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Suitability of inbound VMI at a manufacturing company

Master's thesis in the Supply Chain Management Programme

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ABSTRACT

A main challenge for supply chains concerns how to handle the demand planning and inventory management in the order-delivery process. Vendor Managed Inventory (VMI) is a concept that has been applied in order to meet this challenge. In VMI, the responsibility of the replenishment decision is transferred to the supplier and the buying firm shares the required inventory and demand data. The main benefits highlighted in previous research are improved service levels, reduced inventory levels and reduced administration for the customer. However, studies have shown that by applying VMI, all benefits will not by itself be realised. The study object of this report is a manufacturer that operates several VMI setups. The manufacturer has experienced mixed effects from the application. Many studies have been performed on the subject of VMI but there are not many guidelines of the prerequisites for successful VMI application. Therefore, the aim of this study is to develop a supporting framework for deciding the suitability of VMI as a replenishment method at a manufacturing company.

In order to fulfil the aim, a VMI suitability framework was constructed based on theoretical findings. The applicability of the framework was further evaluated and improved through a case study at the manufacturer and one of its VMI suppliers. The empirical data consists of qualitative data, mainly collected through semi-structured interviews. Recommendations regarding VMI application in general at the case company were formulated together with guidelines of how to apply the VMI suitability framework at the case company.

Firstly, it was found that there are two types of VMI available, which have different effects and also put different requirements on the actors. Secondly, it was found that the type of VMI is dependent on the configuration of VMI at the supplier's site. Thirdly, the risk in a VMI arrangement consists of performance risk and relational risk. It was found that the suitability of VMI depends on the risk that the parties are willing to take and the type of VMI that is considered.

Keywords: Vendor Managed Inventory, VMI, collaborative planning, manufacturing companies, VMI suitability, suitability framework, supply chain management, information sharing.

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1. INTRODUCTION

This chapter introduces the subject of the report and the studied case. The concept of VMI is introduced together with the current challenges related to VMI within the studied company, hereafter referred to as the case company. The aim and four supporting study questions are presented. Finally, the scope and limitations of the study are defined and the outline of the report is described.

1.1 Background

In pursuance of competitiveness on the market, companies seek to improve the efficiency of their operations, decrease cost and keep high service levels. In today's environment, market competition has reached new levels with competition between supply chains, rather than between single companies (Christopher, 2000). Therefore, concerns of how individual firm initiatives affect other actors in the supply chain are rising. This shifts the focus to maximising the overall value of the supply chain through collaboration and integration. Although the landscape is changing, many companies still focus on optimising performance of the individual firm (Chopra and Meindl, 2013).

One of the challenges for companies and supply chains concerns how to handle the demand planning and inventory management in the order-delivery process (Kaipia et al., 2002). In order to handle the challenge, emphasis has been put on information sharing between firms (Chopra and Meindl, 2013). VMI is a common initiative where the information sharing is combined with a higher degree of collaboration between the actors (Sabath and Autry, 2001). In VMI, the responsibility for inventory planning and replenishment is shifted to the actor one step upstream in the supply chain. This means that the supplier is responsible for monitoring the buyer's inbound inventory levels and for making the replenishment decisions in order to meet specific stock level targets (Waller et al., 1999). Instead of sending purchase orders (POs) to the supplier, the buying firm provides the supplier with the required information and forecasts regarding stock level and customer demand (Lee, Padmanabhan and Whang, 1997).

Many studies have investigated the potential benefits of VMI (Disney and Towill, 2003; Holmström, 1998; Vergin and Barr, 1999; Waller et al., 1999). The main benefits in regards to increased supply chain efficiency proved in research are: reduction in the bullwhip effect, improved service levels and decreased inventory levels (Claassen et al., 2008; Disney and Towill, 2003; Waller et al., 1999). Furthermore, VMI can reduce the administration cost for the buying firm (Claassen et al., 2008) and improve the relationship between the actors (Dong, Xu and Dresner, 2007). It also offers opportunities for the vendor in regards to increased competitiveness (Kauremaa, Småros and Holmström, 2009; Pohlen and Goldsby, 2003) and optimisation of transportation and operations (Waller et al., 1999).

However, engaging in a VMI arrangement also brings challenges. For instance, the buying firm might experience loss of control over the replenishment decision that could increase the perceived risk in the order-delivery process (Pohlen and Goldsby, 2003; Waller et al., 1999).

Several companies have implemented the concept of VMI in order to gain the aforementioned benefits (Vergin and Barr, 1999). However, in practice it can be challenging to realise these positive effects. A study, performed by Vergin and Barr (1999) of 10 Fortune 500 manufacturers, showed that the manufacturing firms did not succeed in realising all of the potential benefits of the initiative. Hence, applying VMI does not guarantee that all the potential benefits are realised, there seems to be other determinants that have to be considered. VMI arrangements can have different configurations in regards to a number of design dimensions (Elvander, Sarpola and Mattsson, 2007). Also, all VMI setups are unique in regards to the actors and products involved. In order to understand when the potential benefits can be realised, it is important to understand how the different dimensions affect the outcome of a VMI setup.

The case company, that is the study object of this report, is a manufacturing site that is a part of a large international corporation. The case company produces technological products and their main customers are other businesses. The case company has sought to increase the efficiency in their operations and reduce costs in the supply chain in order to stay competitive. One step in this direction was to introduce the concept of VMI for a number of the company's largest suppliers. The aim was to increase operational efficiency, decrease cost and at the same time generate benefits for the supplier. The actual effects of the VMI application within the company are not confirmed and there are currently no tools available within the company in order to indicate the performance. There are split experiences of VMI at the company. Some VMI arrangements are considered to be successful and others have been terminated due to issues with the setup. There is insecurity about what distinguishes a successful setup from a less successful setup and there is no standardised process of evaluating potential VMI setups. Therefore, the managers at the company consider it to be important to understand in what situations and how VMI should be applied in order to realise the benefits.

1.2 Aim

The aim of this study is to develop a supporting framework for deciding the suitability of VMI as a replenishment method at a manufacturing company.

The framework is the main output of the study and will hereafter be referred to as the VMI suitability framework. The case company should be able to use the framework as a support in the selection of replenishment method. The objective of the application of

VMI within the case company is to increase efficiency in the operations, especially regarding the administration work and ultimately to reduce cost. The company further aims to achieve benefits for the supplier in order for the agreement to be sustainable in the long run. In order to fulfil the aim, the alternative definitions, configurations and the potential effects of VMI are identified, as well as how these effects can be measured. Furthermore, the enablers for realising the benefits are studied. In later stages, the case company plans to use the VMI suitability framework as an input to how VMI could successfully be applied at the company.

The aim is supported by four study questions, which are presented below. The VMI suitability framework is the answer to the fourth question, which is the aim of the study. The first three questions are answered at a generic and conceptual level in order to support the last study question, which is the main focus of this study. The aim of the theoretical framework is to contribute to increased knowledge of VMI and to identify critical aspects to be considered in the development of the VMI suitability framework. In the end of the theoretical framework, a VMI suitability framework is developed and introduced. All the study questions are answered in the theoretical framework. Thereafter, the theoretical findings are evaluated in the context of the case company and the studied supplier. The accuracy of the findings is discussed and further developed in the analysis. The aim of the analysis is further to evaluate the case company's situation and develop guidelines of how the VMI suitability framework could be applied in that context.

Q1: How do manufacturing companies define and configure inbound VMI?

In order to develop the VMI suitability framework, the concept of VMI must be defined. Moreover, it is important to identify the potential configurations of VMI and differences in the process compared to the traditional POs. The aim of Q1 is to identify terms, definitions and configurations of VMI used in research and applied in manufacturing companies.

Q2: What are the effects of using VMI and how can they be measured?

When developing the VMI suitability framework, the potential effects need to be identified. Additionally, it is critical to have the knowledge of how these effects can be measured in order to evaluate the performance of VMI. The aim of Q2 is therefore to identify the potential effects and how these can be measured.

Q3: What are the enablers for reaching the benefits of VMI?

The enablers for VMI suitability need to be identified, since these provide a foundation for deciding when VMI is suitable. The aim of Q3 is to answer what enablers there are for realising the positive effects of VMI identified in Q2.

Q4: When is it suitable for a manufacturing company to use inbound VMI?

The answer to this question will fulfil the aim of this study and result in a VMI suitability framework. The enablers identified in Q3 will be the main input for the development of this framework. The aim of Q4 is to provide a framework for deciding the suitability of inbound VMI at a manufacturing company.

1.3 Scope and limitations

The report is limited to study the VMI arrangement between manufacturing companies and their suppliers, hence the effects further upwards and downwards in the supply chain are not considered. The dimension of the IT system is not handled in the study, since the case company considers the maturity of the IT system to be high. The VMI arrangements at the case company are studied in general combined with a specific setup between the case company and one supplier in order to deepen the understanding. The case company considers this specific VMI arrangement to be one of their most successful arrangements. Therefore, it is considered to be a suitable complementary study object in order to identify some of the enablers for the VMI setup at the case company. The result of the study should be possible to use as an input for changes in the current way of working at the case company, but does not include an implementation plan.

1.4 Thesis outline

In this section, the outline of the report is presented. In chapter 2, the theoretical framework is presented and all study questions are addressed. In chapters 2.5, 2.6.2 and 2.7, the theory that has then been previously introduced will be investigated and different parts of the theoretical findings will be used in order to develop the VMI suitability framework. The VMI suitability framework is based only on theory and therefore belongs in chapter 2. This is followed by chapter 3, which presents and motivates the choice of research methodology applied in the study. In chapter 4, the empirical data collected through interviews is presented in two sections. Firstly, the general situation at the case company is described and secondly, the situation in the specific VMI setup with the studied supplier is presented. In chapter 5, VMI at the case company is analysed in detail. This chapter contributes to evaluating the applicability of the theoretical findings and to further develop these in the specific context of the case company. Based on the findings in the analysis, specific guidelines of how VMI suitability should be assessed in the context of the case company are developed and presented. In chapter 6, the main findings, contribution and quality of the study are presented and discussed.

2. THEORETICAL FRAMEWORK

The main building blocks of the theoretical framework for this study are presented below. The theoretical framework presents prior research on the topic and answers the study questions of this study on a general and conceptual level. Firstly, the background and definitions of VMI are presented. Secondly, different types of VMI are described and alternative configurations of VMI are presented. This is followed by a section that presents the effects of VMI and how these can be measured. Furthermore, the enablers for realising the positive effects of VMI are presented. These are thereafter categorised into VMI readiness categories that are of importance for the VMI performance. Thereafter, a model of the connection between trust, risk and control in relationships, is combined with the readiness dimensions in order to develop the VMI suitability framework. Finally, a general VMI suitability framework based on theory is presented.

2.1 Definitions of VMI

This section aims to identify how VMI is defined in theory, which contributes to answering the first part of Q1. Traditionally, the inventory management and replenishment decision for the inbound flow of purchased items is handled by the use of POs. POs are sent from the buying firm to the supplying firm, based on the demand and stock levels. The buying firm makes the decision of replenishment, in regards to the quantity and timing of the deliveries, and the supplier has to meet these demands (Kaipia et al., 2002). In order to optimise the replenishment activity in regards to cost and service level, several different collaborative planning initiatives have emerged between customers and suppliers.

The terms and setups for these initiatives vary across industries, firms and supplier-customer relationships. Examples of terms that have been used for these approaches are: collaborative planning, forecasting and replenishment (CPFR) (Stank, Daugherty and Chad, 1999), automatic replenishment programmes (ARPs), quick response (QR), efficient consumer response (ECR), continuous replenishment planning (CRP) (Daugherty, Myers and Autry, 1999), Vendor Managed Replenishment (VMR) and Supplier Managed Inventory (SMI) (Pohlen and Goldsby, 2003). VMI is a commonly used term (Sabath and Autry, 2001) but there is a lack of a uniform definition of VMI and there is an inconsistency in the usage and categorisation of the related terms (Marquès, Thierry, Lamothe and Gourc, 2010).

Although there are several variations of the definition of VMI, the definitions share the same main idea of the concept. The definitions mainly differ in regards to the level of detail. For this study, a broad definition of VMI has been formulated which consists of the most basic and common constituents found in definitions in theory (Chopra and Meindl, 2013; Kaipia et al. 2002). The definition is broad in order for the study to include the different configurations of VMI, which are further described in the next section. Here, VMI will be defined as:

An inventory replenishment method where the responsibility and authority of the replenishment decision is transferred to the supplier. The customer shares the required inventory and demand information with the supplier.

The main difference between traditional POs and VMI is that the supplier is responsible for the replenishment decision and that the buying firm shares the required inventory and demand data. In the setting of traditional POs, the buying firm defines quantity and timing of a delivery and sends an order to the supplier. The supplier is then responsible for fulfilling these orders exactly as specified by the buying firm (Kaipia et al., 2002). In the VMI setup, the supplier is instead responsible for meeting agreed targets of inventory levels and/or service levels based on information of demand and inventory levels provided by the buying firm. The responsibility of deciding on replenishment quantities and timing is in VMI transferred to the supplier (Kaipia et al., 2002).

2.2 Configurations of VMI

This section aims to identify the alternative configurations of VMI and thereby answer the second part of Q1. Holweg, Disney, Holmström and Småros (2005) categorised the alternative supply chain configurations of the order-delivery process into four different types based on the level of collaboration. Type 0 is the traditional process where the only demand information shared with the supplier are the POs. Type 1 is when demand information is shared in addition to the POs in order to improve the supplier's forecast and long term planning. Type 2 is when the responsibility and authority of the replenishment decision is transferred to the supplier. Type 3 is the highest level of collaboration and is when the supplier integrates the demand information received from the customer in the planning of the production. Also in type 3, the supplier is responsible for the replenishment decision (Holweg et al., 2005). According to the definition of VMI in this study, the type 2 and 3 in the categorisation of collaborative planning initiatives by Holweg et al. (2005) can be considered to be two types of VMI. The two types of VMI will in this study be referred to as basic VMI and advanced VMI. Table 1 shows an overview of the different types of collaboration initiatives.

Table 1. Different types of collaboration initiatives in the order delivery process (Holweg et al., 2005).

<i>Collaboration type</i>	<i>Type of VMI</i>	<i>Description</i>
Type 0	None	<ul style="list-style-type: none"> • POs are sent
Type 1	None	<ul style="list-style-type: none"> • POs are sent • Demand information is shared
Type 2	Basic	<ul style="list-style-type: none"> • Demand information is shared • Responsibility of the replenishment decision is transferred to the supplier
Type 3	Advanced	<ul style="list-style-type: none"> • Demand information is shared • Responsibility of the replenishment decision is transferred to the supplier • The supplier integrates the demand information in the planning of the production

The definition of VMI leaves room for several alternative configurations of the system. Elvander et al. (2007) developed a framework consisting of a total of 12 design dimensions, grouped into four basic design categories in order to evaluate, compare and categorise different VMI setups. These design categories are labelled inventory control, information, decision-making and integration level and are presented in Figure 1 (Elvander et al., 2007).

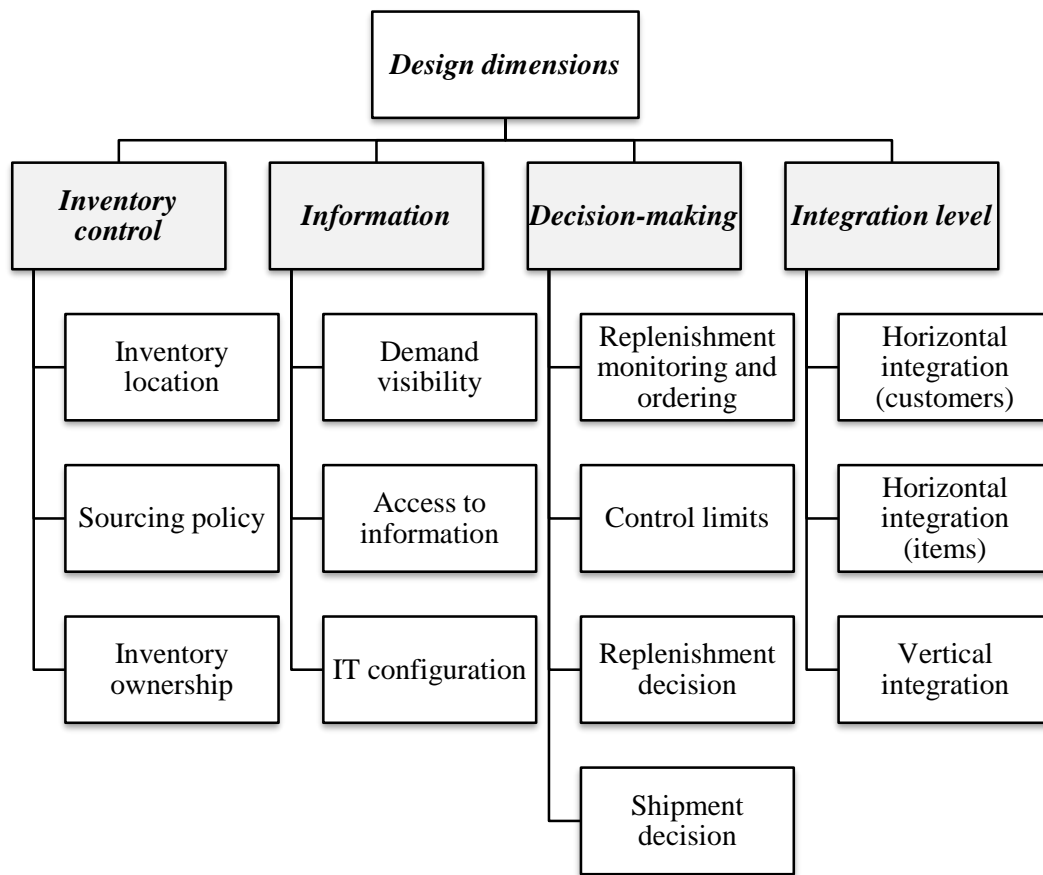


Figure 1. The design dimensions of a VMI system, grouped into four design categories (Elvander et al., 2007).

2.2.1 Inventory control design dimensions

Within the category of inventory control, the three dimensions of inventory location, sourcing policy and inventory ownership can be found. All alternatives within the inventory control design dimensions can be considered to be VMI according to the definition established in this report.

Inventory location considers the physical location of the inventory which can be at the site of the buying firm, at a central warehouse managed either by the buyer or by a third party logistics provider, or at the supplier's and the customer's site. The dimension of sourcing policy describes whether the products supplied to the customer are picked from, either directly from the production process or from stock (Elvander et al., 2007).

The inventory ownership considers when the ownership of the goods is transferred to the buying firm and the point in time the invoice is issued. In the first alternative, the buying firm takes over the ownership and is invoiced when the goods are delivered. This is similar to the process of POs. For the second alternative the payment is delayed until the customer has issued the goods from stocks. The third alternative is that the supplier owns the inventory when located at the site of the buying firm until the point

in time when the goods are picked from stock. This is also the point when the invoice is issued (Elvander et al., 2007). The third alternative is often referred to as consignment inventory. The point in time when the ownership is transferred, will decide which actor carries the cost and the risk of keeping inventory (Pohlen and Goldsby, 2003; Vigtil, 2007). In the case of consignment, the supplier will carry the cost of the capital invested in the inventory, while the buying firm will carry the cost of storing the goods (Nagarajan and Rajagopalan, 2008). Claassen et al. (2008) studied six different VMI setups and found that the inventory cost was always paid by the least powerful actor in the relationship. The actor carrying the cost will also be the actor that will have the main incentive to keep the stock levels down (Vigtil, 2007). The point in time when the invoice is to be paid can have an impact on the cash flow of the supplier (Kuk, 2004).

2.2.2 Information design dimensions

In the second category, information, the three dimensions of demand visibility, access to information and IT configuration are included. The demand visibility refers to what information is shared with the supplier, access to information refers to how the supplier accesses the information and the IT configuration is related to how the IT systems are set up. The dimensions of access to information and IT configuration are related to the IT system, and are therefore assessed to be outside the scope of this study. Thus, these two dimensions will not be further described.

The demand visibility refers to the demand information that is shared with the supplier in order to manage the inventory and replenishment decisions. It also considers how far in time the information ranges. There are three different alternatives for the demand visibility, where the first is to only share historical consumption data. The second alternative is to also share forecasts and/or delivery plans. The third option is to share allocations in addition to forecasts (Elvander et al., 2007). The value of information sharing will depend on what information is shared and contextual factors. Furthermore, the required information for VMI will differ between the basic and advanced VMI. In the advanced VMI, information that enables the supplier to plan the production must be provided. Vigtil (2007) studied what type of information is of importance to share in a VMI arrangement. In a multiple case study, eight types of data were studied: inventory levels, incoming orders, goods in transit, stock withdrawals, production schedules, sales data, backorders and returns. The study showed that stock levels are the most important information to share. Moreover, the study concluded that point-of-sales (POS) data is more important when the demand is unpredictable and the responsiveness of the supplier is considered low (Vigtil, 2007).

2.2.3 Decision-making design dimensions

The third design category, decision-making, consists of four dimensions; replenishment monitoring and ordering, control limits, replenishment decision and shipment decision (Elvander et al., 2007). How the replenishment decision dimension

is configured will determine if the setup is a VMI setup and whether the setup can be classified as basic or advanced VMI.

The first dimension, replenishment monitoring and ordering involves the frequency of the supplier reviewing the stock levels and demand information in order to make the replenishment decision. There are three different options available for this. The first alternative is to continuously examine the articles, and replenish the ones that have reached the reorder point. The second option is to inspect the levels periodically rather than continuously. Lastly, the third option is to manually inspect the stock levels periodically (Elvander et al., 2007).

The second dimension, control limits, refers to maximum and minimum stock levels that have been agreed upon by the customer and supplier. There are four alternative agreements, the first one is that there are no agreed limits, the second and third alternative is that there is either a minimum or a maximum level, and the last alternative is that there are both agreed minimum and maximum levels (Elvander et al., 2007). Some companies combine the control limits with penalty clauses for situations when the agreement is not reached (Claassen et al., 2008). The control limits impact the flexibility for the supplier to plan the production, replenishment and transportation (Claassen et al., 2008). Having too tight limits will restrict the supplier from optimising the production and replenishment. Furthermore, in the case of tight control limits the supplying firms will not be able to consider the total supply chain cost in the replenishment activity (Claassen et al., 2008). Having a high lower limit will keep the inventory levels high and will limit the potential of inventory reductions since the actual stock level is not allowed to decrease under the specified level. However, it can ensure product availability and a high service level (Claassen et al., 2008). Claassen et al. (2008) argue that this can be the underlying reason when companies increase their service level by a VMI arrangement but are realising limited cost benefits related to the inventory levels. Moreover, the upper limit will restrict the inventory levels to a certain level.

The third dimension, replenishment decisions, refers to the extent the supplier is allowed to make the replenishment decisions considering quantity and timing. There are four alternatives of how much flexibility the supplier is allowed. The first alternative is that the supplier has the freedom to plan replenishment without any restrictions regarding quantity or delivery time. The second option is that the supplier is allowed to decide on one of the variables and the other one is decided by the buying firm. The third alternative is when the supplier suggests replenishment, which is then confirmed by the customer. The fourth alternative is that the buying firm makes suggestions to the supplier, which the supplier then is able to either confirm or change without any restrictions (Elvander et al., 2007). Only the first alternative where the supplier is offered the full flexibility can be considered to be in line with the definition of VMI.

The last dimension within decision-making is shipment decision, which refers to which actor is entitled to make the decision of when the shipment should be carried out. There are only two options of this decision, either the supplier or the customer is responsible for making the shipment decision. In the case where the customer is responsible for deciding when and how to ship, the benefits of consolidation of transport will be limited (Elvander et al., 2007).

2.2.4 System integration level design dimensions

The last category of dimensions is the system integration level at the supplier that consists of level of horizontal integration of customers, level of horizontal integration of items and level of vertical integration (Elvander et al., 2007).

The first dimension is the horizontal integration of customers when making replenishment and production planning decisions. It considers to what degree the supplier integrates information from different VMI customers in the replenishment and planning processes. The supplier can, for instance, consider only one VMI customer at a time, all VMI customers simultaneously or the entire customer base including both VMI and regular customers (Elvander et al., 2007).

The second dimension, the level of horizontal integration of items considers the demand information of items. The supplier can either manage one VMI item at a time or manage all VMI items simultaneously. The supplier can also use the information of VMI items in order to optimise the planning of the production and the replenishment for non-VMI items (Elvander et al., 2007).

The last dimension, the level of vertical integration, refers to what parts in the value chain are considered when making replenishment decisions. The lowest level of integration is when only the customer's inventory level is taken into account. In the second level of integration, information regarding the supplier's inventory is also utilised. For the highest level of vertical integration, the production capacity of the supplier is considered along with the inventory levels of the customer and the supplier (Elvander et al., 2007). The two first alternatives can be considered to be in line with the basic VMI, while the third alternative can be classified as the advanced VMI.

2.3 Effects of VMI

This section aims to identify the potential effects of VMI and how these can be measured, which contributes to the answer of Q2. Firstly, the effects for the actors in different types of VMI are presented. The actors included here are the buying firm and the supplier. Secondly, how and why to measure the effects is presented.

2.3.1 Effects for the actors in the two types of VMI

The application of VMI, as opposed to using POs, changes the responsibilities and activities performed by the different actors in the order-delivery process (Kaipia et al., 2002). These changes have effects, both for the buying firm and the supplier. One of

the reasons why VMI has gained attention is that having a VMI relationship can offer various benefits for both partners. There are different levels of collaboration in VMI setups, which can have different effects (Holweg et al., 2005). Several authors have discussed the types of configurations and applications that result in different outcomes (Claassen et al., 2008; Disney and Towill, 2003; Holweg et al., 2005; Kauremaa et al., 2009). The effects of VMI mainly derive from three changes, which are: the increased information sharing, the transfer of the replenishment decision and the integration of the demand information in the planning of production at the supplier. The effects that result from information sharing and the transfer of the replenishment decision are possible to achieve in both the basic and the advanced VMI. However, the effects stemming from the integration of information in the supplier's processes will only be possible to realise in the advanced VMI.

First of all, the POs and the administrative work of placing these at the buying firm will be eliminated. This leads to fewer erroneous orders due to typing errors, which decreases the returned shipments. This can result in the materials handling cost being reduced (Claassen et al., 2008). A negative consequence for the buying firm is that the control of the replenishment decisions is lost (Pohlen and Goldsby, 2003; Waller et al., 1999). Also by sharing the necessary information to the supplier, the buying firm loses the control over the information (Pohlen and Goldsby, 2003).

Taking over the decision-making will increase the administration at the supplier. When the supplier is not obliged to deliver on a specific date or time as long as the inventory levels are met, it brings additional benefits. It results in that shipments can be consolidated, which leads to potential cost savings (Waller et al., 1999). It also gives the supplier the opportunity to prioritise the replenishment for different customers. The suppliers have a better insight into what deliveries to VMI customers can be delayed without causing issues at the sites of the customers (Kaipia et al. 2002; Waller et al., 1999). Hence the VMI setup can increase the service levels towards all customers of the supplier (Kaipia et al. 2002). Furthermore, the increased information visibility and better planning and control at the supplier can lead to increased consolidation and changes in transport modes that can result in reduced environmental impacts (Aronsson and Huge Brodin, 2006).

For PO setups, the information about actual demand is not visible to the supplier, which is likely to result in occurrence of the bullwhip effect (Holweg et al., 2005). VMI can result in decreased bullwhip effect since the delay in information sharing and batching is eliminated, which reduces the demand uncertainty and fluctuations. The supplier is therefore able to see trends in demand that enables the supplier to make better forecasts (Waller et al., 1999). The shared information in a VMI setup helps reducing the bullwhip effect even further. It prevents sub-optimisation since the supplier has an overview of the full picture and can make decisions that are good for both actors (Claassen et al., 2008). Receiving demand information continuously and at

an earlier point in time gives the suppliers extra time to plan and respond to the demand (Kaipia et al., 2002). The time benefit in the planning would not be realised if the suppliers are not allowed to plan the replenishment, despite visibility of demand and frequent information sharing (Kaipia et al., 2002). VMI enables the supplier to improve the service levels towards the buying firm, which can improve the product availability to their customers (Claassen et al., 2008). The increased service level towards the final customers can result in increased sales and fewer emergency orders. The increased responsiveness and service level from the supplier gained from VMI reduces the need of cycle stock at the buying firm (Waller et al., 1999), and decreases the inventory cost (Claassen et al., 2008). Based on this, VMI can result in increased service levels and a reduced cost for both parties (Waller et al., 1999).

VMI also provides an opportunity for the supplier to integrate the demand information into the production planning. In these cases, the VMI can be classified as advanced. It enables the supplier to better plan the production and align it to real demand, which can increase the service level further and reduce the need for finished goods inventory and excess capacity (Kaipia et al., 2002; Waller et al., 1999). Lower finished goods stock reduces the risk for obsolete products and enables faster phase in and phase out of products (Waller et al., 1999). Using the information can also enable the supplier to reduce lead times (Claassen et al. 2008).

Transferring the replenishment responsibility opens up possibilities for the supplier in regards to marketing and could be a practise in order to differentiate from other suppliers on the market (Kauremaa et al. 2009; Pohlen and Goldsby, 2003). It could result in the customer being more dependent on the supplier (Kauremaa et al., 2009), but might also contribute to the establishment of a long-term relationship that could result in secured sales for the supplier (Claassen et al., 2008; Dong et al., 2007).

The potential effects and the type of VMI where these are achievable are presented in Table 2 for the customer and Table 3 for the supplier. The main benefits highlighted in previous research are improved service levels, reduced inventory levels and reduced administration for the customer in the arrangement (Claassen et al., 2008). These are marked in bold in the table below. The effect on the service levels and inventory reduction can be achieved to a higher degree in the advanced VMI. The service level can be improved due to that the supplier can prioritise between orders, the continuous information sharing and also due to the extra time for planning, which is possible in both basic and advanced VMI. However, the significant improvements are achieved when the supplier is able to integrate the demand information in the planning of the production. The table shows that the main improvements in supply chain efficiency, which are reduced inventory levels and improved service levels, are achieved in the advanced VMI.

Table 2. Effects of VMI for the customer in the two types of VMI. The magnitude of the achievable effects, depending on the type of VMI, is showed on the scale of 1-3, 3 being the highest.

<i>Effects for customer</i>	<i>Positive or negative</i>	<i>Type of VMI</i>	
		<i>Basic</i>	<i>Advanced</i>
Loss of control of replenishment decision	-	3	3
Loss of control of information	-	3	3
Improved relationship	+	3	3
Reduced administration	+	3	3
Increased service level	+	1	3
Reduced inventory levels	+	1	3

Table 3. Effects of VMI for the supplier in the two types of VMI. The magnitude of the achievable effects, depending on the type of VMI, is showed on the scale of 1-3, 3 being the highest.

<i>Effects for supplier</i>	<i>Positive or negative</i>	<i>Type of VMI</i>	
		<i>Basic</i>	<i>Advanced</i>
Improved relationship	+	3	3
Opportunities to consolidate shipments	+	3	3
Improved information sharing	+	3	3
Opportunities in marketing	+	3	3
Reduced bullwhip effect	+	2	3
Increased service levels to customers outside VMI arrangement	+	2	3
Increased administration	-	2	3
Reduced need for capacity and finished goods inventory	+	1	3
Increased service level	+	1	3
Reduced inventory levels	+	1	3

2.3.2 Measuring the effects of VMI

It is important to measure what the firm wants to achieve (Gunasekaran et al., 2004). In order to eliminate the uncertainty of potential benefits it is critical to being able to measure the effects (Kaipia et al., 2002). There is a need of a method that enables the management to firstly evaluate the effects and secondly to sell in on the concept across the organisation (Pohlen and Goldsby, 2003). In order to efficiently measure and improve the performance, the organisational goals must be represented by the measurement goals and the metrics that are used should indicate a balance between financial and non-financial measurements (Kaplan and Norton, 1992). It should also be possible to relate those measures to the decision-making and control on strategic, tactical and operational levels (Gunasekaran et al., 2004).

Common goals and objectives are important in order for the firms in the setup to work in the same direction and to avoid conflicting actions (Barratt, 2004). However, Kauremaa et al. (2009) identified that there can be different objectives for applying VMI. Some applications are characterised by individual objectives of the actors in the agreement, which are increased purchasing efficiency for the buyer and increased competitiveness for the supplier. Other applications are characterised by the shared objective of increasing supply chain efficiency, which means improved service levels and decreased inventory levels. These objectives can also be combined with the objective of the supplier to integrate the demand information in their production and inventory decisions. The alignment of objectives and actions of the employees involved are important for the long-term sustainability of the VMI setup (Kuk, 2004). Since it is important to align measurements and incentives with the goals of VMI in order to avoid sub optimal actions (Waller et al., 1999), sharing some KPI's between the two actors in the setups is considered to be a behavioural enabler of VMI (Barratt, 2004). Regardless of the objectives, it is important that what is to be achieved is measured so that the effectiveness of the VMI arrangement can be evaluated.

Van Weele (2010) stressed the fact that the purchasing manager should be aware that not all of the logistics problems that come up are the supplier's fault. Often, problems result from something within the buying company, for example because of insufficient planning or rapid change of POs. Therefore, van Weele (2010) suggested differentiating between internal and external performance indicators. Furthermore, van Weele (2010) emphasised that the performance should not be measured for all products and suppliers, but recommended that focus should be on measuring the critical products and suppliers. Gunasekaran, Patel and McGaughey (2004), pointed out that many companies have a large number of performance metrics, when in fact it is better to evaluate the performance by using few, critical measures. Limited number of measurements minimises information overflow (Kaplan and Norton, 1992). Those few measures should be the ones that best capture the reality of the organisational performance.

2.4 Enablers for realising positive effects of VMI

This section aims to contribute to the answer of Q3 by identifying the potential enablers for VMI performance. Studies have shown that by applying VMI, all benefits will not by itself be realised (Vergin and Barr, 1999). This section aims to identify the prerequisites for VMI to result in positive effects and will serve as an input to the VMI suitability framework. The aspects identified in theory that are presented in this section are: incentives and capabilities for both actors, relationship between the actors, demand volatility and ordering frequency of the product.

2.4.1 Incentives of the actors

A basic prerequisite for considering VMI and for it to be sustainable in the long term is that there must be incentives for both parties to engage in the arrangement (Barratt,

2004; Nagarajan and Rajagopalan, 2008; Pohlen and Goldsby, 2003; Waller et al., 1999). The parties must see the positive effects of VMI and be willing to achieve them, otherwise there will be no incentive to implement or to stay in the VMI setup. The incentives for VMI can differ between firms and the environment, which they operate in. In situations where benefits of a VMI arrangement are one sided, sharing the benefits through transfer payments from the actor that has the greatest benefits to the other, can create the incentives needed for VMI (Nagarajan and Rajagopalan, 2008). For example, the cost of inventory holding might be shared between the partners in order to support a cooperative relationship with mutual benefits (Yang, Ruben and Wester, 2003). In order for an incentive to be in place there must be some improvement potential in regards to that aspect (Kauremaa et al., 2009). Furthermore, it is of importance that the actors work in the same direction without conflicting objectives (Barratt, 2004). Therefore, it is critical that the incentives of the two actors match each other.

2.4.2 Capabilities of the actors

Another dimension that is pointed out as important in theory are the capabilities of the actors involved. Both actors must have competence in performing the required activities in a VMI setup. Das and Teng (2001) pointed out that one of the factors that affect the performance of an alliance is a lack of competence in the partnering firms. Different capabilities are needed from the two actors in the arrangement. Also, the required capabilities will be different in the two types of VMI. Based on the definition constructed in this report, the supplier must be able to manage the replenishment decision and the customer has to be able to share the required information. Additional capabilities required for VMI identified in theory are presented below.

Internal integration at both actors and inter-organisational integration of processes and information sharing is important in order for VMI to be effective in fulfilling the demand (Barratt, 2004). A cross-functional and inter-organisational approach is needed for both the buyer and the supplier in order for VMI to be effective (Claassen et al., 2008). It is therefore of importance that the actors have the capabilities of transferring the information within the firms and to each other in an efficient way on all levels and to have the processes in place in order to be able to utilise the information

In the situation where the advanced VMI is to be applied, it is important that the supplier has the capabilities of performing the additional activities required for the advanced VMI. The supplier must be capable of integrating the demand information in the planning of the production (Barratt, 2004). It is pointed out that the supplier has to receive early demand information for a large share of the total demand in order to be able to utilise the information in the capacity planning and gain planning benefits (Claassen et al., 2008; Kauremaa et al., 2009). Waller et al. (1999) showed that the higher the adoption rates, the larger the inventory reductions. However, integrating

information from a high number of customers into the planning can be challenging and resource demanding (Holweg et al., 2005). The cost of maintaining the VMI setup and relationship will increase with increased number of customers (Raghunathan and Yeh, 2001). Hence, it is preferable for the supplier to have VMI for a limited number of customers that stand for a sufficient share of the production.

2.4.3 Relationship between the actors

Another dimension that is important for the performance of VMI is the relationship between the two actors in the arrangement (Claassen et al., 2008). The main aspect pointed out as a prerequisite for VMI is trust (Claassen et al., 2008; Pohlen and Goldsby, 2003). Trust is important since the buying firm can experience lack of control when transferring the replenishment decision (Kaipia et al., 2002; Pohlen and Goldsby, 2003; Waller et al., 1999). When there is a lack of trust and interpersonal relationships it is likely that the parties try to manage risks by using control tools such as detailed contracts (van Weele, 2010). If the buying firm does not trust the supplier to fulfil the commitments in a VMI arrangement, tight control limits might be set for the stock levels (Kaipia et al., 2002). Claassen et al., (2008) argued that setting tight control limits is not in line with the key idea of VMI, which is that the supplier should be offered flexibility in planning and optimising of the production. Trust is also important in order for the buying firm to be willing to provide demand information to the supplier. If the shared data is not handled in a secure way, it can be considered as a risk to share the data with the supplier, since this could mistakenly be visible to competing firms (Barratt, 2004; Pohlen and Goldsby, 2003). In order to build trust, both partners need to be reliable, honest and keep their promises (Barratt, 2004). Other aspects related to the relationship that are required for successful VMI application are interpersonal relationships, teamwork and strong participation from both actors (Waller et al., 1999). There is also a need for the people involved to understand the role of VMI. Joint training can improve the relationship by helping the employees to create a common understanding of the processes and the challenges (Barratt, 2004).

2.4.4 Demand volatility of the product

The demand volatility impacts the performance of VMI and the requirements of the parties involved in the setup. The impact of the demand volatility on the VMI performance has been studied in previous research but the findings are contradictory (Yang et al., 2003). Historically, VMI has mainly been applied for products with stable demand (Waller et al., 1999). However, the benefits to be gained could be larger for products with higher demand volatility, but that will put higher requirements on the setup. Yang et al. (2003) showed that the need for inventory, when the service level is kept on a constant level in a VMI setup, increases dramatically when the demand variability increases. Raghunathan and Yeh (2001) argued that the inventory reduction potential in these cases are greater. They also stated that demand information is more valuable when there is high demand volatility. When the demand is stable, the information sharing does not add as much value, since the supplier is able to compile

an accurate forecast from the historical demand pattern (Raghunathan and Yeh, 2001; Raghunathan, 2001; Yang et al., 2003). Angulo, Nachtmann and Waller (2004) showed that sharing the forecast in case of volatile demand gives larger inventory reductions than in the case of stable demand. Sari (2007) concluded that information sharing is more valuable in cases with high demand volatility, if the actors in the supply chain are able to use the information to reduce the demand uncertainties. When this is not possible, high demand volatility negatively impacts the benefits, related to inventory reduction and total supply chain cost, gained from information sharing in VMI (Sari, 2007). Dong et al. (2007) argued that in the case of high demand volatility from the buying firm, the supplier might be resistant to apply VMI since this would transfer the demand uncertainty into the operations of the supplier. Also the supplier might be resistant due to the high inventory levels needed in order to meet this demand (Dong et al., 2007). In order to cope with the inventory costs related to a setup with high demand volatility, it is important that both actors are aware of challenges and agree upon terms, which benefit both of them, before entering the VMI arrangement (Yang et al., 2003).

2.4.5 Ordering frequency of the product

The ordering frequency is another product related aspect that impacts the improvement potential of VMI. For products with low ordering frequency the potential inventory reduction and the time benefits gained from using VMI are higher than for products with high frequency (Kaipia et al., 2002; Småros, Lehtonen, Appelqvist and Holmström, 2003), since the more seldom products are ordered, the higher is the risk for demand distortion (Kaipia et al., 2002). In the case of VMI, the supplier receives information of the demand continuously, in comparison to the PO setup where the supplier only receives information through the POs (Kaipia et al., 2002). Therefore, the time benefit for the supplier to meet the demand in the VMI arrangement is greater for the products that are ordered seldom in the PO setup (Småros et al., 2003). Also the potential reduction of the inventory buffer that is used in order to cope with the uncertainty in demand is greater for the products with low ordering frequency (Kaipia et al., 2002; Småros et al., 2003). The products with low ordering frequency are often low volume products (Kaipia et al., 2002). Both Kaipia et al. (2002) and Småros et al. (2003) concluded that these products are likely to gain the most benefits from VMI setups. To sum up, the potential benefits are higher for low ordering frequency than for high, nevertheless VMI is still feasible for products with high ordering frequency. Therefore, low ordering frequency is not considered as a prerequisite of VMI.

2.5 VMI readiness

In this section, the enablers that were found in theory and introduced in the previous section will be categorised and summarised. This is the first step in the development of the VMI suitability framework, which will answer Q4.

The enablers identified in the previous section are incentives and capabilities for both actors, relationship between the actors, demand volatility and ordering frequency of the product. These aspects are either related to the customer, supplier, relationship or product. Based on this, it seems, as the performance of VMI can be determined from aspects related to these four dimensions. It seems reasonable that the aspects must be present to some extent in order for the situation to be ready for VMI. Therefore, the categories are in this study termed customer readiness, supplier readiness, relationship readiness and product suitability. Together, the enablers represent the VMI readiness. Figure 2 gives an overview of the categories. The ordering frequency of the product is not included in the product suitability since it is not considered critical for the VMI readiness. The ordering frequency indicates the improvement potential of the setup but does not impact the VMI readiness in regards to the product. Moreover, it is important to point out that there is a difference between VMI readiness for the two types of VMI since the setups differ in configuration. Hence, when determining the VMI readiness the type of VMI must also be considered.

<i>Customer readiness</i>	<i>Supplier readiness</i>	<i>Relationship readiness</i>	<i>Product suitability</i>
<ul style="list-style-type: none"> • Incentives • Capabilities and resources 	<ul style="list-style-type: none"> • Incentives • Capabilities and resources 	<ul style="list-style-type: none"> • Collaboration • Trust • Mutual benefits 	<ul style="list-style-type: none"> • Planning complexity

Figure 2. Overview of enablers identified in theory.

The category of customer readiness consists of incentives and customer capabilities and determines if the customer will be successful when entering a VMI arrangement. The needed incentives and capabilities will depend on the type of VMI. First of all, the buying firm has to have incentives for establishing a VMI arrangement. The buying firm has to see potential benefits and improvement potential with the application of VMI, otherwise there is no reason for engaging in it. Furthermore, the buying firm has to have the capabilities and resources to perform the activities required for a successful VMI application. The customer needs to have skilled employees and the incentives of VMI have to be in line with the overall strategy of the company.

The supplier readiness area considers if a supplier is ready for VMI and is divided into incentives and capabilities and resources. Also the required incentives and capabilities for the supplier will depend on the type of VMI. First of all, it is required that the supplier has incentives to participate and commit to the VMI setup, otherwise the setup will not be sustainable long term. In order for the supplier to have incentives and gain benefits from integrating demand information in the planning and thereby engage in an advanced VMI, it is important that a large share of their production is handled through

VMI. Secondly, the supplier must be capable and have resources to manage the additional activities that the VMI setup brings. In the basic VMI, the supplier has to have the necessary resources and operational capabilities, in order to manage the replenishment decision. In the advanced VMI, the supplier needs to have the resources and capabilities to be able to integrate the information into the planning of production, which also requires that the supplier has internal integration.

The category of relationship readiness includes relationship dimensions that are important for the performance of VMI. It is important that these are either in place or that there is a potential for developing these aspects in the relationship. The dimensions are collaboration, trust and mutual benefits. Firstly, the level of collaboration in the relationship has to be high, with interpersonal relationships and strong participation from both actors. Secondly, the buying firm has to trust that the supplier can handle confidential information and will fulfil the commitments. Furthermore, trust is important in order for the buying firm to offer the flexibility that is needed for the supplier in order to realise the benefits of VMI. Finally, it is important that there are mutual benefits and that the incentives are not contradictory in order for the arrangement to be sustainable in the long term. If the benefits are one sided the benefits can be shared with transfer payment in order to make sure that there are incentives for both actors. The relationship readiness seems to be tightly related to the capabilities and incentives of the actors. The supplier's ability to fulfil commitments is dependent on the supplier's capabilities. Also the mutual benefits are related to the incentives of the actors.

The area of product suitability considers the product related aspects which impact VMI readiness. Only the dimension of demand volatility was identified in theory. There are greater benefits to be realised with higher demand volatility. However, when the volatility of demand is high it is more complex to plan and consequently also more challenging to have a VMI arrangement. It is likely that there are more aspects that impact the planning complexity of the product which have not been identified in the theory. In order to broaden the view, the dimension will be termed as planning complexity. The planning complexity will put higher requirements on the capabilities of the actors hence also these categories seem to be interrelated.

2.6 Risk in relationships

The VMI readiness categories identified in the previous section seem to be tightly interrelated. These connections can be explained by the framework of risk, trust and control in relationships developed by Das and Teng (2001). In the first section, this framework will be presented. Thereafter, the risk in VMI relationships will be explained based on the framework and theoretical findings presented in previous sections. This is the second step in the process of developing the VMI suitability framework and answering Q4.

2.6.1 Risk, trust and control in relationships

Das and Teng (2001) presented a framework that proposes that perceived risk in a relationship is determined by the present trust and control mechanisms. Furthermore, the trust affects the control and the control affects the trust. The framework, showing the relations between risk, trust and control, is presented in Figure 3. (Das and Teng, 2001).

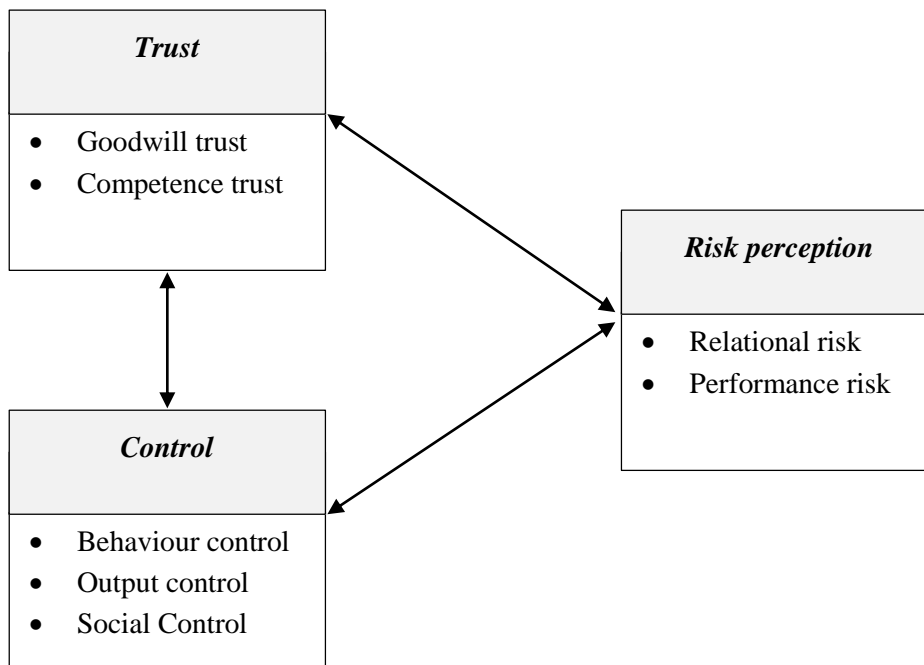


Figure 3. Framework of the connections between trust, control and risk in strategic alliances (Das and Teng, 2001).

Das and Teng (2001) defined two types of risk: relational risk and performance risk. Relational risk is the risk of partners not cooperating in good faith and behaving opportunistically with their own individual interests in mind in a way that does not produce common benefits. A source to relational risk could be individual incentives that conflict with the incentives of the other party or a hidden agenda such as taking over the other firm. Performance risk is the risk of unsatisfactory business performance by not achieving the objectives, regardless of if the cooperation is sufficient or not. Examples of factors that cause performance risk are increased competition, new market entries, fluctuations in demand, new government policies, poor competence of the partnering firms or bad luck. The performance risk is often shared between the partners in the alliance (Das and Teng, 2001).

According to Das and Teng (2001), one of the factors that determine risk is trust. If partners have trust in each other, they expect that good desirable outcomes are likely. Having trust decreases concerns for opportunistic behaviour, and the need for formal

contracting. Trust has two dimensions: competence trust and goodwill trust. Competence trust is the trust in a partner's ability to perform, while goodwill trust is the trust in the integrity of the partner firm or its' will and intentions to perform. Therefore, goodwill trust reduces the perceived relational risk and competence trust reduces the perceived performance risk. Furthermore, both dimensions of trust will enhance effectiveness of control mechanisms (Das and Teng, 2001).

In the framework, Das and Teng (2001) stated that the other factor that determines risk is the control mechanisms. Control is when a firm seeks to impact the partner's behaviour by monitoring or using regulations in order to achieve the organisational goals and minimise the probabilities of undesirable outcomes. Control comes in two forms: formal and informal control. (Das and Teng, 2001)

According to Das and Teng (2001), informal control, or social control, is when shared values and goals for the partner firms are established so the employees are committed to achieve the same goals. The partners influence the behaviour of each other by having frequent communications and thus increasing the understanding and confidence in each other's goodwill and competences. Therefore, social control enhances goodwill trust and competence trust and thus reduces both perceived relational risk and perceived performance risk. Furthermore, social control works best when trust is high (Das and Teng, 2001)

Das and Teng (2001) explained that formal control, on the other hand, has two main modes: behaviour control when the behaviour and processes are measured, and output control when the outcome is measured. Thus, behaviour control reduces the perceived relational risk and output control reduces the perceived performance risk. However, formal control will undermine both dimensions of trust. The reason for that is that having strict rules reduces the autonomy of members to make decisions and can create a mistrusting atmosphere (Das and Teng, 2001).

The different levels of trust and control that are needed depend on the perceived risk. Das and Teng (2001) proposed that:

- The lower the acceptable relational risk, the higher goodwill trust needed or the more use will be of behaviour- and social control.
- The lower the acceptable performance risk, the higher the competence trust needed or the more use will be of output- and social control

2.6.2 Risk assessment

The size of a risk can be assessed based on a combination of the potential financial impact of the risk and the likelihood of it to occur, see Figure 4 (van Weele, 2010). The risks can be plotted into the matrix based on the two aspects. The risks can either be low, medium or high.

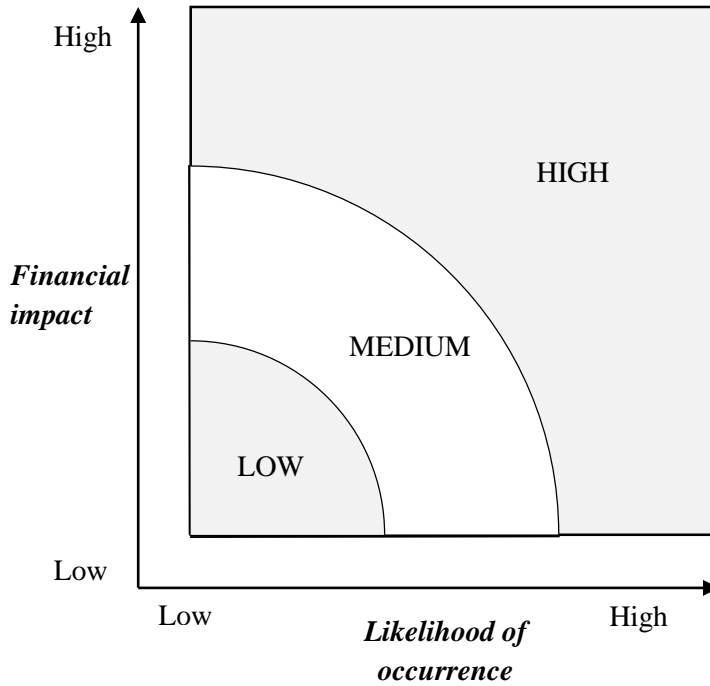


Figure 4. Risk assessment (van Weele, 2010)

2.6.3 Risk in a VMI arrangement

Here, the interrelations of the constituents of VMI readiness, which are the readiness of customer, supplier and relationship and product suitability will be presented and the risk, trust and control framework of Das and Teng (2001) is applied to a situation when a buyer and a supplier enter a VMI arrangement.

The VMI readiness categories impact the perceived performance risk and relational risk in the arrangement. The customer readiness, supplier readiness and product suitability are sources of the two types of risks while the relationship readiness can be related to how the risk can be managed. In VMI, this is the risk of not achieving high service level in a cost efficient way. The links between the two types of risks and the enablers are presented in Figure 5.

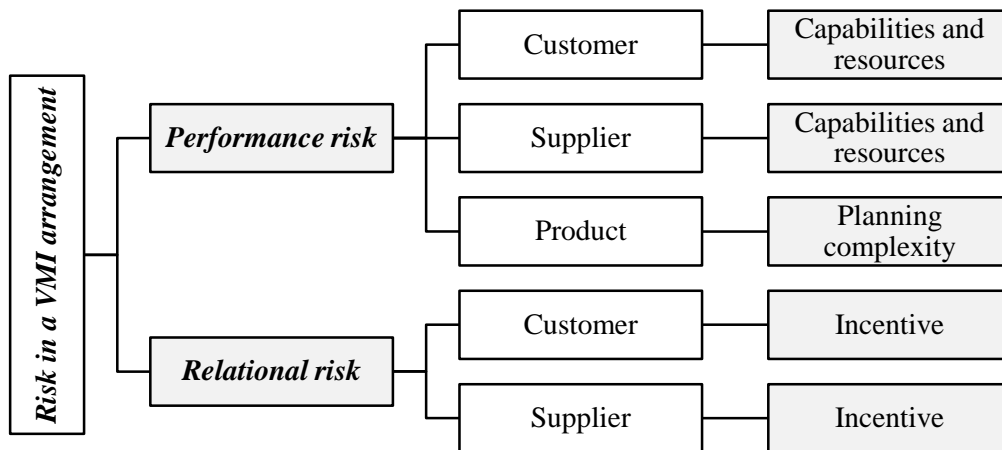


Figure 5. The impact of VMI enablers on the risk in a VMI arrangement.

The performance risk in a VMI arrangement is impacted by aspects related to the customer readiness, supplier readiness and product suitability. The performance risk will be high in the situations where the supplier and the buying firm lacks resources and capabilities. The planning complexity will further increase the challenges of achieving the objectives of VMI. The relational risk, which is the risk of the other party behaving opportunistically, is dependent on aspects related to the customer and the supplier in the setup. It is likely to be high in situations where either of the parties lacks incentives of participating in the setup or in cases where the incentives are contradictory.

Furthermore, the enablers in the category of relationship readiness can be linked to the trust and the control mechanism mentioned by Das and Teng (2001). The relationship readiness considers how the risks in the VMI arrangement can be managed. The relationship readiness represents the relation between trust and control in a VMI arrangement and implies that if there is a lack of trust, some control mechanisms have to be used in order for the arrangement to work. This has been summarised in Figure 6 that shows what measures are suitable for risk management of different types of risks.

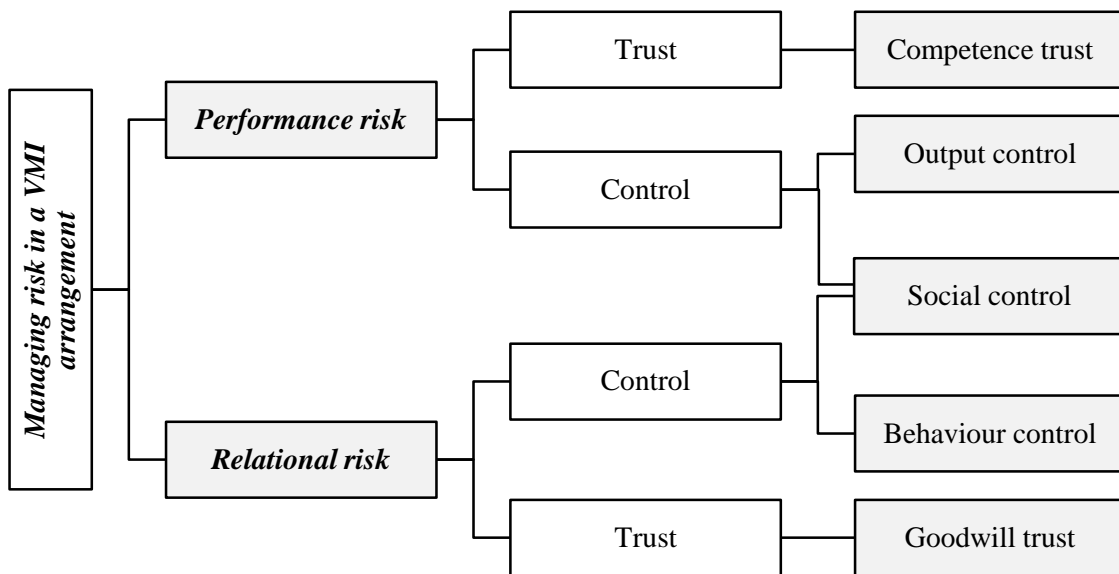


Figure 6. Managing risk in a VMI arrangement.

The performance of the VMI setup will depend on the perceived risk in the arrangement and how the risk is managed. As a customer, the level of control in the order-delivery process is lower than in the PO setup since the responsibility of the replenishment is transferred to the supplier (Kaipia et al., 2002; Pohlen and Goldsby, 2003; Waller et al., 1999). Dong et al. (2007) pointed out that if the supplier lacks operational capabilities, the uncertainty in the inbound logistics process for the buying firm will be high. The buying firm might therefore be resistant to apply VMI since they will lose the control over the process (Dong et al., 2007).

In the situation when VMI is entered although the customer perceives both types of risk to be high and there is a lack of both types of trust there is a need of control mechanisms. Since social control works best when there is trust, only the behavioural and output control remain. Behavioural and output control will undermine both types of trust and limit the flexibility for the supplier. This will further limit the potential benefits gained from VMI, hence VMI might not be suitable. In the situation where both types of risks are perceived to be low and there is a high level of trust, the need of control mechanisms is low. Social control is still recommended since this further builds the two types of trust and does not negatively impact the VMI performance. This situation has the potential to offer the supplier maximum flexibility and to allow for successful application of VMI.

2.7 VMI suitability framework

In this section, the VMI suitability framework is developed. Here, the findings introduced in previous sections will be used in the development of the framework. The framework contributes to the answer of Q4.

Based on the perceived risks in a potential VMI arrangement, the buying firm can assess the suitability of VMI. The buying firm should evaluate the current state risk and the acceptable level of risk of having a VMI arrangement. The acceptable level of risk is dependent on the potential benefits to be gained from taking that risk. When the risk of entering a VMI arrangement is estimated to be higher than the acceptable level of risk, VMI might not be suitable as a replenishment method. However, the perceived risk can be reduced by applying different control mechanism. It is important to point out that the formal control mechanisms should be applied with caution since these can reduce the trust as well as limit the benefits. In order to assess the VMI suitability, the buying firm is recommended to firstly evaluate the company's internal readiness, secondly evaluate the supplier's readiness and thereafter evaluate the product suitability, see Figure 7. The relationship readiness category is not represented as a separate step in the framework, but is included in the assessment of the supplier's readiness.

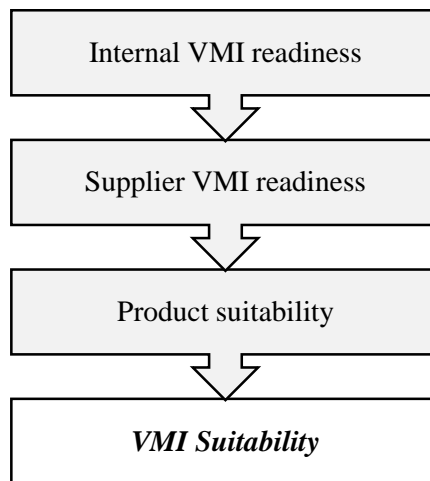


Figure 7. VMI suitability assessment process.

Step 1: Internal VMI readiness assessment

In the first step, the buying firm should assess the internal readiness of the own firm to participate in a VMI arrangement. First of all, the incentives and the improvement potential of applying VMI should be identified. Based on this it could also be decided if basic or advanced VMI matches the firm best. It is important that the incentives are in line with the strategy of the firm and are aligned on all levels in the organisation. If the company lacks incentives, there is no reason to enter a VMI arrangement and the current setup should be kept. Secondly, the buying firm must evaluate if there are capabilities and resources within the firm in order to implement and operate a VMI setup. If the company lacks resources or capabilities, it is recommended that this is developed prior to entering a VMI arrangement.

Step 2: VMI readiness assessment of the supplier

In the second step, the supplier's VMI readiness should be assessed. The supplier's VMI readiness is assessed based on a combination of the perceived performance risk related to the supplier and the perceived relational risk. The perceived supplier performance risk depends on the perceived capabilities and resources of the supplier. The perceived relational risk depends on the incentives of the supplier. Estimating the supplier's incentives provides the buying firm with an insight into if there is a risk that the supplier might behave opportunistically. The size of the risks can be assessed based on the combination of financial impact and likelihood of occurrence according to the risk assessment in Figure 4 (van Weele, 2010).

The combination of the perceived risks will decide whether VMI is suitable or not. This is visualised in the matrix in Figure 8. If both types of risks are low, VMI is likely to be suitable. On the contrary, if both types of risks are high, VMI is not suitable and an alternative replenishment method should be used. In the mixed area, VMI is likely to be suitable in combination with the necessary control mechanisms, which could reduce the risks and move the supplier into the area where VMI is suitable. It is recommended to apply social control in all VMI arrangements since it builds trust and reduces both types of risks.

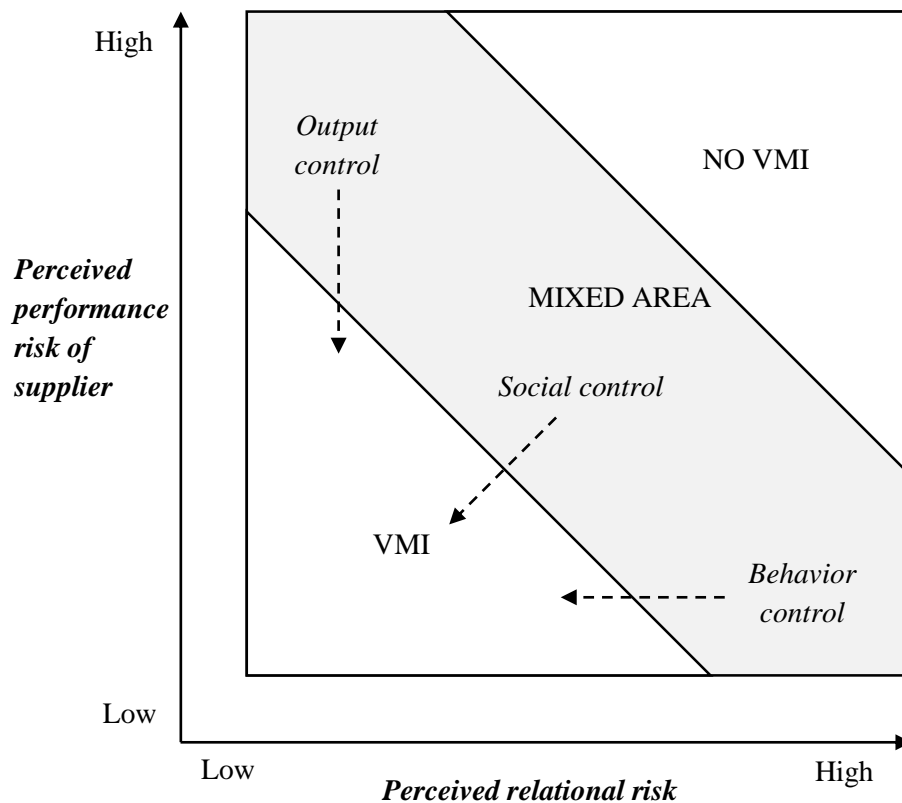


Figure 8. The relationship of the perceived performance risk and perceived relational risk.

Step 3: Product suitability assessment

In the third step, the products suitable to be included in the VMI arrangement should be identified. It is likely that the supplier supplies products within a range of planning complexity, for example with different levels of demand volatility. The products with high planning complexity will require more from the supplier and consequently also increase the perceived performance risk. In the situation where both types of risks are low, the entire product range is likely to be suitable for VMI. However, in the mixed area, the buying firm is recommended to distinguish between products with low and high planning complexity. Initially, it is recommended that VMI is applied for the products with low planning complexity in combination with the required control mechanisms. The VMI setup, could be used for developing trust in order to decrease the perceived risks and ultimately enable the actors to include the remaining products in the setup. This is important since the products with high planning complexity are likely to have great improvement potential. The social control is especially important in this situation, since it enhances both types of trust and thus reduces both types of perceived risks.

3. METHODOLOGY

In this section, the methodology of the study is described and divided into the sections; approach, design and strategy of the study, work procedure and, quality of the study.

3.1 Approach, design and strategy of the study

The approach of this study was mainly deductive with elements of the iterative approach. A deductive approach is when the researcher initially studies theory and then conducts research and data collection based on that. In that way, the research in a deductive approach is based on existing theory (Bryman and Bell, 2003). Abductive approach is when the researcher is constantly going back and forth between theory and data collection, since the theory affects the data that is collected, and the collected data calls for more research of the existing theory (Dubois and Gadde, 2002). Bryman and Bell (2003) termed this as an iterative approach. However, the different approaches should be thought of as tendencies. Having a mixture of the different approaches is a common way of conducting a research, since it is very seldom that a research is purely of one type (Bryman and Bell, 2003). The main parts of the theoretical framework of this report were constructed prior to the empirical data collection. The theory was used for helping formulate the aim and the supporting study questions and thereafter the empirical data was collected. However, the empirical data collection resulted in new findings and it was necessary to go back to the literature to review subjects that were not previously considered relevant to the study.

The research design applied in this study is a case study. The research design is a description of the way a research is conducted. Kothari (2004) explained it as: “the blueprint for the collection, measurement and analysis of data.” Since the aim of this study was to develop a framework for the suitability of VMI and adjusting it to the specific context of the case company, using a case study design was considered appropriate. According to Bryman and Bell (2003), a case study involves exploring a specific case in detail, which can either be a single organisation, a single location, a person or a single event. One single manufacturing plant at an organisation was the main subject and was explored in great detail.

The research strategy of this study is purely *qualitative* which was deemed most suitable, based on the nature of the study questions and the fact that this is a case study. The strategy of a research can either be quantitative, qualitative or a mix of the two, which is termed as mixed methods (Borrego, Douglas and Amelink, 2009). The basic difference between these two main approaches is that the data collection and analysis in quantitative research are based on numerical data, while the qualitative research consists of data that is not quantified (Bryman and Bell, 2003). Since the empirical data was collected from this one specific company and supplier, the sample size, 9 people, was considered to be too small to apply the quantitative approach.

3.2 Work procedure

This section of the methodology describes the elements of the work procedure of the study and includes the steps of literature review, empirical data collection and data analysis.

3.2.1 Theoretical framework

Firstly, in order to study and analyse the VMI setup at the case company, a thorough review of literature on the topic was conducted. Based on the review, the theoretical framework was constructed. In order to fulfil the aim of the study and to answer the supporting questions the following sections were included in the theoretical framework:

- Definitions of VMI
- Configurations of VMI
- Effects and performance measurements of VMI
- Enablers for realising the effects of VMI
- VMI Readiness
- Risk in relationships
- VMI suitability framework

A broad range of literature on the topic of VMI was reviewed. The literature search was conducted on the Chalmers Library database and on Google Scholar. The search words used were: VMI, Vendor Managed Inventory, Collaborative Planning, Configuration, Design, KPIs, Effects, Benefits, Drawbacks, Enablers, Barriers, Risk, Relationship, Suitability, Feasibility, Product Characteristics.

3.2.2 Empirical data collection

Empirical data was collected in order to: evaluate the accuracy of the findings in theory, further develop the framework, and develop guidelines to the case company. Both primary and secondary data, regarding the VMI setup at the case company and the studied supplier was collected. Primary data is original data that is collected for the first time, while secondary data has already been collected and statistically processed (Kothari, 2004). Primary data can be collected through observation, interviews, questionnaires, schedules and other methods (Kothari, 2004). The empirical data in this study mainly consist of primary data and has been collected through interviews. Complementary data from one additional interviewee was collected through e-mail correspondence. Secondary data in the form of internal documents has also been used.

In total, eight interviews, 60-120 minutes each, with seven different people, were conducted. The details regarding the characteristics of the interviews are presented in Appendix I. The interviewees were selected in cooperation with the case company based on their background, position and assumed input in regards to the different topics of the study. Interviews can differ in the level of structure and can either be structured, semi-structured or unstructured. The outcome of the different types of

interviews will differ; hence it is important to consider the aim of the interviews when deciding the level of structure (Kothari, 2004; Leech, 2002). In this study, both unstructured and semi-structured interviews have been conducted depending on the aim of the interviews. The data from the interviews was complemented with additional information collected by e-mail, from a demand planner that is involved in tasks on the strategic level at the studied supplier.

In the initial phase of the study, when developing the aim, scope and supporting questions, one unstructured interview was conducted in order to gain an understanding of the concept of VMI within the case company. Unstructured interviews are not structured on beforehand (Kothari, 2004) and have been described as a conversation where the topic can change during the interview (Leech, 2002). Furthermore, it offers flexibility since the interviewer is able to change the order of the questions and follow up with additional questions (Kothari, 2004). It was considered to be a feasible technique for the first interview in the initial phase of the study since the interviewers had limited knowledge of the topic and therefore it was not possible to create a good questionnaire beforehand. Unstructured interviews were not conducted in other phases of the study due to the importance of being able to compare findings from different interviews, which would have been difficult due to the unstructured nature (Leech, 2002).

The seven remaining interviews were of a semi-structured nature and were conducted after the theoretical framework had been constructed and the aim and study questions had been formulated. At this point in time, the interviewers were highly familiar with the concept of VMI and the related topics. Semi-structured interviews are a mix of the structured and unstructured interviews. A purely structured interview would follow a predetermined list of questions and in some cases also have pre-specified options for the answers. When conducting a semi-structured interview, the researcher has prepared questions beforehand and structured the interview, but is also able to follow up the pre-defined questions by asking additional questions. The semi-structured interview offers “detail, depth and an insider’s perspective” (Leech, 2002). In addition to the interviews, complementary questions were sent by e-mail to one employee at the studied supplier in order to fill in gaps in the empirical data. The interview guides used in this study can be found in Appendixes II-V.

Besides the primary data, the empirical data collection has also been complemented with internal documents from the case company, such as presentation material describing different parts of the VMI setup. This was considered to provide deeper knowledge and understanding of the VMI application and definition at the case company. The employees at the case company have confirmed the accuracy of the secondary data.

3.2.3 Data analysis

In order to evaluate the framework developed from theory and to develop guidelines to the case company, an analysis of the data was carried out. The analysis of the data in this study was firstly carried out by a within-case analysis, and then by comparing empirical findings with the theoretical framework. Within-case analyses are descriptive texts of the cases in the research and are critical for the researchers' insight and understanding of the data (Eisenhardt, 1989). The section "Case Study" in this report presents the within-case analysis of this study that is carried out in two sections. The data collected for the general VMI setup at the company and the data collected for the specific setup with the studied supplier was compiled separately. This approach enables the researchers to distinguish the patterns in each case (Eisenhardt, 1989). In the section "Analysis", the findings from the within-case analysis are compared to theory in order to study similarities and differences. This lays the foundation for case company specific recommendations and guidelines of how the VMI suitability framework can be applied in this context.

3.3 Quality of the study

Both of the interviewers were present at all the interviews in order to ensure the quality of the empirical data collection. That way, the two benefits of having multiple investigators, pointed out by Eisenhardt (1989), were achieved. The first benefit is that by having several interviewers it is possible to contribute with different insights and perspectives and thus increase the probability of realising new aspects of the data. The second benefit is that the contradictory perspectives prevent the researchers from making early conclusions. This contributes to confidence in the findings from the empirical data collection.

Bryman and Bell (2003) defined three different criteria that should be considered when evaluating business and management research: reliability, replication and validity. The criterion of reliability concerns whether or not the study results are repeatable at another time. A study is replicable if the researcher has described the study procedure in enough detail so someone else can conduct it again. The most important criterion is the validity of research, which concerns the integrity of the conclusions (Bryman and Bell, 2003). In the specific context of case studies similar to this one, Yin (1994) described three different challenges for ensuring the research quality. The first one is that often there is a concern about lack of quality and accuracy in the study itself. The second one is concern about it being difficult to generalise from a single case. Finally, there are concerns about information overflow.

Those challenges were dealt with by recording all the interviews, so the interviewers could listen to them again in order to analyse the data accurately. Also summaries of the interview notes were sent to the interviewees in order to clarify any potential misinterpretation. The problem was defined in detail before the semi-structured interviews were held in order to avoid collecting unnecessary data. The questionnaires

for the seven interviews were sent to the interviewees approximately one week prior to the meeting in order for the individuals to prepare for the interviews. This was done in order to ensure the quality of the outcome of the interviews. Furthermore, it has to be kept in mind that the purpose of case studies is to investigate and describe a specific case or a small number of cases in detail. The purpose is not to generalise about other cases beyond the one that is being investigated, since the findings in a case study are considered to be specific to its context (Borrego et al., 2009; Bryman and Bell, 2003). However, a detailed and thorough description of the case study enables the reader to assess if the findings are applicable in any other context and in that case also possible to transfer (Borrego et al., 2009). Therefore, the studied case was described in detail.

4. CASE STUDY

This section of the report consists of a case description where the findings of the empirical data collection are presented. The case description is divided into two parts; the first part presents the case company in general and the second part presents the specific setup with one studied supplier. In both sections the setups are described in regards to the background, definition and configuration of VMI, expected and realised effects of VMI and enablers for realising the effects. Lastly, the important aspects to consider when evaluating the suitability of VMI, generated from the interviews, are summarised.

4.1 General case company description

The general case company description describes the general situation at the company and presents examples from several different VMI setups. Since only one tactical manager was interviewed at the case company, the term “manager” will be used for managers on both tactical and strategic levels.

4.1.1 General introduction of the case company

The manufacturing site studied in this report is located in Sweden and is part of a global corporation. They produce technological products and the main customers are other businesses and organisations. The purchasing operations at the case company are either carried out in a PO setup or a VMI setup. The PO setup can be more or less automated. The least automated setup is when the POs and order confirmations are sent by e-mail, the next level of automation is when the PO is sent through an EDI connection, but the order confirmation is received by e-mail, and the highest level of automation is when a tool called SNC is used. The highest level of automation is called Purchase Order Collaboration (POC). SNC makes it possible to both send POs and receive order confirmations in the system, which eliminates large parts of the administration related to placing POs. In the VMI setup, the supplier is responsible for the replenishment decision and the task of placing POs is eliminated.

The relationships with the suppliers consist of three different levels of interpersonal communication. On the operational level, the purchaser at the case company and the sales support at the suppliers' have daily contact focusing on daily orders. On the next level, the case company has Category Managers that are in contact with the Key Account Managers (KAM) at the suppliers'. They interact on a monthly basis, discussing processes, capacity and long-term upsizing of the business. This is considered to be the closest relationship of the three. The case company is supposed to have monthly meetings where forecasts and potential businesses are discussed with all of their key suppliers, which are suppliers that they purchase from in high volumes or value. However, due to recent organisational changes there are currently not enough resources to maintain these meetings. On the highest level, the sourcing department at the case company is communicating quarterly with KAMs. The relationship is price

focused, aiming at lowering the prices and negotiating contracts. This is visualised in Table 4.

Table 4. Organisational structure of the purchasing function.

<i>Role at Case Company</i>	<i>Role at suppliers</i>	<i>Level in organisation</i>	<i>Frequency of communication</i>	<i>Responsibilities</i>
Operational Purchaser	Sales Support/ Customer Service	Operational	Daily	Purchasing operations
Category Manager	Key Account Manager (KAM)	Tactical	Monthly	Processes and capacity
Sourcing department	Key Account Manager (KAM)	Strategic	Quarterly	Negotiating contracts

4.1.2 General background of VMI at the case company

Approximately 8-9 years ago, when most of the POs were sent in the least automated way, the top management at the case company had set the objective to increase the share of VMI usage. VMI was pushed out and implemented with as many suppliers as possible. The results of the implementations were mixed and several suppliers have since then been taken out of the VMI setup. According to one of the managers, the case company still suffers from this strategy.

There are many reasons why suppliers have been taken out of the VMI setup. One of the operational purchasers stated that POC has put aside the usage of VMI. Another operational buyer suggested that the reason might be that there is more control in the PO setup. Some suppliers were removed from the VMI setup because the case company constantly had to remind the supplier to replenish and the stock levels were not kept as agreed. Also, in some situations, the case company has changed suppliers and then the VMI arrangement has been terminated. Another reason is that the volumes purchased from some VMI suppliers have decreased and therefore the companies have decided to change back to using POs.

There is no standard process of evaluating and deciding when VMI should be applied. When implementing VMI with a supplier, it is usually done by implementing VMI for all the products from that particular supplier, regardless of the different product characteristics. However, there are some examples of suppliers where VMI is only applied for some of the products.

4.1.3 General definition of VMI at the case company

The definition of VMI below has been decided upon at the studied site. The definition is only used at the local site and is not applied globally in the company. VMI is defined as:

“An inventory planning and fulfilment technique in which a supplier is responsible for monitoring and restocking customer inventory at the appropriate time to maintain predefined levels. The vendor is given access to current customer inventory, forecast and sales order information and initiates replenishment as required” (Bridgefield Group, n.d.)

The interviewees were asked to define VMI. All mentioned that in VMI setups the suppliers are responsible for the replenishment of the buyer's stock and to keep the stock level within agreed minimum and maximum levels. Furthermore, the suppliers are given access in the system to the necessary information that enables them to handle the replenishment. The buyer is responsible for making the information available to the suppliers.

The managers also mentioned that the process should be automatic and the suppliers should be able to keep the agreed buffer levels, regardless of the situation. Moreover, the suppliers should place replenishment orders based on the lead time in the system and send out early warnings if the commitments will not be fulfilled.

4.1.4 General configuration of VMI at the case company

In the general VMI setup between the case company and suppliers, the suppliers take over the responsibility of replenishment and the case company provides the required demand data. The suppliers are then responsible for managing the replenishment of the buffer at the site of the case company and to keep the agreed levels. The suppliers are obliged to review the shared data, at a minimum once per day, create the needed replenishment orders and decide what, when and how much to replenish. In situations when the suppliers are not able to deliver in time, they are responsible for sending early warnings to the case company. The suppliers also have to share future supply capacity, status and reason for material shortages or excess material.

The main responsibility of the case company is to provide correct data. The case company shares information such as customer orders and stock levels every 15 minutes but also a strategic forecast on a monthly basis. The case company has to communicate proactively by sharing information about last minute changes of demand and deviations from agreed flexibility. The case company is responsible for planning against the known supply capacity at the suppliers and make forecasts of the future demand. Additionally, their role is to define the minimum and maximum levels for each product and to measure the service levels. The case company defines upper and lower limits of the stock, both at their site and also at the suppliers if there is an agreed outbound stock. Furthermore, the case company is responsible for paying the suppliers.

A logistics agreement (LA) should be signed by both parties and include responsibilities and the safety stock at the site of the case company and at the suppliers'. Unfortunately, it seems as if there are no updated agreements at the case company. The logistics agreement sometimes includes an agreement of the phase out of the product. The suppliers and the case company agree on what should happen with the components left in the buffer when the case company no longer purchases the articles. Often this means that the case company is responsible for paying for the items not sold. The LA includes penalty clauses for when the buffer levels are not met in the agreements. However, the penalty clauses are seldom applied since it could possibly harm the relationship.

4.1.5 Expected effects of VMI in general at the case company

The expected effects of VMI at the case company in general, identified in the interviews are:

- Reduction in administration cost
- Reduction in inventory cost
- Increased service levels
- Risk sharing
- Improved relationship
- Better planning of operations at the supplier
- Increased accuracy and visibility of the demand information shared with the supplier

All the interviewees from the case company shared the idea that the aim of using VMI is to decrease administration at the case company. One interviewee explained that VMI should enable better resource utilisation by working with more proactive activities on the tactical and strategic level instead of the operational activity of placing POs. However, one manager expected that the case company would still have to monitor the suppliers in order to make sure that the commitments of planning and replenishment were fulfilled.

The interviewees also had expectations on the effect on inventory levels. One manager expected potential reductions in the inventory buffers due to the improved transparency of the inventory levels at the supplier and the customer. Another manager expected a slightly higher buffer level at the site of the case company, but that it would result in higher service levels. The same manager expected the supplier to hold more inventories. The service level was expected to increase with VMI and the visibility of demand should help the supplier to plan better and thus decrease the possibility of stock out.

One of the managers mentioned that a VMI setup, where the way of working and the liabilities have been agreed on, could increase cooperation and enable risk sharing of carrying inventories, since it is visible to the suppliers that the buying firm carries one

part of the risk. The early warning process and overall better information flow was expected by some of the managers to lead to increased cooperation between the companies. One of the operational purchasers pointed out that VMI could help to build trust between the buyer and the suppliers.

The early information flow was expected to be beneficial for the suppliers. The suppliers should be able to optimise their production and by that reduce their manufacturing cost. Also, the suppliers should be able to see the trends in the future demand and independently decide if the capacity needs to be increased. The shared demand information in the VMI setup was expected to be more reliable and reduce the uncertainty, which could enable the suppliers to produce in advance with less risk. It was further expected that the flexibility for the suppliers would increase in regards to quantity and timing of replenishment and shipment. The suppliers were therefore expected to be able to consolidate the goods and optimise the transportation.

4.1.6 Realised effects of VMI in general at the case company

The case company did not have tools in place for measuring the real effects of VMI. Consequently, the case company had not been able to evaluate the performance in quantitative terms. The realised effects of VMI are therefore based on the employees' personal experiences of the setup. There seemed to be a common understanding in the company that the realised effects varied between different setups. Supporting facts regarding the experienced effects in general were identified in the interviews and are presented here. The interviewees mentioned the effects on:

- Administration
- Inventory levels
- Service level
- Planning opportunities for the suppliers

Regarding the effect of VMI on the administration, two operational buyers pointed out that when VMI works well, the process does not need any manual handling and therefore the buyers will not notice all the setups that work well. Further, it was explained that since the buyers are responsible for deviation handling, these are the situations that will be paid attention to and therefore their experience of VMI might be negative in regards to the administration. The operational buyers explained that compared to the least automated mode of POs, the VMI setup reduces the administration and the risk for erroneous orders. However, compared to the POC the timesaving was considered to be almost none. One positive aspect regarding administration in VMI was that the supplier has the full picture of the demand and does not have to double check delivery dates with the buying firm, which will save some time. Also, in situations when VMI works well, not much time has to be put into monitoring and controlling and the setup was in these cases considered to work smoothly. However, in situations with more than one supplier and when one of the

suppliers cannot deliver, the rerouting of the demand to another supplier requires manual handling due to system limitations, which is time consuming. In these situations, the administration was considered to be significantly higher than if VMI would not have been used. One operational buyer stated that the potential of the small savings in administration is not worth the risk of these situations. Only in the situation when it flows smoothly, it would not make any difference if the setup was POC or VMI.

There are mixed experiences of the effects on inventory levels. Some interviewees thought the inventory levels for products with stable demand might have decreased due to the additional information available to the supplier, while others thought VMI could have resulted in higher inventory levels. One manager at the case company mentioned that the buffers are not always reduced in the VMI setting. Several interviewees mentioned that some suppliers tend to overstock. For some suppliers, this is especially visible in the end of financial periods. Although there are agreed buffer levels, the case company cannot hinder the supplier to overstock. There are service level measurements in place for the buffer levels but one manager stated that the company does not spend sufficient time on following up on these.

Regarding the information sharing, both operational purchasers pointed out that the increased information sharing allows for better visibility. This makes it possible for the supplier to make better plans, based on the actual demand instead of forecasts. Both of the operational purchasers stated that these planning benefits were only realised for the high running products when the demand was stable. One of the managers gave an example of a successful supplier where VMI was implemented in combination with a nearby hub. The implementation resulted in significant benefits where the supplier could optimise and smoothen their production. Consequently, the service level towards the case company was also stabilised. Another example was mentioned by an operational buyer, also for a supplier with a hub close by, where the supplier is able to consolidate shipments due to the flexibility offered in regards to timing and quantity. The number of deliveries was in this case possible to be reduced.

4.1.7 Measuring the effects of VMI at the case company

Currently the case company does not measure the effects and the performance of VMI. There are no tools in place in order for the company to evaluate the performance and compare it to the PO setup. There are measurements for the service level both in the PO and the VMI setup, but these are not comparable. In the VMI setup, it is measured how well the supplier manages to stay within the control limits of the buffer at the site of the case company. In the PO setup, it is measured how well the quantity and timing of deliveries corresponds to the PO. In the interviews, it was highlighted that the measurements are not always accurate. The inventory levels at the case company are measured, but the total inventory level for the actors in the VMI setup is not evaluated. The operational buyers follow up on individual stock levels when these are over or

under the agreed levels. However, the finance department carries out the follow up on a more general level. No further measurements have been identified in the interviews. The interviewees from the case company stated that it is challenging to measure some of the benefits, but that it has to be improved. Furthermore, interviewees from the case company mentioned that in general, the company is suffering from a shortage of resources, which makes it difficult for them to improve the situation by measuring the performance and following up. One interviewee suggested that one person should be assigned the responsibility for the measurements in order to improve the performance evaluation.

4.1.8 General enablers of VMI at the case company

In regards to the VMI enablers at the case company in general, the following enablers were identified in the interviews:

- Single sourcing
- Customer size
- Limited need of controlling and monitoring of the supplier
- Relationship and willingness
- Dedicated personnel at the supplier
- Formal agreement in place
- The supplier integrates information into the production
- Resources of the case company available

Single sourcing has shown to be an enabler for the case company, in order to achieve benefits in regards to administration. Having several suppliers, where at least one is a VMI supplier, has shown to be challenging due to system limitations. The situation where one of the suppliers cannot deliver and the demand must be rerouted to another supplier requires significant administration. Having several suppliers has also shown to distort the demand towards the suppliers in the setup. If one of the suppliers delivers in big batches, then there will not be any demand visible in the system for the other suppliers until this batch is consumed. Also in the case where one of the suppliers is not able to meet their share of the total demand, this will not be visible to the other suppliers in the system. In this situation, the stock levels at the buying firm will seem to be on an appropriate level to the other suppliers. The case company will then have to go around the system and request the other suppliers to deliver more.

Another enabler for VMI performance is that the case company should be a large customer to the suppliers. Firstly, it was pointed out that if being a small customer, it would be difficult for the case company to introduce the concept to the suppliers. Secondly, being a small customer might result in operational difficulties. One of the operational buyers suggested that in the perfect situation, the case company would be the only customer and get all the attention. Another interviewee mentioned one specific supplier where the company stands for a small part of the supplier's total

volume. The products that the case company purchase are produced when there is an available slot in the production. The interviewee speculated that in a VMI setup, such a supplier would produce and ship products in large batches to the site of the case company and let them carry the cost of the inventory. Another example was given when the case company was a small customer and a VMI agreement was cancelled. The case company experienced issues with the system because the supplier did not put in the time to learn how to use the system. Due to the lack of commitment, the VMI arrangement was terminated.

Another enabler pinpointed in the interviews is when there is limited need of controlling and monitoring of the suppliers. Controlling and monitoring activities of the suppliers limit the savings that can be achieved in regards to administration. Some suppliers do not follow the agreed process of sending early warnings when there are issues with the deliveries. Also, there are suppliers that rely on that the case company should notify them if the inventory levels are not kept as agreed. The case company does therefore not trust that the supplier takes the full ownership of the replenishment and as a result, time has to be spent on monitoring and following up on deliveries. One example was mentioned where the supplier only acts on the directives from the case company and does not put in any extra effort. Also, the supplier does not inform about deviations through the early warning process. An enabler mentioned in several interviews is therefore proactive information sharing. One manager stated that in these cases, the case company is back with the responsibility of ensuring the product availability. Also that in these cases, the PO setup is more preferable since, in the process of sending and confirming POs, the parties agree on quantity and timing which gives more of a black and white picture. In this setup, the responsibilities are clear which makes it easier to handle deviations. In the interviews it is also highlighted that the management expects the operational buyers to be able to provide detailed information regarding product availability, which is not in line with the idea of VMI. In the daily planning meetings, the purchasers receive questions regarding specific stock levels and therefore put time into monitoring those in order to be able to provide the requested data.

All the interviewees stated that the relationship and the willingness are important enablers for the VMI performance. One of the managers pointed out that the people on the different levels in the relationship should know each other. Two interviewees pointed out that the relationship does not necessarily have to be good prior to the VMI but that there must be a willingness to put in resources in order to make it work well. Another interviewee stated that the relationship should be long term before setting up VMI. One example is mentioned when the supplier does not review the system daily which one operational buyer speculated was due to unwillingness. In the case when there was willingness, the same interviewee was of the opinion that the relationship can be built. There was also a common perception that the relationship should be long term and that the outlook is that the suppliers should stay as suppliers. One of the

managers stated that it should be long term and a good relationship, since with the VMI setup the case company puts trust in that the suppliers should be able to fulfil the responsibilities. The contract should cover more than one year in order to enable stability in the operations. It is first after some months that the operations are up and running and in the end of the contract there are uncertainties regarding the future. One of the managers stated that it is also important that the suppliers have the resources to handle a VMI setup and a good organisation. According to this person, it is not sufficient with offshored help desks; there is a need for dedicated personnel at the suppliers'. Another interviewee also stated that dedicated people is a prerequisite and that it is important that the suppliers do not exchange the customer support too often, since this requires training in the system.

Two of the managers, suggested that a formal agreement should be in place. A signed contract could be seen as a formal acceptance of the VMI arrangement. This agreement has to include clearly defined liability clauses regarding responsibilities and ownership of the goods also in the cases of phasing in or out products. One of the managers stated that following the liabilities is more important in the case of VMI than in the regular PO setup.

In order to gain the full benefits of VMI, the suppliers need to use the information received from the case company to trigger the production. According to the managers, the internal productions of the suppliers have to be aligned with the expectations of the customer and there must be a seamless integration of processes. One of the managers in the case company explained that sometimes the control levels are set too tight, which is a barrier since it takes away the flexibility for the suppliers to plan. Then the suppliers cannot utilise the demand information to optimise their production.

Another enabler that is mentioned is that the case company must put resources in the VMI setup. Resources are needed in order to educate the suppliers and build the understanding of how to use the system and understand their responsibilities. One operational buyer, pointed out that the case company should support in the training of employees that are new to the setup at the suppliers'. One of the operational buyers stated that in some cases, suppliers over-deliver due to lack of understanding of VMI and that this is a consequence of the case company not working actively with the suppliers in VMI arrangements. The same interviewee gave an example of a supplier that did not use the system in their production planning due to lack of understanding and said that this often resulted in overstocking. Resources are also required in order for the case company to follow up on measurements. One of the managers pointed out that more time should be spent on following up on the service levels in order to improve the control of the overstocking.

4.1.9 Product characteristics influencing the VMI performance in general

All the interviewees pointed out that different product related aspects impact the performance of VMI. The dimensions mentioned in the interviews will be presented here. These are:

- Demand pattern
- Lead time
- Value
- Size
- Product life cycle
- Complexity of supplier's manufacturing process

All the interviewees at the case company stated that the demand of the product should be high, stable and frequent. The reason was that volatile demand is challenging to handle and requires that the suppliers keep high stock levels, which is costly. Another interviewee pointed out that, when it is too costly and high risk to keep inventories, the suppliers are not likely to do it. It is stated that in these cases there must be a liability agreement in place that states that the case company will carry the cost, which could be costly for the case company. Two of the interviewees pointed out the importance of the suppliers being financially capable of keeping stock. In the situation with volatile demand, it is challenging to meet the required service levels. One of the buyers pointed out that there would be the same challenges in regards to meeting demand in a PO setup with a single supplier. Additionally, if the suppliers are not able to handle the volatility, the case company has to put more time into monitoring and controlling. One of the managers also pointed out that in the end of a product life cycle, there is higher risk for high cost of obsolete goods and that it would therefore be better to have POs. The same manager pointed out that the length of the product life cycle is decreasing. Another interviewee highlighted that there are not many products within their company with stable demand due to that they have a wide product portfolio.

The lead-time was also pointed out, by all interviewees at the case company, as important for the VMI performance. One interviewee pointed out that it was always challenging with long lead times regardless of the choice of replenishment method. The reason given for this was that during long lead times, a lot could happen to the demand. Consequently, the quantity delivered will not correspond to the demand and time has been put into controlling and monitoring. A stable demand and long lead-time is considered to be a possible combination for VMI. One manager pointed out that the case company often expects short lead times in the VMI setup, and therefore the suppliers are often required to keep finished goods or semi finished goods in stock. One successful example was mentioned where a supplier located in Asia has set up a hub nearby the site of the case company. Stock is kept at the hub, which ensures short lead times. However, it was pointed out that the solution is only suitable when demand

is stable, since the supplier is not likely to be willing to keep stock of products with infrequent demand.

Two interviewees also pointed out the impact of the value of the product. One manager mentioned that in these cases the suppliers will have difficulties to keep stock. At the same time, one of the buyers mentioned that there is a risk that the case company ends up with high value items in stock in the cases when the suppliers overstock. Furthermore, two interviewees mentioned the size of the product. It has to be considered in the VMI setup when the products are large and challenging to store. One example is mentioned where there is no space to store the product due to its size. In this case, no control limits can be set since no buffer can be kept.

4.2 Case description of the specific setup with the studied supplier

In this study, a supplier which the case company considers being one of the suppliers that the VMI setup works well with was investigated in more detail. This section describes the background of this specific supplier, the relationship with the supplier, the effects of VMI, and the enablers identified in this setup.

4.2.1 Background of the studied supplier

The supplier is a global company and supplies products and solutions. This study is limited to the supplier's manufacturing site in Eastern Europe. The company is categorised as a strategic supplier and has been supplying to the case company for more than 20 years. The purchasing from the studied supplier stands for approximately 25% of the case company's total purchasing and is split over 200-300 products. The products are single sourced and important for the performance of the case company's end products. The market for these products is considered to be small and there is a limited number of suppliers available. The product characteristics vary both in size, price and demand pattern. Two years ago, the parties signed a three-year contract which could be considered long term since the standard for the case company is to have contracts that stretch over one year. The fact that the case company has allocated all volume with the supplier has enabled them to make the products more competitive. When the three-year contract was signed, the supplier developed a modular concept of the products, which generates benefits for both parties. The VMI setup has been in place since around 2001 and covers all products supplied from the studied manufacturing site of the supplier. This is the largest supplier that the case company has a VMI setup with. Moreover, the case company is the only customer that the supplier has a VMI setup with. For all other customers regular POs are used. The supplier has dedicated people that handle the operational tasks at their site.

In the interviews, both parties described the relationship between the supplier and the case company as close, cooperative and long-term. The power balance is pointed out as healthy by interviewees from both sides. However, since the supplier has developed the modular concept, which no other supplier can offer, one interviewee at the case

company argued that they might be slightly more dependent on the supplier. Still, according to the interviewees at the supplier, the case company is one of the supplier's largest and most important customers. The case company described the communication between the actors to be better and more open than the average. Further it was explained that the supplier is one of the few that the case company still has monthly phone meetings with, despite the organisational changes. In the monthly meetings, the strategic forecast, other sales opportunities and on-going negotiations are shared in order to support the supplier in the dimensioning of their production. Also, the delivery performance of the supplier is discussed. One of the operational buyers pointed out that the products supplied in this specific setup are unique and it is of high importance that the supplier trusts the forecasts. Also, interviewees from the case company consider the supplier to be open in sharing information in cases where there are issues with deliveries. Both partners state that they trust each other to perform to the best of their abilities. One interviewee at the case company stated that it might be good to have a logistics agreement in place but that there is also trust in the relationship and thus this might not be needed.

4.2.2 The studied supplier's definition of VMI

The interviewees at the supplier provided no written definition of VMI. However, their own understanding of the concept was elaborated on in the interviews. One of the interviewees from the studied supplier described VMI as a supply chain model where the customers share demand information such as inventory levels, forecast and sales orders with the supplier. The supplier is responsible for maintaining inventory level of the products in the VMI arrangement based on the demand information provided. In the other interview, the interviewee explained that they see the demand in the system and are responsible for replenishing based on this information.

4.2.3 Configuration of VMI in the setup with the studied supplier

The case company configure the VMI setup with the studied supplier similar to all other VMI setups in the company. However, some parts of the configuration are dependent on the supplier. In this section, the parts of the configuration that the supplier controls will be highlighted. The supplier has an outbound stock for some products with long lead times, but for most of the products the early demand data is utilised in the production planning in order to eliminate the needed stock. The supplier reviews the demand information and stock levels at their own site every day in order to make replenishment decisions. If needed, the available capacity is overviewed in order to see if it is possible to produce what is required in order to keep the stock level within the control limits. The demand information provided by the case company is used as an input to the supplier's forecast in order to plan material supply and capacity requirements. In the planning process, the case company's demand is overviewed separately from the other customers. Furthermore, each item for the case company is considered individually. At the case company, the operational purchaser reviews the

critical products that are deviating from the agreed stock levels. This takes approximately one hour every day.

4.2.4 Effects of VMI in the setup with the specific supplier

The aim of the case company implementing VMI with this supplier, identified in the interviews, was to reduce the manual handling and the internal cost of using POs. The supplier's main idea, stated in the interviews, was to have better visibility of customer requirements and to shorten response time to demand changes. The realised effects identified in the interviews are:

- Reduced administration
- Increased service level
- Improved inventory levels
- Increased accuracy of demand data
- Improved planning of production and transport
- Improved relationship
- More visibility of information

The case company stated that less administration related to placing POs has been experienced after VMI was initiated with this supplier. Prior to the implementation, the activity of placing POs was not automated and therefore involved administration. One of the managers stated that the case company does not necessarily save time in the VMI setup since the supplier is a large and strategic supplier, and therefore, regardless of PO or VMI, the relationship requires that attention is put into it. Another interviewee at the case company stated that the company does not have to spend much time on monitoring and following up in this setup since the supplier is reliable. Also, it is pointed out that since the products are single sourced, the setup does not require much operational work in case of deviations. The interviewees at the supplier stated that more time is spent on administration with VMI than with POs, but that it is worth the benefits gained from VMI.

The interviewees at the case company noticed increased service level in this setup and stated that there are seldom any problems with the deliveries. One of the interviewees from the supplier said that after implementing VMI, the on-time deliveries have been improved and the number of emergency order has been decreased. One of the interviewees from the supplier stated that although all other customers are served through PO setups, the other customers might also benefit from the increased accuracy in planning achieved by the VMI setup. The supplier stated that they are able to be more flexible and agile and provide overall better service with the up-to-date information. Furthermore, the supplier stated that VMI makes the process more simple and shorter, with fewer people involved, which allows for higher responsiveness and quicker reactions. Also, one of the managers at the case company stated that the supplier was better at keeping the right inventory levels with VMI than prior to the

implementation and that the levels might be slightly lower. The supplier is considered by the case company to be good at keeping the right inventory levels.

Another benefit gained from VMI, pointed out by the case company, is that the supplier trusts the information that is provided by the case company. The monthly meetings are considered to contribute to this. The supplier pointed out the benefit that the information is up to date, the real demand is visible and it is possible to see changes in demand directly. The case company has noticed that the supplier is taking advantage of being able to consolidate the shipments and improve their planning. The supplier stated that VMI enables them to improve their logistics and consolidate shipments. Both the case company and the supplier point out that with VMI, the supplier is able to plan the production and capacity based on the additional information received. The demand information and the increased reliability in the forecast is considered to enable the supplier to act earlier and secure materials for their production in time. This is pointed out to be especially important when the replenishment lead times of material is long lead times. It is also considered to enable the supplier to react faster to changes in demand. The supplier states that they have also managed to shorten the lead times for some products and reduce the number of complaints. One interviewee recognised that it was partly due to fewer people being involved in the process, because “people are people, they make mistakes”.

Furthermore, the supplier stated that having a VMI setup has improved the relationship with the case company; this was recognised to be a benefit for both partners. Also, the supplier pointed out that VMI benefits both parties.

4.2.5 Enablers of VMI in the setup with the studied supplier

The enablers in the VMI setup with the studied supplier, identified in the interviews are:

- Trust
- Proactive information sharing
- Willingness of the supplier
- Supplier uses information in production planning
- Single sourcing
- Large customers

The relationship is pointed out as the main reason why the setup with the studied supplier can be considered to be successful. The case company and the supplier highlighted the trust and the open information sharing as enablers. Two of the interviewees from the case company, stated that the fact that the studied supplier is proactive in sharing information when there are issues makes them reliable and that is what distinguishes the setup from other non-performing setups. Due to this, the case company does not have to spend much time on monitoring. Also the willingness was highlighted. One of the interviewees at the case company stated that the case company

is a large customer and there is a willingness to support them as a customer. Another interviewee mentioned the fact that the supplier is willing to improve and suggests potential improvements of the setup. The trust was further pointed out in the handling of obsolete products although there is no written agreement. First of all this is explained that the supplier handles phase out situation in a good way where the risk of obsolete goods is reduced.

The supplier sees the benefits and uses the information in the production planning which is also highlighted as an enabler. The case company stressed that the supplier has adapted their processes in order to use the information in the planning compared to other suppliers that are not forwarding the information to the planning processes. Furthermore, the case company pointed out that the supplier has dedicated personnel in the process that have a good understanding of the system. Another enabler mentioned was that the products are single sourced, and therefore there is no risk for situation with manual handling in case of deviations. One interviewee from the case company mentioned that sometimes the control limits are set too tight which limits the flexibility for the supplier. The supplier stated that sometimes the gap between the upper and lower limit is only two pieces. The case company mentioned that the upper limit should be possible to increase for high runners in order to offer flexibility for the supplier to plan.

One of the managers at the case company mentioned that the restraint resource situation could be a risk for the performance in the long term since that would result in that less time will be spent on the situation and decrease the information sharing. Situations where the supplier communicates that the required stock levels will not be met might not be paid sufficient attention, which could result in material stock-out. The PO setup was considered to be more direct in this sense, since the case company gets an order confirmation with a delivery date.

One interviewee from the supplier said that VMI is only suitable for some of their customers. According to them there has to be a mutual need, close cooperation and trust, and also the customer has to be a rather big customer for them. The other interviewee from the supplier however said that VMI would be a good tool for all of their customers. The only issue might be if each and every customer uses different systems and then the supplier would have to use many different systems. That person therefore said that it might be reasonable to use VMI with only 2-5 of their biggest customers but in order for VMI to work with those customers, both partners need to be reliable and trust each other.

4.2.6 Product characteristics influencing the VMI performance

The product characteristics suggested to influence the VMI performance identified in the interviews are:

- Demand pattern
- Lead time
- Size

Although the setup with the studied supplier was considered to be a well performing VMI setup, the interviewees from the case company stated that it is not suitable for all products that are supplied. It was suggested by the company that the purchasing should be split into both PO and VMI based on product characteristics.

One interviewee suggested that the company should have products with low demand in a PO setup and products with high demand in VMI. This is based on that the supplier is not able to meet the demand when there is a peak in demand for the products with low demand. The interviewee pointed out that it is simply due to the product. The situation is difficult to handle and is not related to how the supplier is handling it. Another interviewee from the case company stated that VMI is suitable for products with frequent demand and that he/she cannot see the benefits from low demand products. There are no issues with the stable and frequent products and the supplier feel no risk. Sometimes the size of the product could also matter. The sizes of the products make it difficult to store the product. Therefore, these products have to be produced to order either way, with VMI or POs.

From the supplier's perspective, all of the case company's products are suitable for VMI, but the benefits are larger for the frequently bought products. High demand products have bigger information value. However, the supplier is of the opinion that it is beneficial to see the demand for all of the products. It is especially valuable to get the early demand information for products with long lead-time. Also, it is more important to get the early demand information for products with fluctuating demand than for products with stable demand. The supplier considers VMI to be a good solution for all the products, except for the products that are ordered seldom. This is due to that it might be too much work to review the demand in the system every day for those products.

5. ANALYSIS

In the analysis, the findings in the empirical data collection are analysed based on the theoretical framework. The aim is to evaluate the case company's conditions for VMI, get further input to the VMI suitability framework and to evaluate the framework. Based on this input, guidelines for how the VMI suitability framework should be applied in the context of the case company are developed and presented.

5.1 Definition of VMI

This section aims to study the definitions used by the case company and compare these to what has been found in theory. First of all it is of importance to evaluate if the definition of VMI at the case company and at the studied supplier are aligned with the actual concept of VMI. Furthermore, it is of interest to evaluate if the definitions can be classified as basic or advanced VMI, since this will have consequences for the potential effects and the requirements for VMI readiness.

It can be concluded that the written definition of the case company aligns with the definition constructed in the theoretical framework. The definition from the case company is more detailed in regards to what is included in the mutual agreement and the information that is shared in the setup. However, both definitions share the elements for the basic VMI, which is that the required information is shared with the supplier and that the responsibility of the replenishment decision is transferred to the supplier. Neither of the definitions specifies how the information is used by the supplier, hence the definitions leave room for both basic and advanced VMI. The studied supplier provided no written definition.

The empirical data showed that the interviewees at the case company and at the studied supplier shared a common understanding of the definition of VMI. This included that the supplier takes over the replenishment responsibility and that the buyer shares the required demand information. This is also in line with the case company's written definition of VMI and the theoretical definition. When defining VMI, none of the interviewees explicitly pointed out that the demand information provided to the supplier should be utilised in the planning of the supplier's production. Consequently, the definitions from the interviewees leave room for both basic and advanced VMI.

5.2 Configuration of VMI

In this section, the configuration of VMI at the case company will be analysed. The framework of Elvander et al. (2007) for evaluating, comparing and categorising different VMI setups will be applied to the general VMI setup used at the case company and to the specific setup with the studied supplier. The main points of interest are if the configuration is aligned with the definition of VMI and whether the

configuration can be classified as basic or advanced VMI. This is important since it will influence the potential effects as well as the prerequisites for VMI readiness.

5.2.1 General VMI configuration at the case company

The 12 design dimensions for the general VMI setup at the case company are visualised in Table 5.

Table 5. Design dimensions of VMI configuration at the case company in general.

<i>Group of design dimensions</i>	<i>Design dimension</i>	<i>General VMI at the case company</i>
Inventory control	Inventory location	Product dependent
	Sourcing policy	Product dependent
	Inventory ownership	Transferred when delivered to case company
Information	Demand visibility	Inventory levels, customer orders, forecast
	Access to information	Outside scope of study
	IT configuration	Outside scope of study
Decision-making	Replenishment monitoring and ordering	Periodic inspection minimum once every day
	Control limits	Upper and lower limits
	Replenishment decisions	Supplier full authority of quantity and timing
	Shipment decision	Supplier responsible
Integration level	Level of horizontal integration (customers)	Supplier dependent
	Level of horizontal integration (items)	Supplier dependent
	Level of vertical integration	Supplier dependent

The inventory control, information and decision-making categories are configured in the same way for all of the case company's VMI setups. However, the dimensions of sourcing policy and the inventory location could be individual on a product level. The category of integration level is dependent on the supplier and therefore the dimensions in this specific category will differ between the setups.

Firstly, the category of inventory control will not affect the type of VMI, but could impact the effects gained from the setup. The dimensions of inventory location and sourcing policy are closely interrelated and are influenced by the product characteristics. Therefore, it is likely that the case company has a mix of configurations of these two dimensions. The dimension of inventory ownership can impact the effects gained from VMI. At the case company, the inventory ownership is always transferred when the goods are delivered to the site. Hence, the case company does not have a consignment inventory in their VMI setups. Consequently, the case company does not control the stock levels that directly impact the inventory carrying cost at their site. This means that the actor that has the incentive to reduce the stock levels, in this situation the case company, is not the actor authorised to control it. This also means that if the case company should achieve improvements of inventory levels, they are dependent on that the supplier keeps the levels low. The case company has experienced the consequences of this and stated that some suppliers tend to overstock. The case company stated that more time should be spent on following up on the stock levels in order to keep the control. However, increased monitoring will limit the effects of VMI on the administration.

The information category could affect the plans that the supplier is able to make and therefore also the possibility of the supplier to integrate the demand information in the planning of their production. Thus, it could affect if the companies are able to reach the advanced VMI setup. The case company provides the information about inventory levels, customer orders and forecasts to the supplier.

The decision-making category affects the realised effects of VMI. The replenishment monitoring and ordering dimension is the frequency of which the supplier reviews the information and decides if to replenish or not. This will affect to what degree the bullwhip effect can be reduced. In the case that the supplier reviews the information more seldom than the case company previously placed POs, the reduction in bullwhip effect stemming from that the delay in demand information is eliminated will not take place. The bullwhip effect could possibly even increase. The case company specifies that the suppliers are obliged to review the information in the system on a daily basis. However, situations where suppliers do not fulfil this commitment have been mentioned. This could be seen as one type of opportunistic behaviour from the supplier. In regards to the dimension of control limits, the case company has both upper and lower control limits for the stock levels. The control limits can be classified as output control, which is one type of formal control. These can therefore be applied in order to reduce the perceived performance risk but could also undermine the trust in the relationship. It has been highlighted that, in some cases, the difference between the upper and lower control limit is only a couple of units. In the absence of consignment inventory, the upper control limits could increase the control of the stock levels. However, this will limit the flexibility of the supplier and thereby also the potential benefits of VMI. The control limits are combined with penalty clauses in the case

when the supplier does not stay within the limits. However, the case company almost never charges penalty fees since they consider it to be harmful to the relationship, which is in line with the trust, risk and control framework by Das and Teng (2001). The case company experiences that some suppliers are always above the maximum levels and others overstock in the end of financial periods. The replenishment decision dimension affects if the setup can be classified as VMI. The case company transfers the full responsibility and offers full flexibility in regards to quantity and timing. Thus, the configuration is in line with the definition of VMI. The shipment decision affects the opportunity to consolidate shipments, and thus the environmental impact and cost of transportation. In the VMI setups at the case company, the supplier is fully responsible for the shipment decision, which enables consolidation of shipments.

The category of integration level is dependent on the supplier and affects the type of VMI. The level of integration is what distinguishes a basic VMI from an advanced and therefore the type of VMI will be dependent on the supplier. It is therefore likely that the case company has a mix of basic and advanced VMI configurations with its suppliers. The horizontal integration of customers dimension affects how the information is used in the planning at the supplier's site. The horizontal integration of products also affects this, but on a product level. The vertical integration dimension affects if the VMI setup is considered as basic or advanced and thus also what effects of VMI can be experienced. Since the integration level differs for different suppliers it is not possible to comment on how this is at a general level at the case company. However, examples have shown that perhaps not all suppliers are that advanced in their integration. In this study, one relationship with a specific supplier has been studied in detail. This supplier is considered to be successful in this matter. The next section will describe the configuration with the studied supplier.

5.2.2 VMI configuration with the studied supplier

The VMI configuration with the studied supplier is the same as the general configuration in regards to the categories of inventory control, information and decision-making. The inventory location and the sourcing policy are product dependent and for the setup with the studied supplier it is mixed. Customised products are made-to-order and are delivered directly from the production. For these products, inventory is either only located at the case company or there are no products in stock. However, some standardised products are made to stock and are therefore delivered from a finished goods stock. In that case, inventory is located both at the supplier and at the case company.

The category of integration level for this specific supplier is presented in Table 6. Regarding the level of horizontal integration in regards to customers and products, the supplier considers the demand for one item from the case company at a time. The case company is the only customer that is served through VMI. Therefore it can be

concluded that VMI customers are planned separately from the regular customers and the VMI articles are considered one at a time.

Table 6. Design dimension for the VMI setup with the studied supplier.

<i>Group of design dimensions</i>	<i>Design dimension</i>	<i>VMI setup with studied supplier</i>
Integration level	Level of horizontal integration (customers)	VMI customers separately
	Level of horizontal integration (items)	One VMI item at a time
	Level of vertical integration	Full integration

Regarding the level of vertical integration, the studied supplier uses the information provided by the case company in order to plan their production and make the replenishment and shipment decisions. This setup can therefore be considered to be categorised as advanced VMI. Consequently, this setup has the potential of reaching all the effects that VMI has to offer.

Additionally, the setup with the specific supplier differs in the design category of information. The case company and the studied supplier have monthly meetings, which is unique for this setup. These meetings could be seen as one type of social control that increases both types of trust in the relationship and thereby also reduces the perceived risks. Other suppliers only receive information regarding inventory levels, customer orders and forecasts. In the monthly meetings, the actors discuss the upcoming forecasts and allocations of capacity at the supplier. The meetings increase the trust in the data that is shared since the reasons behind the numbers are provided. This could be one dimension that enables the studied supplier to actually utilise the additional information received in the VMI arrangement.

5.3 Effects and enablers of VMI

This section aims to evaluate the current VMI performance at the case company. The aim is to identify if there is a gap between potential effects identified in theory and the experienced effects at the case company. This serves as a foundation for identifying the enablers for realising the effects in this specific context and thereby contributes to the VMI suitability framework. Firstly, it is analysed how the performance of VMI is evaluated at the case company. This is followed by an analysis of the effects and enablers at the case company.

5.3.1 Measuring the performance of VMI

The interviews revealed that the performance of VMI at the case company is not actively evaluated and that the case company does not have the tools in place to

measure the effects. Service level is one of the few measurements that are continuously measured. However, the service level measurement for VMI is not comparable to the service level measurement for PO setups. The reason for that is that the VMI service level shows how well the supplier stays within the control limits while the PO service level shows how well they manage to ship in correct time and quantity. Therefore, there is some uncertainty and also split opinions regarding the effects that are actually realised from VMI. None of the interviewees provided any data that confirms the effects of VMI. Consequently, the effects cannot be proved and the evaluation of the performance of the VMI application is based on the interviewees' personal interpretations of working in the VMI setup. This is the case for both the general and the specific situation. In order to enable objective evaluation of the performance of VMI and the objectives with the application, the case company is recommended to establish KPIs.

As mentioned in the theoretical framework, it is important to measure the effects (Kaipia et al., 2002), aligning measurements with the goals of VMI (Waller et al., 1999) and aligning the goals across the different levels of the organisation (Kuk, 2004; Pohlen and Goldsby, 2003). It is better to have few but critical measures (Kaplan and Norton, 1992; van Weele, 2010) that represent the organisational goals and are possible to relate to decision making on all levels; strategic, tactical and operational (Gunasekaran et al., 2004). The critical measures should measure exactly what the company wants to get (Kaplan and Norton, 1992), and in that way it can motivate the employees on all levels to reach the organisational goals. Therefore, the case company should use few critical measures that are aligned with their goals and the goals should be aligned throughout all levels of the company.

At the case company, in general, KPIs could contribute to an aligned view of the performance of VMI. In general, the experiences of VMI were different at the different levels in the organisation. This indicates that the effects of VMI are visible at the different levels. By measuring the effects, the effects could be visible on all levels. The operational purchasers stated that the setups that work well are not visible to them since they are responsible for handling deviations, which often require extensive manual work. Applying KPIs on all levels that are aligned with the strategic goals of the case company could eliminate this issue and contribute to aligning the actions on all levels towards the strategic objectives of the company. Also it is recommended to set up KPIs that are comparable to the measurements of the PO setup. This would enable the case company to evaluate the actual effects of VMI application compared to the performance prior to VMI. Also it could contribute to an improved understanding of the characteristics of VMI compared to POs within the case company.

Both individual and shared KPI's are recommended for the VMI setup in general and with the studied supplier. VMI is a collaborative initiative between the case company and its suppliers. In order to ensure mutual benefits and improvement of the entire

process, it is recommended that the effects on the process, both at the supplier's and at the case company, are measured and evaluated. Setting up mutual KPIs can align the actions of the two parties and avoid sub-optimal decisions and opportunistic behaviour. Having shared objectives can also improve the collaboration since the two actors will work towards common goals. Based on the above, the KPIs for the VMI setup should be:

- Comparable with PO setup
- Aligned with the objectives of VMI, both internal and mutual objectives
- Aligned on all levels in the organisations
- Aligned to the strategic goals of the company
- Few but critical
- Mix of individual and shared KPIs for the actors

It is recommended that the case company and the suppliers measure the effects on the inventory levels, service levels and administration since these are the main effects of VMI. Both individual and shared KPI's are recommended to be established. In order to be able to compare the service level in a VMI setup to the service level in a PO setup, it is recommended that the service level towards production is measured. Comparing inventory levels between the two setups should not be a challenge. However, the case company is recommended to further investigate how the administration in the two setups could be measured and compared. Thus, the case company is recommended to measure:

- Service level towards production
- Inventory levels
- Administration

5.3.2 Effects at the case company

Several of the interviewees pointed out that different effects are achieved in different situations. One potential reason for this is that it is likely that the case company has a mix of basic and advanced VMI setups and the potential effects differ between these types of VMI. However, when pointing out the expected effects of VMI, the interviewees did not distinguish between different types of VMI. Consequently, it could be that the expectations of the effects of VMI are not aligned with the potential effects that can be gained. This could result in disappointing results of VMI applications. This section aims to evaluate the effects of VMI at the case company and the reasons why these are experienced or not. Based on these findings, recommendations to the case company are presented.

When the case company implemented VMI in the beginning, the main objective was to decrease the administration internally by transferring this activity to the supplier. Also, automating the process would eliminate the erroneous orders. The interviewees had split opinions regarding if any time at the case company was saved in the VMI setup in

regards to administration. Firstly, POC is another alternative to the manual POs that has automated the process of placing orders. Compared to this setup, the potential time saving is considered as rather limited. Secondly, when a product is supplied with VMI and from multiple suppliers it is time consuming to handle the situation if one supplier is not performing. It requires manual handling that is more time consuming than when POC is used. Thirdly, in the case when a supplier is not performing, time has to be put into monitoring the supplier and following up which can limit the timesaving. All of the above, points to that VMI might not save much time in the purchasing activity compared to the POC setup and that it in some cases could be more time consuming. However, it can be argued that the administration time is less with VMI than with the traditional, manual POs.

In the specific setup with the studied supplier, the purchasing activity was prior to VMI handled with manual POs. Therefore, the case company has experienced reduced administration since VMI was originally implemented with the studied supplier. However, compared to using the automated POC system the reduction is likely to be similar. The products supplied from the studied supplier are single sourced, and therefore the issues with manual handling in the case of deviations are not present. Also there is a trust in the studied supplier, which is proactive in information sharing. Therefore, the time spent on controlling is limited. The studied supplier stated that the administration in their end is increased with VMI, but that it is worth the benefits to be gained. It is important to point out, that this specific supplier sees the benefits of the advanced VMI. However, not all suppliers might be of the opinion that the additional time spent in the VMI setup is worth it.

Consequently, it can be concluded that the benefits in regards to administration for the case company to be gained from VMI are similar to the benefits gained from POC. However, for the supplier, the administration will increase, but the supplier might get other benefits out of the application of VMI. In order for the administration at the buying firm to not increase, the product should be single sourced and there needs to be trust and proactive information sharing in the relationship. The findings in regards to administration are in line with the VMI suitability framework developed in this report. In the absence of trust, time has to be put into different types of control mechanisms, which will limit the benefits of VMI.

Another benefit expected from VMI, was reduction of the bullwhip effect. However, in general, the realised reduction of the bullwhip effect is not possible to conclude from the interviews. On the other hand, since the case company continuously shares demand data, they should no longer be contributing to the bullwhip effect by delaying and batching the information. Thus it can be assumed that the reduction of the bullwhip effect depends on how often the supplier reviews the information in the system. In the case with the studied supplier, the information is reviewed on a daily basis. Thus it can be concluded that if POs were placed less than once per day before applying VMI, the

information delay has been reduced in the setup with the studied supplier. Therefore, it is expected that the bullwhip effect has been reduced in that particular situation. It seems as if the supplier is committed to the setup and does not behave opportunistically. The reason might be that the supplier also benefits from reviewing the information continuously. In the advanced VMI the supplier gains benefits from the information in their planning, which is why there seem to be mutual benefits of reviewing the information frequently. This is in line with the theoretical framework that points out the importance of mutual benefits.

Furthermore, the usage of VMI was expected to result in increased service level towards the case company and was further expected to be increased towards their customers. In the case company's general situation, it is not possible to confirm the effect of VMI on the service level. However, the empirical data includes an example where significant improvements regarding the service level were experienced when VMI was implemented in combination with a nearby hub. However, it is not possible to distinguish the individual effects of VMI in this example. Thus in general it is not possible to state if VMI has resulted in increased service levels. In the specific case of the studied supplier, the service level towards the case company has increased with applying VMI. This could be due to that the VMI setup is advanced, where the supplier plans the production according to the additional information received. The studied supplier states that the early access to information allows them to be more flexible and agile and that they are able to better plan and optimise the production based on the shared information in the VMI setup. It can be concluded that it has been shown that it is possible to increase the service level by applying VMI. However, it is not fully known to what degree the case company has realised this in the general situation. Therefore, it is recommended that the case company investigate this further, for example by measuring the service level towards their own production line. That way they could compare the service level of VMI to the service level of POs.

In regards to the inventory levels, at the buying firm they are expected to reduce as an effect of the early demand information received by the supplier, which gives the supplier an opportunity to increase the responsiveness. The empirical data points to that buffer levels at the case company could in some cases be higher in the VMI setup than in the PO setup. This could be due to the lower control limits being set too high. Also, although the case company has specified maximum levels for the buffers at their site, some suppliers tend to overstock. The reason could be that in the current setup the case company owns the inventory at their site but is not directly controlling the inventory levels. However, without any general input from different suppliers, it is not possible to draw any conclusion regarding the total inventory reduction of VMI in general at the case company.

In the setup with the studied supplier, the case company has seen that the supplier is better at keeping the right inventory levels in the VMI setup than before. The studied

supplier uses the information provided by the case company when planning production and as a result the supplier does not have to hold finished goods stock for some of the products. Thus it can be concluded that in the specific situation the inventory levels are improved.

This shows that the inventory levels can be improved with VMI. However, it is important to set the lower control limit at a level that enables inventory reductions. Furthermore, benefits in regards to inventory levels also require that the supplier stays within the upper limit. In the specific setup with the studied supplier, integrating the demand information in the planning of the production has shown to be a key for reducing inventories. Furthermore, in order to increase the incentive for the supplier to decrease the inventory levels, it is recommended that the case company investigate the opportunity of sharing the inventory carrying cost with the supplier. For instance, through consignment inventory, transfer payments or applying the penalty fees. Since trust is important for a well functioning VMI setup, the case company should be careful with using the penalty fees, and consider the two other alternatives.

Furthermore, the VMI setup was expected to result in a loss of control for the case company in regards to the replenishment decision and the information. However, in general, nothing negative regarding the loss of control of information has been mentioned in the interviews. Still it is obvious that the case company does not have the same control over the information when it is shared with the suppliers. The loss over the replenishment decision has shown to have some negative impact at the case company, since some suppliers tend to overstock the buffers. This could be seen as a direct effect of the loss of control of the replenishment decisions since this could not occur if the case company decided on the quantity and timing of deliveries. In the situations where suppliers are not fulfilling the commitments, the operational buyers have to put time into controlling and following up.

In the specific setup with the studied supplier, the case company has pointed out that the supplier has become better in keeping the right inventory levels with VMI. This indicates that the supplier does not seem to abuse the system and overstock. Furthermore, the supplier is proactive in their communication and as a result the operational buyers at the case company do not have to put a large amount of their time into controlling. As a conclusion, sometimes the loss of control hinders the company from experiencing the positive effects, but if the supplier is reliable and has genuine incentives then the loss of control should not result in negative effects. This is in line with the VMI suitability framework suggested in this report and therefore, the case company are recommended to evaluate their suppliers before entering a VMI relationship.

Regarding the relationship, the application of VMI was expected to improve the relationship between the parties. In the general setup at the case company, it is not

possible to draw conclusion of if VMI has improved the relationships based on the empirical data. In the case of the studied supplier, the relationship has benefited from applying VMI. The supplier stated that there are fewer complaints now than prior to the VMI setup and that the information flow has improved. Both parties have described the relationship to be close, cooperative and long-term, however it is not possible to conclude if that is a result of VMI. During the last years, a three-year contract has been signed and a modularised design of the products that are supplied has been developed in cooperation between the firms. Based on this, the competitiveness of the supplier has increased but it is not possible to say if it is due to VMI. As a conclusion, the empirical data could not confirm the effects on the relationship.

5.4 VMI readiness

The aim of this section is to further develop the VMI readiness framework with the help of the empirical data. The accuracy of the enablers found in the empirical data is here evaluated. The section is divided into customer readiness, supplier readiness, product suitability and relationship readiness. The customer readiness, supplier readiness and product suitability determines the risk in the arrangement while the relationship readiness is related to how the risk can be managed.

The customer VMI readiness in theory is divided into the incentives, capabilities and resources. The first aspect within this category mentioned in the interviews is resources. Those are needed in order to educate the suppliers and follow up on performance measurements. Examples are mentioned when the supplier lacks understanding of the processes and does therefore not fulfil the commitments. Based on this, it seems reasonable to include this aspect in the readiness framework. The importance of having resources available for following up on performance measurements will depend on the need of control in the situation. The aspect of having resources for operating the necessary control mechanisms will be included in the VMI readiness framework. The second aspect identified in the customer readiness category is alignment of the objectives of VMI and understanding at all levels internally at the buying firm. In the interviews it is highlighted that management expects the operational buyers to be able to provide detailed information regarding product availability. This is not in line with the idea of VMI and hinders the company to achieve reductions in administration. The example proves the importance of aligning the incentives with the strategy of the firm, which is also mentioned in theory. Thus, it is recommended that when readiness of the customer in regards to entering a VMI arrangement is considered, it is necessary to evaluate the alignment of the objectives of VMI on all levels within the firm. The customer readiness aspects identified in the empirical data that are considered to be important for the VMI suitability are presented in Figure 9.

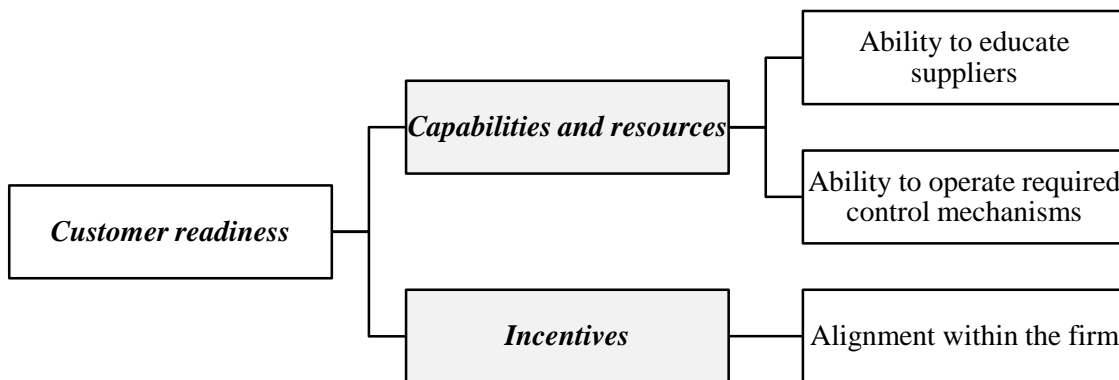


Figure 9. Customer readiness aspects identified in the case study.

The supplier readiness identified in theory is divided into incentives, capabilities and resources. The enablers mentioned in the empirical data which can be categorised as the VMI readiness of the supplier are: capabilities of integrating information into the production planning, having dedicated customer support and the willingness of the supplier. Firstly, the capability of integrating information is important since this is one of the additional activities in the advanced VMI. If an advanced VMI is to be entered, the capability and resources to integrate information in the planning will impact the VMI readiness of the supplier. Secondly, that the supplier has the organisation and resources in regards to customer support is suggested as an enabler. It was stated that dedicated personnel within the company is needed and that it is important that the supplier does not exchange the customer support too often. This aspect could be seen as the supplier's capability and resources to take part in a closer relationship and establish the social control that the VMI setup requires and is considered important in the evaluation of the supplier's VMI readiness. Thirdly, the willingness of the supplier is suggested as an enabler, which is closely related to the presence of incentives for the supplier. The interviewees mentioned that in order for VMI to work, the supplier has to be willing to put in the necessary resources. The importance of the customer size for the willingness was also highlighted. Examples were mentioned of unsuccessful VMI arrangement due to lack of willingness from the supplier where the company was a small customer. The reason for this being unsuccessful was that the supplier had not fulfilled the commitments. This can be considered as opportunistic behaviour; hence the findings in the empirical data support that aligned incentives have to be in place in order to reduce the relational risk. The supplier readiness aspects identified in the empirical data that impacts the VMI suitability are presented in Figure 10.

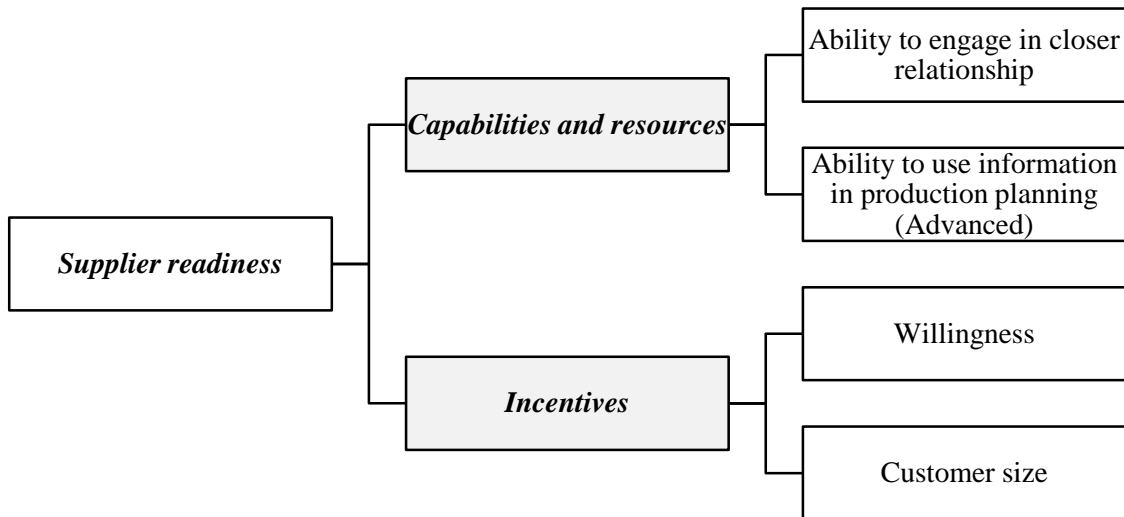


Figure 10. Supplier readiness aspects identified in the case study.

The product suitability category in theory includes the planning complexity. From the perspective of the case company, the products feasible for VMI are products with high, stable and frequent demand, short lead times and products that are not too expensive. The reason given is that in these situations, there is low risk for the actors to end up with high inventory carrying costs and it should be easy to meet the service levels. These setups would therefore not require extensive monitoring or detailed contracts of risk sharing. The product related aspects, mentioned by the case company, are typical for situations with low planning complexity. According to the suitability framework, situations with low planning complexity require less control mechanisms, which is in line with the statements of the case company. Therefore, it seems, as the logic of the suitability framework is applicable in the context of the case company. However, the studied supplier mentioned that the information value is higher for products with long lead times and high volatility. The contradictory opinions at the supplier and the case company are in line with the findings regarding demand volatility in theory. It seems, as the benefits of VMI can be greater for products with high planning complexity. However, these setups are more challenging for the parties and will put higher requirements on the setup.

The product related aspects highlighted in the empirical data that could impact the performance of VMI are: demand pattern, having multiple suppliers for the same product, lead time, value, size and complexity of manufacturing process at the supplier. It is argued by the interviewees that all these characteristics affect the planning complexity for the product. Therefore, these are considered important for the VMI readiness of the product. It should be mentioned that the fact that it is time consuming and complex to plan and handle the deviations when there are multiple suppliers could be considered as outside of the scope of this study. The reason for that is that it depends greatly on the system and thus it is a part of the system dimension.

However, this is something that was deemed as noteworthy to include since it has great effects to the VMI suitability at the case company. Therefore, it was decided to include this enabler in the VMI suitability framework for the case company. However, it should be highlighted that this is not something that should be generalised to other companies, since it depends on the specific system in this setup. The product suitability aspects considered important for VMI suitability are presented in Figure 11.

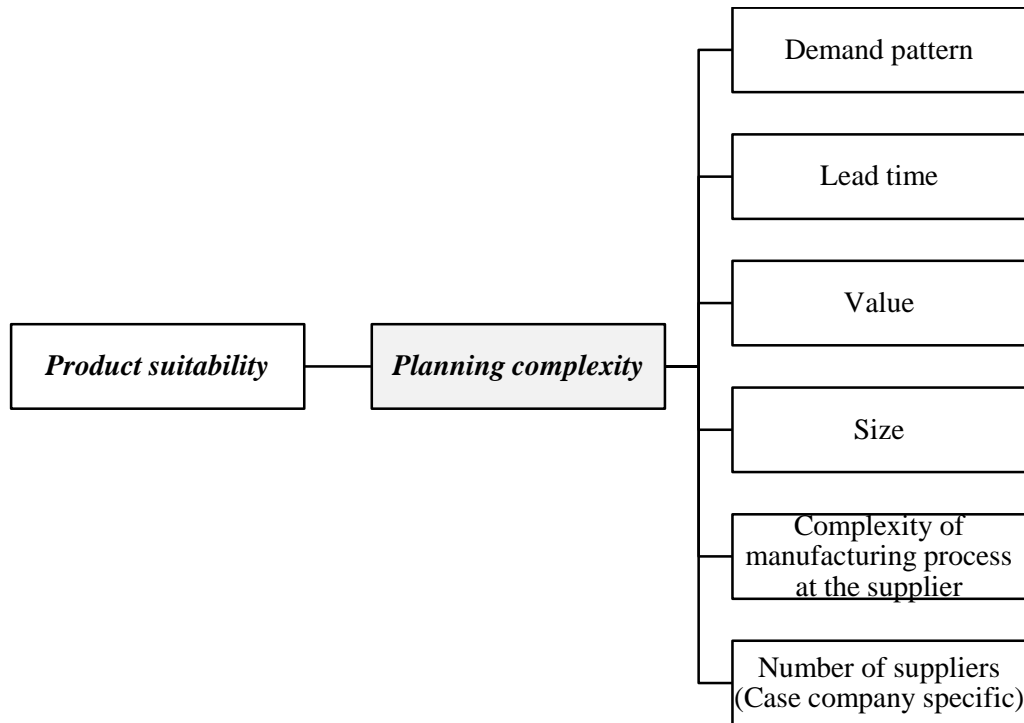


Figure 11. Product suitability aspects identified in the case study.

The relationship readiness consists of aspects that reduce the perceived risk in a VMI arrangement. According to Das and Teng (2001) these aspects can be categorised as trust or control mechanisms. The aspects identified in theory are the collaboration, trust, and mutual benefits in the relationship. The enablers mentioned in the interviews that can be connected to the readiness of the relationship are: trust, interpersonal relationships, proactive information sharing, formal agreement and control limits. The interviewees suggested that trust in that the supplier will fulfil the commitments is important for the VMI performance. When there is a lack of trust, the case company spends time on monitoring and controlling the supplier, which reduces the benefits in regards to administration. The interviewees mentioned examples where commitments are not fulfilled both due to lack of understanding and due to lack of engagement. These are examples of lack of competence trust and goodwill trust. Two other suggested enablers are interpersonal relationships on all levels and proactive information sharing. This could be considered as one type of social control, which is an important control mechanism in order to reduce risk and build trust in the VMI setup. Also the proactive information sharing could be classified as social control. It is

stated that this makes the supplier reliable and that the case company therefore can reduce the need for controlling and monitoring. In some situations, the control limits are considered to be too tight which, according to theory, is another indicator of a lack of trust. However, the control limits at the case company are calculated in a standardised way for all the VMI products and might therefore not reflect the trust in specific relationships. Moreover, it is suggested that a formal agreement with defined liabilities should be in place and that this could be seen as a formal acceptance of the VMI arrangement. According to Das and Teng (2001), the level of formal control required is dependent on the risk in the relationship. Therefore, it could be argued that the importance of a detailed contract will differ between setups. Another type of control that could impact the performance is the control limits. The case company explained that sometimes the control limits are set too tight, which is a barrier since it takes away the flexibility for the supplier. The control limits could be seen as one type of output control. It could therefore be argued that when a high level of output control is needed in order to handle the performance risk, the relationship is not ready for VMI. The aspects of relationship readiness mentioned in the empirical data supports the applicability of the framework of Das and Teng (2001) in the context of VMI relationships at the case company. Trust and control aspects for managing risks in VMI arrangements identified in the empirical data are presented in Figure 12.

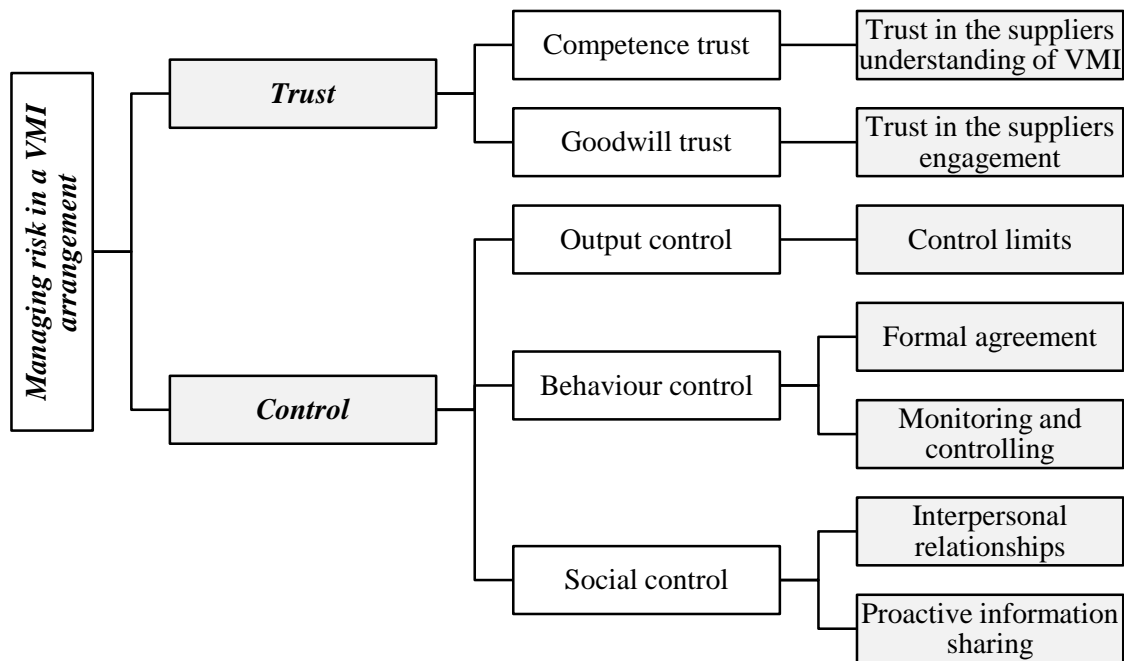


Figure 12. Aspects for managing risk in VMI arrangements identified in the case study.

5.5 Summary and recommendations to the case company

Here, the main findings in regards to definition, configuration, effects and enablers of VMI in the case company's context are highlighted. Based on this, the guidelines regarding the case specific VMI suitability assessment have been developed and are

summarised. It is noticed that the case company lacks some structure in the way of working with VMI. This section presents recommendations of how the case company can move forward and standardise the work and thereby improve and stabilise the performance of VMI setups.

5.5.1 Main findings in the case study

The definitions found at the case company and the studied supplier are all in line with the theoretical concept of VMI and they all leave room for both basic and advanced VMI. The general and supplier specific configurations of VMI at the case company are in line with the definition from theory and the company's own definition. What distinguish basic and advanced VMI are the design dimensions that are dependent on the supplier. Therefore, it is likely that the case company has a mix of basic and advanced VMI with their suppliers. This can result in that they experience different effects for different types of setups. The setup with the studied supplier can be categorised as advanced VMI.

The different types of VMI will result in different effects. When pointing out the expected effects, the interviewees did not distinguish between the types of VMI. In order to avoid disappointing results of VMI applications, the case company is recommended to clearly make a difference of the two types of VMI. The main expected effect mentioned was decreased administration. However, compared to POC, the improvement potential in regards to administration is low. This points to the importance of evaluating the incentives and the actual improvement potential prior to entering a VMI arrangement. Furthermore, this is something that could have been made visible if the performance and effects of VMI were actively evaluated within the case company.

The basic VMI results in the buying firm losing control over information and replenishment decision. There might be a slight improvement in service levels and inventory reduction. However, the positive effects to be gained from basic VMI for the buyer could be considered to be limited. The benefits with the basic VMI are mainly realised by the suppliers. There are potentially similar benefits to be realised with POC for the case company, without losing the control as in the case with VMI. It is therefore recommended that the case company mainly engage in VMI setups that have the potential of being advanced setups. Based on this, the case company should also consider modifying the written definition at the company in order to align it with the advanced VMI setup. Furthermore, it is important to clearly communicate this to suppliers when discussing potential VMI applications.

The configuration of the inventory ownership at the case company has shown to be challenging. It is therefore recommended that the case company investigate the opportunity of having consignment inventory since this could eliminate the need of tight control limits and the need of monitoring upper stock levels. Both control limits

and the monitoring could be categorised as formal control mechanisms, which can undermine the trust in the relationship. Having consignment inventory could increase the benefits gained from the setup. However, it would also result in that the supplier takes over the inventory carrying cost. In order for the setup to result in mutual benefits, transfer payments could be applied.

The effects are currently not known at the case company since these are not measured. In order to measure the effects, evaluate the performance of VMI and to align the goals of the people involved it is recommended that the case company uses KPIs on all levels in the company that are aligned with the strategic goals and comparable to the KPIs of the PO setup. The KPIs are recommended to measure the main effects of VMI, which are inventory, service levels and administration. As was mentioned in one of the interviews, having specific people responsible for the KPIs might be a good way to achieve the regular follow-up. Assigning the task to specific people could be a good way to increase the focus on the KPIs since the case company currently has limited resources available, which could make it challenging to find the time for this task.

The enablers have been categorised according to the readiness at the customer, supplier, relationship and product. The empirical findings are in line with theory. The main customer readiness aspects mentioned in the empirical data were resources and capabilities in regards to education of suppliers, operating the required control mechanisms and alignment of objectives on all levels of the organisation. The supplier readiness aspects mentioned in the empirical findings are that the supplier needs capabilities and resources to take part in a closer relationship and that the supplier has to be willing to commit to the setup. The importance of the customer size for the willingness of the supplier was highlighted. Regarding the relationship readiness, the empirical data confirmed the importance of trust and control for the VMI performance within the case company. This is in line with the risk, trust and control framework introduced by Das and Teng (2001). Furthermore, aspects influencing the planning complexity, which affects the product suitability at the case company, are: demand pattern, having multiple suppliers, lead-time, value, size and manufacturing complexity. These are all aspects that should be considered when assessing the VMI suitability at the case company.

The fact that the case company is recommended to only have advanced VMI setup will put higher requirements on the assessment of the VMI suitability, in particular on the readiness of the supplier. The VMI suitability assessment could also be applied in order to evaluate existing VMI relationships at the case company. Since it is likely that the case company currently has a mix of advanced and basic VMI relationships these are recommended to be evaluated. However, one step has to be conducted prior to adapting the VMI suitability assessment, which is to determine whether the setups are basic or advanced. If the basic VMI lacks potential of being developed to advanced VMI, the case company is recommended to consider to terminate the setup. However,

if there is potential for advanced VMI, the case company is recommended to develop the VMI. Also, the VMI suitability assessment can be applied to the advanced setups in order to evaluate the current setup and identify potential improvements. The VMI suitability assessment at the case company is further elaborated on in the next section.

5.5.2 VMI suitability assessment at the case company

This section presents case company specific guidelines of how the VMI suitability framework can be applied. Since the case company is recommended to have advanced VMI setups, this will affect the VMI suitability assessment. Therefore, the steps of the VMI suitability assessment are re-evaluated here. Examples of detailed questions to be asked in the different assessment steps can be found in Appendix VI.

Step 1: Internal VMI readiness assessment

The evaluation of the internal VMI readiness is divided into the sections of incentives, capabilities and resources. Firstly, the case company should evaluate if there are any incentives for applying VMI. Since the case company is recommended to only apply advanced VMI, it should be evaluated if there are incentives to apply this type of VMI. Based on the effects identified in the theoretical framework the potential benefits for advanced VMI for the case company are increased service level, reduced inventory levels and improved relationship with the supplier. The effect on administration compared to POC is limited, therefore, this could be argued not to be a potential effect in this context. The actual improvement potential in these dimensions should be evaluated in order to avoid disappointing results. The potential benefits can thereafter be weighed against the negative effects of losing control over the replenishment decision and the information that follows from VMI. It should also be evaluated if the objectives of the VMI application are in line with the strategy and other initiatives in the firm.

Secondly, the capabilities and resources for operating an advanced VMI setup should be evaluated. It is recommended that the case company initially map the activities that will be required in the setup. The activities identified in this study are to share the required information with the supplier, which requires internal and cross-company integration, educate suppliers, and to operate the required control mechanisms. Since the supplier is aligning its production to the information, it is of high importance that the supplier receives reliable information. In the specific setup with the studied supplier, monthly meetings have shown to be successful in order to improve the trust in the information shared. After mapping the required activities, the case company is recommended to evaluate if there are capabilities and resources available in the firm for operating the advanced VMI arrangement with the supplier.

Step 2: VMI readiness assessment of the supplier

In the assessment of the VMI readiness of the supplier, the risk of engaging in a VMI setup with the specific supplier should be evaluated. The risk consists of relational and

performance risk which depends on the incentives and, capabilities and resources respectively. Since the type of VMI is determined by the configuration at the site of the supplier, the evaluation of the supplier's readiness is critical. The requirements on the supplier will be higher for the advanced VMI than it is for the basic VMI. The size of the two risks should be assessed based on the risk assessment presented in Figure 4 by van Weele (2010).

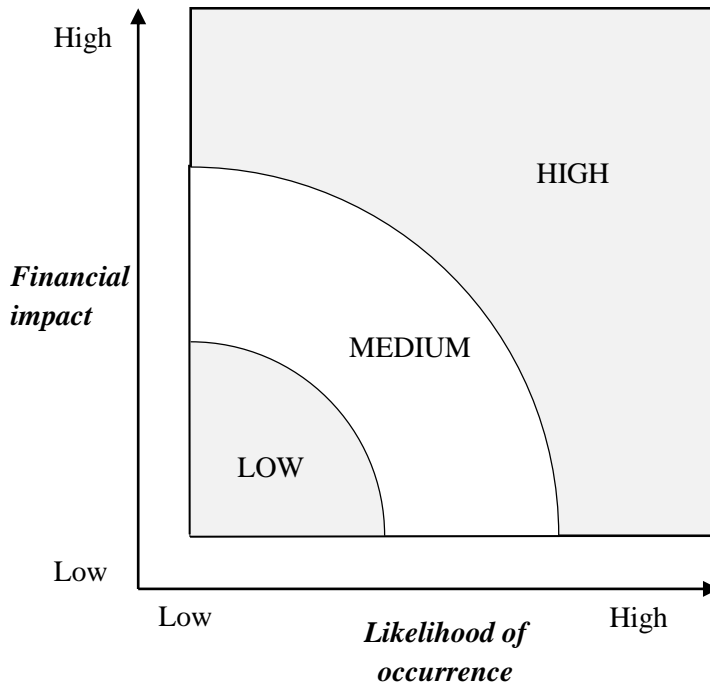


Figure 4. Risk assessment (van Weele, 2010)

Firstly, the relational risk, which is the risk that the supplier behaves opportunistically, should be evaluated. This depends on the incentives of the supplier. It is critical that there are incentives for the supplier to engage in an advanced setup where the demand information is utilised in the planning of the production. The potential benefits for the supplier that will mainly be realised in the advanced VMI are reduced inventory levels, improved service levels to all customers, reduced need for excess capacity and reduction in bullwhip effect. It should be evaluated if these incentives seem to outweigh the additional administration that the supplier will have to perform in the VMI setup. The supplier must have a genuine interest in committing to the setup and the intention to use the information in order to minimise the relational risk. Furthermore, it should be evaluated if the incentives are aligned with the objective of VMI in order to avoid conflicting objectives and opportunistic behaviour. The size of the case company as a customer is critical for the willingness to commit and the potential planning benefits for the supplier. Therefore, the incentives and the customer size should be evaluated.

Secondly, the performance risk, which is the risk of unsatisfactory business performance by not achieving the objectives, should be evaluated. This is dependent

on the capabilities and resources of the supplier to operate an advanced VMI setup. Initially, the case company is recommended to map the activities that the supplier is required to carry out in an advanced VMI. The activities identified in this study are to keep service and inventory on agreed levels, manage replenishment decision by reviewing the demand information at a minimum once a day, integrate demand information in production planning and to engage in closer relationship which involves participating in monthly meetings and sharing information proactively. The supplier must have internal integration in place and sufficient volume handled through VMI in order to actually be able to utilise the information received. After mapping the activities, the case company should evaluate if the supplier is likely to have the required capabilities and resources in order to perform the required activities. Based on this evaluation the case company should have an understanding of the performance- and relational risks and should be able to place the supplier into the matrix, introduced in Figure 8.

Based on the position in the matrix, the case company could estimate if VMI is suitable or not. In the case of VMI suitability, the case company should also be able to estimate the required control mechanisms and thereafter also evaluate the capabilities and available resources within the company to operate these mechanisms.

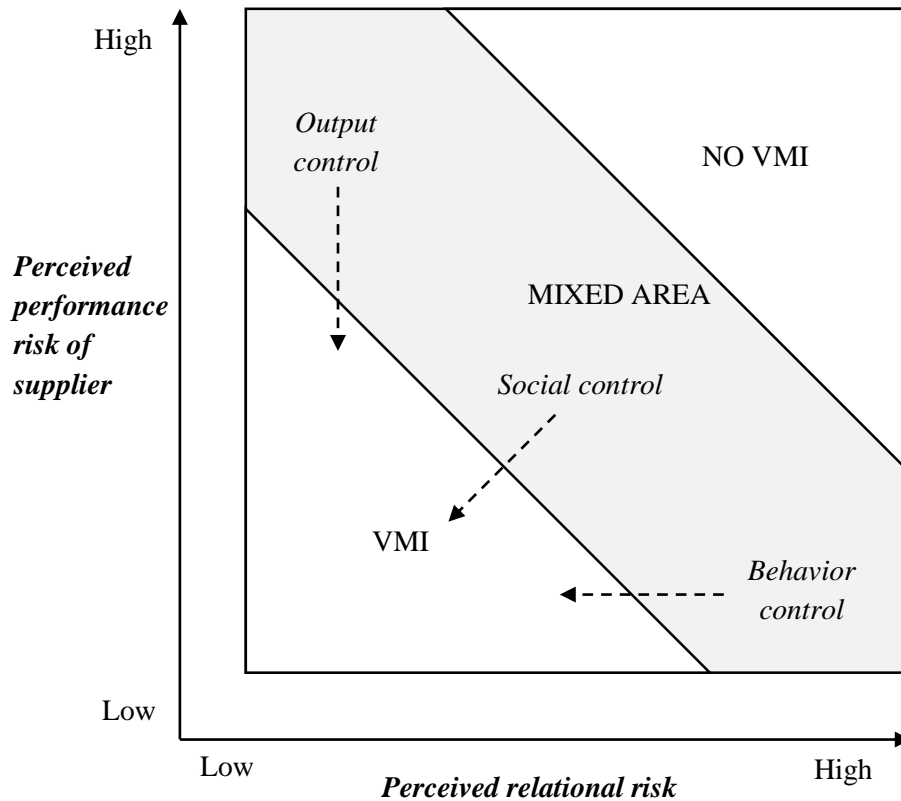


Figure 8. The relationship of the perceived performance risk and perceived relational risk.

Step 3: Product suitability assessment

When assessing if a product is suitable for advanced VMI, the case company should assess the planning complexity of the product. In the context of the case company it has been identified that this includes the demand pattern, lead time, having multiple suppliers for the same product, value, size and complexity of manufacturing process at the supplier. The planning complexity of a product could be indicated by the historical forecast accuracy where a low accuracy indicates complexity in the planning. The product suitability assessment is especially important in the case where a supplier is placed in the mixed area. If that is the case, the case company is recommended to implement VMI for the products with low planning complexity and then work towards developing the relationship with the supplier in order to reduce the risks and move the supplier into the “VMI area” of the matrix. The employees from the case company suggested that the products with high complexity should be handled through POs while products with low planning complexity should be handled in VMI. This is in line with the recommendation when the supplier is placed in the mixed area. However, it is important to point out that the greatest benefits could be achieved for the products with high planning complexity, which is why the case company should strive to include these in a VMI setup.

6. DISCUSSION AND CONCLUSION

In this section, the findings from the study will be discussed. Firstly, the findings and contributions of the study to industry and the case company will be highlighted. Secondly, the quality of the study and future recommendations will be reflected upon.

6.1 Findings and contributions of the study

This study has examined how VMI suitability can be assessed at a manufacturing company. The aim of this study was to develop a supporting framework for deciding the suitability of VMI as a replenishment method. In order to develop the framework, the definition of VMI, configuration, effects and enablers were identified. The study was carried out at a manufacturer where the setup of VMI was investigated, both in general and in a specific setup with a studied supplier. A general framework for VMI suitability assessment was created based on theory, and guidelines for applying it in the specific context of the case company were developed.

The theoretical framework in itself contributes to the general understanding of the VMI concept within the case company and other manufacturing companies by creating an overview of the concept in regards to definition, configuration, effects and enablers. Furthermore, the case study and the following analysis contribute to increased understanding of VMI in the context of the case company, which ultimately could lay the foundation to increased performance of VMI within the company. The study provides an overview of the expected and realised effects at the case company, which can serve as an input for the company to re-evaluate the objectives of VMI application. Therefore, this study contributes to increased understanding of VMI and when it should be applied, both for the industry and for the case company.

One of the findings is that definitions in theory and at the studied companies leave room for two types of VMI, which in this report are termed as basic and advanced VMI. What distinguishes the two types is that in the advanced VMI setup, the supplier integrates the demand information in the planning of the production. This is in line with the categorisation of supply chain collaborations by Holweg et al. (2005). The finding is important for companies that operate VMI setups since both the potential benefits as well as the prerequisites differ between the two types. The advanced VMI offers more potential benefits but also puts higher requirements on the actors involved. This contributes to a greater understanding of achievable effects and the requirements on the setup.

Furthermore, it is concluded that in order to be able to evaluate the performance of VMI and to compare it to alternative configurations of the order-delivery process, the effects must be measured. Comparable measurements are currently not in place at the case company. This study presents guidelines of how the effects should be measured in order to enable the case company to develop the relevant KPI's. It is recommended

that the case company measure the service level towards production, inventory level and administration. These guidelines could be applicable in similar contexts. However, as pointed out by Borrego et al. (2009), it is up to the reader to assess if the findings are applicable in any other context based on the case description provided in the report. Measuring the effects will contribute to a greater understanding of the effects of VMI at the case company and possibly also improve the performance since the measurements could align the goals of the individuals involved towards the objectives of the application.

It is suggested that the suitability of VMI can be assessed based on the acceptable risk in the relationship. Dong et al. (2007) points in the same direction and states that the higher the risk in inbound logistics process, the less likely it is that the buying firm engages in a VMI setup. The VMI suitability framework presented in this study builds on a framework of Das and Teng (2001), which explains risk, trust and control in relationships. The relationship is a commonly mentioned enabler both in theory and the empirical data in this study. The VMI suitability framework contributes by explaining the connections between the relationship and VMI performance. This study suggests that the perceived risk in VMI arrangements can be determined based on aspects related to the customer, supplier and product. The perceived risk can be reduced through trust and control in the relationship. Therefore, the framework provides guidance of when VMI is suitable and what types of control mechanisms could be applied.

The VMI suitability framework could be useful for assessing potential as well as existing VMI arrangements. The general VMI suitability framework contributes to industry and in particular to manufacturing companies operating or considering applying VMI with their suppliers by identifying the prerequisites for VMI application. The framework manages to explain the impact of the relationship on the VMI performance. The authors have not found any similar frameworks that support firms in evaluating the suitability of VMI in theory. Therefore, the study contributes to the industry with an example of how VMI suitability can be structured and reflected upon. The VMI suitability framework based on theory should be possible to apply to companies in other contexts. The framework is built with manufacturing companies in mind, however it should be possible to adjust to other types of companies.

The study further concludes that products with high demand volatility could gain greater benefits from VMI than products with low demand volatility. The impact of the demand volatility on the VMI performance has been studied in previous research but the findings are contradictory (Yang et al., 2003). Historically, VMI has mainly been applied for products with stable demand (Waller et al., 1999). However, it is found that the demand volatility increases the potential benefits of VMI. It is important to point out that it also increases the performance risk and thereby increases the requirements on the relationship. Based on this it is recommended that companies strive to include

products with high demand volatility in the VMI setup in order to improve the order-delivery process.

The suggestions above are supported by the findings in the case study; hence the framework should be applicable for manufacturing companies in the process of assessing VMI suitability. However, it is recommended that the assessment criteria for each evaluation area are defined according to the context in which the framework is applied in order to ensure accurate and replicable assessment of the suitability. The firm that is considering to use the framework is recommended to discuss the relevant aspects based on the categories of internal VMI readiness, supplier VMI readiness and product suitability, identified in this study. In total, this study is considered to contribute to both industry and the case company. The concept of VMI has been studied in the specific context of the case company, and the case company is therefore likely to have the greatest benefits of this report. However, the study also provides an input and a starting point for further studies of VMI suitability.

6.2 The quality of the study and future recommendations

The main output of this study is the VMI suitability framework. In order to ensure that the assessment of VMI based on the framework is replicable it is critical to clearly define how the different steps in the framework should be evaluated. In the current framework the different evaluations are described on a general level and the guidelines do not enable standardised evaluation, which is needed for the assessment to be replicable. The framework does not specify the risks or the effects in more detail than “high” or “low”. When applying this framework in practice, it can therefore be challenging to carry out the VMI suitability assessment and the outcome will be dependent on how different companies and individuals define “low” and “high”. Therefore, it is recommended to clearly define the internal VMI readiness, supplier readiness and product suitability and their constituents. Further, it is recommended to quantify the assessment process.

The suitability framework could be used as an input to the development of a multi-criteria assessment tool, such as an analytic hierarchy process (AHP). AHP is a mathematical method used for decision-making in complex situations (Golden, Wasil and Harker, 1989) where the important factors of a decision are arranged in a hierarchic structure (Saaty, 1990). Therefore, AHP is an option to use in the decision regarding VMI suitability. There are a variety of AHP software available that could be used. However, as a first step, it is recommended that future studies investigate how to quantify the performance- and relational risk. Furthermore, it would be of interest to weight the importance of each effect and how much of each effect can be realised.

The next step for the case company is to further look into how the VMI readiness categories, performance risk, relational risk and planning complexity should be defined in order to have a common view within the company. It is recommended that

the case company discuss the suitability assessment framework and the readiness categories internally. The reason for that is that the employees, who are experts in their field, can probably add more dimensions to the categories since they have better knowledge than the authors of this report.

The VMI readiness aspects developed from theory are general, which is why the framework is considered to be adoptable to a wide range of manufacturing companies. However, it should be pointed out that the content within each readiness category must be modified and clearly defined in order to reflect the specific context that it is applied in. Also, other available replenishment methods in each context have to be taken into consideration. All these aspects have to be considered before applying the framework.

The empirical data only consists of qualitative data based on personal interpretations, which could have impact on the results. Furthermore, the fact that this study was conducted on behalf of the case company might have affected the outcome of the interviews at the studied supplier. Quantitative data of the performance of VMI would have made it possible to draw more accurate conclusions regarding the realised effects. Quantitative data would also have made it possible to estimate potential economic effects of VMI and the size of potential effects. Therefore, it might be interesting to quantify the effects of VMI application at the case company.

In this study a limited number of interviews were conducted and only one case study was performed. Conducting additional case studies at other manufacturing companies might make it possible to deepen the knowledge and to add more dimensions to the VMI suitability framework. Studying a supplier that the case company considers having an insufficient performance could also add more aspects to the framework. Thus, conducting additional studies could enrich the VMI suitability framework with more dimensions.

Since there are a limited number of studies available on the suitability of VMI, it is recommended that more research should be conducted on this topic. For instance, there is a need to look into different manufacturing contexts and adapt the framework in order to investigate if there are more dimensions that did not become visible in this study. Furthermore, the impact of the IT system dimension of the suitability of VMI could be investigated. Also, actors further upstream and downstream in the supply chain could be included in order to broaden the view. That way it could be possible to have a broader view of the effects and enablers of VMI. The framework could be improved by investigating the VMI readiness of the entire supply chain. Finally, it should be mentioned that it could be interesting to investigate the suitability of POs and find a way to compare it to the suitability of VMI.

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APPENDIX I. INTERVIEWS CONDUCTED IN THE EMPIRICAL DATA COLLECTION

<i>Position</i>	<i>Level</i>	<i>Company</i>	<i>Topic</i>	<i>Media</i>	<i>Structure</i>
Supply Chain Manager	Strategic	Case Company	Case company background	Personal interview	Unstructured
Supply Chain Manager	Strategic	Case Company	Previous VMI suitability evaluation	Personal interview	Semi-structured
Process Manager, Purchase to Pay	Strategic	Case Company	Previous VMI suitability evaluation	Phone interview	Semi-structured
Category Manager	Tactical	Case Company	Configuration, definition, effects, KPIs, enablers, suitability	Personal interview	Semi-structured
Operational buyer 1	Operational	Case Company	Configuration, definition, effects, KPIs, enablers, suitability	Personal interview	Semi-structured
Operational buyer 2	Operational	Case Company	Configuration, definition, effects, KPIs, enablers, suitability	Personal interview	Semi-structured
Production planner	Operational	Studied Supplier	Configuration, definition, effects, KPIs, enablers, suitability	Phone interview	Semi-structured
Production planner	Operational	Studied Supplier	Configuration, definition, effects, KPIs, enablers, suitability	Phone interview	Semi-structured

APPENDIX II. INTERVIEW GUIDE SUPPLIER

Definition

- How would you describe VMI?

Introduction

- In total, how large part of the customer orders do you currently handle in a VMI setup?
- How would you describe the relationship with the case company? Does it differ from other customer relationships?
- What kind of products do you supply to the case company?

Configuration of VMI

- How is the VMI setup with the case company configured?
- Do you have the same setup for all VMI customers?
- How do you use the demand information that you receive from case company?
- Does something in the VMI configuration in this specific setup make it easier/more difficult for you to plan or utilise the received data?
- What is your role in the setup with the case company?
- Does the VMI setup change your daily work?

Effects

- In general, what is your aim as a supplier of using VMI setups with customers?
- In general, what effects do expect by applying VMI?
- What effects did you originally expect by applying VMI with the case company?
- Would you say that you have managed to realise the expected effects in the setup with the case company?

Key performance indicators (KPIs)

- Do you measure the effects of VMI?
- How do you measure the effects of POs?
- Is it possible to compare the performance of a VMI setup and a PO setup?
- Do you have any suggestions of KPIs that you think should be measured?

Barriers and enablers

- In your opinion, does the VMI setup with the case company work well or not well compared to other VMI arrangements/customer relationships that you have?

- Can you think of any specific products where the VMI setup with the case company has worked well /not so well?
- For what products is it most important to get demand information in advance?
- In general, for what product characteristics do you think VMI does work well/not work well?
- For what kind of customers do you think VMI works well/does not work well?
- In general, is there anything else, besides the product and customer characteristics that influence the performance?
- Do you have any improvement suggestions regarding the VMI setup with the case company?
- Are you able to use the demand information from the case company in order to optimise your production? Why/why not?

Decision making about when to use VMI

- Have you been involved in the decision-making of whether to apply VMI or not?
- What aspects were considered?
- In your opinion, are there any particular aspects that should be considered in future decision-making?

APPENDIX III. INTERVIEW GUIDE STRATEGIC MANAGER

Definition

- How would you describe VMI?

Introduction and configuration

- How much of the material supply would you estimate that Ericsson currently handles in a VMI setup?
- What is Ericsson's vision in regards to the purchased volume through VMI in the organisation after 5 years?
- Do you have different configurations of VMI or is it the same for all setups?

Effects

- What is the aim of using VMI?
- What effects do expect by applying VMI?
- In general, do you experience that you have managed to realise these expected effects?
- What positive/negative effects have you experienced with VMI?

Key performance indicators (KPIs)

- Do you have any data that can measure the effects of VMI?
- How do you measure the performance of POs?
- Is it possible to compare the performance of a VMI setup and a PO setup?
- Do you have any suggestions of KPIs that you think should be measured?

Barriers and enablers

- In general, for what product characteristics do you think VMI works well/ not well?
- For what kind of suppliers do you think VMI works well/not well?
- Is there anything else, besides the product and supplier characteristics, that influences the performance?

Decision making about when to use VMI

- At what level in the organisation is the initiative suggested?
- What is the reason for considering to apply VMI in the different situations?
- Do you have a standardised process that everyone in the decision making process should follow when deciding if to apply VMI?
- What aspects are considered when you are deciding if to apply VMI or not?
- Have you been involved in the decision-making of whether to apply VMI or not?
- In your opinion, are there any particular aspects that should be considered in future decision?

- In your opinion, what can be improved from how the decisions are made today?

APPENDIX IV. INTERVIEW GUIDE TACTICAL MANAGER

Definition

- How would you describe/define VMI?

Introduction

- How much of the material supply do you currently handle with VMI?
- Do you have any experience from working with the studied supplier?
- How would you describe the relationship with the studied supplier?
- What kind of products does the studied supplier supply?

Configuration of VMI

- How is the VMI setup with the studied supplier?
- Do you have the same setup for all products supplied from the studied supplier?
- Do you know if the setup is the same for other suppliers or is it specific for the studied supplier?
- Does the VMI setup change your daily work?

Effects

- In general, what effects do expect by applying VMI?
- What positive/negative effects that you experience with VMI in general?
- Do you think there can be any additional positive effects with VMI in general? If so, what?
- What positive/negative effects do you experience with the studied supplier?

Key performance indicators (KPIs)

- Do you measure the effects of VMI?
- How do you measure the effects of POs?
- Is it possible to compare the performance of a VMI setup and a PO setup?
- Do you have any suggestions of KPIs that you think should be measured?

Barriers and enablers

- Is there any specific VMI setup that works well/not so well in your opinion?
 - What is it that you think works well/not well?
 - What are the main differences between those two setups?
- Do you consider the VMI setup with the studied supplier to work well or not well?
- In general, for what product characteristics do you think VMI works well/not so well?

- Can you see that the performance differs between products the with the same supplier?
- For what kind of suppliers do you think VMI works well?
- Is there anything else, besides the product and supplier characteristics, that influences the performance?

Decision making about when to use VMI

- What do you think should be considered, before deciding to use VMI?
- In your opinion, what can be improved from how the decisions are made today?

APPENDIX V. INTERVIEW GUIDE OPERATIONAL BUYER

Definition

- How would you describe/define VMI?

Introduction

- How much of the material supply do you currently handle with VMI?
- Are there any specific VMI setup works well/not so well in your opinion?
 - What is it that you think works well/not well?
 - What are the main differences between those two setups?
- Do you have any experience from working with the studied supplier?
- How would you describe the relationship with the studied supplier?
- What kind of products does the studied supplier supply?

Configuration of VMI

- How is the VMI setup with the studied supplier configured?
- Do you have the same setup for all products for the studied supplier?
- Do you know if the setup is the same for other suppliers or is it specific for the studied supplier?
- Does the VMI setup change your daily work?

Effects

- What would you say that the aim of using VMI is?
- Are there any positive/negative effects that you experience with VMI in general?
- Do you think there can be any additional positive effects with VMI in general? If so, what?
- What positive/negative effects do you experience with studied supplier?

Barriers and enablers

- In general, for what product characteristics do you think VMI works well/not so well?
- Can you see that the performance differs between products the with the same supplier?
- For what kind of suppliers do you think VMI works well?
- Is there anything else, besides the product and supplier characteristics, that influences the performance positively/negatively?
- Do you consider the VMI setup with the studied supplier to work well or not well?

Key performance indicators (KPIs)

- Do you measure the effects of VMI?
- How do you measure the effects of POs?
- Is it possible to compare the performance of a VMI setup and a PO setup?
- Do you have any suggestions of KPIs that you think should be measured?

Decision making about when to use VMI

- What do you think should be considered, before deciding to use VMI?
- In your opinion, what can be improved from how the decisions are made today?

APPENDIX VI. EXAMPLE QUESTIONS FOR VMI SUITABILITY ASSESSMENT

Below are examples of questions that could be used in the VMI suitability assessment. The questions are formulated in order to be applicable for a buying firm evaluating the suitability of inbound VMI.

Step 1: Internal VMI readiness assessment

Incentives

- Why do we want to apply VMI?
 - Service level improvement?
 - Inventory level reduction?
 - Reduction in administration?
 - Improved relationship?
 - Etc.
- Are these incentives in line with the strategy and other incentives in our company?
- Is there any improvement potential in regards to the effects we want to achieve?
- In what type of VMI are these effects achievable?

Capabilities and resources

- Are we able to operate a VMI setup?
- What activities will we perform in the VMI setup?
 - Share information
 - Educate supplier
 - Follow up on measurements
 - Regular meetings
 - Operate control mechanisms
 - Etc.
- Do we have the capabilities of performing these activities?
- Do we have the resources to perform these activities?

Step 2: VMI readiness assessment of the supplier

Perceived performance risk in regards to the perceived capabilities and resources of the supplier

- What activities will the supplier perform in a VMI setup?
 - Integrating demand information in the planning of their production
 - Managing replenishment decision
 - Keep inventory and service on agreed levels

- Learn the system
- Participate in regular meetings
- Proactively share information
- Etc.
- Is the supplier capable of performing these activities?
- Does the supplier have the resources to perform these activities?

Perceived relational risk

- Does the supplier have incentives to commit to the setup?
 - Optimise production
 - Increase service level
 - Reduce inventory level
 - Differentiate from other suppliers
 - Develop the relationship
 - Etc.
- Are these incentives aligned with the basic or advanced VMI?
 - Do the incentives match ours in regards to type of VMI?
 - Are the incentives aligned with ours or conflicting?
- Is the extra administration worth the benefits for the supplier?
- Are we a large and important customer for this supplier?
 - Will our purchased volume enable the supplier to optimise their production?
- Is there anything else that could result in that the supplier does not commit to the setup and behave opportunistically?
- Is it possible to share the benefits in order to achieve mutual benefits?

Based on the evaluation of the perceived risk in the setup, the need of control mechanisms can be determined. This results in the following questions to be answered by the buying firm.

- What control mechanisms must be in place?
- Do we have the capabilities and resources to operate these control mechanisms?
- Is there a risk that the control mechanisms will restrict the positive effects to be gained from the setup?

Step 3: Product suitability assessment

In the situation where the supplier is placed in the mixed area there is a need to distinguish the products with high and low planning complexity in order to answer the question of what products to include in the VMI setup. The forecast accuracy of the products is suggested to be used as an indicator of the planning complexity of the products. The planning complexity could also be evaluated based on the characteristics below.

- Demand volatility
- Number of suppliers
- Lead time
- Value
- Size
- Manufacturing complexity