for VMI implementation and a basic VMI implementation process.

2.4.1 Critical success factors for VMI implementation

The supplier decides how many products to produce in the VMI model, the number of outsourcing, and the delivery time. This is because the supplier bears the inventory management responsibility. Singh (2013) put forward some critical requirements for VMI implementation. For example, interpretive structural modelling (ISM) technology used to improve supply chain resilience. Singh (2013) defined various variables in VMI implementation depend on their driving ability or the degree of dependence on VMI and the degree of mutual influence. These factors are further classified according to their driving force and dependence. This model insight can help to VMI model to improve overall supply chain performance. Figure 2.4 lists the key factors for VMI Implementation from Singh's article.

Key factors for VMI Implementation (Singh, 2013)
• Top Management Support
• Employee Involvement
• Automation of Processes
• Investment in Information Systems and Infrastructure
• Effective Marketing Process
• Production Planning and Control
• Supply Chain Integration
• Efficient Inventory Management
• Delivery on Time
• Product Cost Reduction
• Performance Improvement of Supply Chain
• Vendor Development

Figure 2.4: Key factors for VMI Implementation (Singh, 2013)

On the other hand, Sarpola (2007) proposed and described the six dimensions of the VMI system's implementation: inventory location, distribution model, inventory level monitoring and demand visibility, the role of information systems, and replenishment decisions, and inventory ownership. These dimensions consider the implementation requirements of the VMI system. In addition,

Barratt (2004) constructed two dimensions: the relational perspective and the information perspective. The relationship between partners includes interdependence, openness, trust, honesty, chemical reaction, frequency of interaction and commitment, etc. The commitment means whether both parties are willing to build up a long term collaborate relationship. Trust and information quality also two important factors for VMI implementation (Petersen et al., 2005). According to (Claassen et al., 2008), the success of VMI is affected by relationship quality between buyers and suppliers, information systems reliabilities, and information sharing intensity. Disney, Holmström, Kaipia, and Towill (2001) also explained that long-life, non-seasonal products are more suitable for the VMI model. Sari (2008) used Monte Carlo simulation for risk analysis and forecasting procedures, comparing the traditional supply chain model with the VMI model. In the traditional model, each supply chain participant strives to develop local strategies to optimize their organization, regardless of the impact on other members. Because less of information shared between members, the upstream members don't have the access of actual demand from market side. On the other hand, under VMI, suppliers can obtain inventory levels and market data. In return, suppliers are responsible for managing inventory for buyers. In other words, under VMI, distributors need to consider not only their own inventory, but also the retailer's inventory when making inventory plans.

Furthermore, Sainathan & Groenevelt（2019）General mathematical framework to analyze retailer-managed inventory (RMI) and contracts under VMI. They divided contracts into five categories: buybacks, quantity flexibility, quantity discounts, sales rebates, and revenue sharing contracts. When the suppliers freely determine the quantity, they analyzed the contract types under the VMI. The study found that quantity flexibility and sales rebate contracts are usually not coordinated under VMI while repurchase and revenue sharing contracts are preferable for VMI.

2.4.2 VMI implementation process

Big picture process mapping mentioned by Berry & Naim (1996), was used to understand where the goods come from and will go which market. Then, VMI implementation need to issue the production planning process. Marquès, Thierry, Lamothe, & Gourcs' (2010) research shows that VMI is a replenishment system. Suppliers are responsible for replenishing customers' inventory within a pre-established collaboration/long-term range. VMI implementation need production and replenishment decision both in long-term and short-term. The supplier should have a short-term production and replenishment plan based on production constraints.

Industrial partners	
Investigation of seasonality	Selection of everlasting products

All partners	
Review of current system	Investigation of production and inventory

Time
Application of Time Benefit to identify suitable pilots

System	
Investigation of current IT sustem	Selection of a suitable production control system

Implementation
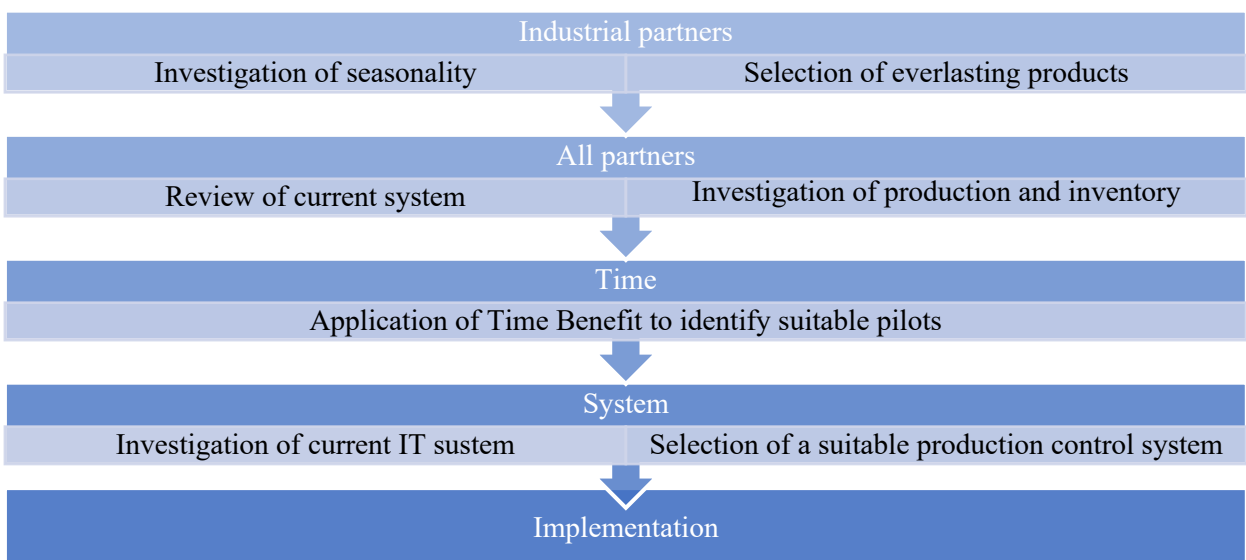
Figure 2.5: Overview of the VMI methodology adapted by Disney, Holmström, Kaipia & Towill (2001).

A Decision Support System (DSS) shows in aboave Figure 2.5 has been introduced, by Disney, Holmström, Kaipia & Towill (2001). The production needs to determine the industrial partner. This includes deciding which times are seasonal or not, and product categories. Secondly, the stakeholders of the VMI model need to review the existing production system and the existing inventory status. For example, weekly cross-checks and revises the production plan established by the ERP system according to the actual situation. Among them, the supply chain planner needs to consider the following important factors, such as capacity, resources, unpredictable yield, transportation, etc. After that, you can consider the time of VMI implementation and find the most suitable time point for pilot project testing. Then, the establishment of the system is based on the

automatic assembly line, inventory and order production control system (APIOPBCS), and the buyer can realize the linkage between the VMI system and other systems (Disney, Holmström, Kaipia & Towill, 2001).

2.5 VMI benefits and risks

In this part I will present the literature review on the topic of VMI benefits and risks. VMI benefits introduce readers more background knowledge of VMI. I will put more focus on the literature reviews related to VMI risks.

2.5.1 VMI benefits

The VMI model has achieved great success in the retail industry in the past 15 years. Retailers such as Wal-Mart (Andel, 1996; Stalk et al., 1992) and Procter & Gamble (Waller et al., 1999) have actively adopted VMI and achieved commercial success. VMI became popular in the grocery industry. Dell, Barilla, Nestlé, Johnson & Johnson have also adopted VMI (Savaşaneril & Erkip, 2010; Blatherwick, 1998; Kaipia et al., 2002).

The most frequently mentioned benefit of VMI is that it can reduce the uncertainty of customer demand through inventory management (Disney and Towill, 2003a; Smaros et al., 2003). By sharing information about customer needs, various supply chain participants can adjust their production levels flexibly and quickly, thereby reducing their own inventory. Specifically, under the VMI model, the bullwhip effect in the supply chain is reduced. When supply information from the downstream is transferred to the upstream supply end, it will not cause information distortion (Çetinkaya & Lee, 2000). This will bring economic benefits to all supply chain members, save inventory costs, and achieve economies of scale and flexible delivery (Fry et al., 2001; Savaşaneril and Erkip, 2010; Zavanella and Zanoni, 2009).

Agreement terms can be set to formulate the maximum and minimum inventory levels so that the supplier can improve performance. After the supplier controls the inventory, the inventory level can be reduced, and the customer can benefit from inventory management (Dong and Xu 2002). To further explain, VMI can help save costs because the increase in replenishment frequency leads to lower inventory levels (Savaşaneril & Erkip, 2010). Much research mentioned that flexible

replenishment time can reach container optimization, whether it is sea or land transportation, it can maximize the use of logistics resources to reduce transportation costs (Lee, 2004). Suppliers do not need to wait for customers to place orders but create orders by themselves using the information shared by customers (Razmi et al., 2010).

2.5.2 VMI risks

Although VMI has many benefits, its risk cannot be ignored, especially need to be focused before making any strategic decision. VMI has achieved surprising success in the retail industry, but it has not yet become a standard supply chain model (Kaipia et al., 2002).

According to the Basic approaches for risk mitigation from a research literature, Tang (2006) studied a supply chain risk management (SCRM) strategy, which analyzed four dimension within supply chain. The four models are (Tang, 2006): **Product management:** involves products design and modification processes, and product assortments. **Supply management:** involves supply network design, supplier selection, supplier order allocation, and supply contracts, cooperation with downstream partners and upstream partners. **Information Management:** involves supply chain visibility, information sharing, collaborative planning. **Demand management:** Product pricing, real-time demand, markets requirement.
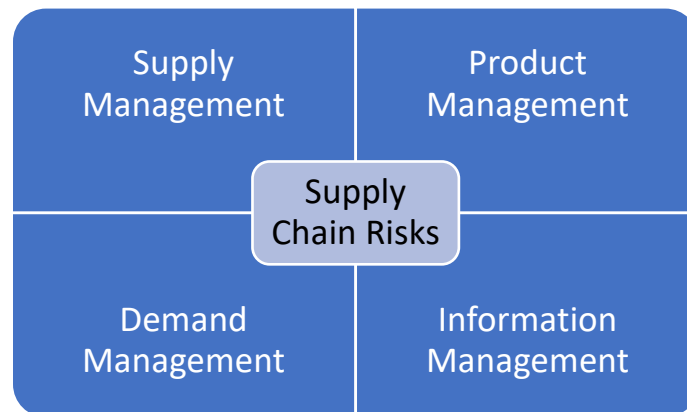

Figure 2.6: Supply Chain Risk Management Model adapted from Tang (2006)

VMI as a supply chain tool to increase the supply resilience, the VMI risk analysis will follow Tang (2006) model, to collect research result and category into four different model as below.

Supply Management：

According to Tang (2006), supply management including five different areas which are: 1. supply network design, 2. supplier relationship, 3. supplier selection process (criteria and supplier selection), 4. supplier order allocation and 5. supply contract.

Under VMI, there are certain risks in the relationship between suppliers and customers. Suppliers have complete control over inventory and logistics, which requires buyers and sellers to establish a positive relationship (Zanoni, Jaber and Zavanella, 2012). For the buyer, the transfer of inventory rights requires special attention to the transfer time of product ownership. Guan and Zhao (2010) introduced a revenue sharing contract in which the customer does not pay the seller any fees before selling the inventory. In addition, although VMI can improve inventory turnover, when it is impossible to ensure that there will be no inventory backlog or shortages. Lee and Cho (2014) proposed the VMI contract, which stipulates that in the event of a stock-out situation, the customer can charge the supplier a fine. In addition, Huynh and Pan (2015) also analysed another type of VMI contract in which the buyer only pays for the goods sold before the end of the sales season. Chakraborty, Chatterjee & Mateen, (2015) studied the VMI system of a single seller-multiple retailers.

According to Sumrit's (2020) research, VMI supplier selection could be a risk, that a supplier could lack of previous experience, had bad delivery record, limited supply flexibility and poor reputation at local market, those will bring uncertainty to VMI efficiently at the end. Sumrit (2020) described several criteria's that can be used, such as past delivery performance, institutional trust, supply chain process integration, supplier flexibility, project implementation time, prior knowledge and experience, reputation, and position in industry, etc. Huoy, Rahim, Rahman, Nawi, & Ahmi, (2018) described that one important factor to drive VMI is resource allocation, use the rehouse based theory (Peteraf, 1993). When the retail company influenced easily by the suppliers, it will create the resource dependence (Yalcin, Özpolat & Schniederjans, 2018).

In addition, the issue of trust between supply chain participants has always been a risk. Pohlen & Goldsby (2003) argued in their research that a certain degree of trust is essential for maintaining supply chain relationships. The implementation of VMI relies on the supplier's ability to manage inventory efficiently. The premise is that the buyer trusts the supplier's ability. If supply chain participants share value and increase communication, it will increase mutual trust. However, opportunistic behaviour can reduce this trust (Morgan and Hunt, 1994). Doney and Cannon (1997) believe that the buyer's size and order size are also vital drivers for trust.

Sufficiently large-scale can reflect the sincerity of cooperation, thereby increasing the motivation for supplier cooperation and guaranteeing long-term cooperation. The realization of the VMI model relies on the joint execution of both parties, and the success of supplier management depends on the cooperative relationship between the two parties.

Product Management

For premium products or special products such as fashion, the purchase may bring a significant risk and unprofitable for the buyers due to the low inventory turnover rate. Therefore, if such products are placed in the supplier's inventory, the inventory holding cost will become much lower than that of the customer (Mishra and Raghunathan, 2004). In addition, customers will be reluctant to buy new products because new products have not been validated by the market yet. Suppliers can be persuaded to take the risk of introducing new products (Sarpola, 2007).

Market research shows that product diversification can increase market share and is an effective strategy. Can meet the needs of different market segments. However, to manufacture different products, it has increased the process difficulty for the manufacturer, thereby increasing the manufacturing cost. Due to the different needs of each product, product types will also increase inventory costs (Tang, 2006). The study of MacDuffie et al. (1996) shows that more product types tend to increase inventory costs. It is important for a company to determine the best product mix to gain more profits.

Product substitution and product bundling can reduce the risk of product backlog. This is because companies can substitute products for each other and transfer customer needs. When a product cannot meet customer needs due to insufficient capacity, another product can be used as a

substitute to negotiate with customers. However, there is currently a clear analytical model for determining the optimal product mix for alternative products (Ulrich et al., 2003).

Acrooding to Yalcin, Özpolat & Schniederjans（2018）research, the product is preferred to be standardized, repeating with low variance and minimum customization under VMI system, it will help to gain economies of scale.

Information Management：

The establishment of a sales network information management system between suppliers and manufacturers is based on a cooperative relationship between the two parties. It is required to increase the degree of dependence between relevant parties, increase opportunity costs, and profit distribution will become a great difficulty. In addition, the supply chain participants are prone to lack of trust and lack of contractual spirit, resulting in insufficient exchange of information and data and information sharing, inability to maintain inventory imbalance, and inability to monitor inventory at a high level. Retailers should communicate promotional activities with suppliers in advance. A stable information system depends on establishing an information-sharing platform, especially how the buyer's system is connected with the supplier's system. One difficulty in the technology in the VMI system is that buyers and sellers cannot share sufficient information based on the principle of benefit protection. For example, manufacturers are unwilling to share market sales data, inventory levels which making it impossible for suppliers. Relying on this information to reduce inventory levels has led to the failure of VMI implementation (Liu & Sun, 2011).

Demand Management：

Lack of resources to keep frequent and large orders: At present, large or medium-sized enterprises are better at supplier management inventory. The VMI system is also more suitable for frequent orders and large quantities of orders to ensure smooth and efficient operation. If the order quantity is too small, the VMI system may not operate successfully between the manufacturer (supplier) and the retailer (distributor). Therefore, the company size in the VMI system is limited (Malone,

2011). In addition, the demand forecast level of the manufacturer/supplier is also the key to the successful implementation of VMI.

2.6 Summary table of literature review

From the literature review, I summarized the key ideas from previous researchers that are relevant for me to address my research questions, which are VMI implementation and VMI risks.

	Authors	Key ideas
VMI implementation	Claassen, Weele & Raaij, 2008	Vendors update the inventory status and end-of-period holding costs to the manufacturer
	Singh, 2013	Described key factors for VMI Implementation
	Sarpola, 2007	Six dimensions of VMI systems
	Barratt, 2004	Adding relationship and information dimensions
	Petersen et al., 2005	Trust and information quality
	Claassen et al., 2008	The success of VMI is impacted by quality of the buyer–supplier relationship, information systems and the intensity of information sharing
	Berry & Naim, 1996	VMI process mapping
	Disney, Holmström, Kaipia & Towill, 2001	A Decision Support System
	Sari, 2008	Monte Carlo simulation
	Sainathan & Groenevelt, 2019	Five VMI contract types
VMI risks	Tang, 2006	Supply chain risk management (SCRM) strategy
	Mishra and Raghunathan, 2004	Special products placed in the supplier's inventory, the inventory holding cost may be much lower
	MacDuffie et al., 1996	Production and inventory costs tend to increase with the increase in product types
	Ulrich et al., 2003	Product substitution and product bundling can reduce the risk of product backorders

	Yalcin, Özpolat & Schniederjans, 2018	Standardized product is preferred by VMI system
	Zanoni, Jaber and Zavanella, 2012	Relationship between suppliers and customers could be a risk factor
	Guan and Zhao, 2010	Revenue sharing contract good for building trust
	Lee and Cho, 2014	Customer can charge fine from supplier for inventory mistakes
	Huynh and Pan, 2015	New contracts type that buyer only pays for the goods sold before the end of the sales season
	Chakraborty, Chatterjee & Mateen, 2015	New contracts type a single seller-multiple retailers.
	Sumrit, 2020	VMI supplier selection could be a risk
	Pohlen & Goldsby, 2003	Degree of trust is essential for the relationship to be maintained
	Morgan and Hunt, 1994	Sharing value and increasing communication may increase trust
	Liu & Sun, 2011	Sales network information management system could be a risk
	Huoy, Rahim, Rahman, Nawi, & Ahmi, 2018	Resource allocation

Figure 2.7: Summary of Literature Review

3. Methodology

In the following section the process of my research is represented with the aim of being transparent and thorough. The method for conducting systematic literature review is presented along with the empirical data collection.

3.1 Research strategy

According to Bell, Bryman and Harley (2018), qualitative research is studying people and how they make sense of the world. It discusses the characteristics of specific social phenomena and lacks emphasis on subjective explanations of specific phenomena. Qualitative research is a description of a specific phenomenon in a specific process. Instead of breadth, qualitative research provides a more depth understanding of how individuals perceive, which offers the possibility to acquire insights into the respondent's knowledge. Polkinghorn (2005) described that qualitative research focus on describing in language from people and capture their experience. Interviewers try to understand the interviewee actions and their opinions and then make hypotheses. Usually, qualitative research applied when the sample is small, but required a comprehensive result. This research is more suitable for qualitative research because the purpose of the research is to interview employees of a Swedish healthcare company, summarize their implementation of the VMI system in the company, and discuss VMI risks, and compare the general conclusions drawn from existing theories, and giving some advice to the management team.

Inductive reasoning is a method of qualitative analysis in which it can integrate experience and observations, including what has been learned from others. Inductive reasoning was defined by Singmann and Klauer (2011) as general principles derived from specific observations (from specific to general arguments). The study uses qualitative analysis by doing an inductive reasoning in order to gain insights of the Swedish healthcare company's experience and observation of its employees, to get a generic conclusion.

One possible limitation of qualitative analysis is that it may lack objectivity, because it focuses on subjective opinions. Besides, researchers' personal judgment could further limit the result objectives. In addition, given that the social environment is dynamic and constantly changing, the possibility of repeating the study is limited (Bell et al., 2018), which means that the respondent answers may differ at different points in time.

3.2 Research design

Research design is how you structure the research, use a specific research method to collect data and analysis data (Bell et al., 2018). There are five difference research design types which are: Experimental design, Cross-sectional design, Longitudinal design, Case study design and Comparative design.

The use of case studies is a well-established approach in research. A case study is a detailed analysis and in-depth study of the case to provide widespread and general insights on the phenomenon (Bell et al., 2018). The case study is more suitable for exploratory research, generating new insights and theories on new phenomena rather than confirmatory research. Although the VMI model is not the latest invention in the supply chain, it is still a new topic in the medical industry. This research uses a qualitative analysis method to study a Swedish healthcare company, which is often used in the case study.According to the definition of Bell et al. (2018), The single case study is a research method to explore a specific case or organization, which can provide a more comprehensive explanation for a specific phenomenon. The advantage of a single case study is that it pays more attention to practice solution rather than theory exploration, especially for the social sciences subject (Gerring, 2007). Moreover, the single case has a particularity to the research object to gain an advantage of investigation in depth. Bell et al. (2018) also mentioned four other types of cases, which to some extents do not fit the scope of this study.
(1) The critical case is investigated based on the clear hypothesis of the researcher, but this research has no such hypothesis.
(2) Unique case refers to the case itself as unusual, so it is exciting to study. The selected case itself is interesting, but based on the organization's general problems with different aspects of innovation, it cannot be considered unusual.

(3) The enlightening case is based on the possibility that the researcher analyzes a phenomenon that the researcher could not touch before, which is fundamentally inconsistent with selected case. (4) Longitudinal cases are similar to longitudinal research designs it based on the analysis of how the situation changes over time, so this type of case does not apply to the same arguments about longitudinal research design.

3.3 Research method

Data collection can be divided into collecting primary data and secondary data. The primary data is obtained through interviews with The Swedish healthcare company and its supplier. The secondary data is obtained by reading the literature and sorting it out. Combining the two types of data and finally cross-checking will help improve the quality of research (Bell et al., 2018)

3.3.1. Secondary data Collection

The secondary data in this article is collected through reading and collating literature. According to the research of Bell et al. (2018), the literature review can help researchers establish a basic theoretical framework, provide a basis to prove the rationality of the research problem, and can also help researchers analyze data in a clean and orderly manner. In addition, a literature review can reflect the researcher's knowledge reserve in the field, including vocabulary, theories, research methods and theory history. A literature review can define research questions, find new ways to ask questions, avoid ineffective methods, gain methodological insights, determine recommendations for further research, and get help from existing research. Finally, after some revisions, the literature review is "legal and publishable academic literature" (LeCompte & colleagues, 2003).

Before starting a literature review, inclusion and exclusion criteria should be formulated to facilitate screening and reading from many literatures and construct a comprehensive and relevant literature review structure. This will also facilitate readers to understand the scope of the research, improve transparency, and clearly explain what the paper involves and what is not. In Figure 3.1, the topics to be included and excluded are listed.

Inclusion criteria
• VMI Benefits and risks for both customers and suppliers
• How to implement VMI between manufacturers and its suppliers
• Critical factors to implement VMI
• Supply Chain innovation
• Risk management in Supply Chain

Figure 3.1, Inclusion criteria

Exclusion criteria
• VMI implementation between customer and manufacturers
• Detailed implementation plan of VMI, including inventory calculation, business negotiation, contract detail etc.
• Risk analysis with financial models
• How VMI works on a techincal level, i.e. software

Figure 3.2, Exclusion criteria

The keywords were chosen by the relativeness of the research topic and the thesis purpose. VMI is one of the supply chain solutions, thus Supply chain is chosen as keyword. Besides, VMI is related to change management and business strategy, and it is different from traditional inventory management and usually, it is a strategic move for the company. VMI also requires information sharing and business collaboration since VMI is a model between different supply chain participants. Innovation management is another keyword because VMI system is still a new concept to the healthcare industry. In order to ensure that the relevant literature is covered, different combinations of keywords and keyword synonyms were chosen. Figure 3.3 illustrates the keywords used.

Keywords	
• Vendor managed inventory, VMI • Supply Chain • Supply Chain coordination • Supply Chain integration • Health care industry • Risk Management • Business strategy	• Information sharing • Business collaboration • Innovation management • Vendor managed inventory + benefit • Vendor managed inventory + risk/challenge/disadvantage • Vendor managed inventory + implementation • Vendor managed inventory + Sweden/Swedish

Figure 3.3, Key words

3.3.2. Primary data collection

The primary data were gathered through an in-depth interview with 9 employees in the Swedish Healthcare Company and 1 sales representative from its supplier in China. The interviews were semi-structured for not limiting the respondents' answers. Interview is commonly used in qualitative research. Both unstructured and semi-structured interview is flexible compared to structured interviews. By comparing these two interview methods, a semi-unstructured interview is used in this assignment. This is because the unstructured interview is easier to generate interviewees answers without limit their thoughts (Bell et al., 2018).

For the interviewee easy reference and have some time to prepared, interview guides were sent before the interview; One for the internal employees from The Swedish healthcare Company and one for the external supplier (see Appendix Interview Guide).

According to the classification of Bell et al. (2018), two sampling methods are introduced: probability sampling and purposive sampling. Probability sampling defined as a random method to select samples, which is mostly used for quantitative analysis. Purposive sampling defined a type of non-probability sampling. When selecting the interviewees, the interviewees are all related to the supply chain work, which are relevant to the research question. The VMI model acts on the supply chain link, and this research mainly focuses on the healthcare company and its suppliers, so the key players are the supply chain planner and logistic developer. Thus, purposive sampling is used for this thesis. Besides, the Swedish healthcare company has many other parts, such as

R&D, quality management, sales, law, etc. Because they are less relevant to this research, the research did not interview relevant employees.

No.	Interviewee	Title	Date	Duration	Location
1	Respondent A	Global Lead Supply Chain Planner	05th March 2021	52min	Teams Meeting
2	Respondent B	Global Supply Chain Manager	08th March 2021	54min	Teams Meeting
3	Respondent C	Global Supply Chain Planner	10th March 2021	48min	Teams Meeting
4	Respondent D	Global Senior Project Manager Operations	12th April 2021	37min	Teams Meeting
5	Respondent E	Senior Process Development Manager	10th February 2021	51min	Teams Meeting
6	Respondent F	Global Project Manager	17th February 2021	82min	Teams Meeting
7	Respondent G	Contract Manufacturing Manager	15th April 2021	44min	Teams Meeting
8	Respondent H	Global Transport Developer	11th May 2021	30min	Teams Meeting
9	Respondent I	Supplier	13th May 2021	73min	Teams Meeting
10	Respondent J	Supply chain Director OR Solutions	5th May 2021	57min	Teams Meeting

Figure 3.4: Respondents Summary

Before the interview, the interviewee accepted an introduction about VMI, which included the concept of VMI, the application of VMI within the company and between customers, a simple introduction to the advantages of VMI, and how VMI was implemented. Since VMI is not popular

in the healthcare field, the purpose of the presentation is to give respondents a basic understanding of VMI so that they can answer related questions. Before the interview, all interviewees received an interview guide (appendix A) to enable them to prepare the main topic and find relevant information before the interview.

During the interview, the interviewer will first ask if it is possible to record and take notes, and then the interview will start when allowed. First, give a general introduction to the interview, and then start the interview questions. The purpose is to make the interviewee feel comfortable. Then it will collect the personal background information of the interviewee, such as position, length of service, and job content. To avoid the infringement of privacy by the respondents, they are anonymous and given a coded name. At the end of the interview, the interviewee will be thanked and asked if the interviewee is willing to receive the research results, and the authenticity of the interview data will be checked.

After the interview, I transcribed the interview content into a word fine. The transcribed content only contains the sentence related to the research question; it will be very time-consuming to transcribe all the interview content (Bell et al., 2018).

The interviews were conducted in English and Chinese based on the respondent's country/region. There is only one Chinese interview with the Chinese supplier of The Swedish Healthcare Company and needed to translate into English. The use of correct and less complex language is essential for the interviewee to fully understand the question, reducing the risk of misinterpreting the question (Bell et al., 2018).

3.3.3. Data analysis

Data analysis is a process that reducing the data collected and identifying patterns and relations among them (Bell et al., 2018). There are two main strategies for qualitative data analysis, which are analytic induction and grounded theory. Analytic induction is that researchers integrate the collected data to develop a set of hypotheses until no inconsistency with the hypothetical explanation of the phenomenon is found. One limitation of analytic induction is that it does not provide helpful guidance about how many cases need to be investigated before there are no

negative cases. Grounded theory is defined as "theory derived from data, systematically collected and analyzed through the research process. In this method, data collection, analysis, and the final theory are closely related" (Strauss and Corbin 1998: 12). When choosing grounded theory analysis strategy, data collection and analysis are carried out and cross-referenced repeatedly. Coding is the core process in grounded theory. Encoding means labeling nouns with potential theoretical significance through notes and transcripts, which means the generation of theories. Compared with the generation of quantitative data, coding is also more tentative (Bell et al., 2018). Since grounded theory can be discovered from data or construct theories, using comparative analysis methods to obtain discoveries is very suitable for this research. Because this research mainly finds similarities and differences by comparing theoretical data and interview data so as to provide new insights for theory and practice.

3.4 Research quality cretieria

How to measure the research quality is important to see how reliable the research result is. There are some measurements are used to validate the research quality, usually they are reliability and validity (Tracy, 2010).

Reliability represents the stability of the research and is usually the most commonly used quality standard in quantitative research. In qualitative research, because the current social environment, the research subject, and the thinking of the interviewee will change over time, reliability measurement is very complicated. Internal reliability means that researchers have reached a consensus on how to interpret the data. In this research, guidance from outsiders, such as thesis tutors and classmates who study together, is needed to reach a conclusion.

Validity means research completeness, which is measured by measuring validity, internal validity, external validity and ecological validity. In general, qualitative research is often difficult to prove these standards compares to quantitative research. Among them, Bell et al. (2018) even describe that it often requires researchers to assess whether the standards are suitable for research, which means that they discuss the importance of the overall quality of the research. There are two alternative categories to evaluate research quality, reliability, and authenticity.

Credibility, ensuring that the research is conducted in good practice (Tracy, 2010). Maintaining good practices by writing reports in an appropriate manner means not to steal and inform the interviewees of the purpose of the research in an appropriate manner. Confirmability ensures that researchers strive to eliminate or clarify bias. This is especially important in a single case study. Otherwise, you may want to know whether the survey results are biased towards a specific organization.

This research respects objective facts and is not based on the author's prejudice but subjectively. However, this research has limitations. In this section, I will consider and discuss, the purpose is to give academic researchers a reference to ensure the fairness and objectivity of the research results.

First, this research defines VMI, but it is a sub-field between manufacturers and their suppliers. Moreover, some experts have more professional explanations for VMI, but due to the strong technical type, including IT system support, it is too complicated for this article, so there is no detailed explanation.

Secondly, this article only discusses a Swedish healthcare company and its Chinese supplier, which has limitations. The first is the industry and product restrictions. It is mainly aimed at a Swedish medium-sized medical equipment company, which is unique, and its products are mainly PPE products, not all of the company's products. Secondly, there are certain cultural differences between Sweden and China. This difference also leads to different opinions, which affects the conclusion.

In addition, people's own prejudice will also affect the objectivity of the data. Because the number of samples is not large enough, the interview results only represent personal opinions, not company opinions and department opinions. This brings the possibility of research and analysis errors. When reading the literature, it is also possible to miss important research papers due to personal bias, and the supervisor's research is not perfect.

In terms of analysis, the thematic approach poses some challenges. Mainly how to deal with complex and large amounts of data objectively. To make the process effective, it is important to to handle information to avoid data missing (Bell et al., 2018), which is analyzed through personal inspection by the researcher and proofreading by the interviewee.

4. Empirical data

In the following section the empirical data will be presented. An introduction of the Swedish healthcare company (The Company) is showing in the appendix 9.2. The empirical data is gathered through an in-depth interview with 9 employees from the Swedish healthcare company and 1 employee from its supplier.

In the below figure 4.1, I present a disposition with three parts for the empirical data chapter. The first part is The Company's current workflow for placing orders to its suppliers to give a better understanding to the readers on the existing process. The second part is about the opinions from The Company employees and its Chines supplier regarding VMI system. This part will talk about why The Company needs to implement VMI, VMI benefits, VMI risks and vendor's opinions will be presented separately. The last part is a summary of my findings from the previous data.
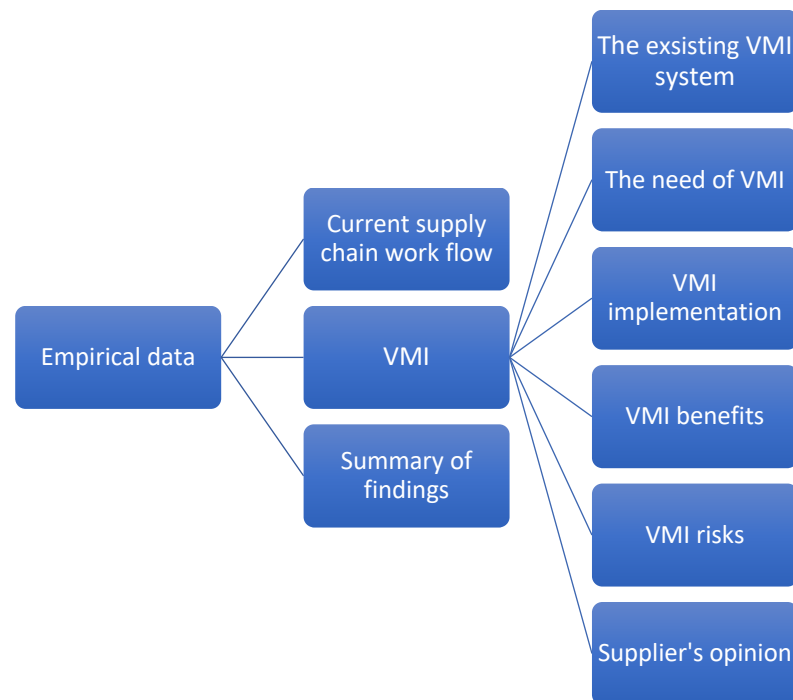

Figure 4.1: Empirical data disposition

4.1 Current workflow with supply chain in The Swedish healthcare company

At present, the supply chain planner of The Company analyzes and processes the sales forecast provided by the sales department to prepare a report, which is differentiated according to the product model and is sent to the corresponding supplier by mail. After the supplier's sales department gets the sales forecast, it will share it with its internal factory and purchasing department. According to the sales forecast, the factory arranges production capacity, and the purchasing department formulates a purchasing plan based on the materials provided by The Company. When the order is placed through The Company's SAP system, The Company will send a formal purchasing order, including product information, price, delivery date, payment method and delivery location, harvest location, etc. The purchasing department of the factory works with the staff of the supply chain management department of The Company to revise the demand plan and revise the raw material purchasing plan. The Companyupply chain planners track the entire process before the material arrives to ensure the average production and the delivery time required by the customer. The Company has a wide variety of materials, geographically dispersed suppliers, and it is challenging to place and manage material orders, which consumes a lot of time and cost. The response process of The Company's suppliers to customer orders and the time taken by each process are as follows, please note this process is only for existing supplier with excising product, as more procedure and validation work needed for new supplier and new products. Below I explain each step feature in the below Figure 4.2.
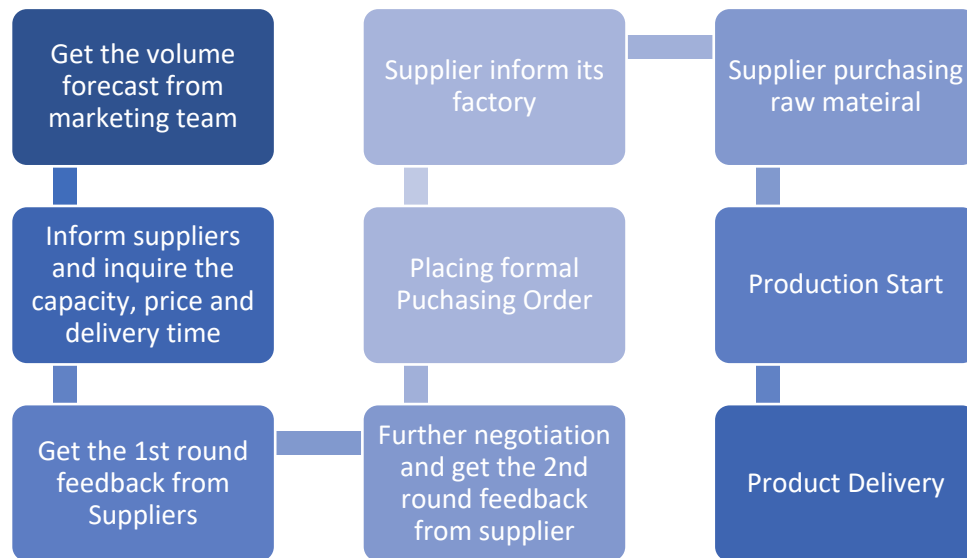
Figure 4.2: The Companies Current Working Flow for Placing Ordering to its Supplier

1. Get the volume forecast from the marketing team: Usually Marketing team will get the tender information from the potential customer and need suppliers price, capacity and delivery time, etc, to evaluate if The Company could meet the tender requirement.

2. Inform suppliers and inquire about the capacity, price, and delivery time: When getting the marketing team's notification, usually by email, Supply Chain Planner and contract manufacture manager will ask the suppliers to provide the information.

3. Get the 1st round feedback from Suppliers: it will take approximately 1-5 working days for the supplier to check with its factory on the capacity left for The Company and the price.

4. Further negotiation and get the 2nd round feedback from the supplier: if the delivery date is too late, the supply chain planner will take the responsibility to negotiate with the supplier. On the price level, the contract manufacturing manager is responsible for negotiating the price and payment terms with the supplier. Usually, the payment term and delivery term are valid with the previous order.

5. Placing formal Purchasing Order: The Company will place purchasing order (PO) via internal SAP system and send the PO to suppliers.

6. Supplier informs its factory: Once the supplier gets the formal PO, they will inform the factory and arrange the production, equipment, labors, etc.

7. Supplier purchasing raw material: The supplier's purchasing team will place the raw material order to its raw material vendor and waits to deliver the raw material. This process will take a longer time, as the raw material is coming from different places, sometimes it is imported from Europe to Asia, which could cost more than one month.

8. Production Start: The supplier will ship the produced raw materials and components to the corresponding factory, and the factory can start the production.

9. Product Delivery: Supplier needs to ship the products by The Company's assigned forwarder and wait for the forwarder to pick up the goods. The supplier arranges production according to the purchased order and sends it to the corresponding warehouse owned by The Company. After the goods arrive at The Company's warehouse and pass the quality inspection, the supplier issues an invoice to The Company, then The Company arranges payment to the supplier; After all finished products are in the warehouse, The Company will ship the finished products to global customers through the third-party logistic Company.

When the product is stored in the supplier's warehouse, it will occupy its inventory space. The supplier has already included the storage cost when quoting The Company's products, that is, The Company actually bears the inventory cost.

4.2 Vendor managed inventory (VMI) in The Swedish healthcare company

In this part, I will start to introduce an existing VMI system between The Swedish Healthcare Company and its customers. Then, I will present what The Company's employees and its supplier opinion toward the VMI implementation, VMI benefit and risks.

4.2.1 The introduction of the existing VMI system between The Swedish healthcare company and its customers

Currently, The Company has an existing VMI system that just launched for its large volume customer. The background of implement the system is that by 2022, The Company sees that operations will be a demand-driven supply chain delivering profitable perfect orders. The

operation Room Solution (ORS) department, which uses VMI system, has the strategic objective of >25% customer real demand visible through digital channels. ORS department has made the Demand Driven Supply Chain maturity measurement with five phases. To climb the maturity ladder, ORS team set separate strategic ideas to implement the VMI:

Support Growth: keep and gain big customers and distributors to secure the top line. ORS team should invest in right sized capacity ahead of the demand and ensure flexibility and scalability. Reliable Service Levels: through customer stock visibility and taking care of their stock & orders and it is the core idea of VMI system. Together with the commercial organization, ORS have been working on the Market Based Management (MBM) improvement program, not only introducing calculated forecast but also improving demand review process as well as supply review process. Improved visibility enables The Company to make better decisions, ensuring reliable supply. Respondent F is the one who take in charge of the existing VMI system and explained that:

> *"More live data, and taking ownership of the data gives us opportunity to act upon deviations much faster." – Respondent F*

Respondent F shows that data's importance when implementing the VMI system with the customer, to increase the visibility to the deviations and The Company as a supplier can respond fast.

Effective & Efficient Supply Network: improved consignment and transportation costs by implementing VMI. Taking a holistic view on E2E supply chain, ORS team has reviewed the manufacturing and logistic footprint to support growth, improving cost structure as well as work on ensuring its fit for purpose considering changes in customer demand. Besides, ORS also checked what capability and capacity needed to support market requirements e.g., next day delivery.

Reduce Complexity: A standard VMI process and implementation package for new onboardings. A new flow is needed to reduce complexity, simplifying and standardizing processes e.g., Product lifecycle management (PLM) with both e-BOM (Engineering Bill of Material) and m-BOMs (Manufacturing Bill of Material) preparing for easier and faster process for dual sourcing. Dual sourcing means purchase product from two or more suppliers.

"Standard interfaces and tools, makes integration easier. The flow should be simple, scalable, speed and smart" – Respondent F

"We ship what we sell, we replenish what we ship, we produce what we replenish, we procure what we produce"– Respondent F

Respondent F described that standard data and tools make the supply workflow easier and stated clearly the VMI could decrease the inventory level.

4.2.2 Need for VMI system in the Swedish Healthcare company
Getting an extra 300 million personal protective equipment (PPE) to healthcare professionals worldwide during the pandemic was an extraordinary feat of the supply chain under pressure. Orders of PPE products increased significantly and made The Company product temporarily out of stock, which caused many backorders and lost profit due to lack of supplies.

To optimize the global footprint and increase supply chain resilience, The Company has decided to secure capacity for peak demand via two business models: one is a relevant and reliable distribution footprint, and the other is a flexible and secured manufacturing footprint. VMI system implementation is part of the flexible and secure manufacturing footprint. When The Company collaborating with its suppliers, The Company is the legal manufacturing, the supplier only focuses on the workmanship or conversion part. This strategy footprint will start with an existing supplier in China, which has been supplied by The Company for years, including wound care and PPE products.

Respondents within the supply chain department (Respondents A-C) described the need of VMI system. The respondents aligned regarding that VMI system could decrease the workload, as the main responsivity for supply chain planner is to make sure the place order in right time, and send the forecast volume, check the lead time with the supplier and placing orders in the SAP system. One important responsibility is to optimize the container, which means try to make each container full to optimize the logistic cost. Besides, if the container is not full, cartons might move during the transportations and may cause packing damages. Respondent A described that VMI could decrease the workload for the supply chain planner since vendor will decide the container quantity,

container size. What a supply chain planner is doing is reviewing the data presented in VMI system and place the order, to confirm the delivery location and price with the supplier and it needs to be designed before implementing the VMI. Respondent A is the global lead supply chain planner who is responsible for placing orders to suppliers.

"It will reduce my workload a lot, if we agree that suppliers to deicide the quantity for each container, and make sure the container optimization." – Respondent A

Respondent A thinks that VMI can reduce the workload since his work responsibility will move to suppliers, he will be the reviewer instead of the preparer.

Respondent B described that the current system needs much more manual work. When marketing department of The Company makes a preliminary volume forecast based on the customer order, and then Supply Chain Planner need to create the order manually through SAP system the and sends it to different suppliers. Due to the wide variety of products, each product requires different raw materials, as well as suppliers locate all over the world, it is difficult to manage, tracking orders. It is also very time-consuming, low efficiency, easy to cause confusion of orders, forget orders, missed orders, thus affecting the production plan. Moreover, due to the frequent changes in orders, purchasing personnel are often busy revising orders, adjusting orders, canceling orders, arranging urgent orders, and then passing them to suppliers. Supplier order personnel also need time to approve orders, confirm orders, and readjust if they are out of stock. The orders are fed back to the purchasing staff of The Company, and the changes in these orders greatly increase the cost of order management.

"Too many mannual work will cause some error, we are humans. And some unknown functions from the system will also leads to errors." – Respondent B

Respondent B also mentioned that forecast is not accurate cause it is an estimated volume based on the current need. However, the supplier will make the capacity planning for the factory to allocate different capacities to different customers. The forecast will determine the future orders quantity to some extent, and will limits the order quantity if suppliers have tight capacity. Supply

chain management focuses on ensuring the stability of delivery. On the one hand, many participants are involved in the supply chain to produce The Company products. Looking at the downstream, The Company had tier-one distributors and tier-two distributors, while upstream, it has tier-one suppliers and tier two or even tier-three suppliers. These result in the demand information not trustable or transferred efficiently from bottom to top. The process is amplified and distorted step by step; that is, the bullwhip effect is generated, leading to the inaccurate demand forecast of The Company, leading to an excessive inventory. Furthermore, the market demand is unstable, the demand for PPE products has increased sharply since the beginning of Covid-19, and the industry competition is fierce. The Company still has a large number of backorders in 2021, as shown in the figure below. Significant brands are vying to get their new products on the market as soon as possible. Once other companies take the lead in launching new models, The Company may lose some of its winning orders, leading to inaccurate demand forecasts.

"Too many backorders is a disaster, we are losing profit." – Respondent C

Respondent C could see the backorder situation of The Company. When there is backorder, it means The Company's customer is placing orders that The Company can't supply. The consequence will be either The Company lose the order or delay to supply. No matter which one, there will be losses to The Company.

4.2.3 Key factors for VMI implementation

In the current VMI model for ORS business, a PipeChian system is generated for information transform between customer and The Company. With PipeChian VMI, the process is transformed from being order driven to be demand driven. When implement VMI between The Company and its suppliers, The Company will sign an agreement with a supplier to replenish the stock without handling purchase orders. Instead, The Company makes information available to the supplier regarding inventory levels as well as real requirements in time and quantity.

Signing a Strict Contract

Signing a clear contract is the first step of VMI collaboration between The Company and supplier. Planning, scheduling, and inventory of products is very important, it should be defined clearly in the contract, described by respondent A, C, D and G. The Company has a comprehensive and

direct business relationship with its suppliers. It participates in warehousing management and system sharing through third-party logistics. The control of the responsibilities and obligations of all parties also needs to be stricter to facilitate the identification of responsibilities and obligations and is more conducive to cooperation between the two parties. Reduce disputes caused by the unclear division of responsibilities. In addition to clarifying responsibilities in the contract, the respective obligations of both parties should also be clarified. There should be right restriction. Both Respondent A and D mentioned the importance to sign a clear contract before VMI implementation.

> *"We need to clear the target at the beginning, to know who is responsible to what." – Respondent A*

> *"It is important that we are playing the same game, following the same rules, that's way we need a strict contract." – Respondent D*

Respondent A emphasized that the division of responsibilities in the contract must be clear. Respondent D stated that both parties must have a unified goal and follow the same rules.

Clear Information Sharing

According to the respondents, it is important to decide which information should be shared and decide the level of transparency of the information. If transparency is very high, for example, should The Company share too much market information? For example, tell the supplier which market the product will be sold to and which customer will buy it? In doing so, will The Company be replaced by suppliers, because some suppliers are also our competitors. If the transparency is not enough, can the supplier have enough information to arrange production in advance and guarantee the inventory level? All these need to be implemented after discussion between the two parties. Respondent G is the contract manufacturing manager and respond A is the supply chain planner, both mentioned the information sharing need to be clear with the supplier.

> *"We need to be very transparent, but do we need to share too much information that our supplier might not need us? "- respondent G*

"A clear target and expectation are important for both sides"-respondent A

Respondent G expressed concern about information sharing. Too much information will make the supplier stronger and may become a competitor of The Company. Respondent A emphasized that buyers and sellers should have the same expectations for the VMI system and should not hinder the implementation of VMI because of information asymmetry.

A Smooth Communication for Both Parties

A smooth communication mechanism can guarantee the effective implementation of VMI. Respondent C believes that both parties should reasonably control the communication and set the frequency, time, and participants of the communication. When the VMI project was implemented at the early phase, the communication between the two parties should be relatively intensive, which would help solve problems in time. When VMI has achieved certain results, and both parties are familiar with the operation process, regular meetings can be held. Besides, the person responsible for communication should be very familiar with the VMI system and the overall process and have the same understanding of the goals of business collaboration. This ensures that everyone is always communicating on the same page. Respondent C also mentioned The Company can assign a particular person to check if both sides are implemented correctly and can report the problem happened in the supplier side to The Company. Respondent C is the global supply chain supplier:

"An intermediary job could be good, to report problems from one side to another." - Respondent C

Respondent C expressed this view because VMI is a new system. In the initial stage of the implementation of the new system, both parties will encounter problems. If there is a person responsible for communication, this person can be an internal person of The Company or a third party can help both parties to communicate more efficiently.

Risk analysis

Risk analysis has been mentioned during the interview with respondents B, C, D and G. Before implementing VMI, The Company need to analyze how much benefit can get from it and how much investment it needs, not just financial analysis but also a comprehensive risk analysis, which

requires large amounts of data support. The Company also needs to conduct related investigations and feasibility demonstrations on the implementation of VMI. Companies need to analyze their own situation and the environmental conditions of the industry and supply chain in which they are located. Based on the analysis of VMI model implementation in the industry, analyze The Company's position and status in the supply chain, such as analyzing and demonstrating whether The Company could initiate the VMI model or just follow the VMI model; The Company also needs to analyze the adoption of the VMI model in the future, the advantages and disadvantages that companies have will face opportunities and risks. Respondent G is the contract manufacturing manager, who expressed that:

"Maybe VMI is expensive to implement. "-Respondent G

Respondent G is worrying the cost for implementing VMI. If the capital investment is greater than the economic benefits VMI can bring, then the implementation of VMI is uneconomical.

Human resource

The implementation of the VMI model is a very complex and large project. Not only the lead buyer who needs to participate, but also the participation and supports from multiple departments such as procurement, production, logistics, sales, personnel, information technology, and finance. For this VMI project, The Company should set up a VMI project team, including: project sponsors (the high-level managers of The Company's internal supply chain management department, whose participation and supervision of project progress ensure and support the smooth implementation of the project, which is also the channel through which the project team will gradually upgrade the difficulties and obstacles to seek solutions when encountering obstacles and difficulties in the progress of the project), the project manager, the personnel involved in support of the various departments involved in the project, and the coordinator (the coordinator is mainly responsible and involved The interface of each department to communicate and coordinate on project matters) and so on. Since VMI will pass market information to suppliers, the marketing team will take on more responsibilities. Because the supplier will make sales forecasts based on the product sales information delivered by marketing, or the marketing team will directly give sales forecasts. Usually, the salespeople overestimate sales forecasts, this kind of human variables should be

known by the team. Respondent D is the global senior project manager and Respondent G is the contract manufacturing manager:

> *"The participant is not only between main buyer, but it should also another level" - Respondent D*

> *"VMI put high responsibility on marketing side. Salesperson always to overrate about sales forecast" -Respondent G*

Respondent D believes that the implementation of VMI should be based on the team, not just the Buyer who is responsible for supplier communication. Respondent G believes that to implement VMI, The Company needs to provide more accurate demand forecasts, but demand forecasts are often the responsibility of the sales team, and their data is often exaggerated.

Reliable supplier

Some respondents said that choose a mature supplier to cooperate with VMI is essential. The supplier should be a large company with long-term cooperation experience with us, strong technical support, and strong willingness to cooperate, as well as the ability to deal with crisis issues. If there is no good planning ability or problems occur a lot in the past cooperation, The Company should not consider such a supplier. Our order quantity should be large, long-term, rather than small short-term contracts.

Respondent H is the global transport developer and Respondent G is the contract manufacturing manager, they said:

> *"We need a Supplier to be comfortable to work with."- Respondent H*
> *"A mature supplier to work with, not poor planning supplier."- Respondent G*

Both conveys that a reliable supplier needs to be selected, that will help the VMI implementation smoothly.

Education in company

The Company should develop a complete set of VMI blueprints and plans and be prepared to implement VMI application software. At the same time, it is also very important for employees and suppliers to understand these solutions and technologies. If suppliers do not understand our company's VMI model and process well, it will inevitably hinder the successful implementation of VMI. Therefore, The Company provides comprehensive and specific training for employees and suppliers. Besides, all stakeholders should also receive training, such as company executives, logistics companies, marketing departments, etc., to ensure that everyone has a unified understanding. Respondent G as the contract manufacturing manager said:

"All stakeholders, we need to force them to be align. ."- Respondent G

All stakeholders refer to the various departments and suppliers within The Company and related raw material suppliers, logistics companies, and non-business departments, such as legal, human, IT support, etc. All departments are aware of what VMI brings changes and everyone's responsibilities.

Product assortments

The Company has a wide range of products, and its suppliers are distributed all over the world. The Company needs to determine the scope of VMI implementation by suppliers or by product category. After evaluating and discussing the project team, it was decided to conduct experiments from one supplier first.

"What kind of product will be included with VMI system needs to be clarified."– Respondent H
"Good sense for PPE products, but not for wound care products, as we product wound care core business in house." – Respondent B

According to the current global product demand, the project team preferentially selected PPE products to participate in the VMI model. PPE products include different product code, it requires an easier manufacturing process compared to wound care products, and face significant demand,

which is more suitable for VMI mode management. A product list that is theoretically suitable for VMI management can be generated based on historical data such as past purchase amount and purchase frequency. Then the project team and the purchaser can work together to have a kick-off meeting with the suppliers, introducing the basic plan for the implementation of the VMI project, share the project blueprint, introduce the estimation of the supplier and the inventory level improvement of The Company, etc. Besides, negotiate the responsibility and information technology system foundation and the feasibility analysis of the implementation of VMI cooperation with the supplier. Respondent H stated that the product type must be confirmed before implementing VMI. Respondent B stated that PPE products are more suitable for The Company.

IT system foundation

The implementation of the VMI model requires strong technical support. Supplier I believes that VMI model requires the transformation and upgrading of system processes and the need to invest more in software. The existing systems are OA, SAP and Saleforces. Suppliers need to develop resources for the system, as well as the participation of logistics, supply chain, and sales departments. Respondent B and G believes that the construction of an IT system is crucial for VMI implementation. If there is no good platform that information cannot be shared, VMI could not played its role. On the other hand, a poor system needs to be repeatedly debugged manually, which will increase the workload.

"I am afraid IT system is a major issue when implement VMI" – Respondent G

"The VMI platform should work easily with SAP system and should not add more manual work." – Respondent B

In addition, barcode technology is also a technology that The Company is proficient in, as long as it is used for electronic management of product data. Barcode technology is by far the most economical, practical, and most widely used automated identification technology. Its fast input speed, strong reliability, high accuracy, a large amount of collected information, easy operation, and low cost make it widely used in various fields. Moreover, significantly save the production efficiency and service efficiency of each application field. The Company's PPE products entirely

apply barcode technology, and the logistic. The Company uses barcode technology to control the entry and exit of products, which dramatically improves operational efficiency.

An interesting topic about IT system ownership, i.e., whether they are preferring internal or external system, most of respondent answered that it doesn't matter. As long as the VMI system is functional, it is best if there is a ready-made one. I don't care whose system is used.

VMI inventory control

The Company should determine how to send the forecast quantity to the supplier, how long the forecast is, and how often it will be shared with the supplier. Whether it is used for long-term planning or short-term planning and how many working days, the supplier must give a response and jointly negotiate the maximum and minimum inventory limits.

4.2.4 VMI benefits

Less manual work through automation and training by improving what The Company has in place, VMI will get higher productivity within supply chain, described by respondent D. Respondent F indicated that VMI will increased service offer to customers by taking care of their supply planning, replenishment, and order handling. Better for customer collaboration, satisfaction, relationship, intimacy, and loyalty by implementing VMI. Besides, better allocation of goods in cases of shortage thanks to the visibility and improved Backorder handling for PPE business during the pandemic. Respondent G described that VMI could increase service level through higher product availability when delivering what customers really need at the right time, which will help The Company less firefighting and lower express delivery cost to serve.

VMI could help The Company to improve forecast accuracy thanks to direct visibility of consumption and inventory for the forecast volume site. This could be treated as an agile and proactive response to changes in customer demand with a longer time to act. More accurate input for production planning and raw material procurement means the supplier will benefit from it as it is a demand-driven supply chain. Digitalized, demand data-driven, automated supply chain -> high value and crisis safe company with a competitive advantage.

The high replenishment fulfillment rate of VMI suppliers reduces the risk of out-of-stock. In the VMI mode, The Company will issue demand plans every week and combine the factory production plan and customer demand plan to generate the minimum inventory and maximum inventory of each product in the current season through SAP calculations. These data are transmitted in real-time to Suppliers. Suppliers can produce and purchase according to the demand plan to ensure delivery. When the VMI inventory is lower than the minimum inventory, the VMI system will promptly remind The Company and the supplier. These measures have effectively guaranteed The Company's production materials are required to avoid the risk of shortage of goods.

4.2.5 VMI risks

This part will present all the VMI risks mentioned by the respondents within The Company and its supplier.

Supplier will become stronger

In the VMI mode, the supplier is likely to become very strong. This is because they have mastered the terminal market information, which is dangerous. For some of our suppliers, they are also competitors for The Company. If share too much market information to suppliers, they may replace The Company or squeeze the market share. There is also a possibility that the supplier will know the product better than The Company. Suppliers know which products are popular by the market, and not favored by the market. After they get access to this information, they will plan their own production, even strategic planning. This will help suppliers to better integrate into the market because they gain more information. If they are strong enough, they can develop their own integration upgrade, develop their own secondary supply chain, logistics, etc., and enhance their competitive advantage.

Inventory control

There is also a risk of product backlog or out-of-stock with inventory under supplier control. This depends on the supplier's inventory management capabilities. At the same time, different products have a different shelf life period, and the supplier cannot be sure that a specific batch of products

will be sold before the shelf life expires. Respondent H claimed that who bears this risk should be discussed and resolved together by both parties.

> *"The supplier can't ensure they won't produce more and build the stock." – Respondent H*

The reason why Respondent H said this is that when the supplier controls the inventory, it cannot guarantee that the inventory will be reduced, which depends on the supplier's ability to manage the inventory.

Trust issue between The Company and its supplier

Confidence crisis between vendors and The Company might happen. Both parties need to build trust by clarifying what information can be shared and the responsibility distinction for each other. Lack of cooperation is another risk that The Company might not be willing to share market sales forecast and other information with the supplier. Respondent G expressed the concern about information sharing:

> *"Real-time volume from a tender is confidential information that usually not shared with suppliers. "– Respondent G*

The information from marketing is a usually sensitive message that conveys the market share and competitiveness of one company; That is why respondent G concerns sharing the information with the supplier will be a risk.

Fear to change

For a large company, change in the supply chain would be difficult. If everyone feels comfortable and agrees with the existing supply model, it will take time to persuade employees to change. Moreover, the change is not accomplished overnight. It requires preliminary training, implementation, and staged results testing. The final mature operation often takes 2-3 years.

Lack of resources

Both suppliers and The Company may lack guidelines to implement VMI. The guideline is about how and when to communicate, what and what level of information needs to be shared, and how to evaluate the result, and by whom. The Company needs to set up a guidebook for every stakeholder and make sure everyone follows the same rule. An IT system is another essential resource, including software support, a standard format, a readable data, and the appropriate language. These items could be different between The Company and its supplier in their own system. Respondent A believes that VMI needs the support of a well-functioning IT system, and employees should know how to operate and the operating principles behind it.

> *"The system needs to work well, and we need to know what we are doing. "*
> *– Respondent A*

Usually, it takes years to get the IT system to work smoothly. When it comes to a Chinese supplier, internet connecting is another factor to consider. Sometimes, Chinses supplier has poor internet connection due to limitation, this could bring more uncertainty to VMI system.

Lack of supplier commitment

Firstly, suppliers' inventory responsibilities increase, and they may not be willing to bear additional costs and expenses. Although they can obtain market information, suppliers need to analyze the pros and cons. If the harms outweigh the advantages, they may not agree to provide VMI services.

Secondly, suppliers have different customers and The Company is only one of them. If The Company is a premium customer to a supplier with more buying power, the supplier would like to implement VMI. Otherwise, the supplier needs to implement a different VMI system with each customer and brings more responsibilities to the supplier, who are unwilling to provide VMI services.

Unclear information

Unclear information will cause more manual work and unnecessary technical development requirements. But the problem is that people don't know whether it is caused by incorrect or inaccurate information transmission or because of the failure of the IT system, which causes a lot of time to check. Besides, the local market and headquarters finance will discuss the forecast figures and compare them with the budget, which adds to the uncertainty of the VMI inventory status. Respondent C expressed concern about information instability.

> *"Booked to one plant, but later changed to another plant. Will VMI fail going back and how to connect to SAP?" – Respondent C*

If there is no clear information shared, the VMI system will often need to be updated and debugged, which could lead to the failure of VMI after a long time.

Long lead time for employees to learn a new system

Both employees from The Company and supplier need to correct the use of VMI solution "by the book", the new training is needed and an initial test period. There is no guarantee that all VMI users will be trained in extreme circumstances that can cause backup issues. The organizational set-up, in general, is too people-dependent and, therefore a business risk.

Lack of knowledge about VMI

Employees who lack knowledge of the VMI system or are unfamiliar with operating procedures may require The Company to hire more talents to solve problems. Especially when market demand is high, time-consuming manual work involving multiple departments has even required more manual work since the pandemic.

4.2.6 Vendor's opinion towards VMI

One of The Company's suppliers in China believes that the customer will give the supplier the right to be responsible for supply under the VMI system. However, there are the following risks described by this supplier:

1. The VMI model will increase supplier inventory and capital pressure.

2. The VMI model requires the supplier to transform and upgrade the supply system process.
3. The VMI model requires the supplier to increase logistics investment.

Within the supplier organization, they also have different views on VMI. The supply chain department believes that the implementation of VMI has the following difficulties: the current product unit price is low, it is difficult to withstand the capital and cost pressure caused by the model transformation. Moreover, the current personnel and technical capabilities are all blanks. Besides, the supplier has no relevant experience. The sales department believes that the VMI model can open up the information channels in the supply chain, expand market opportunities for suppliers, and is very interested in VMI implementation.

The supplier believes that if it is determined by The Company to implement VMI, the current barriers can be solved by the following methods: First, more investments in IT software to establish a VMI system connected with customers system. Alternatively, another solution is that the customer establishes a website platform and grants the supplier login authority. This network platform shares orders, inventory, demand forecasts, and other data, and customers can perform real-time inspections of suppliers. Second, in terms of staffing, suppliers need to recruit experienced and management personnel responsible for the implementation of VMI. When establishing the VMI model, it is necessary to cooperate with the logistics department, planning department, sales department, and other departments. Finally, before this model is launched, responsibilities and obligations need to be clarified, and contracts are signed to ensure the system's stability and information flow. The supplier also mentioned that if it is determined to implement VMI, they need The Company's assistance to open up the information flow, provide market demand information, and also need financial subsidies to develop the VMI system jointly.

4.3 Summary of findings

The below table shows a summary of the empirical findings from The Company's employees and supplier. The refined codes and themes are not all the vocabulary used by the interviewee, but

simplified phrases, which are more suitable for academic research. Since these are semi-structured interviews, some of the codes and themes were not mentioned by every respondent.

Summary of observations –VMI in The Swedish Healthcare Company
Key factors for VMI Implementation
• Signing a strict contract • Information sharing • Communication for both parties • Risk analysis • Human resource • Reliable supplier • Education in Company • Product assortments • IT system foundation • VMI inventory control
VMI Risks
• Supplier will become stronger • Inventory control • Trust issue between The Company and its supplier • Lack of resources • Lack of supplier commitment • Fear to change • Unclear Information • Long lead time for employees to learn a new system • Lack of knowledge about VMI

Figure 4.3: Summary of observations –VMI in The Swedish Healthcare Company

5. Data analysis

The following section will compare and analyze the interview data mentioned above from internal and external of The Company and literature reviews. I chose the VMI implementation methods suitable for The Swedish Healthcare Company by comparing literature review and interview data and analyzed the risks that need to be paid attention to in VMI implementation.

5.1 VMI System implementation (link to research question 1)

Through interviews with The Company's internal employees and the external supplier, I found that they have put forward some new views on VMI implementation, some of which are aimed at The Company itself, and some can also be applied to other companies. The views that are not mentioned in the literature review, especially the discussion on the Change management level. This chapter mainly analyzes the reasons behind the interviewed data and how to combine it with the literature review to draw a conclusion that can be applied to The Company. With the analysis focus of literature and interview data, to answer the research question 1, I combined the key factors of VMI implementation and VMI implementation process steps together and designed a suitable VMI implementation workflow for The Company. It can be divided into two main steps (1) VMI preparation (2) VMI implementation. Below Figure 5.1 shows the structure of analysis findings. VMI preparation refers to the preliminary preparations that The Company needs to do before implementing VMI, to ensure the smooth progress of VMI. VMI implementation refers to the work that needs to be done when VMI is officially implemented.
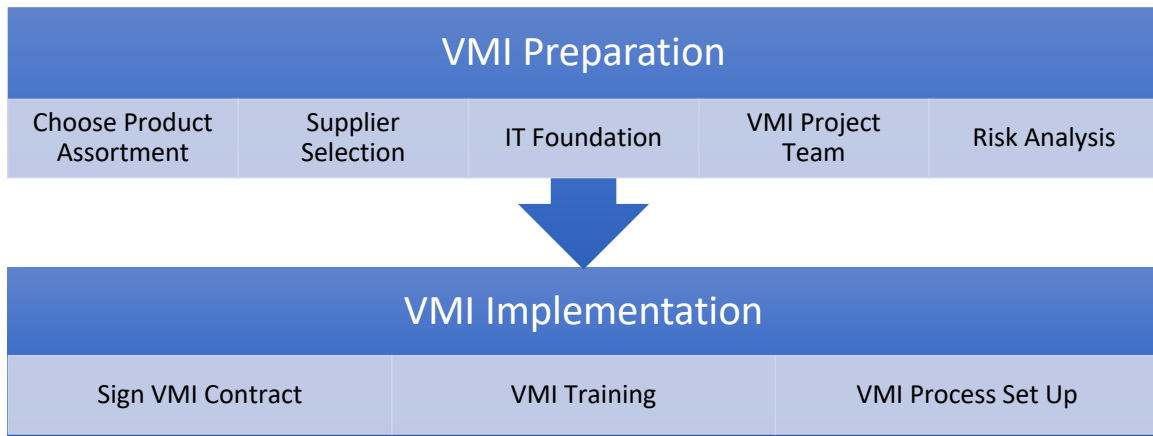
Figure 5.1: VMI Implementation steps for The Company

VMI preparation

The VMI preparation content consists of five parts, which are Choose Product Assortment, Supplier Selection, IT Foundation, VMI Project Team, and Risk Analysis.

(1) Choose product assortment

Respondent H described product assortments that need to be determined at the beginning to clarify the VMI implementation scope. Respondent B mentioned that PPE products are suitable for VMI implementation because suppliers produce a significant volume for PPE business. Disney, Holmström, Kaipia & Towill (2001) mentioned in their research that the characteristics of VMI determine that its strategy is to give priority to those products that have a long-life cycle, significant market demand, insensitive market response, mature production technology and relatively small market changes to achieve VMI goal.

(2) Supplier selection

Claassen et al., (2008) mentioned that a healthy relationship between buyers and suppliers is a key success factor for VMI implementation. If suppliers have significant management, financial, and staff quality problems, no matter how good the historical sales data are, The Company is unwilling to implement VMI with them. To implement VMI, The Company needs to select cooperative suppliers from the three criteria of cost, quality, and service. The following are the evaluation criteria for The Company to select VMI partners based on primary data:

- A mature supplier, who has long-term cooperation experience

- A big size supplier who has strong IT platform and potentials
- Corporate social reputation
- VMI well knowledge of employees
- Good collaborate relations with The Company

(3) IT foundation

IT foundation refers to all relevant information technology systems and electronic information exchange systems used in VMI implementation. The VMI technology lays down the essential information flow framework for the implementation of VMI. Respondent B described that IT system support is crucial for VMI implementation. A poor platform could cause more manual work than the traditional supply chain model. All respondents mentioned that a reliable IT platform is the success factor for VMI implementation. The Decision Support System (DSS) introduced by Disney et al. (2001) clearly states that an effective control system needs to be selected to implement VMI. Singh (2013) mentioned that the critical factor of VMI implementation also includes Investment in information systems. Sarpola (2007) claimed that information system is one of the six dimensions to build a VMI system. According to Claassen et al. (2008), the success of VMI is impacted by the information systems. Based on mutual trust and complete cooperation, maintaining the transparent, fast, and accurate transmission of information in the supply chain is the key to the successful implementation of VMI, which requires advanced information technology to achieve. As a multinational company, The Company has always attached great importance to the investment and application of information technology. SAP system, Prime, and the latest online 3DX system, ERP system, and barcode technology have been widely used in The Company. Using these technologies, information transmission and sharing with suppliers can be realized, and the company's IT department needs to rely on the development and customization of business model requirements.

(4) Build VMI project team

Both respondents D and G mentioned that implementing the VMI model requires the participation and support of multiple departments, and The Company should establish a VMI project team. Singh (2013) indicated in the research that employee participation is crucial, but he did not emphasize that employees from different departments should collaborate. Many works of literature

focus on coordinating relationships with suppliers rather than how to cooperate within the company. I think the promotion and participation from employees are very important. If employees are satisfied with the current inventory management and order management, they are reluctant to make changes. However, if employees know that VMI can bring benefits and convenience to both The Company and themselves, then they have the motivation to change. All this requires a dedicated team to be responsible. The primary responsibility is to coordinate the conflicts between the various departments of The Company, coordinate the resources of all parties, and check the progress of VMI, so that each small team can communicate and share professional knowledge. Respondent C mentioned that a particular person (employee of The Company or a third party) should also be assigned as an intermediary to coordinate The Company's resources and the supplier, supervise whether the two parties follow the contract, and find problems in time.

(5) Risk analysis

Sari (2008) conducts risk analysis through Monte Carlo simulation. The inventory level under the traditional model and the VMI model is compared. Sari (2008) believes that a careful benefit/cost analysis of VMI is critical. Respondent B, C, D, and G described that Risk analysis needs to be done before VMI implementation. The primary purpose of the VMI model is to achieve a win-win situation by reducing inventory waste. The Company needs to make a complete risk analysis and quantify it before implementing VMI. The data that needs to be analyzed and predicted include inventory amount, inventory turnover days, the on-time delivery rate of finished products, transportation costs, overall inventory level, reduction of inventory costs, and finally, the entire supply chain cost. When the cost is less than the benefit, it can be preliminarily determined that VMI implementation can bring benefits to The Company.

VMI Implementation

The VMI Implementation content consists of three parts, which are Sign VMI Contract, VMI Training, and VMI Process Set Up.

（1）**Sign VMI contract**

Sainathan & Groenevelt (2019) believes that different contract types will bring different effects to VMI. The study found that repurchase and revenue sharing contracts are effective for VMI.

Respondent A, D, and I all mentioned that an unambiguous contract is helpful to clarify the responsibility for both sides. After The Company completed the above preparations, the project team negotiated with the supplier, negotiated the VMI model, and drafted a VMI model agreement based on the negotiation results. The agreement clarified vital issues such as inventory responsibilities and risk division, such as the validity period of the agreement, The maximum and minimum inventory setting method, the longest inventory time of the product, the generation method of the forecast information, the transmission method, the generation method of the VMI order, the delivery period, the delivery method, the settlement method, the return method, the responsibility and obligation of both parties, the termination clause of the agreement, Force majeure situation, conflict resolution method, etc. Before the formal agreement is signed, The Company also needs to sign a confidentiality agreement with the supplier companies participating in the VMI.

（2）**VMI training**

Few researchers in the literature review mentioned the importance of VMI education and training. Most interviewees mentioned that before implementing VMI, employees and selected suppliers must be fully trained. The training content includes the VMI operation method, VMI project goals, the work content that each team should be responsible for, and the system operation process. Training requires investments of human resources, capital, and management support.

(3) VMI process set up

The Company should determine how to send forecasted quantities to suppliers, how long the forecast will take, and how often it will be shared with suppliers. To apply long-term planning or short-term planning and the lead time for suppliers to respond to and negotiate the maximum and minimum inventory limits between The Company and the supplier. The basic implementation process of the VMI project is as follows:

a.The company sends demand forecasts to suppliers through the VMI system.
Marquès, Thierry, Lamothe, & Gourcs' (2010) research shows that VMI is a replenishment system. The supplier should have a short-term production and replenishment plan based on production constraints.

The Company's demand forecasts can be divided into two types: strategic forecasts and short-term forecasts. Strategic forecasting to forecast demand in the next 15 months. It is mainly used for supplier's long-term planning and procurement plans to avoid bottlenecks. The short-term forecast is the demand plan for the next six months. Short-term forecasts are mainly used to promote product demand and are the primary data source for supplier replenishment. At the same time, suppliers must comply with the maximum and minimum inventory limits negotiated with The Company when replenishing goods. The following figure 5.2 shows an example of a short-term forecast:

The first column refers to the product code, in The Company it is called SKU code. The second column are the different planning items. The third column is the current inventory volume, as an initial start point. The flowing columns are the planning inventory for different weeks that can be added.

SKU code	Planning inventory	Current inventory	Week 26 2022	Week 27 2022	Week 28 2022	Week 29 2022
****1	Net volume		15000	16000	20000	23000
****1	Minimum Inventory		30000	31000	32000	35000
****1	Maximum Inventory		60000	62000	64000	40000
****1	Delivery period (Min days)		7	7	7	7
****1	Delivery period (Max days)		14	14	14	14
****1	Planning inventory	40000	32000	26000	42000	54000
****1	Estimated delivery volume		0	28000	48000	48000

Figure 5.2: An example of inventory short-term planning for The Company

In the VMI project, the supplier is responsible for maintaining a certain amount of inventory, which is limited by the maximum and minimum inventory. The Company and the supplier determine the maximum and minimum inventory through cost optimization calculations. The default maximum inventory could be 14 days of average demand. The default minimum inventory could be 7 days of average demand.

b. The supplier responds to the demand forecast. If the supplier's response quantity is inconsistent with the demand, The Company's purchaser shall contact the supplier and the factory to negotiate a solution together.

c. While doing step b, the VMI system will automatically generate a purchase order, which is different from the purchase order generated based on customer needs in the traditional way. The

VMI order is based on the confirmed factory production plan and is automatically triggered to generate. In this way, VMI orders will be more accurate.

d. The supplier delivers goods to the VMI logistics center. All shipping information, including shipping reminders, shipping packing lists, etc., are sent to The Company and the logistics company assigned.

e. VMI system will generate inventory reports every day and send them to The Company and suppliers so that The Company and suppliers can keep track of the inventory information and material status of the VMI logistics center.

Figure 5.3 summarizes the VMI implementation part and compares the contents mentioned in the literature review and interview data in the two steps of VMI preparation and VMI implementation.

VMI implementation			
		Literature Review	Interview
VMI Preparation	Choose Product Assortment	✓	✓
	Supplier Selection	✓	✓
	IT Foundation	✓	✓
	VMI Project Team		✓
	Risk Analysis	✓	✓
VMI Implementation	Sign VMI Contract	✓	✓
	VMI Training		✓
	VMI Process Set Up	✓	✓*

Figure 5.3: The Summary of VMI implementation

*Literature reviews present a basic implementation process of the VMI, while respondents from interview didn't discuss the VMI implementation process in detail.

5.2 VMI risk management (link to research question 2)

A Conceptional model is analyzed for VMI risk management, combing the empirical findings and literature review. The new conception model is based on the Supply Chain Risk Management

Model by Tang (2006), consisting of Supply Management, Product Management, Demand Management, and Information Management, as I add a new dimension, Change management (see Figure X). From the primary data, I found that some new opinions do not belong to Tang's four dimensions; that is why I add a new dimension to include all the aspects.
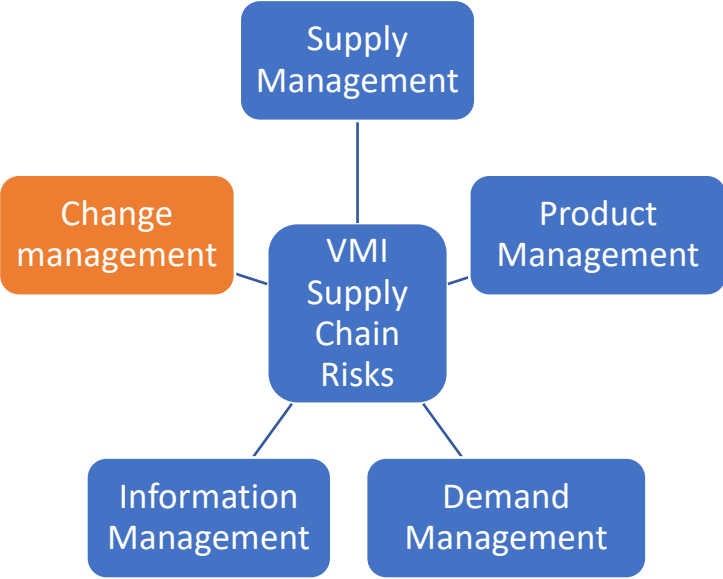

Figure 5.4: Conceptional Model of VMI Risk Management based on Tang (2006) supply chain risk management model

Supply Management：

The relationship between The Company and the selected supplier is another risk. Zanoni, Jaber and Zavanella (2012) proposed that if the supplier manages the inventory, the buyer and the seller need to trust each other to establish a positive relationship. There are some criteria for selecting suppliers, such as choosing experienced suppliers with good delivery records and good reputations in the local market. Suppliers also supplemented the respondents' answers with long-term cooperation experience and good IT capabilities. If the supplier's capability is not good, it will inevitably affect the effect of VMI implementation. On the other hand, if the supplier makes a profit through the VMI model, for example, to obtain more market information, this also has certain risks. Because the supplier will become stronger, if the supplier integrates the supply chain

and forms its supply chain vertical integration, the supplier may become a competitor and seize The ComCompany'srket share. In addition, the lack of trust between the two parties is also one of the risks. Pohlen & Goldsby (2003) believe that trust is essential to the implementation of VMI. The Company exchanges supplier-managed inventory at the cost of sharing market information. Among them, The Company needs to trust the supplier to have the ability to manage inventory, and the supplier needs to trust The Company's demand forecast. How to convince suppliers, have a win-win collaboration for them to want to be transparent, and sell it internally and get enough priority and dedication.

Inventory control is another risk factor in Supply Management. Suppliers may not fulfill the commitment and did not manage the inventory well. It might be because suppliers have poor planning capability, or their tier-two suppliers are not trustworthy, or something wrong with the logistics. A VMI system can't guarantee zero stock. It all about how suppliers and The Company collaborate and the ability to planning supply.

Huoy et al. (2018) mentioned that lack of resources is a potential risk for determining VMI implementation. Whether it is a supplier or a buyer, whoever is more powerful has more control over resources. (Yalcin et al., 2018). Respondents subdivided the scope of resources. For example, interviewee A believes that one of the resources is establishing guidelines for implementing VMI for both parties to follow. Most of the remaining interviewees mentioned that IT systems are another essential resource, explained in Information Management.

Supply network design is the process to bring the goods to the market, mentioned by Tang (2006) that is a risk under Supply Management. The respondents do not mention this in the interview. Supply network design first needs to understand the existing supply network logic. For example, where the raw materials are sent to the supplier and which distribution centre the supplier will send the finished product to after the completion of production. Then, The Company needs to analyse the relationship between each supply chain participant and optimize the distribution route. This will affect the entire delivery period, especially from logistics. There are too many uncertain factors that require companies to plan and design crisis response plans when transporting goods across continents.

The contract is a kind of risk in Tang (2006) supply chain risk model. Guan and Zhao (2010) introduced a revenue-sharing contract in which the customer does not pay the seller any fees before selling the inventory. Lee and Cho (2014) proposed that if the inventory is out of stock, the customer can charge the supplier a fine. Different contract types can determine the effect of VMI, so the design of the contract is critical. Interviewees also mentioned that clear contracts must be drawn up before implementing VMI because contracts are the basis for cooperation between upstream and downstream suppliers in the supply chain environment. Without contracts, there will be no cooperation, and companies cannot gather forces to coordinate. Under the legal contract framework, all enterprises come together for common interests and effectively divide labor and cooperation under the contract framework. A contract with an unclear division of responsibilities will bring legal risks to The Company and cannot guarantee the operability of VMI.

Product Management

For companies, it is vital to determine the best product assortment to maximize their profits. In terms of product categories, Mishra and Raghunathan (2004) mentioned that VMI is not suitable for advanced products or unique products because of the low inventory turnover rate and high value. Sarpola (2007) stated that customers may be reluctant to buy new products because the market has not yet recognized them. Tang (2006) mentioned that product diversification could increase market share, but it will also increase production and inventory costs (MacDuffie et al., 1996). Product substitution and product bundling can reduce the risk of product backlog (Ulrich et al., 2003). A study by Yalcin, Özpolat, and Schniederjans (2018) found that the first choice for VMI is standardized products. The Company believes that PPE products are more suitable for VMI implementation because of the high product production standards and the dependence of core products on suppliers. The order volume is relatively large, and there is also a long-term stable demand. However, The Company did not mention the content of product substitution and product bundling. The Company will risk that if a product cannot be supplied in time, it can quickly find a substitute. Suppose The Company can prepare in advance, for instance. In that case, if the production capacity of product A is insufficient, it can be replaced by product B, and a lot of validation work can be done in advance, which can save delivery lead time. Alternatively, if there is a product portfolio, it can be bundled so that the popular products sold can drive slow-moving products.

Information Management：

Information management can be composed of two aspects. One is how to share information between suppliers and manufacturers, which depends on the degree of dependence and trust between related parties. Suppose the business members in the supply chain lack trust and contract spirit, resulting in unclear and insufficient exchange of information and data. In that case, VMI cannot maintain inventory balance and cannot monitor inventory in the warehouse (Liu & Sun, 2011). At present, few companies are willing to share their own market and logistics information thoroughly, and everyone expects others to share more information for their own use. This leads to relatively little factual information being truly shared and effectively used. Without highly accurate information sharing, VMI's platform cannot help companies in the supply chain complete their own production and logistics plans. The foundation of VMI is challenged because VMI's decision-making is based on customers providing relatively accurate demand information. Respondents generally mentioned the risks of information sharing: what information to share and how to share information. The VMI system relies on sharing market information, such as product sales data, sales forecasts. This information is very sensitive. If all information could be shared with the supplier, the supplier will open the upstream and downstream of the supplier and become more potent with more symmetrical information. Suppliers may become competitors and threaten The Company's market position, which The Company unwilling to see. This can correspond to the supplier relationship in Supply Chain Management.

Another aspect is establishing IT systems because VMI systems rely on robust information systems (Liu et al., 2011). Respondent C mentioned that the VMI system might not link with The Company's existing SAP system, which will cause more manual work. To ensure the effectiveness of information technology, The Company should make full use of network and software technology to develop demand forecasting and inventory replenishment modules to effectively control the entire supply chain operation to the greatest extent. Suppliers can make demand forecasts based on their own market research data combined with The Company's demand forecasting system and grasp the direction of product production, price determination, and supply planning.

Demand Management:

Danese (2006) mentioned that VMI requires a more accurate level of demand forecast. The demand forecast is a problem that cannot be fixed quickly, and no demand forecasting system can accurately predict market demand. VMI system is no exception. Its forecast accuracy is affected by many internal and external factors, especially customer demand fluctuations, such as product changes, unpredictable items in the market, etc. In the face of a changing market, VMI can only be relatively accurate, and companies' inventory level forecasts are required to provide more compelling data. Respondent B agrees that the VMI system is more suitable for PPE products because the PPE business has stable demand and usually, the volume is higher than other product assortments.

Furthermore, Respondent G mentioned that sales forecast is the responsibility of the marketing department. VMI relies on accurate forecasts, so the marketing department will put forward higher requirements, such as not exaggerating the demand forecast data and updating it in time. Besides, Malone (2011) believes that VMI cannot maintain the resources of frequent and large orders. Moreover, VMI is limited by the company's size, and large or medium-sized enterprises are more suitable for VMI. The size of the company is not a problem. As one of the largest medical device manufacturers in Europe, The Company enjoys a particular reputation in the European market and has stable customers. The only worry is that when special events (such as Covid-19) occur and global demand is unstable, The Company should learn from the lesson and prepare for it in advance. When looking for alternative products, alternative suppliers, and finding new suppliers, The Company should implement the VMI model with suppliers as soon as possible.

Change management

What is often mentioned in interviews is how The Company faced the changes brought by implementing VMI. In the supply chain risk model of Tang (2006), there is no mention of the risk of change management, so I added this to his foundation as a supplement. In the interview, I learned that for a mature company, change requires more effort. This is because employees have become accustomed to the existing model, and changes require time to learn new knowledge and new systems. When they do not understand the concept of VMI, employees do not know what

benefits this change will bring to themselves and The Company, so they lack the motivation to learn early. In addition, no matter what kind of inventory management model, no matter what kind of information system, it is managed by people and operated by people. High-quality talents can give full play to the efficient operation of the VMI system. Developing and training talents is an essential part of a talent guarantee. The Company shall ensure that all VMI strategic layers, management, and operation layers are thoroughly trained and have a deep understanding of the management, operation, and maintenance of the VMI system. Reinforce the knowledge and ability for management level with some coaching and Q&A training could be an option. Related work guides and documents should be circulated between The Company and the supplier. Before implementation, the VMI project team should create a standard implementation checklist with best practices. Below Figure 5.5 summarizes the VMI risk's part and compares the contents mentioned in the literature review and interview data for the five dimensions listed below.

VMI Risk			
		Literature Review	Interview
Supply Chain Management	Supplier relationship	✔	✔
	Inventory control	✔	✔
	Lack of resources	✔	✔
	Supply network design	✔	
	Contract	✔	✔
Product Management	Product diversification, substitution bundling and standardization	✔	
Information Management	Unclear Information	✔	✔
	IT system support	✔	✔
Demand Management	Lack of Accurate demand forecast	✔	
	Hard to keep frequent and large orders	✔	
	More responsibility from marketing		✔
Change Management	Fear to change		✔
	Long lead time for employees to learn a new system		✔
	Lack of knowledge about VMI		✔

Figure 5.5: The Summary of VMI Risks

6. Conclusions

In the following section, the conclusions are presented to summarize and depict the main findings fort the two research questions separately.

6.1 Background to the Research Questions

The purpose of this study is to explore how to implement VMI with suppliers through a single-case study of The Swedish Healthcare Company, and what are the risks that need to be considered in implementing VMI in order to help management make decisions. First, the author lists the two research questions as below. Then conclusions for each research question will be summarized after.

6.2 Addressing Research Question 1

♦ *How can a healthcare company in Sweden implement the VMI model with its vendor?*

Based on the researcher's understanding and definition of the VMI model, combined with The Company's own situation as a multinational company that produces medical device products, a conclusion is drawn.

The implementation process of VMI can be divided into two steps. The first step is VMI preparation, which includes Choose Product Assortment, Supplier Selection, IT Foundation, VMI Project Team, Risk Analysis. The Second step is VMI implementation, which includes Sign VMI Contract, VMI Training and VMI Process Set Up.

In the first step VMI preparation, The Company needs to decide which products should be covered in the VMI model. Through interviews, it is learned that PPE products are more suitable because of the large demand and long project time, and PPE core business is more dependent on suppliers, which is more suitable for the implementation of VMI projects. Then, determine the suppliers' scope and choose reliable suppliers who has long-term cooperation experience and strong technical support. After that, an IT system needs to be established. This will be a long-term process because the establishment of the IT system needs to coordinate with the different departments of The

Company, and the system should link the supplier and The Company's internal IT systems to achieve the effect of dialogue between different systems. Moreover, before the VMI project starts, a professional team is needed. The project manager is responsible for coordinating resources, determining the timeline and team member of the project, and clarifying the responsibilities and obligations of each member. Finally, the project requires rigorous Risk Analysis. By comparing the pros and cons of the VMI model and the current supply chain model, predict the risks and revenues that VMI will bring, and make it digitized. By doing so, the analysis work can help management to allocate resources and make further decisions.

In the second step VMI implementation, The Company needs to sign VMI Contract with the supplier to clear the responsibility of both sides and claim the details of inventory control in the contract. Then, a VMI training needs to be conducted for The Company's employees and suppliers to ensure all the stakeholders know the VMI workflow and how to operate the VMI system. Finally, the VMI process needed to be set up to design the maximum and minimum inventory level, ordering process and logistic arrangements.

6.3 Addressing Research Question 2

♦ *What risks are associated with implementing VMI with a vendor for a healthcare company in Sweden?*

In this article, the author studies the risks of The Swedish Healthcare Company's use of the VMI system. The author created an analysis model based on the integration of the four dimensions of Tang (2006) supply chain risk management and interview data to assist in the analysis of the research. At the end, the author identified 13 risk factors in five dimensions. As a contribution to the existing supply chain risk model, a new dimension Change management is added.

Supply Management	- Supplier relationship - Inventory control - Lack of resources - Supply network design

	• Contract
Product Management	• Product diversification, substitution bundling and standardization
Information Management	• IT system support
Demand Management	• Lack of resources • Keep frequent and large orders • More responsibility from marketing
Change management	• Fear to change • Long lead time for employees to learn a new system • Lack of knowledge about VMI

Figure 6.1: 13 VMI risk factors in five dimensions

7. Future research

As a new type of inventory management mode, the VMI model breaks the traditional supply chain where each node enterprise is closed and independent of each other in inventory management. It fully embodies the integrated management idea of the supply chain. VMI has been fully used in some well-known multinational manufacturing companies and has achieved good economic benefits. Due to the limited level of the author and the limitations of data collection, the author believes that the research on the VMI inventory management method of the supply chain needs to be continued in the following aspects:

(1) Needs to systematize in order to see if this knowledge is applicable to more companies.

This thesis in a single cast study that only focus on one Swedish healthcare company. In future research, more companies and more industries in more countries could be developed and explored.

(2) Research on the continuous improvement of VMI

The implementation of the VMI model is based on the joint participation of all node companies in the supply chain. It has high requirements on the internal systems, business processes, and personnel quality of supplier companies and buying companies and requires full communication and explanation from all parties. During the implementation process, regular meetings should be held to continuously track and evaluate the VMI process, monitor the operation of the process, and analyse each step's necessity and effectiveness to create a more efficient process. Timely feedback and summary of the problems, the implementing party, and the participants continue to run in, optimize, and adjust. The research and exploration of the continuous improvement mechanism of VMI will undoubtedly further improve the implementation effect of the VMI model.

(3) Optimized profit analysis of suppliers and implementing companies (user companies) under the VMI model

Due to the limited availability of the data that the author wants to collect and the limited space of the paper, this article does not conduct further research on suppliers' profit optimization analysis and profit distribution problems and implementing enterprises under the VMI model. The implementation of VMI will increase the profits of user companies by reducing inventory costs. Under the optimization of matching conditions and the long-term incentives of user companies,

the implementation of VMI will also increase suppliers' profits. The author believes that the optimization of profit analysis and profit distribution mechanism of participating companies under the VMI model will provide better data and theoretical basis for successfully implementing the VMI model.

(4) Innovative research on the realization mode of VMI

The author believes that the innovative research on the VMI implementation model is also significant. For example, they apply VMI to more organizational and industrial fields, apply it to non-profit organizations, or establish a VMI model with individual consumers. Is it possible to realize these ideas? Its innovative significance and practical significance need to be further studied and verified.

8. References

Asian Development Bank (ADB). 2020a. Asian Development Outlook 2020: What Drives Innovation in Asia? https://www.adb.org/publications/asian-development-outlook-2020-innovation-asia

Andel, T. (1996). Manage inventory, own information. Transportation & Distribution.

Axsater, S. (1985). Control theory concepts in production and inventory control. International Journal of Systems Science, 16(2), 161-169.

Barratt, M. (2004). Understanding the meaning of collaboration in the supply chain. Supply Chain Management: an international journal.

Battini, D., Gunasekaran, A., Faccio, M., Persona, A., & Sgarbossa, F. (2010). Consignment stock inventory model in an integrated supply chain. International Journal of Production Research, 48(2), 477-500.

Bell, E., Bryman, A., & Harley, B. (2018). Business research methods. Oxford university press.

Berry, D., & Naim, M. M. (1996). Quantifying the relative improvements of redesign strategies in a P.C. supply chain. International Journal of Production Economics, 46–47, 181–196. https://doi.org/10.1016/0925-5273(95)00181-6

Bielecki, T., & Kumar, P. R. (1988). Optimality of Zero-Inventory Policies for Unreliable Manufacturing Systems. Operations Research, 36(4), 532–541.

Blatherwick, A. (1998). Vendor-managed inventory: fashion fad or important supply chain strategy?. Supply Chain Management: An International Journal.

BOSE, D. C. (2006). INVENTORY MANAGEMENT. PHI Learning Pvt. Ltd.

Bown, C. P. (2020). COVID-19: Demand spikes, export restrictions, and quality concerns imperil poor country access to medical supplies. COVID-19 and Trade Policy: Why Turning Inward Won't Work, 31.

Çetinkaya, S., & Lee, C.-Y. (2000). Stock Replenishment and Shipment Scheduling for Vendor-Managed Inventory Systems. Management Science, 46(2), 217–232.

Chakraborty, A., Chatterjee, A. K., & Mateen, A. (2015). A vendor-managed inventory scheme as a supply chain coordination mechanism. International Journal of Production Research, 53(1), 13-24.

Chee, H. L. (2007). Medical tourism in Malaysia: international movement of healthcare consumers and the commodification of healthcare.

Choudhary, D., Shankar, R., Tiwari, M. K., & Purohit, A. K. (2016). VMI versus information sharing: an analysis under static uncertainty strategy with fill rate constraints. International Journal of Production Research, 54(13), 3978-3993.

Claassen, M. J. T., van Weele, A. J., & van Raaij, E. M. (2008). Performance outcomes and success factors of vendor managed inventory (VMI). Supply Chain Management: An International Journal, 13(6), 406–414. https://doi.org/10.1108/13598540810905660

Croson, R., & Donohue, K. (2006). Behavioral causes of the bullwhip effect and the observed value of inventory information. Management science, 52(3), 323-336.

Cuatrecasas-Arbós, L., Fortuny-Santos, J., Ruiz-de-Arbulo-López, P., & Vintró-Sanchez, C. (2015). Monitoring processes through inventory and manufacturing lead time. Industrial Management & Data Systems.

Dan Wang, & Shaoqiang Yu. (2009). Profit allocation mechanism for VMI under risk factors. 2009 IEEE International Conference on Automation and Logistics, 1078-1082.

Danese, P. (2006). The extended VMI for coordinating the whole supply network. Journal of Manufacturing Technology Management, 17(7), 888–907. https://doi.org/10.1108/17410380610688223

Disney, S. M., Holmström, J., Kaipia, R., & Towill, D. R. (2001). Implementation of a VMI production and distribution control system.

Disney, S. M., & Towill, D. R. (2003). The effect of vendor managed inventory (VMI) dynamics on the Bullwhip Effect in supply chains. International Journal of Production Economics, 85(2), 199–215. https://doi.org/10.1016/S0925-5273(03)00110-5

Doney, P. M., & Cannon, J. P. (1997). An examination of the nature of trust in buyer–seller relationships. Journal of marketing, 61(2), 35-51.

Dong, Y., & Xu, K. (2002). A supply chain model of vendor managed inventory. Transportation research part E: logistics and transportation review, 38(2), 75-95.

Drakaki, M., & Tzionas, P. (2019). Investigating the impact of inventory inaccuracy on the bullwhip effect in RFID-enabled supply chains using colored Petri nets. Journal of Modelling in Management.

Fry, M. J. (2010). Vendor-Managed Inventory. Wiley Encyclopedia of Operations Research and Management Science.

Fry, M. J., Kapuscinski, R., & Olsen, T. L. (2001). Coordinating production and delivery under a (z, Z)-type vendor-managed inventory contract. Manufacturing & Service Operations Management, 3(2), 151-173.

Gerring, J. (2007). The case study: what it is and what it does. In The Oxford handbook of comparative politics.

Glaser, J. P., DeBor, G., & Stuntz, L. (2003). The New England Healthcare EDI Network. Journal of Healthcare Information Management—Vol, 17(4), 43.

GONG Rui-e，ZENG Lan-man，LI Chun-hui， et al.Problems and coping strategies in the use of personal protec- tive equipment in COVID-19 isolation wards[J].Chin J Infect Control，2020，19(4):324-327.DOI:10.12138/j.isn.1671- 9638.20206504.

Guan, R., & Zhao, X. (2010). On contracts for VMI program with continuous review (r, Q) policy. European Journal of Operational Research, 207(2), 656-667.

Huoy, C. S., Rahim, S. A., Rahman, N. A. A., Nawi, M. N. M., & Ahmi, A. (2018). Determination the key success factor for the success implementation and long-term sustainability of vendor managed inventory (VMI). International Journal of Supply Chain Management, 7(2), 62-67.

Huynh, C. H., & Pan, W. (2015). Operational strategies for supplier and retailer with risk preference under VMI contract. International Journal of Production Economics, 169, 413-421.

Kaipia, R., Holmström, J., & Tanskanen, K. (2002). VMI: What are you losing if you let your customer place orders?. Production Planning & Control, 13(1), 17-25.

Kaipia, R., & Hartiala, H. (2006). Information-sharing in supply chains: five proposals on how to proceed. The International Journal of Logistics Management.

Keskin, B. B., Melouk, S. H., & Meyer, I. L. (2010). A simulation-optimization approach for integrated sourcing and inventory decisions. Computers & Operations Research, 37(9), 1648-1661.

Kontuš, E. (2014). Management of inventory in a company. Ekonomski vjesnik: Review of Contemporary Entrepreneurship, Business, and Economic Issues, 27(2), 245-256.

Lancioni, R. A., Smith, M. F., & Oliva, T. A. (2000). The role of the Internet in supply chain management. Industrial Marketing Management, 29(1), 45-56.

Larson, P. D., & Rogers, D. S. (1998). Supply chain management: definition, growth and approaches. Journal of Marketing Theory and Practice, 6(4), 1-5.

LeCompte, M. D., Klinger, J. K., Campbell S. A., & Menke, D. W. (2003). Editor's introduction. Review ofEducational Research, 73(2), 123-124.

Lee, H.L. (2004), "The triple A supply chain", Harvard Business Review, Vol. 82 No. 10, pp. 102-12.

Lee, J. Y., & Cho, R. K. (2014). Contracting for vendor-managed inventory with consignment stock and stockout-cost sharing. International Journal of Production Economics, 151, 158-173.

Lin, T. Y. (2010). An economic order quantity with imperfect quality and quantity discounts. Applied Mathematical Modelling, 34(10), 3158-3165.

Liu, X., & Sun, Y. (2011). Information Flow Management of Vendor-Managed Inventory System in Automobile Parts Inbound Logistics Based on Internet of Things. JSW, 6(7), 1374-1380.

MacDuffie, J. P., Sethuraman, K., & Fisher, M. L. (1996). Product variety and manufacturing performance: evidence from the international automotive assembly plant study. Management Science, 42(3), 350-369.

Malone, C., Zahran, M., & Karri, R. (2011, October). Are hardware performance counters a cost effective way for integrity checking of programs. In Proceedings of the sixth ACM workshop on Scalable trusted computing (pp. 71-76).

Marquès, G., Thierry, C., Lamothe, J., & Gourc, D. (2010). A review of vendor managed inventory (VMI): from concept to processes. Production Planning & Control, 21(6), 547-561.

Mishra, B.K. and Raghunathan, S. (2004) "Retailer- vs. vendor-managed inventory and brand competition", Management Science, 50(4), 445-457.

Monden, Y. (2011). Toyota Production System: An Integrated Approach to Just-In-Time, 4th Edition. CRC Press.

Moynihan, J. J. (1997). Improving the healthcare supply chain using EDI. Healthcare Financial Management, 51(3), 78-79.

Mula, J., Poler, R., & Garcia-Sabater, J. P. (2007). Material Requirement Planning with fuzzy constraints and fuzzy coefficients. Fuzzy Sets and Systems, 158(7), 783–793. https://doi.org/10.1016/j.fss.2006.11.003

Netessine, S. & Fuqiang Zhang. (2005). Positive vs. Negative Externalities in Inventory Management: Implications for Supply Chain Design. Manufacturing & Service Operations Management, 7(1), 58–73. https://doi.org/10.1287/msom.1040.0058

Oluwaseyi, J. A., Onifade, M. K., & Odeyinka, O. F. (2017). Evaluation of the Role of Inventory Management in Logistics Chain of an Organisation. LOGI – Scientific Journal on Transport and Logistics, 8(2), 1–11. https://doi.org/10.1515/logi-2017-0011

Ozpolat, K., & Dresner, M. (2018). A dark side of long-term VMI relationships: supply chain trust. Research in Logistics & Production, 8.

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: coordinating product, process and supply chain design. Journal of operations management, 23(3-4), 371-388.

Peteraf, M. A. (1993). The cornerstones of competitive advantage: a resource-based view. Strategic management journal, 14(3), 179-191.

Pohlen, T. L., & Goldsby, T. J. (2003). VMI and SMI programs. International Journal of Physical Distribution & Logistics Management.

Polkinghorne, D. E. (2005). Language and meaning: Data collection in qualitative research. Journal of counseling psychology, 52(2), 137.

Prak, D., Teunter, R., & Syntetos, A. (2017). On the calculation of safety stocks when demand is forecasted. European Journal of Operational Research, 256(2), 454-461.

Razmi, J., Rad, R. H., & Sangari, M. S. (2010). Developing a two-echelon mathematical model for a vendor-managed inventory (VMI) system. The International Journal of Advanced Manufacturing Technology, 48(5-8), 773-783.

Sainathan, A., & Groenevelt, H. (2019). Vendor managed inventory contracts–coordinating the supply chain while looking from the vendor's perspective. European Journal of Operational Research, 272(1), 249-260.

Sari, K. (2008). On the benefits of CPFR and VMI: A comparative simulation study. International journal of production economics, 113(2), 575-586.

Sarpola, S. (2007). Evaluation framework for VMI systems. Helsinki: Helsinki School of Economics.

Savaşaneril, S., & Erkip, N. (2010). An analysis of manufacturer benefits under vendor-managed systems. IIE Transactions, 42(7), 455–477. https://doi.org/10.1080/07408170903459968

Singh, R. K. (2013). Analyzing the factors for VMI implementation: A framework. Global Business Review, 14(1), 169-186.

Singmann, H., & Klauer, K. C. (2011). Deductive and inductive conditional inferences: Two modes of reasoning. Thinking & reasoning, 17(3), 247-281.

Småros, J., Lehtonen, J. M., Appelqvist, P., & Holmström, J. (2003). The impact of increasing demand visibility on production and inventory control efficiency. International journal of physical distribution & logistics management.

Stalk, G., Evans, P., & Shulman, L. E. (1992). Competing on capabilities: The new rules of corporate strategy. Harvard business review, 70(2), 57-69.

Stevens, G. C. (1989). Integrating the supply chain. international Journal of physical distribution & Materials Management.

Strauss, A., & Corbin, J. (1998). Basics of qualitative research techniques. Thousand Oaks, CA: Sage publications.

Sumrit, D. (2020). Supplier selection for vendor-managed inventory in healthcare using fuzzy multi-criteria decision-making approach. Decision Science Letters, 9(2), 233-256.

Tang, C. S. (2006). Perspectives in supply chain risk management. International journal of production economics, 103(2), 451-488.

Tavakkoli-Moghaddam, R., Alinaghian, M., Mollaverdi-Esfahani, N., & Parsa, M. (2016). Introducing the time value of money in a non-consignment vendor managed inventory model. International Journal of Engineering, 29(5), 637-645.

Tracy, S. J. (2010). Qualitative quality: Eight "big-tent" criteria for excellent qualitative research. Qualitative inquiry, 16(10), 837-851.

Tsay, A. A. (2001). Managing retail channel overstock: Markdown money and return policies. Journal of Retailing, 77(4), 457–492. https://doi.org/10.1016/S0022-4359(01)00055-0

Ulrich, P. V., Anderson-Connell, L. J., & Wu, W. (2003). Consumer co-design of apparel for mass customization. Journal of Fashion Marketing and Management: An International Journal.

Valentini, G., & Zavanella, L. (2003). The consignment stock of inventories: industrial case and performance analysis. International Journal of Production Economics, 81, 215-224.

Waller, M., Johnson, M. E., & Davis, T. (1999). Vendor-managed inventory in the retail supply chain. Journal of business logistics, 20, 183-204.

World Health Organization. (2020). Rational use of personal protective equipment (PPE) for coronavirus disease (COVID-19): interim guidance, 19 March 2020 (No. WHO/2019-nCoV/IPC PPE_use/2020.2). World Health Organization.

Yalcin, M., Özpolat, K., & Schniederjans, D. (2018). Post-implementation analysis: Dependence and trust in VMI context. International Journal of Physical Distribution & Logistics Management, 48(7), 724-740.

Yu, Y., Chu, F., & Chen, H. (2009). A Stackelberg game and its improvement in a VMI system with a manufacturing vendor. European Journal of Operational Research, 192(3), 929–948. https://doi.org/10.1016/j.ejor.2007.10.016

Zanoni, S., Jaber, M. Y., & Zavanella, L. E. (2012). Vendor managed inventory (VMI) with consignment considering learning and forgetting effects. International Journal of Production Economics, 140(2), 721-730.

Zavanella, L., & Zanoni, S. (2009). A one-vendor multi-buyer integrated production-inventory model: The 'Consignment Stock'case. International Journal of Production Economics, 118(1), 225-232.

9. Appendix

9.1 Interview guide

FOR Internal employee

A: Background

1. Could you please give me a brief introduction about yourself, including:
   - What's your role?
   - How long have you worked for The Company?
   - What department are you working for?
   - What is the objective of your department?

B: What is VMI and Why VMI?

2. How you define Vendor Managed Inventory (VMI)?
3. What is your opinion about VMI model benefits?
4. What is your opinion about VMI model risks?
5. Do you think we need VMI model? From a range 0 to 10.

C: VMI implementation

6. What is the most important factor when implementing VMI in your opinion?
7. What potential challenges will be when we implementing VMI in your opinion?
8. What initiatives need to be carried out to bridge potential challenges mentioned?
9. How to implement a VMI system:
   -What resource needed when implementing VMI?
   -Do you prefer to use external or internal VMI system? Or involve a third party?

D: External relations

10. Do you know any medical device companies that have already implemented VMI?
    NO.
11. I am thinking of having an interview with Winner, which information would you like to know from them?

FOR External Supplier

A: Background

1. Could you please give me a brief introduction about yourself, including:
   - What's your role?
   - How long have you worked for The Company?
   - What department are you working for?
   - What is the objective of your department?

B: What is VMI and Why VMI?

2. How you define Vendor Managed Inventory (VMI)?
3. What is your opinion about VMI model benefits?
4. What is your opinion about VMI model risks?
5. Do you think we need VMI model? From a range 0 to 10.
6. Would you like to use VMI in the future with us? Why?
7. If you would like to use VMI model, what goal do you want to achieve?

C: VMI implementation

8. What is the most important factor when implementing VMI in your opinion?
9. What potential challenges will be when you implementing VMI in your opinion?
10. What initiatives need to be carried out to bridge potential challenges mentioned?
11. How to implement a VMI system:
    -What resource needed when implementing VMI?
    -Do you prefer to use external or internal VMI system? Or involve a third party?
12. What kind of supports that you would like to get from us?

D: External relations

13. How VMI looks in the healthcare industry?
14. Do you know any buying companies have already implemented VMI? And what's the result?
15. Do you know any vendors/manufacturers have already implemented VMI? And what's the result?

9.2 The Swedish healthcare company

The Swedish healthcare company (The Company) is a global company which develops, manufacuterer, markets and sells meidal csolutiosn within the field of prevention, wound and skin care and surgical. The Company was founded in the 19th century, and it's headquartered in Sweden. It was a textile manufacturer and supplied medical gauze to various hospitals in Sweden in the early days. With its long-standing brand and muscular strength, as well as the world's leading technology and excellent quality level, The Company became one of the world's strongest medical device manufacturers. The Company's products are exported to more than 100 countries worldwide and are generally welcomed and sought after by consumers in all countries. Like other large multinational companies, The Company comprises several major departments, including marketing, sales, operations, quality, regulations, R&D, supply chain management, procurement, IT (information technology), HR (human resource management), finance, and law. Moreover, The Company lists several departments separately according to their product particularity, such as Operation Room solution. The main R&D center of The Company locates in Sweden, and Operating departments (supply chain, procurement, contract manufacturing) locates in Europe, America, and Asia, Sales and marketing departments locates in major countries in the world. The Company has approximately 8,000 employees worldwide.

Since Covid-19 started, PPE product orders have surged in this Swedish company while its own factories can no longer meet the market competition needs. So The Company began to outsource some products to several well-known medical factories in 2020 for OEM cooperation. In early 2021, in order to reduce inventory costs and logistics costs, The Company expects to establish a relationship VMI (Vendor Managed Inventory) model with its suppliers model. Here, the author will describe the VMI implementation background, implementation goals, implementation steps, implementation effects in this thesis.