A Framework for Modelling of Vendor Managed Inventory

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Ein kjem ikkje til fjells på ein flat veg

Ivar Aasen (1813-1896)

(fra Norske Ordtak, 2003, 4. utg)

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Abstract

The overall objective of a supply chain is to provide markets with goods while maximizing profit. A product's path from raw material to end consumption involves many actors, and traditionally they aim at maximizing their own profit. However, over the last decades there has been a growing awareness of opportunities for further cost reductions by cross company optimization.

Supply chain management involves long term planning of facilities and resources as well as short term planning of production and transport activities. Coordination of activities is a major task within the management of supply chains. When coordination fails, inventories build up and the leanness and cost efficiency of the material flow suffers. Coordination across inter organizational boundaries require collaboration, and over the years many collaboration models have been applied. Some of them have been well defined, structured and based on negotiations and contracts, while others have been based on gentlemen's agreements and business as usual.

One model which for some time has been considered State Of the Art in supply chain integration is Vendor Managed Inventory (VMI). VMI is a concept for inventory management aiming to improve the replenishment process (manufacturing and distribution from supplier to customer), and the main objective is to improve product availability without increasing associated inventory, distribution and production costs.

The core of VMI is that the supplier has the authority and responsibility to maintain product availability for the customer. The customer places no orders and the supplier does not have to await orders to initiate replenishment. The result of this distribution of responsibility is that one decision level in the supply chain is removed. The effect is that one source of information distortion and delays is removed and the material flow can be related to a more correct demand pattern. Reduced demand information disturbances reduce demand uncertainty, and safety stock levels can be reduced.

Decision authority allows the supplier to adjust production and distribution volumes and frequency to smooth his own operation by utilizing the flexibility in the customer's inventory. Suppliers engage in VMI to improve service level, to gain access to advance demand data to improve their own operation and to assure customer retention. Undoubtedly, many suppliers engage in VMI upon the customer's request.

For the customer VMI is a form of automatic replenishment. Customers engage in VMI to reduce cost associated with traditional purchasing and inventory management activities, and employees can be engaged in more strategic purchasing decisions.

VMI is of particular interest because new and intelligent use of information and information technology is required to make it work efficiently, and VMI is gaining ground in multiple industries worldwide. However, there is little work done to identify what is important parameters for building a VMI collaboration program, both regarding the conditions under which VMI will work and what to include in the planning process.

The main purpose of this work has been to develop a framework for how to build a VMI collaboration program. The focus has been on how to obtain logistical benefits, and other

political or strategic motives that can be determinants in the decision process are not highlighted.

There were four objectives set out to prepare the framework. These were to

- Identify and describe benefits and opportunities of VMI collaboration
- Identify and describe obstacles, pitfalls and limitations to VMI success
- Describe and understand how material and information flow is affected by the implementation of a VMI solution
- Identify, describe and understand key points for successful VMI collaboration

These particular objectives were selected to increase operational comprehension and the practical applicability of the results.

The research methodology applied in this work was a combined literature review and multiple case study. Empiric data and experience from five cases of VMI collaboration formed the fundament. This approach was selected because real life examples increases the recognition and comprehension and thereby the applicability of the results towards practitioners. Additionally, a multiple case study would embrace many parameters, some of which might not be available in single cases. These parameters would differ in relevance according to case specific circumstances and conditions. In order to identify which ones were key, it was essential to observe cases with different settings.

The *scientific contribution* of this work was a framework for how to model a VMI collaboration program, and the framework was based on key points for VMI success. Basic recommendations from the framework are:

- There should be a minimum business interaction volume over time to justify costs and efforts
- A mutual understanding of each party’s business environment and requirements is needed
- Use a well defined and flexible system for data exchange
- Implement routinely exchange of demand data and production schedules where exchange frequency is determined by planning frequency
- Use fair and purposeful performance measures that reflect priorities and the ability to influence the outcomes
- Establish an open collaborative environment for continuous refinement of the content and scope of the agreement

The validity of these parameters rest on mutual trust and honest intentions, yet every party has the right and obligation to act precautious and safeguard against abuse. Further details on these points are found in the analysis section of this thesis.

As a *managerial contribution* of this work a Practitioners’ Guide to VMI was developed. The guide contains a set of general advice and a set of decision areas.

1. In order to make practitioners considering a VMI solution it is essential to present the benefits and opportunities, and it is equally important to highlight the pitfalls and

limitations. It is also important to build comprehension to make the actors understand what a VMI solution will do to the material and information flow. Therefore the guide contains a section for advice to increase the reader’s comprehension of VMI as a complex and dynamic relationship between a customer and a supplier.

2. The main purpose of the guide is to aid in the development process. Therefore it contains a section for decision support. Ten fundamental decision areas are presented, and recommendations to what decisions to make are presented. Fore some of the decision areas the recommendations are specified as to whether the user is a supplier or a customer.

The modelling framework and an introduction to the Practitioners’ Guide are presented in chapter 11 of this thesis. The complete Practitioners’ Guide with reading instructions is presented in Appendix B.

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To my darling Ingeborg Johanne and Einar Martin

This is what your mother has been doing at work.

1 Introduction

Supply chain management (SCM) is about the management of material and information flow for a product from point of origin to end consumption and disposal. It encompasses all processes and activities required to produce a product and make it available for a customer, like purchasing, transportation, warehousing, manufacturing, ordering processes, funds transfer etc. (e.g. Harrison & van Hoek 2002). Lately, post consumption activities and processes like return handling, recycling and disposal have been included in the concept of supply chain management. A proper supply chain strategy is now considered an essential element of a company's overall competition strategy.

Costs build up all along the supply chain and improving supply chain efficiency is one of the major challenges supply chain managers are faced with. Total supply chain costs can be reduced by coordinating activities across inter-organizational boundaries but this is difficult to achieve in complex supply chains where autonomous organizations are faced with simultaneous and sometimes conflicting requirements from many stakeholders. However, it has been argued that competition in today's markets is on supply chain level and the success of a company depends on how well its supply chain relationships are managed (Christopher 2005, Simchi-Levi et al 2000).

1.1 Background

Over the last decades of the 20th century the subjects of logistics and supply chain management have gained significant ground in business and industry worldwide. When the industrialized world started recovering after world war two and the availability of products and merchandise exceeded market demand, the competitive situation for manufacturers changed (Persson et al. 2006:41). There has been a significant change in focus from internal cost reductions to overall supply chain improvements as managers have realized that their own operation rely on the performance of their suppliers and customers. Additionally, there has been an increasing awareness of the effects of information availability. New opportunities within planning, coordination and synchronization have evolved with knowledge about demand, inventory levels, lead times and costs in the supply chain.

The move from an internal to a supply chain focus has been impossible without the parallel development of Information and Communication Technology (ICT). ICT has enabled faster data transfer and the ability to handle more and more information is substantial. Information overload is common and the challenge is now to filter out and identify what information is important for different purposes. The move in focus is further described in the text box in Figure 1-1.

In parallel to the increasing awareness of logistics and SCM as a competitive tool among managers, the subjects have gained significant ground in research and education. According to for instance Arlbjørn & Halldorsson (2002) logistics emerged as a scientific discipline in the early 1960's while the term "Logistics" entered the academic literature in the early 1980's and represented an integration of physical distribution and materials management (see e.g. Bowersox et al. 1986). "Supply chain management" was introduced in academic literature in the early 1990's (e.g. Coyle et al. 1992) and it was based on a realization that management of production and transport also rested on management of the relationship between the different actors involved (Christopher 1998). During the 1990's the interest in SCM among academics grew and the number of colleges and universities that teach some level of logistics or SCM is still growing.

Internally, optimization techniques were used to reduce costs in the production process and computers were used to solve complex equations. Similar techniques were applied to optimize distribution as the importance of product availability grew. Along with stabilizing economy the focus turned to the cost of capital employment. Time reduction in material flow evolved as a competition strategy. Computers were used to speed up product development and to monitor inventory levels. As a result of time reduction, coordination of processes and activities across business boundaries was required. The focus turned to supply chains, supply networks and network relations (Persson et al. 2006:44) and computers were used for information exchange.

We have witnessed a move from point automation in the factory to computer integrated manufacturing (CIM) where all manufacturing resources were controlled by the same computer system. The next step was a move to Computer integrated business (CIB) where administrative processes were included in the computer systems, and the following step was to make the business system interact with the business systems of customers, suppliers and logistics providers. The main benefit of an integrated computer system is the global availability of information that facilitates process coordination.

Figure 1-1, from internal optimization to supply chain cost reductions

Supply chain integration has come to focus both for researchers and practitioners. The necessity of coordination of supply chain activities in order to maintain competitiveness and achieve total cost reductions is well known. Over the last 20 years several models for inter-organizational collaboration have been developed and applied to support coordination. These models draw some main lines to what activities are encompassed and how responsibilities are distributed. Different models take different approaches as there are multiple types of activities to coordinate. In SCM typical activities are ordering, invoicing, production, inventory, distribution and other activities related to material and information flow through the supply chain. The models come in multiple formats, they are customized to facilitate the particular business relationship they are a part of and frequently they are given unique names. In purchasing and supply chain management literature these models are described as sourcing strategies or strategies within customer relations management (CMR) or supplier relations management (SRM) programs (e.g. Chopra & Meindl 2007, van Weele 2005).

Some of the most prevailing collaboration models focusing on efficient replenishment are Quick Response (QR), Continuous Replenishment Programs (CRP), Efficient Consumer Response (ECR), Collaborative Planning, Forecasting and Replenishment (CPFR) and Vendor Managed Inventory (VMI). They have in common that they are designed to improve product availability without increasing accruing costs, and a main objective is to reduce upstream demand uncertainty by increasing knowledge about future demand. Means to reduce uncertainty are for instance

- increased responsiveness,
- improved forecasting,
- improved market monitoring and
- change in distribution of responsibility.

The models are more easily managed in a dyadic relationship but the effects gained should be used to gain further improvements along the supply chain. Some models, their similarities and differences are further presented in section 2.3.

1.2 Vendor Managed Inventory

One of the models that have developed irrespective of industry is Vendor Managed Inventory (VMI). VMI is a model for improved inventory management and the ultimate goal of this model is to increase service level without increasing inventory levels or distribution costs. The intention is to achieve this by coordination of activities enabled by extended communication and information sharing (Figure 1-2). The core of VMI is to use information more purposely to enable change in distribution of responsibilities.

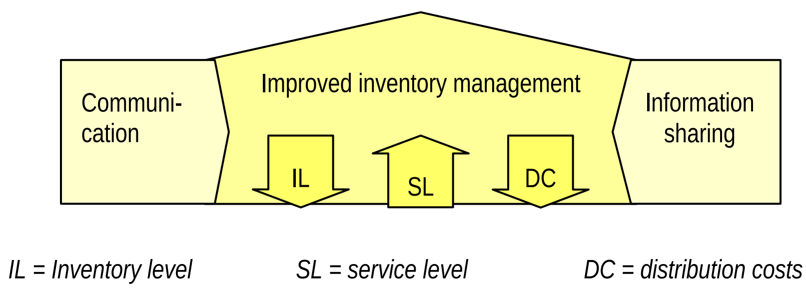


Figure 1-2, goal of VMI is to increase service level while reducing inventory and distribution costs by use of communication and information sharing

Though the term "Vendor Managed Inventory" can only be dated back to the mid 80's and the partnership between Wal-Mart and Procter & Gamble (Simchi-Levi et al. 2000), the basic idea was presented in 1958 by John F. Magee (Magee 1958) when discussed who should control inventories, those who use them or those who feed them. He realized that both parties had legitimate interest in keeping control and he suggested that the supplier should control the inventory within some preset limits based on demand information supplied by the customer. A small extract of his discussion is reproduced in chapter 3 along with a further elaboration on theoretical aspects of VMI.

From the acceptance that both parties have a legitimate interest in maintaining inventory control, a VMI collaboration program can be identified by some specific criteria. The five criteria used to describe VMI encompassed by this research are:

1. *The replenishment decision is in the hands of the supplier*, both with respect to frequency, volume and time.
2. *Supplier's replenishment freedom is limited to predetermined performance standards,* these could be maximum - minimum inventory levels, reorder point agreements, inventory turnover measures, required service levels and others.

3. *Some sort of demand information is transferred from the customer to the supplier*, type of demand information, frequency and format of information exchange may differ.

4. *There are no customer orders initiating a purchase*, stock withdrawals are made by customer on demand and related invoice is issued periodically or by activity.

5. *The receiving warehouse is owned by the customer or operated by some 3rd party on his behalf*. The customer possesses the goods and the supplier is not free to tranship goods to other customers.

Ownership of the goods makes no important difference. Ownership may be transferred to the customer upon delivery or remain with the supplier until physical stock withdrawal.

VMI programs are subject to detailed specifications, and programs can differ on terms and content. In the individual case descriptions it is outlined how each program conforms to the criteria listed above. For an elaboration on interpretation of the term VMI in comparison to other models of supply chain collaboration and to support the selected set of criteria, see section 2.6.

From the definition of VMI above it is argued that VMI implies a somewhat untraditional allocation of responsibility in the replenishment process. As opposed to traditional purchases where the customer decides when and how much to purchase based on his own demand, the supplier makes the replenishment decision for the customer in VMI. Based on predetermined performance measures like e.g. inventory turns and customer service levels (Norek 1998) the supplier does not have to await a customer order. The customer will not review the suggested shipment, (Simchi-Levi et al 2000, Norek 1998). Figure 1-3 shows how the control boundary is moved closer to the customer in a VMI relationship to indicate that the supplier is in control of the customer's production buffer stock. The VMI stock can be located within the customer's facilities or it can be handled by a 3rd party inventory hub operator.

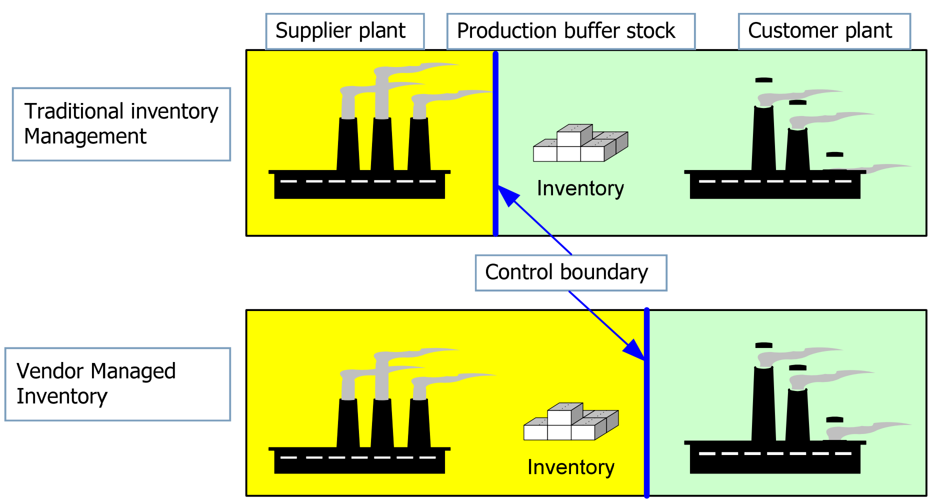


Figure 1-3, the control boundary in VMI compared to traditional inventory management (McBeath 2003)

The concept has received multisided attention among researchers in the field of supply chain management, both with respect to potential benefits and opportunities and the inter-organizational challenges of making it work. The main benefit of letting the supplier be responsible for inventory replenishment is automated replenishment for the customer and increased flexibility for the supplier. The supplier's increased flexibility is based on increased knowledge about future demand combined with extended response time. This rests on two basic conditions.

1. The supplier must have access to demand information in order to plan production and distribution.
2. The supplier must have the authority to decide when to ship what volumes.

It is important that both conditions are present. If the supplier has no advance demand information he will not be able to prepare plans, and if the supplier has no authority to be in charge of replenishment he will not be able to exploit the opportunities. The other collaboration models listed in the previous section do not include condition number two. Though the supplier has access to demand data (e.g. forecasts or production plans), the final replenishment decision is still with the customer, and the supplier is left with a finished goods inventory ready to ship whenever the customer request arrives. The result is that the goods are stored at two levels in the supply chain and total inventory volumes are not reduced. Many other positive effects from VMI are expected and experienced. These are further described in chapter 3 of this thesis.

Figure 1-4 illustrates how the customer's VMI inventory level is monitored by the supplier who replenishes from his own production or finished goods (FG) inventory to maintain availability to the customer. This is a very simplified illustration. In reality there are more elements affecting the operation of VMI but this shows the basic information and material flow.

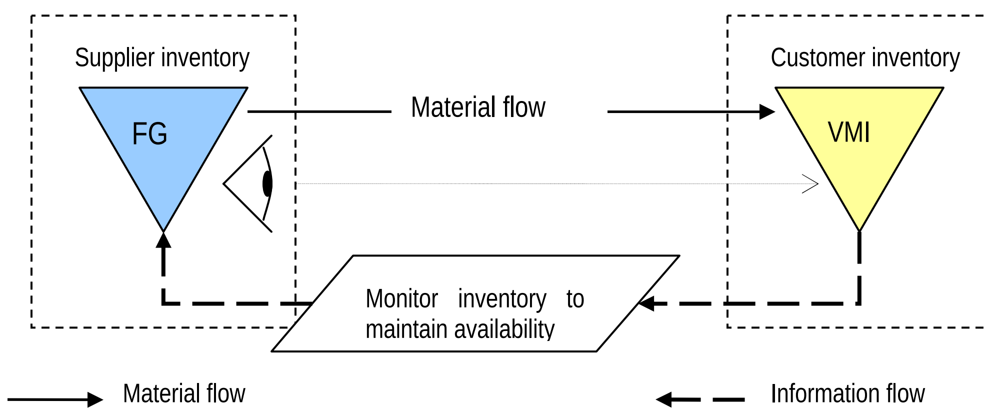


Figure 1-4, supplier monitors VMI inventory level and make replenishment decision

The peculiarity of this concept becomes visible when studying responsibility and costs. The supplier is responsible for maintaining product availability, and the customer is responsible to pay for the received goods. The supplier will thus benefit from shipping large volumes unless the customer has some means to prevent it. Frequently applied means are performance measures and time for transfer of ownership. In reality it is often about setting limits for maximum and minimum inventory levels and delaying time for payment until goods are actually drawn from stock. In the last case the supplier is left with the costs of capital employment and has a prime incentive to keep inventory levels down.

This model has become very popular in the US retail sector, mostly consumables, but also for instance electric appliances and high tech electronics. The model is also applied in the automotive industries in Europe and USA where component suppliers have served the assembly lines on VMI contract terms since the end of the last millennium. We also see simple solutions applied for e.g. stationery and for spares and consumables for construction sites. It is said that VMI represents a powerful tool to take costs out of the supply chain if implemented properly (van Weele, 2005).

The concept of VMI is important to study on a general basis because it has proved to work irrespective of industry. However, most success stories come from retail level, and the concept seems less applied in relationships further upstream the supply chain where volumes and demand patterns are different from the retail level. It is therefore important to study how the concept can be applied upstream from a manufacturer so that the benefits of VMI can be exploited throughout the supply chain.

1.3 VMI adoption rate

As an introductory part of this work, an informal survey among a limited number of logistics practitioners (manufacturers and retailers) was conducted. This survey revealed that there was some experience and knowledge on the subject of VMI, and those who were currently or had previously been involved in such collaboration had mainly positive experience while remembering that the implementation process was challenging. Those who had no experience with VMI found the topic of interest and wanted to learn more about the concept. They primarily wanted to know

- *Would the concept be suitable under the conditions of which they were operating?*

And supposing they were convinced this concept would work for them:

- *How would they move on and*
- *How much investments would be required.*

Questions regarding information sharing, safeguarding and trust were of particular interest.

Despite all opportunities and possible benefits of VMI presented in literature, a national survey called Norsk Logistikkbarometer 2003 (www.logistikkbarometeret.no) indicated that only 2% of Norwegian businesses are involved in VMI collaboration programs. The exactness of this figure is not verified but compared to what is found in other countries, it can still be argued that the use of VMI is limited in Norway. A survey including the largest US retailer and consumer goods firms in 1998 (RIS 1999) indicated that 50% of the companies were involved in automatic replenishment and VMI in 1998, and it was expected to increase to 75% by 2001. Mattson (2002) and Olhager & Selldin (2003) indicate that the adoption rate is 16% and 15% in Sweden respectively.

For the purpose of this study, fellow researchers with specific interest in VMI in both Sweden and Finland were asked if there was any recent survey indicating VMI adoption rate in their country but there were none known to them. However, a follow-up national survey called Norsk Logistikkbarometer 2005 indicated an increase in focus on value chain integration, collaboration and inventory concerns. This survey did not ask specifically for use of VMI

The US figure of 75% is related to retail (e.g. grocery, electrical appliances) while Norsk Logistikkbarometer 2003 and 2005 encompass a wider selection of industries (retail included). Both the 2003 and the 2005 surveys indicated that building of long term relations with suppliers is expected to be of high importance in the future. Simultaneously, competence building in logistics was found important. One out of four respondents of the 2005 survey believed that shortcomings in logistics competence were a major limitation to the development of efficient supply chains.

The limited adoption of VMI in Norway could be because Norwegian industry has deliberately ruled out VMI as a relevant collaboration model, it could be low due to shortcomings in knowledge and competence in the area among practitioners or it could be because Norwegian practitioners are lagging behind.

The cause of limited adoption is likely to be a combination of limited knowledge, competence, capacity and engagement. If existing solutions work satisfactory there is less focus on this type of change. Norwegian economy has been stable for some time, and the financial downtimes often required to trigger change projects have not been highly evident.

1.4 Existing work and shortcomings

A lot of work has been done to identify benefits and opportunities of VMI, both for the supplier and the customer. Documented supply chain performance improvements from VMI include e.g. reduced inventory and distribution costs, smoothed manufacturing and increased sales and customer retention. Most researchers discussing benefits and opportunities claim that VMI is a means to reduce inventory build-ups along the supply chain, also described as the bullwhip effect.

Some researchers look at obstacles and potential problems to establishment of VMI. These include lack of trust between the supply chain partners, high investments in computer systems to facilitate communication and information sharing (ICT) and reluctance to relinquishment of responsibility (e.g. De Toni & Zamolo 2005, Disney & Towill 2003, Harrison and van Hoek 2002). These observations and reflections are just as important contributions to the description of the concept as the benefits and opportunities. Both upsides and downsides are described in chapter 3.

An aspect of VMI not so well documented in literature is what a practitioner should focus on in order to increase the likelihood of succeeding with VMI. Different implementation models have been presented but they are either too general or too narrow to guide in the planning and implementation of VMI.

- ~ Simchi-Levi et al. (2000:136) summarizes VMI implementation in a two step model. Some interesting key words are expressed but the model takes a general perspective and come to short in the details.
- ~ McBeath (2003) has very detailed recommendations on performance measurement and forecasting. He encompasses many elements and the recommendations are very valuable contributions, but his focus is on the high tech electronic industry and he still cover only part of the elements of a VMI collaboration program.
- ~ Based on the study reported by McBeath (2003), Roberts (2003) present a four step methodology which is comprehensive and has many key words included. However, he does not come down to recommendations.
- ~ The Supply Chain Resource Consortium (SRCR) at North Carolina State University (http://scrc.ncsu.edu) has developed a six point list for how to implement a successful VMI system. They do not get down to earth on specifications applicable to VMI, their list of "do's" is somewhat general and could be applicable to many implementation projects.

Other researchers have studied specific elements and call them success criteria in VMI without presenting methodologies or recommendations, (e.g. De Toni & Zamolo 2005, Pohlen & Goldsby 2003, Småros et al. 2003, Kaipia et al. 2002, Kulp 2002, Lapide 2001, Simchi-Levi et al. 2000, Hoyt & Huq 2000, Ellinger et al. 1999, Waller et al. 1999). These works will be further studied in the search for key elements of VMI application as described in chapter 3. To capture the shortcomings in current knowledge on practical implementation and application of VMI the following statement is developed for this work:

"The goal at the end is bright and shiny but the road ahead is a labyrinth filled with pitfalls and dead ends and the existing roadmaps cover only sections of the path".

Based on this gap, the prime outcome of this work is a framework for how to build a well functioning VMI collaboration program. The framework is founded on a scientific study and analysis of existing work and empirical data.

1.5 Research domain

The construct of the framework is developed on the basis of a set of objectives, a set of hypotheses about what will influence the results, and a corresponding research question. The research domain is also expressed by a summary of the motives and arguments for why this work is conducted.

1.5.1 Objectives

The primary objective of this work is to identify and describe key elements and properties of a supply chain that influence the logistics benefits of VMI replenishment. These will form the fundament for the framework. The framework is then used to build the managerial contribution of this work which is a Practitioners' Guide to VMI that is further described in the outcome section below. In order to understand the consequences of the decisions made during the development process it is important to understand the concept and how it affects the material and information flow of a company. When the concept is understood it is equally important to understand how to get on to the planning and implementation of a successful collaboration program. Two supporting objectives are included to build comprehension of the mechanisms of VMI. The hierarchy of objectives and the resulting framework and guide is illustrated in Figure 1-5.

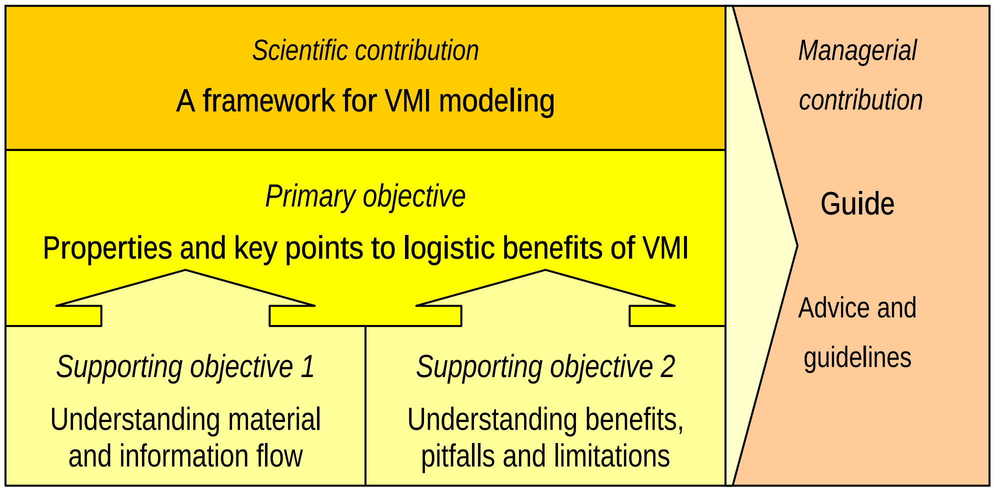


Figure 1-5, hierarchy of objectives and results

The main scientific contribution of this work is a framework for how to model a VMI collaboration program. It is built on the primary objective of this work which is:

To identify, describe and understand what are properties of supply chains and key points of supply chain collaboration that give logistic benefits in VMI collaboration programs.

Two supporting objectives are stated to establish an educational platform. This is to support practitioners' understanding of the concept. These are based on review of existing literature and they will be supported by empiric results from the study. They are included because they are required to support the primary objective.

Supporting objective 1: To identify and describe how a VMI collaboration program affects the material and information flow of a company.

Supporting objective 2: To identify and describe what are the benefits, limitations and pitfalls of VMI collaboration.

1.5.2 Outcomes

The framework for modelling of VMI is the scientific outcome of this research. The findings from the work are contributions to theory on requirements to VMI success. This will draw the line between what are expected benefits of VMI and how to obtain these benefits.

The managerial outcome of this research is a guide that will support practitioners in the process of entering a VMI collaboration program. This guide should help practitioners to focus on the right decisions and to avoid common pitfalls. In order to make the results easily accessible for practitioners the guide is presented in a handbook format where there are no discussions or references to scientific publications. The advices and recommendations are founded on the scientific contribution of the work which is presented in the analysis section of this thesis.

It is important to be aware that the framework and guide take a particular focus on the decisions directly related to the logistic issues of planning and preparation. Initiation and management of changes in an organization is first of all subject to project management and the initiation of a VMI collaboration program is from a top management perspective not much different from other change processes and implementation projects.

Literature on project management is plentiful, and while the topic is outside the scope of this thesis some generalities are included in order to fit the guide into the larger picture. Some of the most prevailing project management processes are formulation of goals, planning and monitoring and controlling the execution (see e.g. Kolltveit & Reve 1998). These processes are iterative and form a process loop. The guide will primarily contribute to the initiation and planning of the project but it can also be applied for improvement purposes after the initial development process is closed. Figure 1-6 copied from Baca (2005) shows the project processes, how they iterate and form the process loop. To place the guide in the project context the original figure is edited. The guide and post project operation boxes are added to illustrate where during the project of implementing VMI the guide can be applied. It is assumed that the implementation is completed when reaching the “Closing” part of the project.

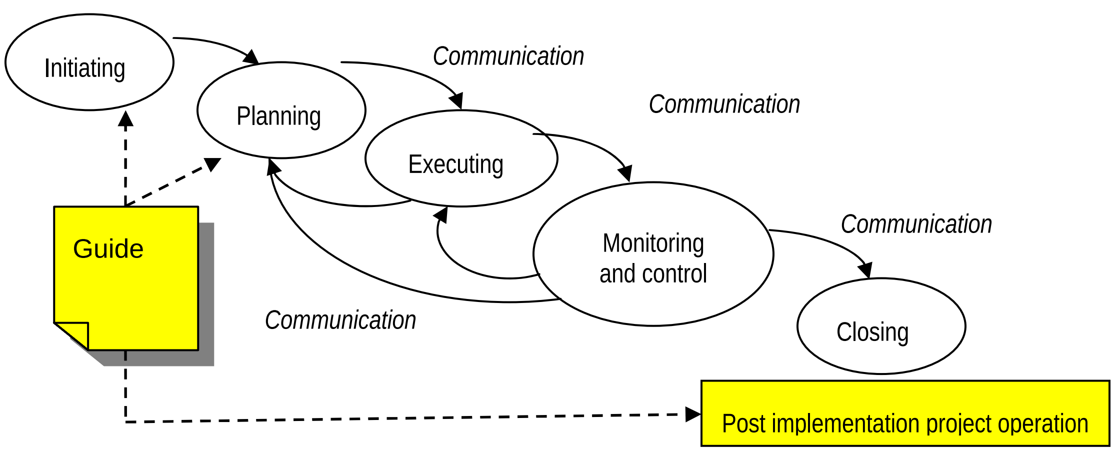


Figure 1-6, the guide in an implementation project (original figure based on Baca 2005)

1.5.3 The hypotheses

On the basis of an initial literature review and a pilot case study some assumptions regarding requirements for VMI success were identified. These assumptions were pronounced as hypotheses that form a fundament for the proposition of the research question. The hypotheses suggest that there are at least five aspects of supply chain collaboration that will have an influence on the effect of a VMI program. These are

H 1. The way ICT is used to support communication and information exchange
Because information is exchanged by different means and frequency and that different types of information are shared

H 2. *How performance is measured*
Because the actors focus on performance indicators, sometimes disregarding other opportunities for improvements

H 3. *To what extent the parties collaborate initially and during operation*
Because some programs are founded on discussions and cooperation while others come about more or less by imposition.

H 4. *There are production, product and market characteristics that affect the appropriateness of VMI.*
Because there are many elements in a supply chain that influence how it should be designed and controlled

H 5. *To what extent the parties trust each other*
Because VMI require exchange of possible sensitive information

Further it is presumed that in cases where these properties are not in such state that they support the VMI program, logistic performance will suffer, costs will rise and the actors will look for alternative options. Figure 1-7 illustrates how these five aspects support a higher performance level of a VMI program while increased costs and other opportunities are likely causes of reduced performance.

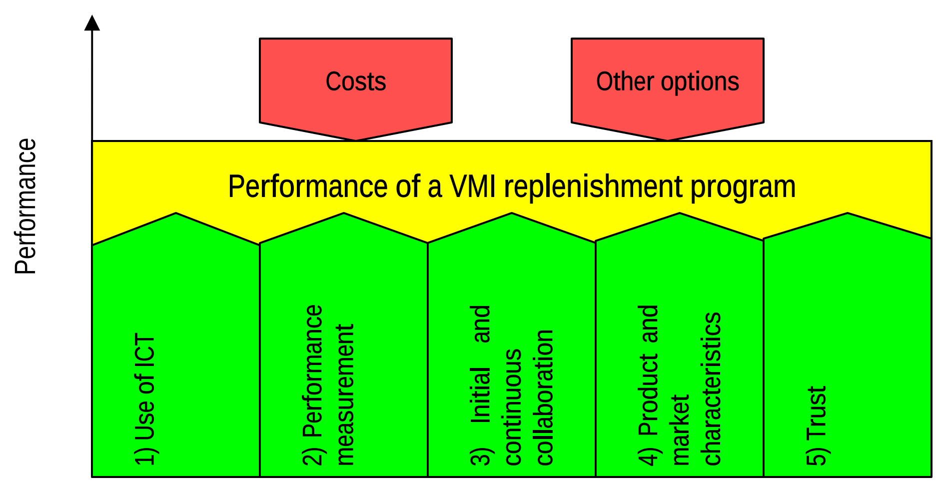


Figure 1-7, five aspects of supply chain collaboration that will influence VMI effect

At the end of the analysis section of this thesis this illustration will be revisited to summarize on the details of the findings within each of the aspects.

1.5.4 The research question

The research question posed for studying the hypotheses and meeting the objectives focuses on the practical aspects of a VMI program. It is formulated to answer questions asked by a practitioner considering VMI collaboration like; what are important areas of collaboration, what information should be shared, what will be the important logistic decisions, who should bear what responsibilities and which party should carry accruing costs. These and related questions are rarely discussed in VMI literature or the four implementation models mentioned in section 1.4. Several aspects are briefly mentioned or even proposed. However, they appear only as reasonable assertions in empirical work and support by research is limited. The main research question pursued in this work is:

Research question

What are properties and key points for successful VMI operation in the areas of information sharing, performance measurement, collaboration areas, inter-organizational relations and other product and market characteristics?

Further detailed research questions under each area referred to in the main question are:

Information sharing, for instance:

→ What type of information would the supplier need?

→ What information would the customer need?

→ How should this information be transferred?

→ How often should this information be updated?

Performance measurement, for instance:

→ How should supplier performance be measured?

→ How should customer performance be measured?

→ How should success in a VMI collaboration program be measured?

Areas of collaboration, for instance:

→ What should the parties agree upon at the initial stages of the establishment process?

→ What elements should be subject to continuous discussions and collaboration?

Product and market characteristics, for instance:

→ What product and market characteristics appear determinants for success?

Trust and contract regulation, for instance:

→ What regulation mechanisms are needed to support a successful VMI collaboration program?

~

The answers to these questions are sought by conducting a combined literature review and multiple Case study. This methodology was selected assuming that success parameters vary with context, and in order to identify key parameters it is essential to study the same topic within different contexts. Studying different contexts is important when the purpose is to generalize, a multiple case study will facilitate this approach. The theory of case studies methodology and an outline of the work performed in this study are further described in chapter 4.

1.5.5 Why studying Vendor Managed Inventory

The main argument for conducting this research is based on the realization that literature is scarce on how VMI collaboration should be developed. There is an increasing awareness of VMI in other industries than retail, and practitioners are curious about the suitability of the concept. Practitioners want to know whether VMI is suitable for their company, and if so, how they should proceed. Among other things, they need to know what products to include and what supply chain actors to approach. Taking a suitability perspective to VMI will add to existing theory.

Elaboration on the concept of VMI is important because the sharing of responsibilities in this type of collaboration program make the focus on incentives fundamental.

There is less literature on VMI collaboration upstream the supply chain, for instance between a manufacturer and a component supplier. It is important to study VMI in this type of relation because there is a fundamental difference in demand pattern, demand volume and predictability compared to the well documented retail level.

According to the survey Norsk Logistikkbarometer 2005 there is an increasing focus on supply chain integration among practitioners, but the limited use of collaboration models is presumed to be caused by limited knowledge. A scientific yet easily understandable presentation of the concept and recommendations is therefore long overdue.

The use of case studies in logistics in general and on VMI in particular is limited but wanted (Halldorsson & Aastrup 2003, Frankel et al. 2005). The trend shows an increasing use of case studies and the increase is welcomed because aspects of logistics in a system are highlighted. It is also about time to tell some stories, both successes and failures, and to present some lessons learned in order to build a comprehensive framework for VMI collaboration.

1.6 Context and limitations

So far the main lines of this work have been drawn. The subject is outlined, the objectives, hypotheses and research questions are presented and the choice of research method is outlined and argued. The following elaborates on some central definitions and outlines on limitations.

1.6.1 Logistic aspects of VMI

It is argued in the scope of this work that only logistic aspects of VMI are studied. The term “logistic aspects” is used to include activities and decisions that influence the speed, quality and cost efficiency of material and information flow, and therefore it describes the operational performance of the VMI program.

1.6.2 Collaboration, cooperation and contractual agreements

Different terms are used to indicate that businesses interact and usually these terms describe different types of relations, duration of interaction period, level of interaction, purpose of interaction and strength of bonds between the businesses. Polenske (2004) describe collaboration and cooperation as two forms of collective behaviour and while they are similar in many ways they also differ.

Collaborative relationships include direct participation in e.g. designing, producing and/or marketing a product. It is an internal and closed arrangement that excludes other parties from participation, and usually it is a vertical relationship in a supply chain.

Cooperative relationships are defined as formal or informal arrangements. The actors don't work together but they agree to share information, resources, managerial and technical training etc. for mutual benefits. These relations are open and horizontal.

Harrison & van Hoek (2002) indicate that both cooperation and collaboration are terms used to describe vertical supply chain relationships. They claim that cooperation has short time horizon and the scope of activities involved is narrow while collaboration includes long term interaction, joint activity and high level of integration.

While realizing that many of the existing QR, CRP and VMI relationships are not highly integrated, the term "collaboration" is used in this thesis because conceptually they focus on time related contractual agreements, they are vertical and closed arrangements and they build on sharing of responsibility, joint planning and execution of supply chain activities. This conforms to definitions of collaboration described by e.g. Min et al. (2005) and Simatupang & Sridharan (2002).

1.6.3 Use of the phrase "VMI collaboration program"

The phrases "VMI collaboration" and "VMI collaboration program" are frequently applied in this thesis and they are used to describe VMI collaboration in general terms.

→ The phrase "VMI collaboration" is used to indicate collaboration between two supply chain parties in general terms where the criteria specified in section 1.2 are in place.

→ The phrase "VMI collaboration program" refers to an individual set of terms and operational agreements constituting a collaboration environment prepared by two supply chain partners.

1.6.4 Level of integration

In the discussion on means for data transfer, different ICT technologies are suggested. The main purpose of including different technologies is to focus on level of data integration and to what extent level of integration has an effect on VMI successfulness. In this context *level of integration* is defined as to what extent the transferred data is automatically incorporated into the recipient's computer system. A low level of integration indicates that the transferred data must be manually collected from the sending system and/or re-entered manually into the receiving system.

1.6.5 Visibility and Transparency

Supply chain transparency and demand visibility are terms describing the effect of information availability in a supply chain. Demand visibility refers to who or how many actors along the supply chain can observe end consumer demand. Demand visibility will enable upstream actors to prepare forecasts and plans based on real demand in addition to purchase orders from direct downstream customer. Figure 1-8 illustrates the availability of demand data to create demand visibility.

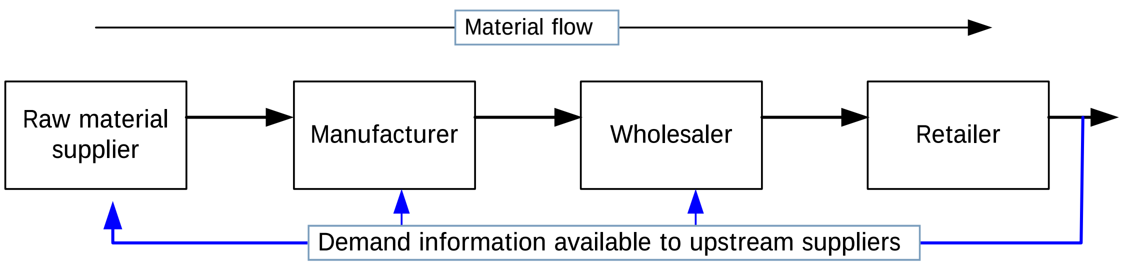


Figure 1-8, demand visibility

The transparency of a supply chain is not restricted to the sharing of end consumer demand. Transparency refers to openness, visibility and information sharing from multiple logistics activities initiated to fulfil the replenishment process. In addition to consumer demand information these could be for instance purchase orders, manufacturing orders, inventory levels and shipment information going between the different supply chain actors. Figure 1-9 illustrates how data storage is centralized and made available to multiple actors in the supply chain.

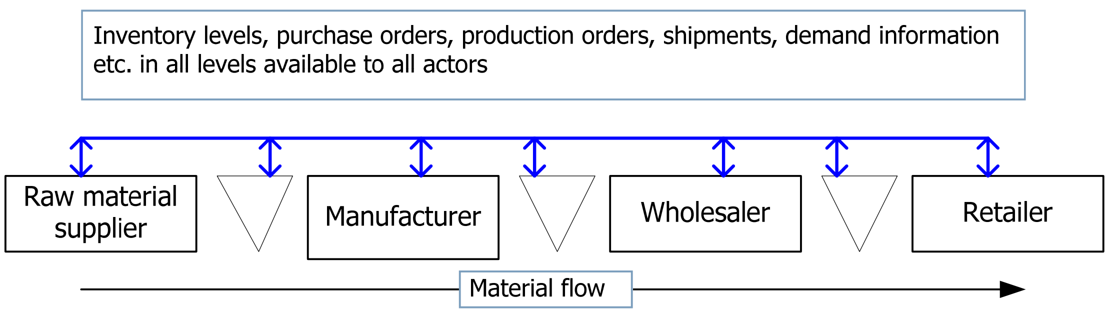


Figure 1-9, data availability to create supply chain transparency

1.6.6 How success in VMI collaboration is defined

In order to claim successful VMI, a definition of success is required. This is particularly important in case studies where the outcome of the case is central for the interpretation of results.

Business success is usually measured in profits, but from a logistic perspective, also non-financial measures should be included in the definition of success. Technically, a VMI program can be operating successfully in the respect that the supplier is replenishing the customer’s inventory, but if the total costs of running the VMI program exceed the savings (benefits), the project will appear unsuccessful.

There are two factors that should be included in a discussion of successful VMI, first these is time and then there are experienced cost reductions related to expected cost reductions.

1. Firstly, a new collaboration program need some time to mature and stabilize. The lack of cost reductions in the initial stages of the program should not be conclusive for long term performance.
2. Secondly, it can be argued that if expected cost savings are not reached the VMI program is unsuccessful. However, ambitious goals could cause termination of less than expected but still beneficial collaboration programs.

As VMI is expected to have some effects on the parties' logistic performance, for instance improved service levels or smoothed capacity utilization, the identification and assessment of these effects are vital in success evaluation. The non-financial measures will however have a direct or indirect effect on the financial performance.

The identification of financial and non-financial measures used to evaluate VMI success and how to obtain the effects measured is the basic behind the scope of the research question. It is not the purpose of this work to assess the case specific VMI programs in order to claim success or failure. The main objective is to identify what benefits have evolved from the program. In this work the cases are considered successful or unsuccessful based on the companies' perception of success, and it is observed that in all cases the programs are judged by their financial contribution.

The time perspective and case specific variances between expected and experienced cost reductions are discussed individually.

1.6.7 Sampling restriction

The empirical work of this research is limited to cases of VMI collaboration where the customer is a manufacturer. This limitation was selected purposely because much empiric literature deal with cases of VMI where the customer is a wholesaler or retailer (e.g. Holmström 1998, Simchi-Levi et al. 2000 pp 137-139, Achabal et al. 2000, Disney et al. 2001, Kaipia et al. 2003), and cases where the customer is a manufacturer have received less attention (Pohlen and Goldsby, 2003). Pohlen and Goldsby (2003) define a distinction between VMI when the customer is a manufacturer and VMI when the customer is a distributor or retailer. They claim that when the customer is a manufacturer the term should be Supplier Managed Inventory (SMI) rather than Vendor Managed Inventory because VMI is about coordinating the flow of finished goods to a retailer while SMI concerns coordination of raw materials and components to a manufacturing process. The cause of this difference is the nature of the demand which in the SMI case is easily derived from the production schedule while in the VMI case it is related to end customer demand. Figure 1-10 depicts the difference in application area as claimed by Pohlen and Goldsby (2003).

For this distinction to be valid one essential presumption is implicit. The difference described is valid only when the manufacturer (customer in the relationship) makes to stock and uses finished goods inventory to decouple manufacturing and demand. If the manufacturing process is based on a make to order strategy the components supplier faces the same type of demand as the manufacturing process. The main decision one has to make is whether one prefers applying the term SMI, thereby accepting that under certain conditions it is synonymous to VMI, or one prefers applying one general term accepting that under certain conditions details will differ but still some basic principle apply.

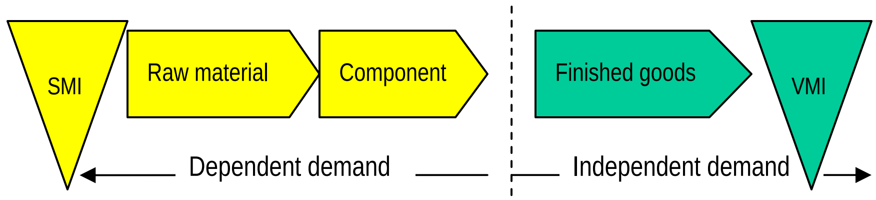


Figure 1-10, Supplier Managed inventory for dependent demand and Vendor managed inventory for independent demand

SMI is not applied in this thesis despite the realization that the cases studied in this work initially fall into the description of SMI. This is because the underlying presumptions regarding the nature of demand are not always true and therefore the more widely used term is applied.

1.6.8 Presumptions

Some subjects related to supply chain collaboration are excluded from this work. Contract governance, supply chain politics and motives for establishment of VMI collaboration are not further studied. It is an underlying presumption of this work that both parties enter the agreement with the best intentions and want the VMI program to become a success. Within this presumption it is still accepted that each party is an autonomous actor that has to make precautions to safeguard against the other party's inability to perform. Mechanisms to control the other party's logistic performance are therefore included because they are considered means to enforce the collaborative environment when applied correctly.

Products encompassed by this work must be demanded by a certain volume over some time. They must be of such kind that maintaining inventory is appropriate. Only in these circumstances it could be adequate for the supplier to manage the inventory on the customer's behalf. Products like project related one-off items are not included in this study.

1.7 Structure of thesis

The thesis has three main parts,

I. literature review and theoretical contemplations,

II. case descriptions,

III. scientific and managerial contribution

Figure 1-11 shows the construct of the thesis and the content of each part is outlined below.

Part I presents the theories of logistics and supply chain collaboration applied and discussed, (chapter 2). This is for setting the epistemology and scope of the work. A number of terms and acronyms are used by different researchers to name collaboration programs, and there is little consistency in interpretation and application of the terms. Though the definition of VMI applied in this work has already been defined, chapter 2 presents a literature review focusing on interpretations of VMI and other terms used describing collaboration models.

Chapter 3 presents the knowledge base of the core of the study. It is an in depth literature review on benefits, obstacles and success criteria for VMI collaboration. This chapter closes with a summary of what elements are encompassed by this study, thereby building a fundament for an interview guide used in the data collection process.

Chapter 4 closes part I with a description of the methodology applied for the study, both with respect to why this particular methodology was applied, how it contributes to science and how this particular study was conducted.

Part II contains detailed case descriptions. All five cases are described in detail (chapters 5 through 9), and it is outlined how they correspond to the research question. This part therefore represents the background and origin of the data analyzed in this work.

Part III is the scientific contribution of this work. In chapter 10 all case specific responses to the interview guide are compared and analyzed and findings are discussed. Here it is also expressed how the research respond to the hypotheses. The modelling framework is presented in chapter 11. Chapter 12 is the closing of the thesis. It presents the story line of the work, the conclusions drawn, reflections on the methodology applied in this work, and suggestions for further research. The closing of this thesis summarizes on the essence of the results.

Appendix A holds a blank interview guide and a collection of completed interview guides for all five cases studied.

Appendix B presents the applied edition of the framework which is the Practitioners' Guide to Vendor Managed Inventory.

	Abstract
Chapter 1	Introduction
Part I	**Literature review and theoretical contemplations**
Chapter 2	Theoretical framework of supply chain collaboration
Chapter 3	The concept of Vendor Managed Inventory
Chapter 4	Research methodology
Part II	**Case descriptions**
Chapter 5	Pilot, Teeness ASA and Sandvik Coromant
Chapter 6	Case 1, Smurfit Norpapp and Pipelife Norge
Chapter 7	Case 2, Raufoss Chassis Technology (RCT) and GM Opel
Chapter 8	Case 3, Tingstad AS and Kverneland Klepp AS
Chapter 9	Case 4, Hydro Automotive Structures and GM Opel
Part III	**Scientific and managerial contribution**
Chapter 10	Data analysis and Cross case pattern-matching
Chapter 11	A Modelling Framework for Vendor Managed Inventory
Chapter 12	Conclusions
	References
Appendix A	Interview guides
Appendix B	A Practitioners' Guide to Vendor Managed Inventory

Figure 1-11, thesis structure

Part I

Literature review and theoretical contemplation

This part includes a presentation of the theoretical framework applied for this study, a detailed description of Vendor Managed Inventory as a concept, including benefits, opportunities and risks, and a description of the research methodology approach used in this work.

2 Theoretical framework of supply chain collaboration

This chapter presents the theoretical framework of this thesis which is founded on a collaboration strategy approach to supply chain management. The scope is within logistic benefits of supply chain collaboration, and most essential are the mechanisms of coordination that make collaborative supply chains outperform local initiatives.

The starting point is an exemplified description of a supply chain and a realization that there are different perspectives to this view. Further, supply chain management (SCM) is defined. It is argued that focus on supply chain management is essential to sustained competitiveness and that coordination of activities along the supply chain is key.

After this introductory the scope is explained. It outlines on the components of SCM and shows how Vendor Managed Inventory fits into the SCM picture. As the logistic effects of VMI are at focus relevant logistic elements like production and inventory management are described. Elements included are inventory control techniques to decide when and how much to order, e.g. reorder point, economic order quantity, maximum/minimum inventory levels and two bin systems. Managerial decisions on distribution of warehouses and location of goods, in essence central and regional warehouses are also included. Inventory management is highly related to production planning and control. The VMI customer's market interaction strategy (e.g. make to stock or make to order) will affect his own production planning and subsequently it also affects the applicability of the input to the VMI supplier in his replenishment planning. The advance demand information aspect of market interaction strategies is therefore included as well.

It has been argued by many researchers that supply chain collaboration rests on information sharing (e.g. Angulo et al. 2004, Kulp 2002, Simatupang & Sridharan 2002, Thonemann 2001, Simchi-Levi et al. 2000). The benefits of information sharing in general and demand visibility and the Bullwhip effect in particular form a fundament for this work. New knowledge on benefits derived from applying more integrated means of communication technology is also part of the theoretical framework. So is performance measurement for control and as a means to performance monitoring. The theoretical perspective is described in a general manner, and in parallel it is applied in a VMI context.

SCM was presented to include many types of processes and strategies in addition to logistics. One can therefore ask whether studying logistics alone is meaningful (Arlbjørn & Halldorsson 2002). In this work some clearly defined components of logistics are studied, yet it is acknowledged that outcome in each case can be determined by other elements than logistics. Therefore this chapter also outlines on some components of SCM that are outside the main scope of this work.

Such components are for instance politics and motives for entering VMI collaboration other than those related to logistic and economic benefits. Inter-organizational relations and contract regulations are discussed because they can be managerial determinants for success. Level of integration, transaction cost theory and agency theory are theoretical elements that support these issues. Though it has been stated that logistic benefits derived from application of Information and Communication technology (ICT) is part of the framework, the technological aspect of ICT is not studied.

The chapter closes with an in depth study of how different authors use and interpret the term VMI compared to other collaboration models.

2.1 What is a supply chain

Product availability and price are two of the most important criteria when a customer makes a purchase. Other order winning criteria can be product quality, label, product range, new technology and after sales service. Criteria differ with product and market characteristics. A product's way to the market is long and filled with obstacles. From turning raw materials into finished products there are usually multiple actors involved, such as suppliers, manufacturers, assemblers and logistics providers. The goods pass through various production, warehousing and retail facilities. The set of actors and facilities is usually described as a supply chain, and the most important task of a supply chain is to provide the customers with available products at an acceptable price. Example 1 in the text box below presents the supply chain of a woollen sweater.

Example 1, woollen sweater supply chain

Sheep are usually sheared twice a year. The farmer performs the shearing and sends the wool to a woollen mill. At the mill, the wool is washed, carded, spun, dyed and converted to yarn in various qualities and colours of which the knitwear is manufactured. Sweaters are stored and distributed, perhaps via a wholesaler to designated outlets where the consumer may do the purchase. Figure 2-1 illustrates this supply chain.

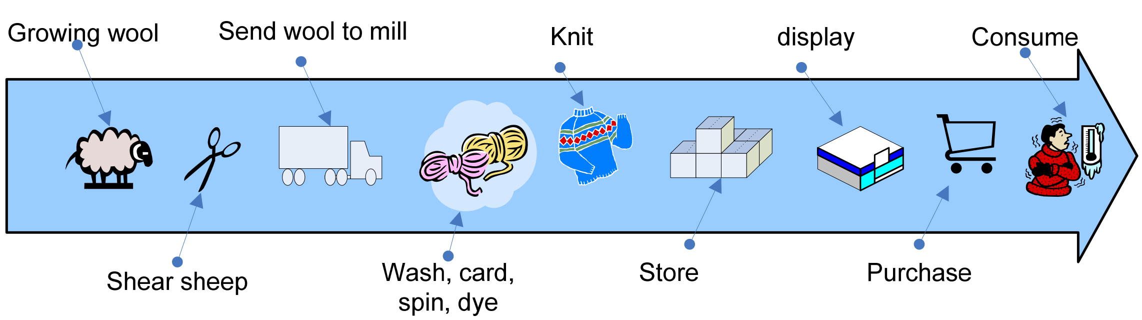


Figure 2-1, the supply chain of a woollen sweater

This supply chain appears simple and straight forward. However, there are many challenges and obstacles. First, raw materials are produced only twice a year. As they are not perishables they can be stored awaiting demand but storage costs are accrued. Next, the wool is washed, carded, spun and dyed. The number of variants explodes as qualities and colours differ. Decisions regarding which quantities of what qualities and colours to make must be related to expected demand for finished sweaters prepared by the apparel industry. Additionally, some yarn is sold to specialized retailers to serve domestic crafts. Sweaters come in different colours, patterns, designs and sizes. The variant number is further exploded. The apparel industry suffers from high seasonality and demand uncertainty. The customers are multiple, they have different preferences regarding, colours, quality, price, place of purchase, demand etc. Additionally, competing supply chains offer similar or different sweaters and the customers are faced with multiple choices. Figure 2-2 illustrates the complexity and how the supply chain picture becomes more difficult to follow when more options and possibilities are included.

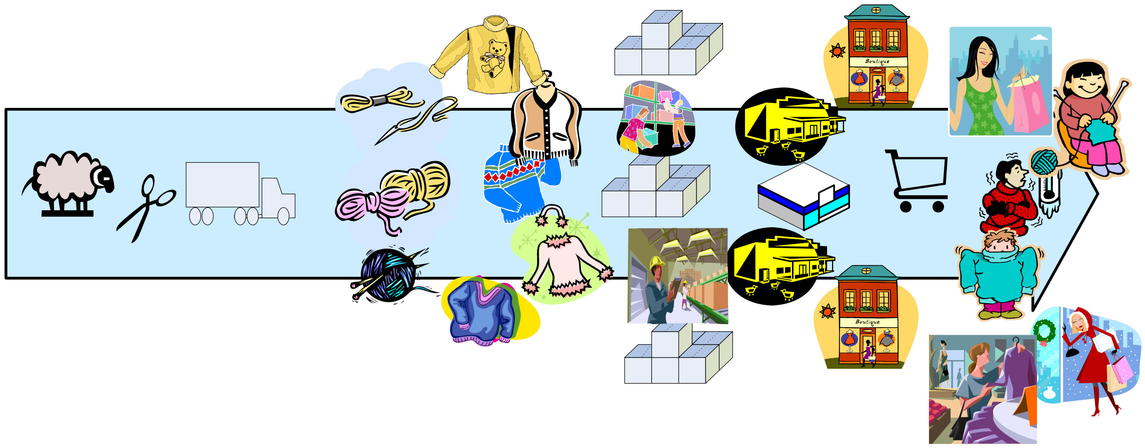


Figure 2-2, a supply chain is complex when more options are available

Critical for a purchase is availability, and making the right decision as to what designs and sizes to send to what markets is crucial. Sending all sweater designs in all sizes to all markets will assure availability but the costs will suffer. Neither is it feasible nor necessary. Different models for coordination of upstream information and downstream material flow are used to better match supply and demand while reducing costs. They rest on information sharing and cooperation between the supply chain partners. Vendor Managed Inventory (VMI) is one such model.

2.1.1 Supply chains and networks

A classic approach to supply chain description is applied by Lambert et al. (1998) who see the supply chain from a focal company's perspective (Figure 2-3). A focal company, e.g. an original equipment manufacturer (OEM) faces multiple tiers of suppliers and sub-suppliers upstream and multiple tiers of customers downstream the supply chain. Each raw material and component follows straight lines from origin to end consumption.

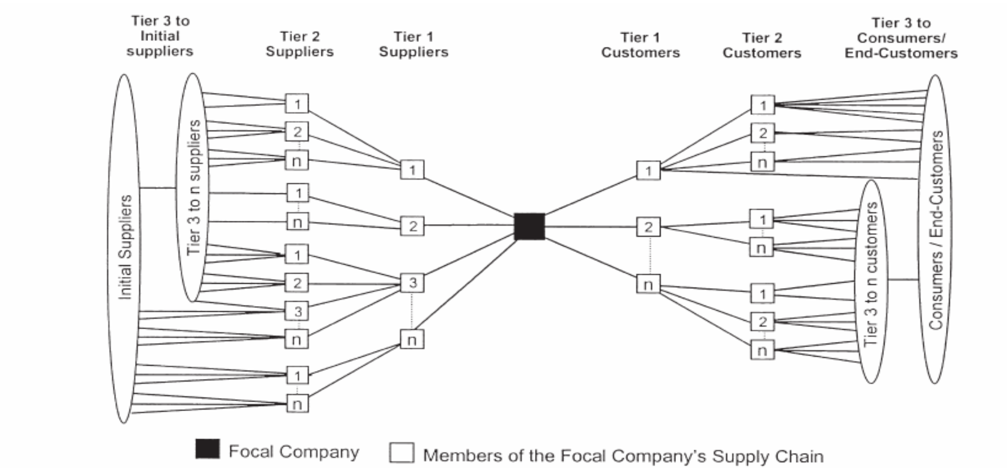


Figure 2-3, a classic approach to supply chain description (Lambert et al. 1998)

However, several authors (e.g. Jagdev & Toben 2001, Lamming et al. 2000, Christopher 1998, Lambert et al 1998) argue that supply chains are not restricted to chains of subsequent activities and organizations. Increasingly the supply chain is a network of mutually interdependent customers and suppliers where all organizations do business with several other organizations that again do business with others and each other, see Figure 2-4. There are both parallel and subsequent actors in a supply network. The number of parallel actors indicates a span in the network while the subsequent activities form the chain structure. The consequences of being part of a network are increased complexity, more considerations in coordination, and more uncontrollable factors. On the other hand, a network offers more alternatives and opportunities for smart solutions.

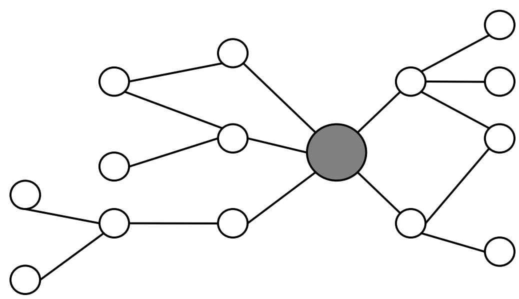


Figure 2-4, the supply chain as a network (Christopher 2005)

In this thesis the term supply chain is applied because the focus is on material flow between actors. It is still realized that the relationship between two actors is influenced by the existence of other actors.

2.1.2 Supply chain management

Lambert et al. (1998) define supply chain management as the management of activities and relationships across the supply chain. Council of Supply Chain Management offers an extensive definition of the term "supply chain management" (SCM).

> **"Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology."**

Simchi-Levi et al (2000:1) define supply chain management as:

> **- a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores so that merchandise is produced and distributed at the right quantities to the right locations and at the right time in order to minimize system wide costs while satisfying service level requirements.**
>
> ***(Simchi-Levi et al. 2000, p 1)***

Both definitions reproduced above indicate that SCM is about coordination of multiple activities performed by multiple actors for the purpose of optimizing total performance. They also support Christopher's (1998) assertion that "successful supply chains will be those which are governed by a constant search for win-win solutions based upon mutuality and trust".

Harland (1996) present four descriptions of the term "supply chain management".

1. The internal perspective involving the integration of business functions taking place within the boundaries of the company, the flow of material from inbound to outbound ends.
2. The integrated material flow of a two party relationship, a buyer and a supplier.
3. The integrated material flow of a multi party relationship, a chain of subsequent actors.
4. The network of interconnected businesses involved in end product provision.

Nowadays many companies have a Supply Chain Manager. This position usually includes an overall responsibility for the internal material flow but the more important part of this position usually includes interaction with customers and suppliers to develop solutions for information and material flow that offer benefits for multiple actors.

In order to build a competitive supply chain it is vital to manage and coordinate the different activities taken care of by the different actors. Supply chain managers typically face the traditional challenge of conflicting interests. At the interest of their stock-holders, autonomous businesses strive to optimize their own operations. Sub optimization on nodes in a chain, whether on business or process level frequently contradicts total supply chain optimization and the supply chain's overall competitiveness can be reduced. In many supply chains, the way to overcome such conflicts is collaboration and inter-organizational partnerships. One main purpose of supply chain collaboration is to avoid sub optimization. Profit sharing, mutual adaptation, standardization and simplification of activities and processes are means applied to establish collaboration.

2.2 Components of Supply Chain Management

In a broad sense and general SCM literature (e.g. Chopra & Meindl, 2007), supply chain management is described to encompass two distinct decision areas. These are

- designing the supply chain, and
- controlling the material flow

Supply Chain Design includes building a structure where location, role and capacities of facilities are determined. A facility can in general be a production facility, a warehouse facility, an innovation centre or a combined facility. The structure decisions must be related to the selected supply chain strategy. A supply chain strategy includes for instance make or buy decisions, source base decisions and collaboration decisions. The supply chain strategy must also be matched to the market or competitive strategy. The supply chain must be designed so that actors and facilities have roles that enable the chain to provide the market with the kind of products that accord to the market strategy.

Supply Chain Control includes planning and managing material and information flow on a tactical and operational level. Tactical planning includes determining the main streams for material and information flow, and operation refers to managing the short term reaction to customer orders. This is also described as Operations Management (e.g. Bozarth & Handfield 2006). Figure 2-5 shows how SCM is built on the explained components.

Supply chain management			
Supply chain design		**Supply chain control**	
Strategy e.g. Make or buy, sourcing, collaboration	**Structure** e.g. Location, role and capacity of facilities	**Planning** e.g. assign facilities/capacities to markets	**Operation** e.g. Allocate capacity or inventory to customer orders

Figure 2-5, the components of supply chain management

VMI is one approach to SCM and it rests on a strategic decision to involve in collaboration. Companies have different motives for applying collaboration strategies. The structure decisions include selecting a collaboration partner. Sharing of roles in VMI implies for instance that the supplier is responsible for replenishing the customer's inventory. On the tactical planning level decisions are made regarding for instance targeted inventory levels, information sharing and performance measurement. On the operational level, the supplier uses available demand information to plan and execute replenishment. Figure 2-6 illustrates the SCM components in a VMI context.

Vendor Managed Inventory			
Design		**Control**	
Strategy e.g. Motives for collaboration	**Structure** e.g. Select a partner, relations and contracts	**Planning** e.g. Build a collaborative environment	**Operation** e.g. Replenishment decisions

Figure 2-6, the supply chain components in a VMI context

In this work the control components of VMI are studied in particular and it is realized that the design components must be in place before the control components can be specified.

The SCM components form the fundament of the theoretical framework used this work. Figure 2-7 outlines the theoretical framework and highlights the components described in this chapter. It is assumed for this work that the actors want to pursue a collaboration strategy and therefore the starting point of this theory chapter is a presentation of some of the most frequently described collaboration models. This is to make a distinct description of the specific features of VMI.

Further the design components of VMI are explained. These include motives for collaboration, inter-organizational relations and the governance of contracts. These components are outside the prime focus of this work but they are managerial determinants for success and therefore they must be explained. The prime focus of this work is on the control components. Planning on a tactical level refers to building a collaborative environment and defining a fundament for the operation. This includes sharing of responsibilities, establishment of a set of targeted performance measures and defining availability of advance demand information including the customer's market interaction strategy. The operational level includes inventory control decisions and scale benefits in production and transport.

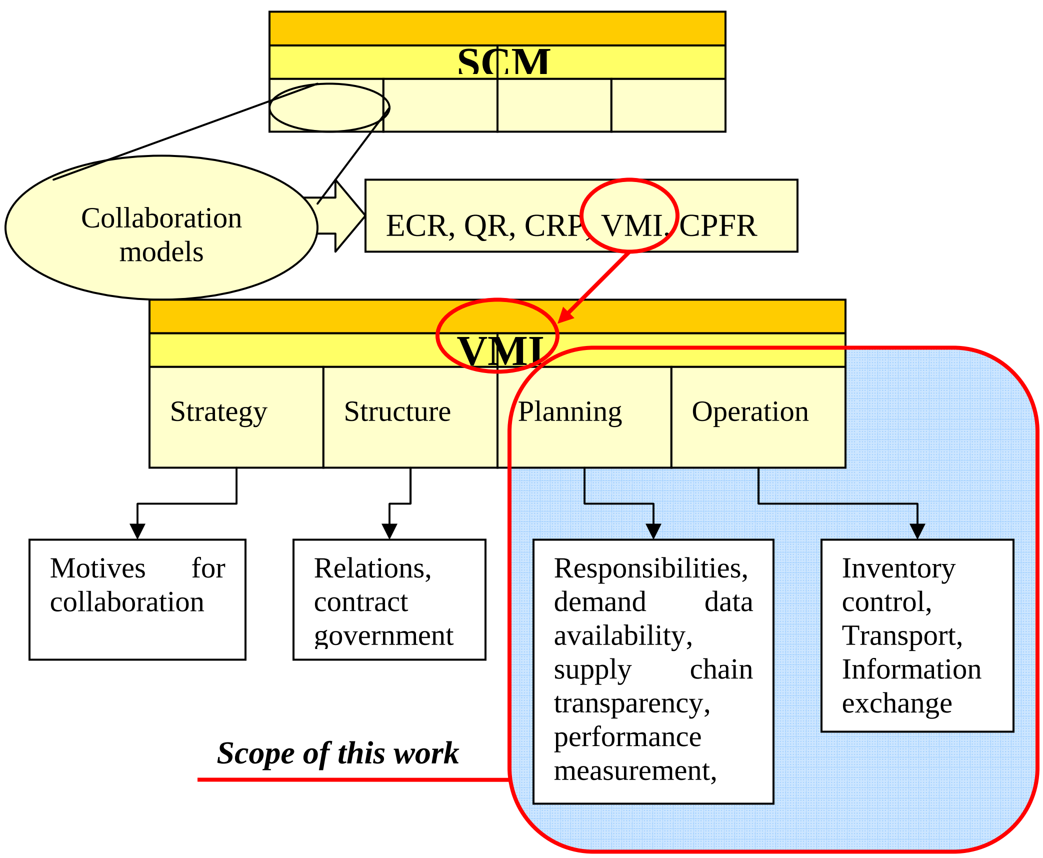


Figure 2-7, the theoretical framework

2.3 Collaboration models

As the benefits of supply chain collaboration have become common knowledge among business managers, different models for collaboration have evolved. The various models are employed depending on purpose and conditions. These models are characterized by different types of governance structures, different levels of trust, different levels of integration and they are designed to offer different types of benefits to the parties.

One of the main purposes of collaboration along the supply chain is to offer a product or service required by the customer at the largest possible revenue and lowest possible cost for the actors involved. Christopher (1998) identified three key issues for management of competing supply chains: responsiveness, reliability and relationships.

- *Responsiveness* is the ability to meet customers' needs in less time than before.
- *Reliability* is about reducing uncertainty. Demand visibility throughout the supply chain reduces upstream demand uncertainty and thus the need for safety stock between the actors.
- *Relationships* is an emerging trend, experience indicates that supply chain goals are more easily achieved by collaboration and long term relationships.

Responsiveness enables rapid material flow and reliability reduces inventory levels throughout the supply chain. Building relationships is the means to achieve responsiveness and reliability within a supply chain, and during the last two decades different forms of collaboration have been developed to deal with this.

Early collaborative solutions rest on bilateral agreements typically standardized within specific industries or geographic areas (e.g. efficient consumer response in retail grocery industry). Principles have been refined and adapted to suit other industries (e.g. Quick response in the apparel industry), and as new solutions prove their efficiencies they become more widely adopted, perhaps even regardless of industry characteristics and original purpose.

Below are introductions to some evolving collaboration models developed to improve the replenishment process. These are Efficient consumer response (ECR), Quick response (QR), Continuous Replenishment programs (CRP), Vendor Managed inventory (VMI) and Collaborative planning, forecasting and replenishment (CPFR). Though initially industry specific, some elements have evolved into general principles applied in multiple business areas. This section is included in order to show how VMI is related to some alternative collaboration models.

2.3.1 Efficient Consumer Response (ECR)

Efficient consumer response (ECR) is a supply chain management concept that was first defined by Kurt Salmon Associates in 1993 (Svensson 2002), and it originated in the grocery retail industry. The content of ECR has grown and it has become quite extensive. The basic assertion of ECR is that close integrated collaboration between the wholesaler and the retailer in the four core business areas of *replenishment, product promotion, product introduction* and *store assortment* will offer significant cost reductions (Skjoett-Larsen et al. 2003). The aim is to fulfil changing customer demands by collaboration across all supply chain members (Harrison & van Hoek 2002). ECR encompasses multiple management processes within the four business areas and the main focus is on marketing and learning from consumers' purchasing patterns to find the most efficient replenishment strategies. Figure 2-8 depicts the four business areas of ECR and the multiple process components of replenishment.

ECR requires capabilities within joint inventory management, cross-docking, continuous replenishment, quick response and efficient logistics strategies and product flows, and the working of ECR rests heavily on computer technology for information exchange (Harrison & van Hoek 2002). Point of sales (POS) data is used for assortment optimization, forecast improvements and demand driven replenishment (Reyes & Bhutta, 2005).

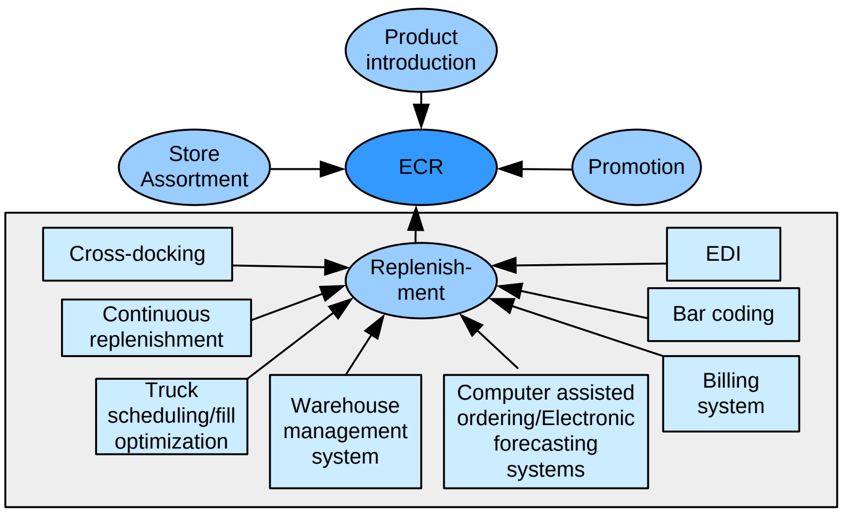


Figure 2-8, Efficient Consumer Response (De Toni & Zamolo 2005)

2.3.2 Retailer-Supplier partnerships (RSP)

Simchi-Levi et al. (2000) present quick response (QR), continuous replenishment programs (CRP) and vendor managed inventory (VMI) as three types of retailer-supplier partnerships (RSP). From ECR literature it can be read that QR and CRP are elements of an ECR agenda. CRP is found as an element of ECR Replenishment in Figure 2-8 by De Toni & Zamolo (2005). Harrison & van Hoek (2002) include QR in this picture and Jespersen & Skjøtt-Larsen (2005:97) claims that ECR can be built on both QR and VMI. A further discussion on hierarchies of these concepts and interpretation of terms is presented in section 2.6.

The QR concept originated in the US apparel and textile industry (Harrison & van Hoek 2002, Christopher 1998) as a response to overseas competitors. Just in time principles are used to pull products from the supplier to the retailer. In QR, POS data is transferred from the retailer to the supplier who uses this information to improve their forecasting and scheduling and to be able to respond to the pull signal from the retailer without large safety stocks. The replenishment decision is taken by the retailer but the sharing of POS data increases demand visibility in the supply chain.

In a continuous replenishment program (CRP) POS data is transferred to the supplier who prepares shipments within predefined intervals and stock levels (Simchi-Levi et al. 2000). The supplier still has to await an order confirmation before dispatch and the customer is therefore in charge of managing his own inventory. The demand visibility is used to enable supplier's further preparations for the fast response to customers demand.

To further relinquish replenishment responsibility to the supplier, Simchi-Levi et al (2000) present Vendor Managed Inventory (VMI). In a VMI program the supplier is responsible for restocking the customer's warehouse without the interference of the customer. VMI can be described as a form of supply chain collaboration where the supplier resumes replenishment responsibility on the customer's behalf (e.g. Disney & Towill 2003a, Harrison & van Hoek 2002).

Table 2-1 summarizes on supplier's responsibilities and who makes the replenishment decision in the three collaboration models described as RSP's.

Table 2-1, responsibilities in Retailer-supplier partnerships

Collaboration model	***QR***	***CRP***	***VMI***
Supplier responsibility	MTS or reserve production capacity to respond quickly to orders	Prepare shipment suggestions and await order confirmation	Ship goods and replenish customer warehouse within predefined limits
Final replenishment decision	Customer	Customer	Supplier

2.3.3 Collaborative planning, forecasting and replenishment (CPFR)

Collaborative Planning, Forecasting and Replenishment (CPFR) is described by Fliedner (2003) as a means to integrate all members of a supply chain, distribution and retail activities included. It is founded on the idea and benefits of supply chain transparency, and a web based tool is developed to increase demand visibility. Retail level demand forecasts are used to synchronize replenishment and production plans throughout the supply chain. By the use of a web server, CPFR is a technological improvement of collaboration based on Electronic Data Interchange (EDI) or eXtended Markup Language (XML) files. Lately several software programmers have developed modules to support CPFR collaboration (e.g. Manugistics, i2 Technologies, SAP APO, Numetrix, Oracle, Baan and PeopleSoft (Jespersen & Skjøtt-Larsen, 2005)).

Fliedner (2003) presents a five step process for establishing CPFR collaboration and Harrison & van Hoek (2002) and Jespersen & Skjoett-Larsen (2005:99) present similar nine step processes. Whatever the number of steps, the main implementation activities are:

1. the establishment of a partnership including objectives, requirements and confidentiality,
2. the establishment of joint business planning routines including a joint calendar and planning sequences
3. the development of demand forecasts, sharing and comparing these forecasts, and

4. once the sales forecasts from the supplier comply with the demand forecasts from the customer, the order forecasts become actual orders.

CPFR represents a means to information exchange and handling and it is a tool that enhances the collaboration models presented above (Simchi-Levi et al. 2000).

2.4 The Design components of Vendor Managed Inventory

Research on collaboration and relationships involves multiple aspects and a proper pronouncement of what aspects and related theories are included in a study is essential. It has already been argued that collaboration along the supply chain is a prerequisite for sustained competitiveness. Collaboration builds on inter-organizational relationships and research in these types of relationships involves different aspects like economics, social and legal aspects, logistics and information systems (Trienekens & Beulens, 2001).

In this particular study the focus is on the logistics aspect. The other aspects are design components that fall outside the main scope of this work. These include for instance motives and purposes for collaboration, levels of integration, governance of relationships, business politics and strategic planning. All of these are subject to research in their own field and they represent pieces of a larger picture of which VMI is a part. They represent important components of supply chain collaboration and they are important for setting the context of this research. They are outlined to offer a framework for supply chain collaboration and they are referred to in encompassing the full context of the cases described in this thesis. They are also used to support the presumptions made further along the research. They are important components of supply chain collaboration as they shed light on why actors collaborate, why they continue collaborate and what can affect the decisions they make regarding with whom they choose to collaborate and how tightly they are attached to each other.

These aspects will be discussed under the four main headings:

- Motives for collaboration
- Relationship duration and strength of bonds
- Business politics and governance
- Technological and technical properties

Additionally, the role of trust will be discussed in this section. Trust is considered one of the most important components of collaboration and level of trust will influence the other design decisions.

2.4.1 Motives for collaboration

Inter-organizational collaboration is motivated by the realization that stand-alone businesses rarely have the resources to compete on their own and the evolving focus on supply chain competition as opposed to single firm competition (Christopher 1998). Simchi-Levi et al (2000) present seven motives for entering strategic alliances with supply chain partners:

- Adding value to products,

- Improving market access,
- Strengthening operations,
- Adding technological strength,
- Enhancing strategic growth,
- Enhancing organizational skills and
- Building financial strength.

An extensive literature review on benefits from supply chain collaboration is performed by Busi (2005). Many of the identified benefits are related to cost reductions and improved performance coming from improved visibility, coordination and utilization of resources. Other benefits are related to gaining access to other's competence and resources. Some benefits are also related to managing the competitive situation. His findings and related causes are briefly repeated in Table 2-2 below. It is probably never so that one specific collaboration program offers all the benefits listed but they can all be recognized as possible effects of VMI collaboration and therefore possible underlying motives for choosing a collaboration strategy.

Table 2-2, benefits of supply chain collaboration

Benefits related to:	***Reported benefits (Busi 2005)***
Cost reductions by improved visibility, coordination and resource utilization	Increased asset utilization
	Enhance service level and responsiveness
	Reduce lead times
	Increase cycle-time
	Reduced inventories, obsolescence and deterioration
	Increased product and service quality
	Increase internal value to shareholders
	Push the "information decoupling point" as far upstream as possible
	Reduce number of stocking points
	Increase flexibility
	Reduce total order fulfilment time and increase order fill rates
	Have access to up-to-date information
	Improve forecasting accuracy
Management of the competitive situation	Increase existing market share or gain rapid access to new markets
	Present a unified face to large corporate customers
	Turning potential rivals into allies
	Pre-empt competitors entering into collaboration
	Secure reliable supply sources
Gaining access to other's competence and resources	Share and reduce costs, e.g. R&D, product development
	Share and decrease risk of failure in product development
	Enhance skills and knowledge development
	Technological gains as participant firm
	Decrease capacity requirements
	Access to specialized resources, human and technological
	Focus on core competencies, outsource non-core competencies
	Decrease time to market for new products

2.4.2 Relationship duration and strength of bonds

Many authors have described different types of bonds and links between supply chain partners (e.g. Harrison & van Hoek 2002, Bowersox et al 2002, Jagdev & Thoben 2001, Simchi-Levi et al 2000, Christopher 1998, Cooper & Gardner 1993). Jagdev and Thoben

(2001) present five types of collaboration classified by level of integration. They argue that the strength of bonds is often analogous to the duration of a relationship. Their types of relationships are presented along a continuum according to level of formalization, commitment and duration of relationship and the five types of relationship are Market transactions, Non-contractual agreements, Contractual agreements, Joint ventures and Integrated Company. The continuum is reproduced in Figure 2-9.

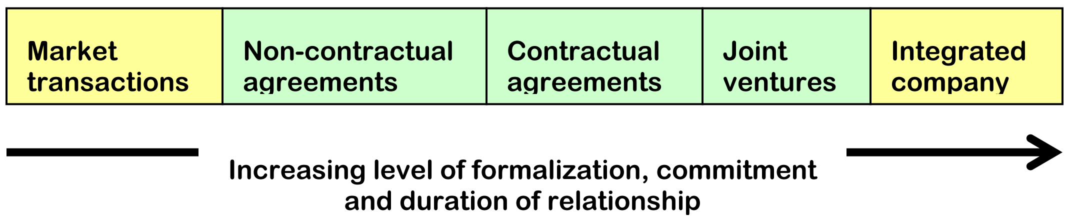


Figure 2-9, continuum of relationship integration (Jagdev & Toben 2001)

This list of relationships is neither complete nor exhaustive but they represent levels of closeness between autonomous parties forming supply chains or supply networks. The three middle boxes represent relationships based on collaboration while market transactions represent no collaboration and integrated company is beyond collaboration. VMI collaboration is in most cases regulated by a contract between the customer and the supplier and is usually a "contractual agreement". Joint ventures are also possible VMI targets.

In general partnerships have been based upon sharing of information, trust and openness, coordination and planning, mutual benefits and sharing of risks, recognition of mutual interdependence, shared goals and compatibility of corporate philosophies (Harrison and van Hoek, 2002). These characteristics are also recognized in VMI.

2.4.3 Business politics and governance of relationships

Governance of a relationship on an organizational level is a discussion on organizations' political motives for establishing and staying in a relationship as opposed to the operational benefits already discussed. Governance of relationships is widely discussed and explained by several authors (e.g. Williamson 1979, Buvik & John 2000, Buvik 2002, Rindfleisch & Heide 1997, Eisenhardt 1989b). Two widely employed theoretical frameworks, also described by Trienekens and Beulens (2001) are transaction cost theory and agency theory.

Williamson (1979) use *transaction cost theory* (TCT) to argue that the parties' intention to stay in a relationship is relative to the costs of leaving it. The starting point of TCT is a "make or buy" decision, and TCT is widely used in outsourcing decisions.

The outcomes of TCT include that building relationship is important when transactions are specific and when high frequency justifies investments required. It is also recommended when transactions are specific but interaction is rare. When transactions are non specific, suppliers are multiple and prices are reflected by market value, classical contracts and market governance is more appropriate.

Williamsons work is widely referenced in multiple academic disciplines including economics, organization theory, corporate finance, marketing, business strategy, contract law and political science (Rindfleisch & Heide 1997).

Agency theory is used to describe under what conditions outcome based or behaviour based contracts between principals and agents are suitable, (Eisenhardt 1989b). The main presumption is that the parties have different goals and attitudes towards risk. The trade-off is between the principal’s costs of measuring the agent’s behaviour versus the cost of measuring the outcome of the work while transferring the risk of wrong outcome to the agent.

Outcome based contracts are more suitable when the behaviour of the agent is of less importance for the outcome, when the behaviour is difficult to monitor and when the agent is more risk averse than the principal.

Behaviour based contracts are suitable when the behaviour of the agent can be monitored by the principal and the principal can control the outcome by corrective action.

Like TCT, agency theory has been applied on multiple issues, e.g. acquisition and diversification strategies, compensation, ownership and financing structures, vertical integration and innovation (Eisenhardt, 1989b).

With the aspects of TCT and agency theory in mind one should be aware that there is always an element of risk involved in entering a collaboration program. The other party might fail to perform as agreed, either unintentionally or on purpose. It is therefore important to establish routines and means for governance of the relationship, usually regulated in a contract. It is however argued that no contract can encompass all contingencies but as long as the parties have trust in each other they will have an excellent opportunity to work out difficulties (Dwyer et al. 1987).

2.4.4 Technological and technical properties

The technological and technical aspect refers to the compatibility of organizations’ technical and technological systems. These systems include both computer systems that facilitate information interchange and physical distribution systems that facilitate efficient material exchange. The compatibility of such systems enables collaboration. Incompatibility is a limitation to economic improvements, and usually special arrangements are required to overcome such obstacles.

Compatibility of computer systems is described as to what extent data can be safely and automatically transmitted from one system to another, where both systems interpret the data exactly alike. Standardization of data and technology is critical for automatic data transfer (Simchi-Levi et al. 2000).

Examples of compatibility in logistic operations are

- Means of automatic data collection
- Bar codes
- Radio Frequency Identification Device (RFID) technology
- Means for physical handling of goods

- Standardized container dimensions
- Handling equipment with fitting brackets and spreaders

These technical barriers can represent a limitation to success in VMI collaboration but for the purpose of this research it is assumed that technical and technological obstacles are overcome. A presumption is made that technological issues do not represent limitations to supply chain collaboration and this subject will not be further exploited.

2.4.5 The role of trust

Supply chain collaboration depends on trust between the parties (e.g. Thoben & Jagdev 2001, Simchi-Levi et al. 2000, Childe 1998, Dwyer et al. 1987). Trust is not a control mechanism but a substitute for control, reflecting a positive attitude about another's motives (Rousseau et al. 1998). Contracts and incentive mechanisms can to a certain extent replace trust but it is unlikely that a relationship is initialized without some basic presumption that the other party is trustworthy in some sense. Childe (1998) refers to three types of trust in business partnerships;

- *Goodwill trust*, honesty, a partner is trusted to take decisions without unfairly exploiting the other party
- *Contractual trust*, keeping promises, maintaining confidentiality and intend to act as agreed
- *Competence trust*, believing that the other party is capable of performing as agreed

He argues that arm's length contractual agreements only depend on contractual and competence trust while long term relationships also build on goodwill trust.

Similarly, Rousseau et al (1998) present two types of trust related to duration of relationship.

- *Calculative trust*, circumscribed and limited to discrete exchanges and reinforced by deterrents. Exchanges are likely to be terminated once violation occurs.
- *Relational trust*, includes a broader array of resource exchange and entails a greater level of faith in the intentions of the other party. This is resilient trust that survives a violation, especially if an effort is made to restore the good faith.

Figure 2-10 illustrates the model of trust development over time.

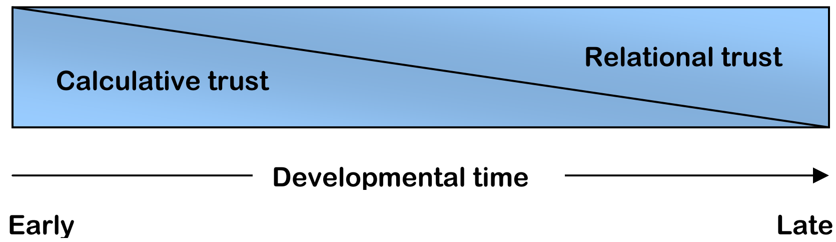


Figure 2-10, model of trust development over time (Rousseau et al. 1998)

A parallel can be drawn between the Childe (1998) and the Rousseau et al. (1998) descriptions of trust. Goodwill trust and relational trust both reflect on long term relationships where the parties have proven their trustworthiness. Contractual trust and competence trust can be described as elements of a limited trust based on a calculative risk that makes the parties restrain from total submission.

The governance of inter-organizational relationships offers multiple viewpoints and it is an important aspect of supply chain collaboration. For the purpose of this research the presumption is made that both parties are genuinely interested in making the relationship work and that politics and governance structures represent no limitations to successful collaboration. The level of trust between the parties will however be a central variable studied in this work.

2.5 The control components of Vendor Managed Inventory

The design components described above are concerned with the foundation of supply chain collaboration. The control components are related to how the collaboration program is organized and run. This is about how the different tactical and operational decisions are made and it is where the logistic effects of the different decisions can be evaluated. This section looks at constructs that will influence the logistic performance and include sharing of responsibilities and roles, demand data availability and performance evaluation. It also encompasses inventory control in general and how this is applied in VMI in particular. The main headings in this section are

- Information systems
- The bullwhip effect and demand visibility
- Market interaction strategies
- Regional warehouse or VMI
- Inventory performance measurement
- Decisions in inventory management.

2.5.1 Information systems

Most companies apply computer systems to manage corporate information. Such computer systems are called Enterprise Resource Planning (ERP) systems and they are software packages of different sizes and capabilities that support the different functions and business areas of the company.

Many ERP systems are module based and the user can apply a selection of modules to cover the specific company needs, these are for instance modules for

- Customer Relations Management (CRM),
- Procurement,
- inventory management,
- production management,
- distribution management,
- product configuration,

- accounting and finance

More recently developed functionalities include web portals that facilitate web shopping for wholesalers and retailers.

An ERP system facilitates storage and retrieval of information and is therefore fundamental for controlling the planning and operation processes of a company. Exchange of information between supply chain partners will encompass exchange of information between ERP systems. Some ERP software providers have developed functionality that support automatic sharing of ERP data by use of EDI or XML technology (illustrated by Figure 2-11).

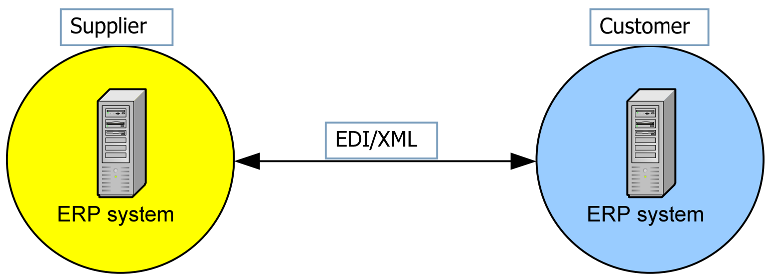


Figure 2-11, information exchange between customer's and supplier's ERP systems

The most common limitation to VMI in traditional ERP systems is the restriction to accept an invoice where no related purchase order is available. This is a security function in traditional purchasing and the purpose is to automate control of coherence between purchase orders and invoices. In VMI operation where there will be no purchase order and special solutions that facilitate VMI are required.

A VMI function will allow for invoicing on open orders and call-offs. It will also facilitate consignment storage where ownership and possession of goods is with different organizations. Some of the largest ERP software providers have developed solutions for VMI functionality, for instance Lawsons M3 (former Movex, see www.lawson.com), Oracle Demantra Demand Management (www.oracle.com), SAP Inventory Collaboration Hub (www.sap.com) Infor SRM (former Baan, see www.infor.com). These are solutions that facilitate information exchange and use of consignment inventory.

Many small and medium sized companies do not have complex and commercial ERP systems. Their information systems are usually mixes of home made spreadsheets and single purpose commercial systems. Such systems often work satisfactory for small companies, but they have to be managed and updated individually by local ICT experts. Special VMI software providers have developed “bolt-on” software that can easily be incorporated into customized and standard ERP systems (see e.g. www.videlity.com, www.JDA.com, www.pan-pro.com).

The importance of ERP systems as information providers in modern VMI operation is indisputable. The challenge appears to be within utilizing the functionalities and capabilities of the available technology to increase integration level between VMI partners (e.g. Norsk logistikkbarometer 2003 and Norsk Logistikkbarometer 2005, Krishna (Ed) 2007, McBeath 2003). ERP system functionality will not be further exploited in this work but as information sharing and level of integration is at focus the role of the computer system is implicit.

2.5.2 The Bullwhip effect and demand visibility

The Bullwhip effect is an old phenomenon but the new term, Bullwhip, was introduced by Lee et al. (1997) in an article describing the effect of information distortion in a supply chain. The Bullwhip effect is the phenomenon where orders to upstream suppliers have larger variance and lower frequency than sales to downstream customers giving an unlevelled upstream information and downstream material flow (e.g. Lee et al. 1997, Childe 1998, Disney & Towill 2003a). A very brief example can illustrate this:

A retailer sells one pallet of diapers a week but reorders to his wholesaler four pallets a month. The wholesaler observes a demand for four pallets once a month while a more accurate a demand pattern is one pallet a week. A fairly even end demand pattern is distorted. As this happens at every echelon upstream the supply chain the distortion of demand information over a period can be seen as an amplification of demand variation. The result is that a generally smooth and stable end consumption of a product will eventually show a large variation in demand for the raw material supplier.

Figure 2-12, the bullwhip effect in a four echelon supply chain (Chopra & Meindl, 2007)

Figure 2-12 illustrates how demand amplifies in a four level supply chain. Consumer sales at retailer (top left curve) are fairly stable. Retailer's orders to wholesaler (top right curve) are slightly distorted. Orders in higher volumes and lower frequency can be observed as amplified peaks and valleys of the demand curve. The bottom left curve shows wholesaler's orders to manufacturer. The peaks and valleys are further amplified as order volumes are increased and frequency is reduced. The bottom right curve shows the manufacturer's orders to the raw material supplier.

Lee et al. (1997) present four sources of bullwhip effect in a supply chain. These are

- *demand signal processing* or the Forrester effect which is the delay of demand signals when real time information is unavailable and old demand information is used to update forecasts.
- *order batching* or the Burbidge effect where the real demand is hidden because orders are adjusted to suit other conditions like full truck loads or economic order quantity.
- *price variations* or the promotion effect which moves sales intentionally. Promotions usually cause periodic high sales followed by periodic low sales, causing variation in demand, and
- *rationing and gaming* or the Houlihan effect which occurs when supplies are uncertain and customers place strategic orders to safeguard against anticipated supply shortage.

All these effects are likely to occur in a traditional supply chain and all together they can give a significant distortion to upstream demand.

Demand visibility is known to reduce the bullwhip effect (e.g. Småros et al. 2003). When upstream suppliers can view end demand and base their replenishment planning on advance demand data they reduce uncertainty and can maintain a high service level without jeopardizing the cost level.

Disney and Towill (2003a) simulated the four different sources' effects on the manufacturer's production ordering activities in a two echelon supply chain. They concluded that with a successful VMI program both the Burbidge effect and the Houlihan effect may be completely eliminated. They also found that the effect of price induced variations will be reduced and that VMI has a positive effect on high volume products suffering from the Forrester effect

2.5.3 Market interaction strategies

A company's market interaction strategy is described as how the manufacturing process is designed to react on demand from the customers (Browne et al. 1996). In particular it is a question of making to stock or making to order. The term most frequently applied to describe this is the Customer Order Decoupling Point (CODP) (e.g. Browne et al. 1996, Andersen et al. 1998, Mason-Jones et al. 1999, Christopher & Towill 2001, Rudberg & Wikner 2004, Alfnes 2005). Other terms applied are for instance order penetration point (Andries & Gelders 1995) or buffer barrier (Bozarth & Chapman 1996). In supply chain literature the CODP is also called the pull-push boundary because it marks the position in the supply chain where goods are pulled from market rather than pushed by suppliers (described by e.g. Berry & Hill 1992). The term applied here is CODP. In general there are four possible positions for the CODP within a manufacturing company and they represent four different market interaction strategies.

- If the company manufactures to stock and serves every incoming order from a finished goods warehouse the strategy is Make to Stock (MTS). Manufacturing and sales is decoupled.
- If the manufacturing process is initiated by an incoming order the strategy is called Make to Order (MTO). The decoupling is between purchasing of raw materials and manufacturing.
- One strategy gaining ground is Assemble to Order (ATO). Components and semi-finished products are made to stock and final assembly or configuration is performed on order. This is an increasingly popular strategy because it allows for both customization and fast response.
- When the product is not even designed and no raw materials are purchased until order receipt the strategy applied is called Engineer to order (ETO). This strategy is mostly applied for manufacturing of large one-of-a-kind products like ships, platforms and buildings and where the product require very specific configurations, e.g. modification kits and tools to machinery.

Being conscious about the CODP is important when applying demand information and forecasting in the production planning process, (see also the discussion on the terms VMI vs. SMI in the introduction to this thesis). In an MTS environment production planning is based on forecasts and expected demand. Inventories are used for buffering between real demand and cost efficient manufacturing where economy of scale and production smoothing can be at focus. In an MTO environment the production is initiated by real demand, which requires a highly responsive and dynamic supply chain. Figure 2-13 illustrates how the CODP is moved towards the supplier as the product is assigned to one specific order early in the manufacturing process.

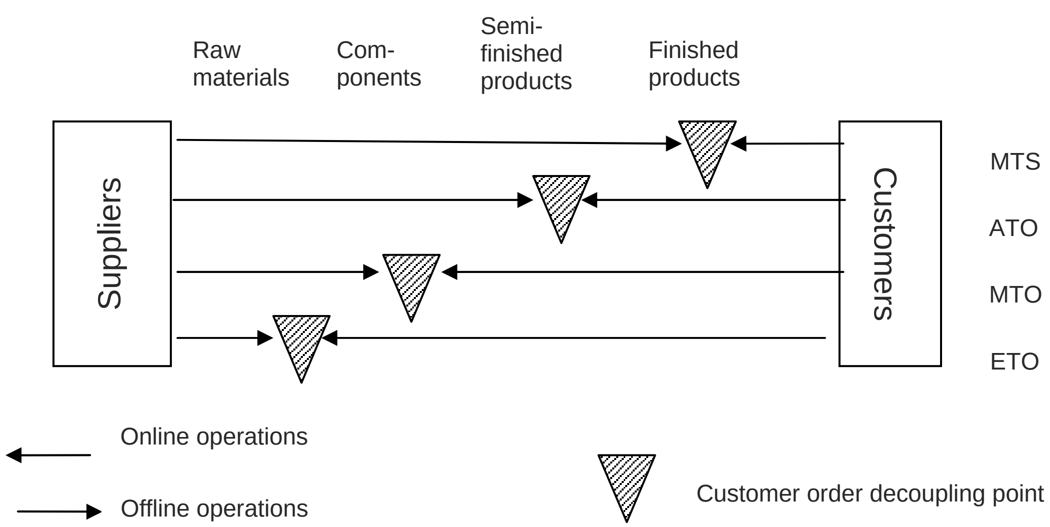


Figure 2-13, Customer Order decoupling point (CODP), after Browne et al. 1996

The concept of market interaction strategies is an important parameter in the design of a supply chain (see e.g. Fisher 1997, Christopher & Towill 2001, Lee 2002). There are benefits and obstacles inherent in both MTS and MTO and it has been advocated that the selected strategy must be the one best fitted for serving the customers' needs. Management decisions and control principles applied will differ between the strategies and the concept of market interaction strategies and position of the CODP will form a theoretic fundament in the discussion on what type of demand information should be shared in a VMI collaboration program.

2.5.4 Regional warehouse or VMI

In many cases the supplier has a warehouse close to the customer and sometimes there are doubts about whether the warehouse is a regional warehouse or true VMI. In many collaboration programs claimed to be VMI, it can be questioned whether all principles required to qualify as a VMI relationship exist. The purpose of this section is to clarify differences in forms of warehousing and thereby add an element to the definition of a VMI relationship as presented in the introduction.

<u>Regional warehouse</u>

A regional warehouse is described as a warehouse positioned close to a particular market (Bowersox et al. 1986) and its main purpose is to enable short response time at low cost. At a regional warehouse the goods are owned and controlled by the supplier, the supplier has full possession of the goods and he makes the replenishment decision. The goods are not assigned to one specific customer. The ownership of the actual warehouse facility might be on the supplier or a third party service provider but the costs of maintaining a warehouse operation is either way in the hands of the supplier.

<u>VMI warehouse</u>

In a VMI relationship the supplier assumes responsibility for stock replenishment on behalf of the customer. Once arrived at the VMI warehouse, the goods is assigned to the customer and the supplier cannot reassign the goods to serve another customer. As previously discussed, ownership of the goods might remain with the supplier or be transferred to the customer. The supplier takes replenishment decision while the customer or some third party on his behalf has physical possession of the goods.

<u>Consignment warehouse</u>

A third form of product distribution is the use of a consignment warehouse. This form of warehousing is very similar to VMI. The goods belong to the supplier while stored at the customer's premises. It is, however, the customer who has control of the stock and makes the replenishment decision. The supplier is paid by consumption over which he has no control. In fact it is similar to an interest free loan to the customer who might easily be tempted to stock up to assure product availability at the cost of the supplier. This form of warehousing rests heavily on trust between the parties and is often avoided by suppliers.

<u>Replenishment decision as determinant</u>

There are four elements that separate these forms of warehousing.

1. Who has legal ownership of the goods

2. Who has possession and control of the goods
3. Who makes the replenishment decision
4. Who assumes the warehouse holding costs

Status on these elements will decide the form of warehousing as presented in Table 2-3.

Table 2-3, regional, VMI or consignment warehouse

Elements	Regional warehouse	VMI warehouse	Consignment warehouse
1. Ownership	Supplier	Supplier/customer	Supplier
2. Possession	Supplier	Customer	Customer
3. Replenishment decision	Supplier	Supplier	Customer
4. Warehouse holding costs	Supplier	Customer	Customer

This clarification highlights one major element of VMI. The determinant that makes it different from a consignment warehouse is **who makes the replenishment decision**. In a consignment warehouse where the customer makes the replenishment decision and the goods are owned by the supplier, there are no incentives on the customer to keep the volumes down. On the contrary, unless there are capacity constraints the customer has every reason to keep the volumes high in order to secure product availability. As the physical possession and control of the goods is also with the customer, there is not much the supplier can do to assess the customer's real demand. In the VMI case it is the supplier who makes the replenishment decision based on inventory level information. If the supplier owns the goods it is in his own interest to keep the volumes down to reduce capital employment. On the other hand, if the ownership of the goods is transferred to the customer, the supplier's incentives to keep the volumes down lie in the customer's ability to control the volumes and assess the supplier's performance. The shared control of inventory levels offers distinct opportunities for mutual benefits that characterize VMI relationships.

2.5.5 Inventory performance measurement

Performance measurement in logistics is a field receiving increasing attention (Busi 2005:69). The old sayings "you cannot control what you cannot measure" and "What is measured gets done" are as valid today as whey they were fist expressed. One will always make an extra effort performing well on the evaluated elements. Also, choice of performance indicators reflects priorities. One is more likely to measure performance on activities found highly important to operation than those activities not influencing the outcome to the same extent. Performance measurement is an important tool for evaluation of a VMI program and it can be used to identify areas for improvement.

It is not within the scope of this work to elaborate on performance measurement in general but it has been indicated by several authors (e.g. Gunasekaran et al. 2001, Lambert et al. 2001, Lee et al 1992) that the use of performance indicators is vital for successful supply chain collaboration. Performance measures are used to build a framework for controlling and improving supply chain performance towards the end customer as well as between supply chain partners. Therefore, a particular focus on performance measurement in VMI collaboration is included in this study.

To evaluate whether the right control technique is applied, inventory performance must be measured and assessed. When the supplier is responsible for inventory management this will be part of an assessment of supplier performance and the quality of his service. Inventory performance is usually based on product availability and the costs of maintaining availability. Frazelle (2001:110) presents two key *financial* indicators for inventory performance, two key *productivity* indicators and two key *quality* indicators. These indicators are presented in Table 2-4 and further detailed below.

Table 2-4, key indicators of inventory performance

Financial		**Productivity**		**Quality**	
Inventory investments	**Inventory carrying costs**	**Inventory turnover rate**	**No. of items managed by an inventory planner**	**Forecasting accuracy**	**Fill rate and service level**

Inventory investment is used to describe the average value of goods in stock. This is an average over time, a sum of inventory values of all individual items in stock. Average inventory value (AIV) is the result of Average inventory level (AI) times Unit inventory value (UIV).

$$AIV = AI \cdot UIV$$

Inventory carrying costs (ICC) are the costs of keeping inventory, calculated as average inventory value (AIV) times the cost of investing in inventory, e.g. storage and handling, obsolescence, insurance, taxes and shrinkage due to damages and pilferage (inventory carrying rate, ICR).

$$ICC = AIV \cdot ICR$$

Who is carrying these costs depends on the sharing of responsibilities in the VMI relationship. If the ownership of the goods is transferred to the customer, he is also carrying the costs. These measures can be used to determine maximum – minimum inventory levels that the supplier has to relate to in the replenishment planning.

Inventory turnover rate is an essential logistic measure that indicates how many times a year the stock is replaced. Inversely it indicates how many days/periods the goods spend in stock. The inventory turnover rate (ITR) should be high and respectively, the number of days in stock would be low. What values are considered high and low will differ with industry and product characteristics, e.g. product value, demand characteristics, risk of obsolescence etc. Also, spare parts inventories have requirements different from a traditional inventory. ITR is calculated as the ratio of annual sales to average inventory value.

$$ITR = \frac{Sales}{AIV}$$

ITR can be applied to decide on inventory levels as an alternative to maximum – minimum decisions.

Number of items managed by an inventory planner is a productivity measure indicating how many employees are required to control inventory. Nowadays, this job is most commonly supported by computer systems and large numbers of items can be controlled by minimum managerial effort. This measure can be applied to calculate the supplier's financial compensation for managing the customer's inventory.

Forecasting accuracy is a statistic calculation on how well forecasted demand match real demand. When there is little deviation, safety stock levels can be reduced. Large deviations can be a signal to apply other forecasting methods. This measure should be directed to the party preparing the forecasts. Frequently this is the customer in the VMI relationship, sometimes the parties make a joint effort in preparing them and sometimes the supplier prepares the forecasts.

Fill rate and service level are expressions of one of the most important logistic performance measures. They indicate how many times a stock-out occurs. Choosing service level is a trade-off between inventory carrying costs and lost sales costs, and setting the right priorities it is a managerial decision. In VMI maintaining service level is the supplier's responsibility. His ability to perform will depend on several elements but forecasting accuracy is essential if he is not a highly responsive supplier by other means.

2.5.6 Decisions in inventory management

General models on inventory management are assumed to apply irrespective of who is responsible for replenishment, and though the techniques presented are most frequently described in traditional ordering models they are also applied in VMI programs.

Inventory decisions are critical for many supply chain activities. Availability of goods will maintain sales and is a market qualifier. High availability is often a market winner, (e.g. Christopher & Towill 2001, Harrison & van Hoek 2002, Ballou 2004). Additionally, component or material shortages can shut down a manufacturing line and force expensive rescheduling of production plans. Appreciating the importance of product availability it is just as important to realize that inventory has associated costs. Costs of keeping inventory are e.g. warehouse operation costs, increased capital employment, insurance, taxes and risk of obsolescence and damages (Bowersox et al. 2002). Overstock increases these costs and reduces profitability. It is important to maintain availability without jeopardizing cost efficient operations.

Inventory is used to assure instant availability of a product or component. Inventory is a buffer between the supplying and the consuming process allowing both processes to operate decoupled from each other. Inventory management rests on the two main operational questions (Bowersox et al. 2002):

- When to reorder and
- How much to reorder

The answers to these questions depend on multiple factors, these could be

- *Cost issues*, referring to e.g. ordering costs, transportation costs, storage costs, capital costs
- *Demand uncertainty*, referring to e.g. volume uncertainty, end-of-life uncertainties, competitive situation, seasonal variations
- *Replenishment lead times*, referring to e.g. order processing time, transportation, manufacturing, risk of damages

Priorities and presumptions guide the decision process. Control mechanisms to assure correct information, forecasting and downstream demand information sharing are tools required. Based on individual priorities and requirements different inventory control techniques are applied. This section presents some of the most commonly applied and described control techniques.

When to order

The traditional answer to when to reorder is when the current stock level equals total demand during the replenishment lead time period. In theory, the goods will arrive just in time for consumption and stock-outs will not occur. However, for calculation purposes average values for demand and lead time are used, and these will most likely diverge from observed values. Additionally, some of the remaining products in stock can be damaged, and there is always a risk of inventory level discrepancies. Safety stock is used to handle uncertainties in demand and availability during lead time. The equation for calculating reorder point is

$$R = D \cdot T + SS$$

(R = Reorder point (in units), D = average daily demand (in units), T = average replenishment lead time (days), SS = Safety stock (in units)).

How much to order

How much to order is influenced by multiple elements. Quantity discount and volume transport rates often reduce unit costs and many suppliers restrict their sale volumes to batches, full boxes or other types of interval loads. One of the most widely described formulas for calculating lot sizes is the Economic Order Quantity formula (EOQ or Wilsons formula, e.g. Ballou 2004, Bjørnland et al. 2001, Browne et al. 1996).

$$EOQ = \sqrt{\frac{2Sd}{C}}$$

This formula identifies the optimal lot size based on a trade-off between the costs of establishing the order and the costs of carrying inventory. (*EOQ = Economic order quantity, S = ordering costs /set-up costs per order, D = demand per period, C = inventory carrying costs per unit per period)*

This calculation assumes that demand is constant and known and that both ordering costs and inventory carrying costs are known. In reality this is rarely the truth and while the formula is used to guide in the decision process, it should never be conclusive.

As the limitations to the formulas described are recognized, different techniques using these equations are applied to support the *how much* and *when* decisions. Some of the most common techniques are presented here.

Fixed order quantity

In the fixed order quantity technique an order for a fixed quantity is issued when inventory levels reach a predetermined reorder point. The same lot size is ordered every time but frequency will vary, see Figure 2-14.

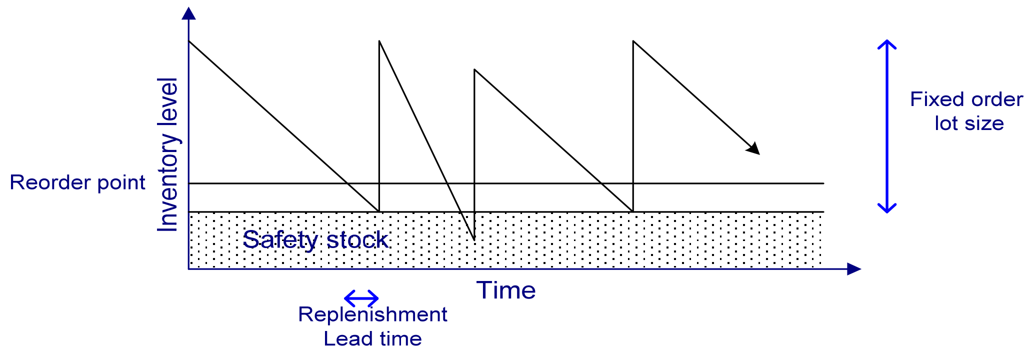


Figure 2-14, example of inventory levels using reorder point techniques

Frazelle (2001) presents two combinations of reorder point and volume decisions

- Reorder point and EOQ
- Reorder point and order-up-to-level

In the first combination the reorder volume is calculated using the EOQ formula and this volume is ordered when the reorder point is reached. The inventory level situation can be illustrated as in the graph sketched in Figure 2-14.

In the second combination a predefined maximum inventory level is determined. The criteria on which this maximum level is determined are not specified by Frazelle (2001) but one example is maximum available transport or storage space (frequently applied when the goods are liquids or gasses and are stored on tanks). When the reorder point is reached an order is issued to build inventory level up to the predetermined "up-to level".

Fixed order period

In a fixed order period technique, inventory is checked in predefined fixed intervals, for example every Monday morning. The inventory levels are reviewed and orders are issued based on exact stock withdrawal over last period. The order size can be determined on an "order up to"-strategy and the order size will vary, see Figure 2-15.

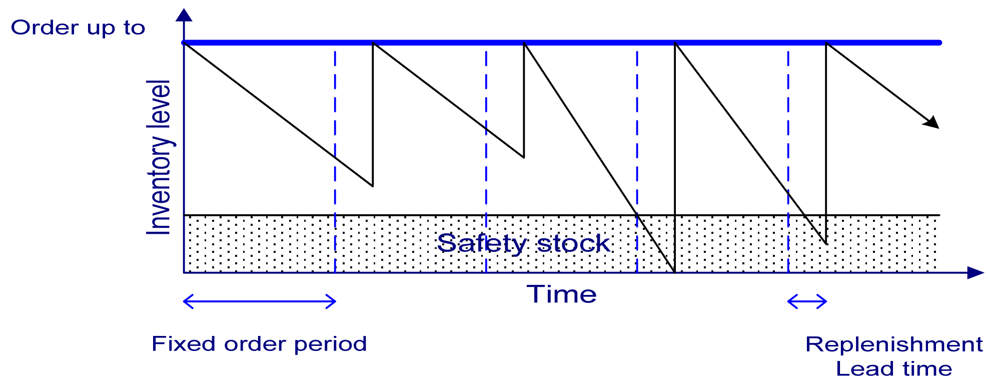


Figure 2-15, example of inventory levels using fixed order period technique

On this point Frazelle (2001) presents two combinations,

- Review time period and order-up-to-level
- Review time period with reorder point and order-up-to-level

Combination one is the situation depicted in Figure 2-15. Inventory levels are reviewed periodically and orders are released on an up-to-level basis.

In combination two, inventory levels are reviewed periodically, but new orders are released only when the level has reached a preset reorder point. One main disadvantage using periodic review as opposed to continuous review is the risk of stock-outs in case of highly variable demand. When demand is unstable or uncertain, the review periods should be shorter. The main advantage using periodic review is reduced resources spent on monitoring inventory levels.

Maximum – minimum inventory levels

One inventory control technique frequently applied in a VMI relationship is the "max-min" model. In this model, predefined maximum and minimum inventory levels are established and the inventory manager (or the supplier in case of VMI) is responsible for maintaining a continuous stock level within these limits. A latest reorder point can easily be calculated based on expected demand over respective replenishment lead times, and separate levels can be defined for different products or components with respect to individual demand patterns and replenishment lead times. Figure 2-16 depicts the max-min model indicating that the reorder point is somewhere between the maximum and minimum inventory levels. Theoretic calculation of reorder volume is just as trivial as the reorder point calculation. The remaining inventory level when replenishment arrives plus reorder volume should not exceed maximum inventory level.

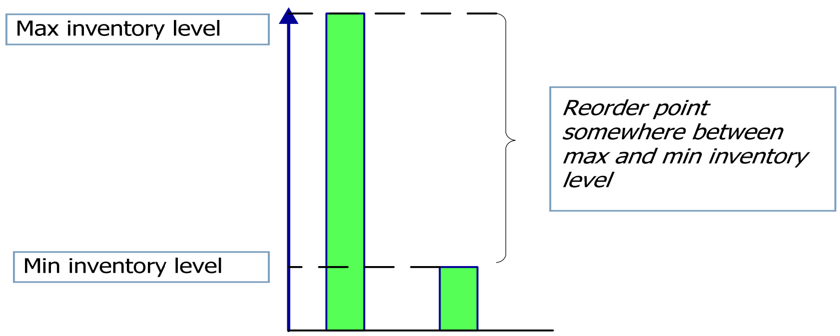


Figure 2-16, inventory levels and reorder point in a max-min model

Two-bin systems

A two-bin system is in fact a reorder point system with fixed reorder point and reorder volume. In a two-bin system, parts or components are stored in two parallel containers. When one container is emptied a replenishment order is released, and the second container is opened for stock withdrawal. It is presumed that by the time the second container is emptied the first container is restocked. This is a very visual and simple technique that can be operated manually and without computer systems. The reorder point is on 50% of maximum inventory level and reorder volume equals the predefined volume of one container. The 50% level must at least reflect the expected demand over replenishment lead time plus safety stock. Figure 2-17 illustrates reorder point and reorder volume in a two-bin system.

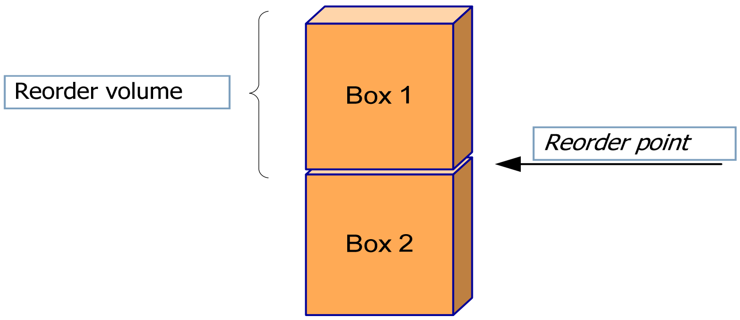


Figure 2-17, reorder point and volume in a two-bin system

Further advanced inventory control techniques are sophisticated models of the techniques described here. They focus on reducing uncertainty by applying advanced forecasting models and information sharing for improved demand visibility upstream the supply chain, (see e.g. Ballou 2004, Bowersox et al 2002, Frazelle 2001).

This section has described some common techniques for inventory control applied in traditional replenishment. In a VMI relationship the incoming inventory on the customer side is managed by the supplier and it is argued that the same control techniques can be applied by the supplier in a VMI relationship as by the customer in traditional replenishment systems. In a VMI context the reorder points and order volumes are subjected to individual adjustments to fit the supplier's activity level within the limits he has agreed to operate.

2.6 Terms and interpretations in supply chain collaboration

The term Vendor Managed Inventory and its abbreviation VMI has been used by many researchers and authors in the field of Supply chain management (see e.g. Elvander 2006, McBeath 2005). In section 2.3 some characteristics of the most common collaboration models were described. However, the interpretations of the terms are almost as numerous as the authors. Simultaneously, it is recognized that many businesses do not use the term VMI at all, and there are many other names for the VMI collaboration programs. It is not the name but the principles applied that is vital to identify VMI collaboration programs.

This section is an overview of what terms are found in literature and real life. Further, this is a clarification of terminology on forms of supply chain collaboration. The main focus is to identify different interpretations of VMI. The purpose is to differentiate this term from other terms to support the applied definition. A clearance and standardization of definitions and terms among academics is long overdue. This statement is supported by case interviewees expressing *"Oh, that's what you academics call it these days…"*, and frankly they could not be bothered.

2.6.1 Different names, different principles?

Buyer-supplier relationships take different names, and so do VMI relationships. When identifying "VMI relationships" one cannot judge solely by the name. One might come across "VMI relationships" that are not true VMI because some specified criteria are missing. On the other hand, by ruling out collaboration programs that do not have "VMI" or the like in the name, one is likely to miss out on many true VMI relationships. Within the five VMI relationships studied in this work, several appellations are found. Even within one relationship the two parties might use different names on the program. One actor had different names for inbound and outbound relationships. Table 2-5 summarizes the terms used in literature and those found in the empiric part of this research.

Table 2-5, names for collaboration programs

Terms found in literature	Terms found in cases
• Efficient Consumer Response (ECR) • Quick Response (QR) • Continuous Replenishment (CR) also named Continuous Replenishment processes (CRP) • Rapid Replenishment (RR) • Profile Replenishment (PR) • Supplier Managed Inventory (SMI) • Supplier owned inventory (SOI) • Vendor Managed Inventory (VMI) • Vendor Managed Replenishment (VMR) • Co-managed Inventory (CMI) • Automatic Replenishment Programs (ARP) • Consigned inventory • Secure inventory • Pay On Use or Pay By Scan • Supplier assisted inventory management (SAIM)	• Vendor managed inventory • Vendor managed replenishment • Automatic replenishment • Demand chain replenishment • Direct line feed • Consignment inventory

All together 16 terms are found in literature and 6 terms are used in the cases studied.

The definition of VMI applied in this thesis was presented in the introduction and it is copied here for the purpose of simple comparison.

1. *The replenishment decision is in the hands of the supplier*, both with respect to frequency, volume and time.
2. *Supplier's replenishment freedom is limited to preset performance standards,* these could be max/min inventory levels, reorder point agreements, inventory turnover measures, required service levels and others.
3. *Some sort of demand information is transferred from the customer to the supplier*, frequency and format of information exchange may differ, as do type of demand information.
4. *There are no customer orders initiating a purchase*, stock withdrawals are made by customer on demand and related invoice is issued periodically or by activity.
5. *The receiving warehouse is owned by the customer or operated by some 3rd party on his behalf*. The customer possesses the goods and the supplier is not free to tranship goods to other customers.

Based on a study on VMI application in US high tech industry Roberts (2003) present a definition of VMI collaboration fairly similar to the one applied in this work. He uses the term VMI to describe an inventory program with the following common elements:

I. The primary responsibility for maintaining target inventory levels lies with the supplier.

II. The program eliminate the classical discrete purchase order process with a dynamic replenishment process

III. The program delays the time of title transfer from supplier to customer closer to the time the part is used in manufacturing.

IV. It involves reserving finished goods inventory at predefined levels for a particular customer, usually by placing that inventor in a location closer to the manufacturing site.

Comparing the two definitions:

- Point I in Roberts' definition encompasses points 1 and 2 in the definition applied in this study.
- Point II is similar to point 4 and point IV is similar to point 5.
- Roberts claim that transfer of ownership is delayed in a VMI program (point III) but this is considered not important in the definition applied in this study.
- Point 3 of the definition applied in this study states that some sort of demand information sharing must take place. This subject is not included in Roberts' definition.

This comparison shows that the definition used in this work is compatible with other definitions used.

2.6.2 Establishment of a reference

In the presentation of the theoretical framework it was stated that who makes the replenishment decision makes an important determinant for whether a warehouse is a regional warehouse or a VMI warehouse. When studying literature on collaboration models there are three functions used to differentiate between models. These are

- Who has juridical ownership of the goods,
- Who has physical possession or custody, and
- Who is in charge of inventory control or who makes the replenishment decision

Traditionally these three functions have been in the hands of the same organization, usually the customer. However, some collaboration programs break this link, and owning, possessing and controlling goods is split between two juridical units. The objective of this section is to describe how different authors interpret different collaboration schemes based on ways to share these functions. More than 30 books and articles are reviewed and the purpose of this review is to shed light on the complexity of the terminology that has developed over the last decades.

Mattson (2002) define three collaboration models where he makes a clear distinction by the way they encompass the responsibility for replenishment decision, ownership and possession. Here his definition will be used as a reference to the other definitions studied. The three terms are Co-managed inventory (CMI), Vendor managed replenishment (VMR) and Vendor managed inventory (VMI). For the purpose of making these terms references they are denoted CMI[a], VMR[a] and VMI[a] to indicate that these are the definitions prepared by Mattson (2002).

In CMI[a] the supplier plans replenishment based on current stock levels and expected demand. Supplier prepares a shipment which must be confirmed by customer prior to dispatch. Juridical ownership and physical possession of the goods is with the customer when stored at customer's location.

In VMR[a] the customer will not confirm shipments prior to dispatch. Replenishment is managed by supplier based on for instance predefined intervals of maximum and minimum inventory levels, customer's service levels, inventory costs etc. Like in the CMI[a] scheme, ownership and possession is with the customer, but inventory control is solely in the hands of the supplier which has the opportunity to use the inherent flexibility to smooth his own operations.

VMI[a] is the alternative where the supplier undertakes most responsibility for customer's inventory. While the physical possession of the goods is with the customer, juridical ownership and control remains with the supplier. This highly integrated alternative requires detailed agreements on trade terms, e.g. who bears the costs of obsolescence, waste and pilferage. Mattson also indicates there are accounting issues to be clarified in a VMI[a] program.

The three collaboration models represent different levels of integration based on to what extent the vendor undertakes responsibility for the management of the customer's inventory. Table 2-6 shows the reference model with respect to responsibility within each collaboration scheme.

Table 2-6, Sharing of responsibility within the different collaboration schemes as defined by Mattson (2002)

Term	Replenishment decision	Ownership	Possession
CMI[a]	Customer	Customer	Customer
VMR[a]	Supplier	Customer	Customer
VMI[a]	Supplier	Supplier	Customer

2.6.3 Interpretations of VMI

From the following literature review it appears that the most frequently used interpretation of VMI includes both VMR[a] and VMI[a], i.e. in VMI the ownership of the goods can be transferred to the customer but it can also stay with the supplier when stored at a customer operated warehouse.

1. Some authors state that transfer of ownership is not a determinant for use of different terms
2. A few authors use distinctive terms and agree with Mattson (op.cit)
3. Mostly this possible difference is not mentioned at all

The bullet numbers refer to columns in Table 2-7 that summarizes on what authors take the different approaches to interpretation of the term VMI.

Table 2-7, approaches to interpretation of VMI

(1) Pointing out that VMI = VMI[a] + VMR[a]	(2) Pointing that VMI[a] is different from VMR[a]	(3) Make no distinction between VMI[a] and VMR[a]
Kalsaas 2004, Holmström et al. 2002, Lapide 2001, Simchi-Levi et al. 2000, Waller et al. 1999, Christopher 1998	McBeath 2003, Mattson 2002, Norek 1998,	De Toni & Zamolo 2005, Angulo et al. 2004, Kuk 2004, Disney & Towill 2003a, b, Kaipia & Tanskanen 2003, Lysins & Gillingham 2003, Småros et al. 2003, Pohlen & Goldsby 2003, Bowersox et al. 2002, Harrison & van Hoek 2002, Kaipia et al. 2002, Kulp 2002, Bosersox et al. 2002, Yu et al. 2001, Sabath et al. 2001, Disney et al. 2001, Gustafson & Norrman 2001, Achabal et al. 2000, Ellinger et al. 1999, Holmström 1998, Cachon & Fisher 1997, Clark & Hammond 1997

Additionally, some authors use the term VMI without further defining their interpretation (e.g. Olhager & Selldin 2004, Disney, Potter & Gardner 2003, Skjött-Larset et al. 2003, Xiande Zhao et al. 2002, Zhenxin Yu et al. 2001, Lee, So & Tang 2000, Lee et al. 1997).

Table 2-7 shows that most authors interpret VMI to be an approach to inventory and order fulfilment where the supplier is responsible for stock replenishment. They do not discuss time for transfer of ownership at al. This is also the main interpretation used in this thesis.

2.6.4 Other terms compared to VMI

Further it appears that there are other terms used to name collaboration models that fit the descriptions of CMI^a, VMR^a and VMI^a. These can be described as parallel terms. Table 2-8 summarizes on some authors' use of parallel terms. There are diversions in interpretation observed but a main stream is still identified. Some authors state that VMI is VMR^a and some state that VMI is VMI^a, but most authors use various terms for VMR^a + VMI^a. One reference even indicates that VMR^a + VMI^a is termed CRP while all the other authors using CRP defines it like CMI^a.

Table 2-8, other terms described that matches the reference descriptions

Reference:	**CMI^a**	**VMR^a**	**VMI^a**
Bowersox et al. 2002, Sabath et al. 2001, Norek 1998	QR, ECR, CRP	VMI	
Van Weele (2005)		VMI/CR/SMI	
McBeath 2003, Roberts 2003			VMI
Clark & Hammond (1997)		CRP	
De Toni & Zamolo 2005, Kalsaas 2004, Pohlen & Goldsby 2003, Holmström et al. 2002, Lapide 2001, Simchi-Levi et al. 2000, Christopher 1998,	QR/CRP/RR	VMI/CMI/SMI	

It is clear that no authors use the term VMI to describe a model where the replenishment decision is in the hand of the customer.

2.6.5 Umbrella terms

Even further, some authors apply umbrella terms where one term is used as a common name to encompass multiple other terms. In this dimension the picture becomes quite complex. Here it turns out that some use VMI as an umbrella term for other terms while others put VMI under some other umbrella term. Figure 2-18 depicts six different umbrella terms found in literature and what terms are encompassed by the umbrellas.

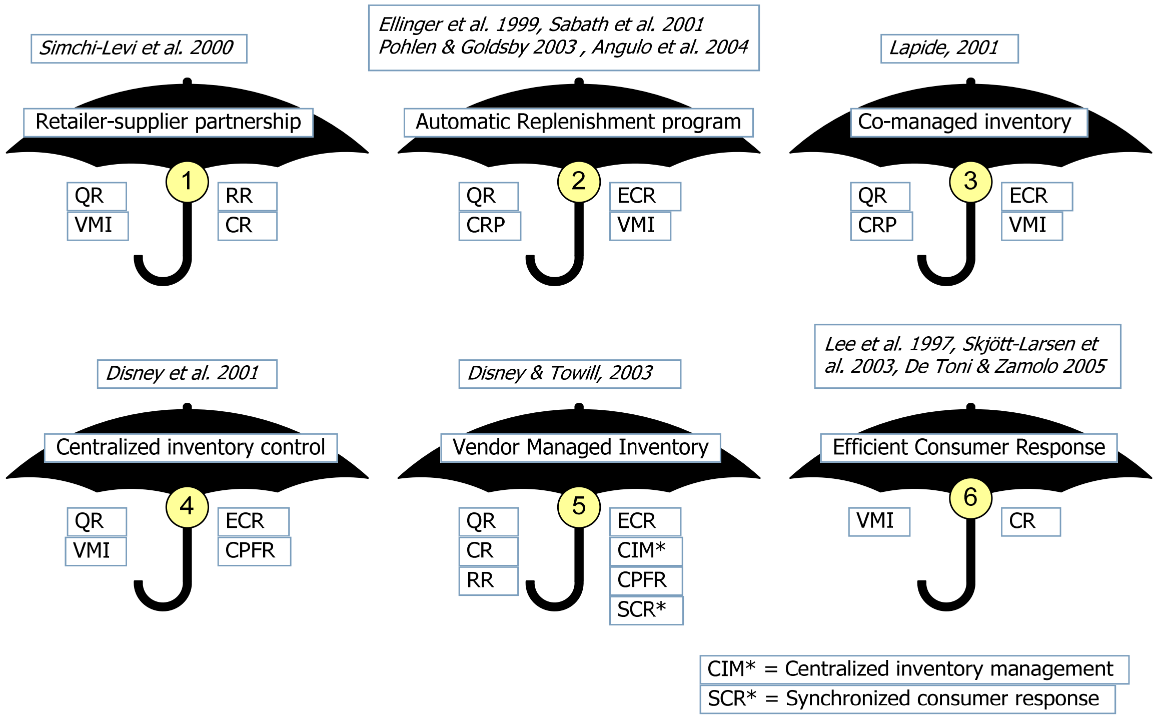


Figure 2-18, six umbrella terms and the terms they encompass

Umbrella 1, Retailer-supplier partnerships

Simchi-Levi et al. (2000) defines VMI as one type of *Retailer-Supplier Partnership* (RSP) where information sharing is a prerequisite for supply chain improvements. They see partnerships along a continuum where *Quick Response* (QR) in one end includes the transfer of POS data for the supplier to plan more efficiently while he still have to act on customers orders. Further along the continuum is a *Continuous Replenishment* (CR) or *Rapid Replenishment* (RR) strategy where the supplier uses POS data to prepare shipments awaiting customer’s request. The shipments are prepared based on previously agreed upon inventory levels. At the other end of the continuum is VMI “*or sometimes called a Vendor Managed Replenishment (VMR) system*”. In a VMI system the supplier handles the replenishment process and the customer has no influence on specific orders. Figure 2-19 illustrates this continuum.

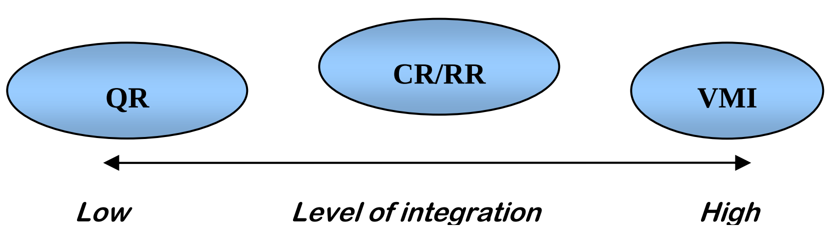


Figure 2-19, integration continuum, (after Simchi-Levi et al. 2000)

Umbrella 2, Automatic replenishment programs

Ellinger et al. (1999) study components of Automatic Replenishment programs (ARP), and they claim that there are several types of ARPs in use, for instance VMI and CRP and more industry specific programs like ECR and QR. Their use of the term ARP is very similar to Simchi-Levi et al's (2000) use of RSP.

This definition of ARPs is referred to by Sabath et al. (2001) who investigate the impact of organizational structure to ARP. They describe ARP as an umbrella term including Effective Consumer Response (ECR), Quick Response (QR), Continuous Replenishment Programs (CRP) and Vendor Managed Inventory (VMI). ECR and QR are industry-specific programs (ECR in grocery and QR in apparel) and it is indicated that though information sharing is vital, the buyer makes the replenishment decision.

Pohlen & Goldsby (2003) refer to Sabath et al. (2001) when describing their definitions of VMI and SMI. They state that VMI is the right term when used to describe automatic replenishment downstream from an Original Equipment Manufacturer (OEM) and the automatic replenishment of raw materials to an OEM is called a Supplier Managed Inventory (SMI) program.

Angulo et al. (2004) also refer to Sabath et al. (2001). They discuss information sharing in VMI and they describe VMI as one type of ARP. Other types of ARP are ECR, CRP and QR.

Umbrella 3, Co-managed inventory

Lapide's (2001) umbrella is the term Co-managed Inventory (CMI). He refers to VMI as one element of a "broad class of co-management inventory programs". In addition to VMI they include CRP, QR and ECR. His definition of an umbrella term is very similar to both Simchi-Levi et al. (2000) and Ellinger et al. (1999) but his use of CMI is very different from the reference CMI[a].

Umbrella 4, Centralized inventory control

Disney et al. (2001) take a very similar approach. They indicate that VMI is a form of Centralized inventory control, and other terms used to describe such models are ECR, QR and CPFR.

Umbrella 5, Vendor managed inventory

Two years after the publication of the umbrella 4 reference Disney and Towill (2003a and b) take a much wider perspective on VMI. They now seem to indicate that VMI is the umbrella term encompassing QR, SCR, CR, ECR, RR, CPFR and CIM. First they describe VMI as a supply chain strategy where the supplier is given the responsibility for managing the customer's stock. Further they claim that VMI come in many different forms and list

1. QR, referring to Lee et al. (2000),
2. Synchronized consumer response (SCR), CR and ECR, referring to Cachon and Fisher (1997),
3. RR and CPFR, referring to Holmström et al. (2000) and

4. Centralized inventory management (CIM), referring to Lee et al. (1997).

Closing the list they state that "- *depending on sector application, ownership issues and scope of implementation, they are all specific applications of VMI*". However, when studying the references made to the different terms, a rather unstructured picture is revealed.

Lee et al. (2000) briefly describe QR but their interpretation of QR appears similar to Simchi-Levi et al. (2000) and to Christopher (1998). They do also mention VMI as a program based on information sharing but it cannot be read from the text that QR is a form of VMI.

Cachon and Fisher (1997) state that CR is a protocol under ECR, (later supported by e.g. De Toni & Zamolo 2005) where daily updates of demand and current inventory is used to determine replenishment shipments. They also state that CR and VMI are synonymous terms used in different industries. Cachon and Fisher (1997) interpret VMI as an element of ECR, while the purpose of referring to this article was to state the opposite.

Disney and Towill's (2003b) listing of forms of VMI also referred to Cachon and Fisher (1997) for Synchronized Consumer Response (SCR), but this term and its abbreviation is never used in the article.

The Holmström et al. (2000) reference is a working paper not made available to this study. A paper published in *Supply Chain Management: an International Journal*, Vol. 7, No. 3, 2002, pp 136 - 145 written by the same authors bearing the same title is however made available at their university homepage and will be used for further discussion of Disney and Towill's (2003b) reference on RR and CPFR. RR is not discussed in the Holmström et al. 2002 reference, but as this is not the original reference made by Disney and Towill (2003b) this issue will not be further pursued. Though not directly stated, it can be understood from Holmström et al. (2002) that they interpret VMI as a solution in the Replenishment aspect of CPFR. Again, it appears that Disney and Towill (2003b) make a reference to work stating the opposite of the intention.

There is not identified any discussion on CIM in the Lee et al. 1997 reference. Their attempt to establish VMI as an umbrella term is therefore not supported by the literature they build their arguments on.

Umbrella 6, efficient consumer response

Skjött-Larsen et al. (2003) take a different view than the others described above. While the others have stated that VMI and ECR are collaboration programs with slightly different content, Skjött-Larsen et al. (2003) state that VMI is part of an ECR program. This is the opposite of what Disney & Towill (2003) tried to establish, but it is in line with Cachon and Fisher (1997), Lee et al. (1997) and De Toni & Zamolo (2005). When studying new literature on ECR in particular it appears to be a general contemplation that VMI is a replenishment program that can be applied in an ECR agenda.

2.6.6 The main lines of interpretations

It is suggested that there are different levels of integration within the scope of VMI based on what aspects of the inventory are actually managed by the vendor. This review indicates that few authors specify what management activities are actually performed by the supplier in the VMI relationship they describe, and this is particularly observed for authors using analytical or simulation based methods. Some case studies have proven to be more detailed in this matter. Inventory management is a complex task involving many aspects including customer service levels, inventory levels, product range, stock location, ordering decisions, forecasting and replenishment lead times, just to name a few (Simchi-Levi et al. 2000). In addition there are physical handling decisions regarding operating a warehouse facility for stock keeping.

The review indicates that in a fully integrated VMI program the supplier assumes full responsibility for all inventory activities, replenishment volumes and frequency, stock levels and withdrawal control within some predefined measures of customer service level. Simchi-Levi et al. (2000) present examples of highly integrated VMI programs where the customer doesn't pay for the goods until they are sold to the customer's customer.

In the simpler form a VMI program can be based on supplier managing only the replenishment process. Supplier decides when to replenish what items at what volumes based on own, customer's or jointly developed forecasts while ownership of the goods is transferred to customer somewhere during transport. In this form of the VMI program only the replenishment process is managed by the supplier and all other warehouse activities are controlled by the customer. The incentive to keep the volumes down is provided by inventory level monitoring. In line with Mattson (2002) it can be argued that the simple form of VMI where supplier only takes responsibility for replenishment while other inventory control activities are managed by customer or jointly on a collaborative basis is defined as VMR.

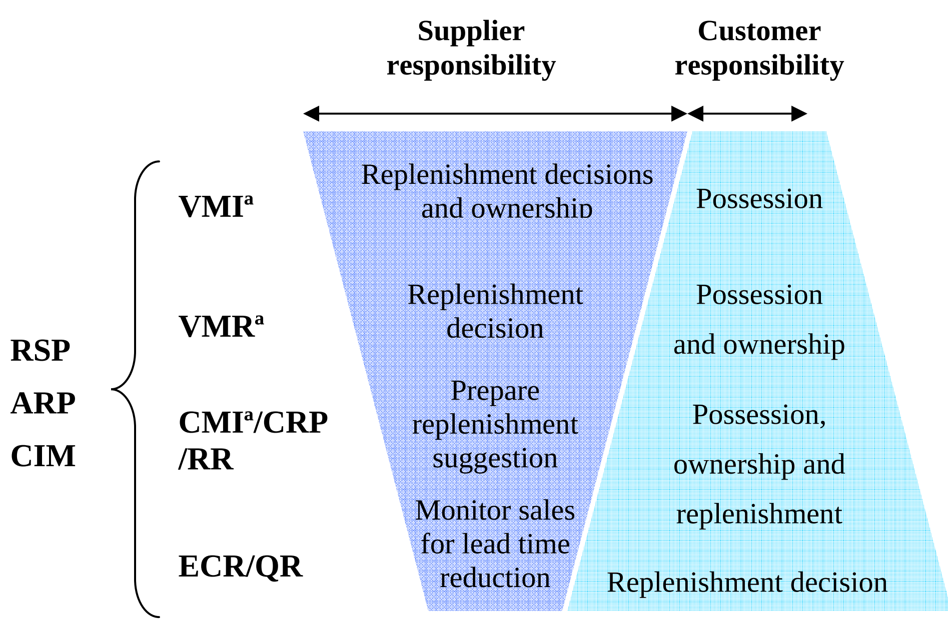


Figure 2-20, allocation of responsibility for customer's inventory in different supply chain collaboration schemes

Figure 2-20 expands the definition presented in the reference Table 2-6 slightly and it summarizes the sharing of replenishment responsibility between customer and supplier within the different collaboration schemes discussed in this section. All of the terms described in umbrellas 1 to 4 will match this description. For umbrella 6 this figure will be slightly adjusted (Figure 2-21).

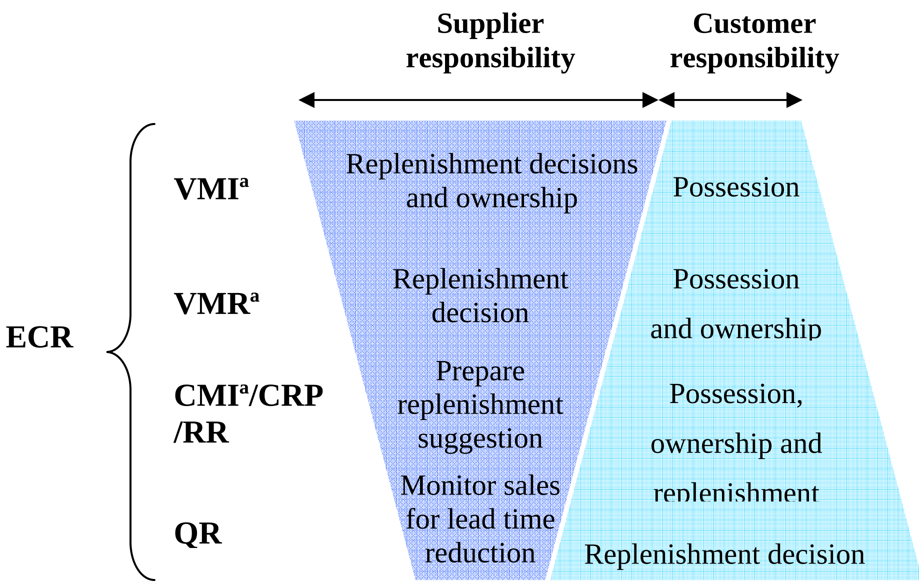


Figure 2-21, alternative view of allocation of responsibility for customer's inventory in different supply chain collaboration schemes

From this brief review on interpretation of terms used in supply chain collaboration literature it can be seen that though there is inconsistency in definitions some main lines can be drawn. The points of difference made by Mattson (2002) as in who makes the replenishment decision, who possesses and who owns the goods are recognized by several authors. The most frequently found interpretation of VMI is represented by Simchi-Levi et al. (2000) that set the line by replenishment decision and define VMI as when supplier replenishes without customer interference. The general interpretation of VMI is VMI[a] + VMR[a]. For the purpose of the work presented in this thesis, the general interpretation of VMI is used. When case specific programs are presented, references to Mattson's definitions will be used to differentiate on the ownership issue.

From this discussion it is argued here that VMI is not an umbrella term. VMI is a model for supply chain collaboration where the supplier is responsible for replenishment. VMI is used both when ownership of the goods is transferred to the customer when in the customer's possession and when ownership remains with the supplier. The term is not industry specific. It is applied for instance in electronics industry (e.g. De Toni & Zamolo 2005), in high tech industry (e.g. McBeath), in the automotive industry (e.g. Kalsaas 2004) and in consumables (Holmström 1998).

The definition of VMI used in this work therefore focus on the sharing of replenishment responsibility. There is no limitation towards industry application and there is no limitation as to how this can be applied within an ECR agenda.

2.7 Summary

This chapter has presented the theoretical background for this thesis. Some basic elements of logistics and inventory management have been presented because they form a fundament for the discussions and findings of this work. While understating the generality of inventory management in logistics the emphasis has been on arguing how the elements described can be applied in a VMI discussion.

It has been argued that collaboration has become more and more important for sustained competitiveness and several strategic and organizational aspects of supply chain collaboration have been outlined. These aspects can have an impact on the successfulness of the collaboration program applied on a managerial level and they should therefore be taken into consideration when capturing the context of the cases studied. These aspects are though outside the scope of this work which focus on the logistics control part of the collaboration program.

Further, this chapter has clarified on terms used for describing different models for sharing of responsibilities in supply chain collaboration. This was done to outline the definition of VMI applied in this thesis and to compare characteristics of VMI to other collaboration models.

The next chapter offers a detailed description of the concept of VMI, both with respect to how it is supposed to work and some of the benefits and obstacles inherent. This chapter is included in order to build a fundament for the data collection process and to establish the competence platform as indicated by the two supporting objectives described in the introduction.

3 The concept of Vendor Managed Inventory

The previous chapter outlined the theoretical framework for supply chain management and inventory control. This chapter describes the concept of VMI. It includes theoretically expected and empirically experienced success elements, benefits and obstacles to the implementation of VMI collaboration. This chapter describes how and why incoming inventory control can be undertaken by a vendor and what is considered important for VMI success. Some other elements that will influence the value of VMI are also discussed. The purpose of this chapter is to increase comprehension of VMI as a concept and to build a fundament for the data collection process.

3.1 Retrospect

Inventory management is about maintaining inventory levels according to e.g. predefined product availability and cost measures. The inventory management models described in the previous chapter indicated that replenishment decisions were often made on inventory status and expected demand during replenishment lead time. The models described can be applied by a vendor when he is responsible for replenishing a customer's inventory. In order to perform appropriately the vendor will need the same type of information that the customer should apply if he had been responsible himself (Mattson 2002), e.g. sales data, incoming orders and inventory levels.

The subjects of information sharing and future demand decisions are essential in VMI collaboration. According to John F. Magee (Magee 1958) both parties should have a genuine interest to participate in the control process. In his 1958 edition of the book "*Production planning and inventory control*" Magee discussed who should control inventories, those who use them or those who feed them. He discusses authority over inventory and states (emphasis added by author):

> **"Frequently there is argument as to who should control inventories. For example, should it be the sales organization or (some) other unit that draws on the stocks and wants to be sure they are there, or the operation that supplies the stock point and wants to feed it economically? There is probably no resolution to this question as stated; the difficulty is that both have a legitimate interest. It is possible to restate the question slightly and reach a solution. The user has to be sure the material he needs is there. He has corresponding responsibility to state what his maximum and minimum requirements will be. Once these limits are accepted as reasonable, the supplier has the responsibility of meeting demand within these limits, making whatever use he can of the flexibility the inventory provides. Thus both have a share in the responsibility for and control over a stock unit. One specifies what the maximum and minimum demands on the stock unit will be; the other has the responsibility of keeping the stock unit replenished but not overloaded as long as demand stays within the specified limits" (Magee, 1958, p 298).**

Magee shed light on a fundamental conflict of interests and his solution has become the basic idea behind the modern VMI concept. It is interesting, though, to observe that more than 20 years passed before his ideas received enough attention to materialize in the successful and well described collaboration model between Wal-Mart and Procter & Gamble (Simchi-Levi et al. 2000). Since then, many researchers have explored the subject, and many approached the subject with a purpose to identify and document supply chain performance improvements from VMI collaboration, both analytically, by simulation and case studies (e.g. De Toni & Zamolo 2005, Pohlen & Goldsby 2003, Småros et al. 2003, Disney & Towill 2003, Kaipia et al. 2002, Zhao Xiande et al 2002, Yonghui & Raiesh 2002, Yu Zhenxin et al 2001, Disney et al. 2001, Achabal et al. 2000, Simchi-Levi et al. 2000, Waller, Johnson and Davis 1999, Holmström 1998, Lee et al. 1997).

3.2 Expected benefits of VMI collaboration

A lot of work has been done to identify benefits and opportunities of VMI collaboration, both for the supplier and the customer. Increased transparency in the supply chain caused by information exchange has been addressed and effects of transparency and demand visibility have received growing attention (Jespersen & Skjøtt-Larsen 2005, Angulo et al. 2004, Småros et al. 2003, Kulp 2002). The most frequently described benefit of VMI is reduced bullwhip that was described in the previous chapter.

Effects and benefits of VMI will depend on the objective of the implementation. Kauremaa et al. (2007) have proposed two modes for VMI adoption, the collaboration-centric and the service-centric mode. In the service-centric mode the supplier’s primary objective is to gain competitive advantage through offering a service, while in the collaboration-centric mode the main objective is to develop a competitive supply chain based on mutual commitment.

3.2.1 Performance improvements by demand visibility

The effects of VMI on Bullwhip are related to the elimination of the customer order activity and increased demand visibility. The bullwhip effect is reduced by the centralization of demand data, as described analytically by Simchi-Levi et al. (2000:88) and termed Demand Visibility or Supply Chain Transparency (e.g. Borgström et al. 2005, Jüttner 2005, Småros et al. 2003). When the customer no longer processes demand information, this source of information distortion is eliminated. Amplification of demand variation can be reduced if the supplier can act on end demand data rather than customer order data.

The supplier’s ability to predict customer’s demand at an earlier stage increases his flexibility and extends his delivery time window. This has an effect on both his manufacturing and inventory operations (Waller et al. 1999). The supplier may smooth his manufacturing operation for economic capacity utilization and he might plan for economic full truck load distribution.

Improved demand visibility can offer cost reductions. Reduced demand volatility reduces the need for buffer stocks of different product variants, lower obsolescence and faster new product introduction.

Småros et al. (2003) simulate benefits of demand visibility which is described as planning based on customer’s sales data rather than replenishment orders. They use the term “sell-through information" which is described as when the supplier has access to the customer's sales information. When applied in a VMI context they indicate that one demand decision level is removed and therefore one source of bullwhip is reduced. Figure 3-1 illustrates this information flow.

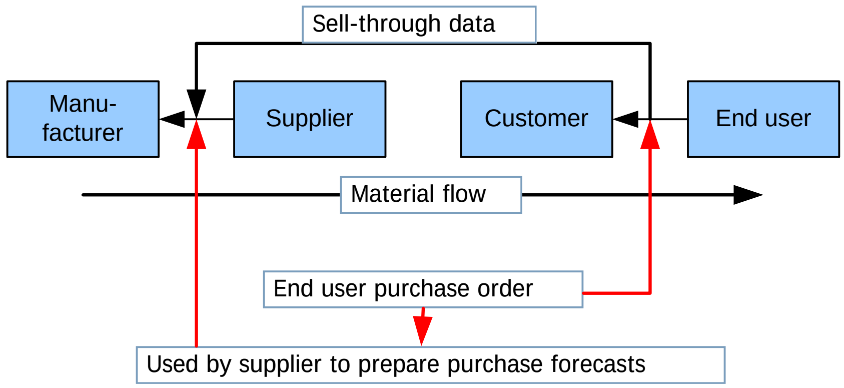


Figure 3-1, Sell-through data information flow

Furthermore, demand visibility can improve product availability because the time window for planning and delivery is increased. This can be obtained for both reduced stock-outs and a wider variety of Stock keeping units (SKUs). Demand visibility allows the supplier to play with the manufactured goods and reassign loads to serve more urgent orders if the products are standardized. VMI suppliers might therefore experience service improvement towards non-VMI customers (Waller et al. 1999).

Lapide (2001) proclaims that the benefits of VMI to the supplier lie in the demand information transmitted from the customer. This information should be used for production and inventory planning purposes, and the experienced benefits, reduced stock-outs and total inventory are direct results of improved planning capabilities.

3.2.2 Cost improvements

Mattson (2002) discusses costs and how they are affected by VMI. His findings indicate that most costs are reduced for both parties or they are reduced for the customer or the supplier and stay unaffected for the other. Some of the costs he studied will rise but from a total relationship perspective most costs are reduced. His discussion is based on an explanation of correlation between costs and responsibilities in a general VMI perspective and the suggested cost improvements are not quantified. His conclusions are translated and reproduced in Table 3-1 below.

Table 3-1, costs affected by VMI (Mattson 2002)

Type of costs	Customer	Supplier	Total in the relationship
Transport costs	Unchanged	reduced	Reduced
Inventory costs	Reduced	Unchanged	Reduced
Warehouse costs	Reduced	Reduced/Increased	Reduced
Management costs	Reduced	Increased	Reduced
ICT costs	Increased	Increased	Increased
Manufacturing costs	-	Reduced	Reduced

Efforts made to develop a VMI relationship build an inherent wish to maintain it. This makes both the supplier and the customer prioritizing each other and VMI is therefore a means to safeguard against supply shortages and to improve customer retention.

3.2.3 Experienced benefits

In section 2.5.1 it was argued that several software providers have developed solutions to facilitate VMI collaboration, and all these companies present success stories from their portfolio of customers and implementation projects.

A US based consultancy company who developed a computerized VMI bolt-on tool, has performed a survey amongst their customers in order to analyze the business benefits of VMI (www.datalliance.net). The survey included 10 suppliers and 21 distributors, all US based, and they focused on some key business indicators before and after VMI for locations having used VMI for 1-2 years.

On primary business results they found

- an average of 24 % increase in sales (increased business between the two partners),
- improved inventory turns and
- reduced stock-outs (improved customer service).

Related benefits listed are lower inventory, reduced obsolescence and returned items, reduced administrative expenses and enhanced supply chain visibility.

Gustafsson and Norrman (2001) present an implementation of the software program PipeChain for network collaboration in Ericsson Radio Systems. The purchasing department started using PipeChain for VMI collaboration with their suppliers. They list several positive experiences of the implementation such as

- Main effects are identified within months
- Investments start to pay off within months
- Increased knowledge and understanding for each others businesses
- Fast implementation of software tool
- Stable workload for operative logistics personnel

Benefits experienced from an implementation presented by Holmström (1998) are reduced demand variability, increased cost efficiency, reduced delivery lead times, improved customer service, reduced inventory levels and an increased responsiveness.

Achabal et al. (2000) present a decision support system for VMI and outline both motives for entering a VMI relationship, means to obtain expected benefits and performance measures for monitoring vendor performance. The primary objective of the VMI case described was to increase customer service levels through better forecasts and inventory efficiency. Customer service included both product availability and product mix. Key performance measures were customer service level and inventory turnover and the improved forecasts were built on the implementation of weekly sales forecasts from customer into the supplier’s production schedule.

A long list of expected and experienced benefits of VMI has so far been listed in this chapter and motives for entering a VMI collaboration scheme are plentiful.

3.2.4 Summary on opportunities of VMI

Logistic effects of bullwhip reduction and VMI are widely discussed in literature and they are the operational evidences of logistic benefits from bullwhip reduction. A summary of the review presented above is listed in Table 3-2 and in general they can be categorized as reduced costs, improved utilization and increased flexibility.

Table 3-2, improvement opportunities when bullwhip is reduced

Opportunities of reduced bullwhip	Reference
Increased flexibility	De Toni & Zamolo 2005, Pohlen & Goldsby 2003
Extended delivery time window	De Toni & Zamolo 2005, Kalsaas 2004, Pohlen & Goldsby 2003, Kaipia et al 2002, Disney et al. 2001, Simchi-Levi et al 2000, Achabal et al. 2000, Waller et al 1999
Smoothed manufacturing	De Toni & Zamolo 2005, Pohlen & Goldsby 2003, Kaipia et al 2002, Disney et al. 2001, Waller et al 1999
Reduced distribution costs	Van Weele 2005, Pohlen & Goldsby 2003, Mattson 2002, Simchi-Levi et al 2000
Economic capacity utilization	Kaipia et al 2002, Waller et al 1999
Reduced throughput time	Pohlen & Goldsby 2003, Achabal et al. 2000
Reduced capital employment	Pohlen & Goldsby 2003, Mattson 2002,
Reduced inventory costs	Van Weele 2005, Mattson 2002, Simchi-Levi et al 2000
Reduced inventory levels	Kalsaas 2004, Pohlen & Goldsby 2003, Simchi-Levi et al 2000
Improved product availability	Van weele 2005, Kalsaas 2004, Pohlen & Goldsby 2003, Achabal et al. 2000, Simchi-Levi et al 2000
Extended product assortment	Waller et al 1999
Reduced buffer stocks	Kalsaas 2004, Pohlen & Goldsby 2003, Simchi-Levi et al 2000, Achabal et al. 2000, Waller et al 1999
Lower obsolescence	Pohlen & Goldsby 2003, Waller et al 1999
Improved forecasting	De Toni & Zamolo 2005, Pohlen & Goldsby 2003, Simchi-Levi et al 2000, Achabal et al. 2000
Fast new product introduction	De Toni & Zamolo 2005, Waller et al 1999
Improved customer retention	Van Weele 2005, Waller et al 1999
Improved service to non-VMI customers	De Toni & Zamolo 2005, Achabal et al. 2000

As already indicated, the bullwhip effect is a compound of several different outcomes from supply chain activities and the importance and magnitude of the effect will differ with specific business environments. It is argued though, that under appropriate conditions product profitability can increase by 10 – 30 % if the bullwhip effect was eliminated (Metters, 1997).

3.3 Barriers to VMI

While this chapter so far has presented benefits of VMI, it is equally important to be aware of the barriers, limitations and obstacles. The following is a summary on barriers to successful VMI.

It can be interpreted from this review that barriers and obstacles in general are found within communication and can be exemplified by

- willingness to share data,
- ability to share data and
- ability to use the shared information properly

Occasionally there are legal and ethical obstacles to establishment of VMI collaboration. The findings are summarized in Table 3-3 where the barriers are listed in the left hand column and respective references are listed at the right. Along this section the literature findings are further outlined.

Table 3-3, barriers to VMI implementation

Obstacles	**References**
Commitment and willingness to share data, reluctance to engage.	De Toni & Zamolo 2005, McBeath 2003, Kulp 2002, Harrison & van Hoek 2002, Forrest & Martin 1990
Investments and restructuring costs, time consuming and risky implementation of systems, technology investments and expenses	De Toni & Zamolo 2005, Kuk 2004, McBeath 2003, Harrison & van Hoek 2002, Gustafsson & Norrman 2001, Lee & Whang 2000, Waller et al. 1999, Tirole 1993
Vulnerability, agreement on liability, trust, confidentiality and risk of information abuse	Van Weele 2005, McBeath 2003, Harrison & van Hoek 2002, Simchi-Levi et al. 2000, Lee & Whang 2000, Waller et al. 1999, Forrest & Martin 1990
Quality of shared data, seasonal variations and forecasting quality	McBeath 2003, Kulp 2002, Harrison & van Hoek 2002, Lee & Whang 2000, De Toni et al. 2005
Ability to utilize information to improve performance	Van Weele 2005, Kuk 2004, Kulp 2002, Lee & Whang 2000,
Geographical distance between parties	De Toni & Zamolo 2005
Inventory ownership	Mattson 2002, McBeath 2003, Simchi-Levi et al. 2000
Critical volume	De Toni & Zamolo. 2005, Waller et al. 1999

The three main elements most frequently described as limitations to success are risks, costs and the properties of information sharing.

3.3.1 Risks

Several types of risks are outlined. In a VMI context the customer loses control of the replenishment process and becomes dependent on an outside company's performance. To relinquish responsibility of supplies is a strategic and risky decision. This will be particularly risky if all sourcing activities are outsourced because there will be no in house backup competence. Customer vulnerability relates to inter-organizational trust and dependability (Harrison & van Hoek, 2002).

VMI rests on advance demand information sharing and there is a risk that information can be abused. This will cause unwillingness to share data and must be handled by aligning incentives (Lee & Whang 2000). Difference between the supply chain partners on incentives and performance measures, confidentiality and trust, reaching agreements on liabilities, agreeing on operational issues, policies and procedures are typical limitations to success, (Angulo et al. 2004, McBeath 2004).

Further there is the risk that information sharing in certain settings can be subject to antitrust regulations, (Lee & Whang 2002, Angulo et al. 2004).

3.3.2 Costs

The information systems and technology usually required have frequently been found expensive and work intensive to install, (Disney & Towill 2003a). Costs included are for instance investments and restructuring costs, (Harrison & van Hoek 2002) and increased administration costs, (Kuk 2004).

Additionally, implementation of a cross-organizational information system is costly, time-consuming and risky (Lee & Whang 2000, Angulo et al. 2004). Insufficient Return on investments (ROI) is also an important cause for cancellation (McBeath 2003).

However, Several authors underline that though the companies' information systems have to communicate, the complex and specially assigned decision support systems (DSS) are not needed and standard solutions are usually sufficient (Waller et al. 1999, Holmström 1998).

3.3.3 Properties of information sharing

The sharing of demand data requires that the quality of the information shared must be at focus. Firstly, lack of infrastructure for data exchange is a limitation (McBeath 2003), but this is increasingly overcome in most parts of the world.

Forecast predictability and data accuracy should receive special attention (De Toni & Zamolo 2005, McBeath 2003). Lack of standard procedures and system maintenance are limitations to efficient information exchange (Harrison and van Hoek 2002). Increased level of details required for planning and ineffective ordering and fulfilment processing are also observed limitations (Kuk 2004).

Finally it is noted that information sharing is just an enabler for supply chain coordination and that the value of information is restricted to the companies' capabilities to utilize the shared information (Lee & Whang 2000, Angulo et al. 2004, Kuk 2004).

3.3.4 Timeliness and other limitations

Establishment of a VMI relationship is time consuming. Gustafsson and Norrman (2001) found that it is a timely process to make personnel accept and adapt to changes in working procedures and responsibilities. Even when a standard interface is used, implementation takes time and much work. The system they studied in particular didn't fit random suppliers and seldom supply.

Many practitioners believe they must be of a certain size for another party to bother establishing VMI with them. Large actors are prioritized and priority to some customers can cause shortage to others (Kuk 2004). The idea of a "critical volume" has been suggested by some authors (De Toni & Zamolo 2005, Waller et al. 1999). They assume there must be a minimum volume of goods transferred from the supplier to the customer before setting up a VMI relationship is advantageous.

Harrison & van Hoek (2002) claim that VMI doesn't work for seasonal products. Other obstacles indicated by are reluctance to considering benefits of cooperation, investments required and long geographical distance between the parties (De Toni & Zamolo 2005).

Tirole (1993) propose that limiting factors to the success of buyer-supplier partnerships are Legal and ethical issues, Time and energy required to support the effort and a decrease in the value of the partnership as the life-cycle advances.

Forrest and Martin (1990) offer five reasons for failure in supply chain partnership; the partner was not paying enough attention to the partnership, there was lack of continuous and mutual trust, there were changes in the market, the partner was perceived to be a potential competitor or the project was too long.

From this review it is clear that barriers are found in both strategic and operational aspects of a VMI relationship.

3.4 VMI success criteria from literature

Literature on operational solutions required to be successful in VMI is limited. Focus in this section is on performance measurement, information sharing, collaboration areas and inter-organizational relations, and how they contribute to improved total supply chain performance. Together with the review on benefits and barriers this review forms a fundament to the interview guide applied in the data collection process of this work.

Simchi-Levi et al. (2000) discuss five requirements for retailer-supplier partnerships. The research question posed in the introduction is founded on these requirements. Simchi-Levi et al. (2000) discuss the requirements in general but they underline that for VMI partnerships they are of particular importance. These are

- Advanced information systems,
- Performance measurement,
- Communication and cooperation.
- Trust,
- Top management commitment,

These requirements form the basis of the review of success criteria, and other researchers' statements and presumptions are sorted according to where they conform to these requirements. Some findings fall outside the frames of these requirements, these are findings related to *product and market characteristics*. They will be incorporated after the five first requirements are discussed.

3.4.1 Information sharing

This requirement refers to the first part of the research question. This includes properties of information sharing such as means and frequency of data transfer, level of data integration and what data is sent between customer and supplier on a regular basis in a VMI relationship.

Exchange means

Simchi-Levi et al. (2000) claim that the most important requirement for VMI success is using an advanced information system. Electronic means of data transmission is important to cut down on data transfer time and entry mistakes, and bar codes and scanners are essential. Inventory, production control and planning systems must be online, accurate and integrated to take advantage of additional information available.

Mattsons (2002) proposition of ICT solutions in VMI is not as absolute as Simchi-Levi et al. (2000). He suggests that batch transmission of data is an alternative to online communication. Batch transmission equals periodic update of data, exemplified by overnight updates of last 24 hour period's movements. Suggested information to be transferred is inventory levels, historic consumption, forecasts and planned promotions.

Online communication offers the supplier the opportunity to manage customer's inventory directly in customer's computer system (Mattson 2002). The supplier has a complete overview over all products required by the customer and he has the opportunity to optimize product mix in the shipments to the customer. This is feasible if volumes per customer are high and product variety large. But if customers per product are numerous, decentralized management will be complex. Demand data from each customer should be aggregated for optimal manufacturing by supplier. When using centralized management facilitated by the supplier's own DSS batch transmission of data is more convenient. The frequency of transmissions must be adjusted to facilitate individual needs.

Kulp (2002) focuses on the information sharing aspect of supply chain inventory management systems. She presents a study that identifies and investigates effects of information precision and reliability as vital success criteria for VMI. The main issues are the customer's willingness to share detailed sales and inventory information with the supplier (*information precision*) and to what extent the information sent by the customer can be safely incorporated into the supplier's decision making process (*information reliability*). Kulp (2002) develops a double newsboy model to generate specific hypotheses about the conditions under which firms will choose to use VMI. She indicates that VMI success rely on information properties, unreliable information calls for traditional ordering systems. She concludes that the extent of VMI use increases with information precision and reliability. Her findings on information reliability are not as conclusive as Simchi-Levi et al. (2000). Use of such systems facilitates VMI but they are not vital. Her finding complement Mattson (2000) who say that though manual systems work, electronic systems are most frequently used because electronic equipment facilitate more efficient data handling.

Properties of information precision she used are

- inventory levels,
- Warehouse withdrawals and
- Point-of-sales (POS) data.

Information reliability is presented by the use of EDI systems and information available through these are

- Purchase orders,
- Invoices,
- Warehouse inventory data and
- Production schedules.

Pohlen & Goldsby (2003) claim that use of IT is a vital ingredient of successful VMI and Supplier managed inventory (SMI). It is important for information sharing about inventory status, changes in demand from customer to supplier and timely information concerning replenishment from supplier to customer. Similarly, Kuk (2004) claim that database linkages are required because VMI is information intensive, and incompatible technology is likely to lead to conflicts.

Mattson (2002) suggests that manual VMI is an alternative to electronic communication of inventory levels and sales data. In manual VMI a representative of the supplier physically present at customer's premises register current inventory levels and invoices customer based on replenished volumes and difference in current levels from last count. This is obviously a much slower system and it is subject to human errors. Bar coding and POS data can still be used for faster data acquisition and collaboration on forecasting and promotions planning etc. can still be included in the VMI program. The only difference is the manual vs. automatic electronic data transmission. The transition from manual to automatic VMI is also outlined by Harrison and van Hoek (2002).

Other authors discuss ICT as a prerequisite for successful VMI but none are as categorical as Simchi-Levi et al. (2000). Waller et al. (1999) suggest that inventory could be monitored both physically and by electronic messaging. Though they do state that successful VMI often depend on computer platform and communication technology they also stress that EDI is just an enabler and not a requirement, and in particular this is true when number of stock keeping units (SKUs) is low. Holmström (1998) describes a case of VMI implementation based on fax, e-mail and spreadsheets, and Ellinger et al. (1999) indicate that electronic data collection and transmission though frequently used is not absolutely required. Kaipia et al. (2002) include an assertion that standard product identification and integrated information systems are required.

Frequency and means

Most researchers appreciate the benefits of highly automated electronic systems for information acquisition and transfer but there are diverging opinions as to whether the use of integrated systems is a criterion for success. There is little discussion on frequency of exchange, but basically it can be online or periodic. To summarize on transfer means and frequency there are three main combinations found in this review:

1. Full integration, electronic data access and online information sharing (continuous read access)
2. Integrated electronic sharing based on periodic updates (data automatically integrated into recipients' system when transmitted)
3. Disintegrated electronic sharing based on periodic updates (data must be manually entered into recipient's system)

Lapide (2001) suggests very strongly that a critical success factor is the supplier's ability to utilize customer inventories and replenishment requirements for planning his own operation. He indicates that it is not about the exchange system but how the received information is applied. Lapide's conclusion is referred to by Småros et al. (2003) in their discussion on the impact of increased demand visibility on production and inventory control efficiency. They support Lapide's view. Harrison and van Hoek (2002), though they do not refer to Lapide (2001), also share this view. They claim that the supplier's ability to dampen demand amplification caused by infrequent, large orders from customers is key to VMI success.

<u>Exchanged data</u>

Disregarding means and frequency for data transfer it is equally important to study what kind of demand data to exchange. The following is a review of what data different researchers suggest for transfer, and the findings are summarized in Table 3-4 below.

Harrison & van Hoek (2002) discuss the effect of demand amplification on supply chain performance. A prerequisite to dampen demand amplification is information sharing and the benefits can be realized in terms of cost reductions in reduced surplus capacity requirements and safety stock levels. Data subjected to sharing are *customer sales* and *inventory levels*, and in order to create a pull schedule this demand information should be integrated into the supplier's production planning procedures.

De Toni & Zamolo (2005) suggest *selling forecasts, stock levels, incoming orders and promotional actions*, Angulo et al. (2004) suggest *inventory levels and positions, sales data and forecasts, order status, production and delivery schedules and capacity and performance metrics* while Holmström (1998) presents a case where only free stock and cumulative goods receipts were transmitted from customer to supplier.

Mattson (2002) does not specify which information should be shared but indicates that in order to manage the customer's inventory the supplier needs the same kind of information that the customer's personnel need to manage this inventory. He then exemplifies by suggesting *inventory levels, current sales, forecasts, planned promotions* and other kinds of demand information.

Thonemann (2002) suggests *POS data, forecasts* and *production schedules*. McBeath (2003) underline the importance of *POS data*.

Christopher (1998) describes VMI as a means of demand management where demand information replaces customer orders in the replenishment process. Demand information relates to *actual usage or sales, current inventory levels* and marketing activities such as *promotions*. Benefits to customer are reduced inventory levels and reduced stock-outs while benefits to the supplier are reflected in reduced safety stock and improved production and distribution planning and scheduling.

Table 3-4 summarizes on what data to transfer between a customer and a supplier in VMI. The first two columns indicate what reference is reviewed and what data is suggested. Some of the authors have suggested the same data and the third column therefore presents a summary.

Table 3-4, summary of suggested data to be transferred in VMI collaboration

<table>
<tr><th>Author</th><th>Data for transfer</th><th>Summary</th></tr>
<tr><td>De Toni & Zamolo 2005</td><td>Sales forecasts, stock levels, incoming orders, promotions</td><td rowspan="11">1. stock levels,
2. incoming orders,
3. promotions,
4. stock withdrawals,
5. production schedules,
6. POS data
7. Sales forecasts,
8. Delivery schedules
9. Performance metrics</td></tr>
<tr><td>Angulo et al. 2004</td><td>Inventory levels and position, sales data and forecasts, order status, production and delivery schedules and capacity, performance metrics.</td></tr>
<tr><td>Småros et al. 2003</td><td>Sell-through information</td></tr>
<tr><td>McBeath 2003</td><td>Point of sales (POS) data</td></tr>
<tr><td>Harrison & van Hoek 2002</td><td>Customer sales, inventory levels</td></tr>
<tr><td>Mattson 2002</td><td>Inventory levels, current sales, forecasts, promotions</td></tr>
<tr><td>Kulp 2002</td><td>Inventory levels, stock withdrawals, Point of sales data, purchase orders, production schedules</td></tr>
<tr><td>Thonemann 2002</td><td>POS data, forecasts, production schedules</td></tr>
<tr><td>Achabal et al. 2000</td><td>Sales forecasts</td></tr>
<tr><td>Christopher 1998</td><td>Actual sales or usage, inventory levels, promotions</td></tr>
<tr><td>Holmström 1998</td><td>Free stock, cumulative goods receipt</td></tr>
</table>

The first seven data listed in column three represent different types of information that will offer some kind of information on future demand and could be sent from customer to supplier. Delivery schedules will be one type of data to be sent from supplier to customer. Performance metrics will represent an indication on supplier performance measured against some preset standards. Application of performance measurement will be further discussed below.

3.4.2 Performance measurement

Performance measurement in this context relates both to how each party prepare internal measures to assess the successfulness of their participation in the VMI program and to how they assess the other party's performance. This relates to the second part of the research question.

Simchi-Levi et al. (2000) state that performance measurement parameters must be agreed upon. These are both traditional financial and non-financial measures. They don't list any traditional financial measures but they list some non-financial measures like *point-of-sale*

(POS) accuracy, inventory accuracy, shipment and delivery accuracy, lead times and *customer fill rates*.

Harrison & van Hoek (2002) claim that VMI depends on a sound business system, effective teamwork between the parties and the use of appropriate performance measures of which *product availability* at the customer is top priority.

Kaipia et al. (2002) indicate that one difference between a traditional ordering system and VMI is the way performance is measured. Traditionally supplier's delivery time and preciseness are measured but in VMI *availability* and *inventory turnover* are measures of supplier's performance.

De Toni & Zamolo (2005) present a case study on going from traditional replenishment to VMI in the household electrical appliances sector. They claim there are two main performance indicators in VMI, *inventory levels* and o*rder fill rate towards the customer's customer*. They list variables that affect performance and application field of VMI compared to traditional replenishment systems. They also list variables that at not important determinants for applying VMI. Table 3-5 shows the important and unimportant variables.

Table 3-5, important and unimportant determinants for using VMI

Important variables for using VMI	**Unimportant for using VMI**
Exchange volume	Distance between the parts
Reliability of dispatched information	Flexibility
Predictability of demand	Production capacity
Variability of demand	Lot sizes
Reliability of supplier	
Computerization level	
Product criticality	

Ellinger et al (1999) list 11 goals typically found in Automatic Replenishment Programs engagement which they use to gauge the effectiveness of ARP programs in general and on the association between level of implementation and goal achievement in particular

These goals are:

Improved customer service

Fewer stock-outs

Improved reliability of deliveries

Reduction of discounting

Reduced returns and refusals

Faster inventory turns

Reduced overstock

Reduced product damage,

Reduced inventory holding,

Reduced handling,

Reduced costs

Some of the more fundamental customer service related goals are frequently reached successfully. These are improved customer service, fewer stock-outs and improved reliability of deliveries. The lowest level of success is reported on cost reductions. They do however indicate that there are positive associations between level of ARP involvement and level of success.

Performance measurement is not frequently described in VMI literature. Most of the measures or indicators described are based on the supplier's ability to maintain product availability and some refer to the benefits evolved from a VMI program. Kulp (2002) describes how the supplier must be able to trust the data transferred from the customer, thereby indicating that data quality should be measured.

In this work this subject is highlighted by enquiring what performance measures are used and why they are used in each case, and the purpose is to study what effects performance measurement had on the perception of success.

3.4.3 Areas of collaboration

Areas of collaboration refers to the third part of the research question and involves a search for what issues are subject to collaboration in the initial stage of a collaboration program and along the contract period. This is included to study what is jointly agreed and what conditions are dictated by one of the parties. In the literature on success in VMI there is little reference to how cooperation should be used as a tool to refine the program.

Simchi-Levi et al. (2000) highlight communication and cooperation to solve initial problems. Details on what to communicate and what levels to cooperate on are not discussed but an example offered indicates that coordination of forecasting methods is required. Lapide (2001) discusses forecasting and VMI. He is quite explicit on the fact that forecasting rests on demand information from the customer and he assumes it is the supplier's task to prepare his own forecasts. He does not indicate that forecasting should be a joint effort.

In Holmström's (1998) case the supplier needed reorder point and minimum replenishment batch to be determined prior to operation. These are fairly static values that set some of the control parameters for the replenishment program. Additionally, collaboration on promotion planning was required.

Ellinger et al. (1999) identify several collaboration areas, meaning what should be decided jointly between the partners. First there should be establishment of cross-functional teams and they should collaborate in:

- Pre-season planning with trading partners,
- Joint planning of replenishment/promotion and
- Joint forecasting.

From this review it appears that little has been written about the negotiation and pre implementation phase of VMI. Areas for collaboration identified are forecasting, promotion planning and elements for determining service level. From the cases described it can be read that the parties have come to an agreement on how to operate and therefore communication is taking place. The degree of cooperation and collaboration seems more limited. This might be related to trust which is further described below.

3.4.4 Trust

Trust refers to the fifth part of the research question and theory on trust and development of trust over time has been presented in chapter 2. It was argued that different types and levels of trust and commitment exist between supply chain partners depending on duration of the relationship and previous interaction experience.

Simchi-Levi et al. (2000) claim that a certain level of trust must be developed between the parties for VMI to succeed. Confidential information must be entrusted, and there is also a perceived risk that the other party fails to perform as agreed. The other party's long term demonstration of performance capabilities develops trust and the perceived risk is reduced.

Hoyt & Huq (2000) assert there is a growing need for and importance of trust in buyer-supplier relationships. They look at the evolution of buyer-supplier relationships and present a "framework for understanding how buyer-supplier relationships have evolved over the past two decades (…) from arms length agreements to collaborative processes based on trust and information sharing." They make a reference to Forrest and Martin (1990) and emphasize Lack of continuous and mutual trust. The full list is already referred to in the set of obstacles presented in section 3.3. Hoyt & Huq (2000) also present five reasons for ending a supply chain alliance (from Serapio and Cascio, 1996). These are

- the realization that they were no longer successful,
- there are differences between the partners (personalities or management styles),
- breach of agreement has occurred,
- the relationship cannot longer be justified or
- one of the parties have found better opportunities elsewhere

Pohlen & Goldsby (2003) claim trust is a vital ingredient of VMI success. Trust will ensure that the parties fulfil their obligations, and only long term relationships built on mutual benefits and trust are likely to succeed. Ellinger et al. (1999) indicate that the longer the companies' experience with Automatic replenishment programs, the more extensively they commit to collaboration.

Uncertainty and the lack of trust are also asserted obstacles to VMI success by Kaipia et al. (2002).

Trust appears to be a vital ingredient in a VMI relationship. However, as cooperation and collaboration is scarcely discussed it appears that contract regulations and sanctions are more described than the use of incentive mechanisms and dynamic interaction.

3.4.5 Top management commitment

Commitment from top management is described in organization literature as important in change processes. This is because top management need to approve changes above certain financial, juridical and structural levels. Employees also need approval and encouragement from the managers to engage in larger change projects. Top management commitment is not a separate element of the research question but it will fall into the scope of trust as it is appreciated that the decision makers are the ones that need to trust each other. The importance of top management commitment is discussed in just a small part of the literature reviewed, and the statements found are general to change processes and do not apply to VMI in particular.

Simchi-Levi et al. (2000) claim that top management commitment is vital as the information sharing required will include information that is considered confidential. VMI implies an inherent shift in work tasks. Jobs previously being taken care of by sales and marketing will be shifted to logistics personnel. Top management involvement is required to handle internal personnel matters.

Kuk (2004) underlines that VMI implementation is a company-wide effort because business processes and supporting technology must be streamlined. Unless the whole organization is involved, wasteful practices will not be eliminated. Ellinger et al. (1999) underline the importance of a significant managerial commitment. Benefits of automatic replenishment cannot be realized without time and financial resource commitment.

3.4.6 Product and market characteristics

During the literature review several elements considered to be important for VMI success was found which did not fit Simchi-Levi et al's (2000) framework. These are mainly characterized as properties of the market or the product offered.

This section adds to the ongoing discussion on what kind of supply chain VMI is best suited. Not surprising, this is a question posed by many practitioners, particularly those who face different demand characteristics for different products or different markets. As can be seen from this review, opinions differ. Therefore the subject of product and market characteristics is further outlined below. This topic refers to the fourth part of the research question.

Kulp (2002) discusses the relation between VMI and consumer demand variability and refers to Fisher (1997) and Xu (1996) who has conflicting opinions. Xu (1996) supposedly argues that when consumer demand is fluctuating, information sharing provides more accurate demand information which improves the manufacturer's planning efficiency. Kulp then claims that Fisher (1997) contends that manufacturers should use VMI for more stable demand. Fisher (1997) however, never actually mentions VMI at all, but he does suggest that supply chains experiencing stable demand should focus on reducing inventory throughout the chain which VMI is a means to obtain. The Xu reference is not reviewed but with regard to the discussion of the Bullwhip effect it is inherent that, presuming Xu's arguments are referred to correctly he is in line with e.g. Lee et al. (1997) and Disney & Towill (2003b) who have stated that information sharing is a means to reduce bullwhip. De Toni & Zamolo (2005) have also discussed this conflict and they argue that VMI has an effect on both innovative and functional products. The effect of end demand information sharing on the uncertainty amplification upstream the supply chain is also described analytically by Simchi-Levi et al. (2000:88-89). Kulp (2002) closes her discussion on this conflict by claiming that consumer demand variability is not an important variable when choosing between a traditional and a VMI replenishment system.

Harrison & van Hoek (2002) identify product seasonality as a limitation to VMI success. Their assertion is that seasonal variation erodes the benefits of VMI. Due to short and unpredictable selling seasons manufacturing still has to be based on forecasts and the burden of owning inventory and disposing of excesses has just been moved upstream to the supplier.

De Toni & Zamolo (2005) refer to Kulp (2002) in a discussion on demand variability, but as opposed to Kulp (2002), they claim that it depends on the flexibility of the manufacturing systems. Flexibility is described as the ability to respond to market changes and they argue that for highly flexible systems the potential savings from improved planning and forecasting are lower than for inflexible system. They therefore indicated that the effect of VMI will be lower for more flexible systems. They agree with Kulp (2002) in her conclusion on information reliability and accuracy as important variables for successful VMI. Further, they refer to Fisher (1997) and his discussion on supply chain strategies for functional and innovative products and they indicate that VMI based on high levels of communication and information sharing can replace responsiveness. Innovative products suffer from demand uncertainty and according to Fisher (1997) such products should be managed by responsiveness and agility. The improved information sharing incorporated in a VMI partnership reduces this uncertainty.

Waller et al. (1999) use simulation technique to understand the effect of VMI on supply chain inventories. They simulate the effect of order frequency on inventory levels with different levels of demand uncertainty. They find that shortening the order review period accounts for most of the benefits of VMI whilst the relative benefits are slightly larger with low than with high demand variability. They also conclude that demand volatility is not an important issue in VMI.

Disney and Towill (2003a and b) take a simulation approach to investigate how VMI can reduce Bullwhip. They conclude that VMI reduces inventory and demand fluctuations, and has a positive effect on low volume products suffering from the Burbidge effect (order batching based on e.g. EOQ or planning periods) and a positive effect on high volume products suffering from the Forrester effect (non-stationary demand and past demand information is used to update forecasts).

Kaipia et al. (2002) claim that benefits can vary in different supply chains and according to product demand. They use a time-based analysis method to measure VMI benefits and they conclude that the benefits are higher for slower moving goods that suffer from Bullwhip. The same conclusion was drawn by Småros et al. (2003) who studied demand visibility's impact on production and inventory control at the supplier side of the VMI relationship. Their findings are very similar to Waller et al. (1999) and they conclude that the impact of demand visibility is

- larger for C-products, products with lower replenishment frequency which usually are more subject to batch ordering
- lower for products already showing stable demand
- larger the higher the share of VMI vs. non-VMI customers

- larger for shorter planning periods

Småros et al. (2003) claim their conclusions are in contrast to previous findings from Cooke (1998) that have argued that benefits can only be gained for high volume products.

Ellinger et al. (1999) indicate that most retailers limit the ARP engagement to major suppliers of high volume high turn items, though in certain circumstances low turn products can also be good candidates. Blatherwick (1998) claims a VMI solution is beneficial only where the customer is unaware of the damages he brings to the supplier by transferring his erratic demand forecasts and the supplier would be better off controlling the supply chain himself.

The discussion on what kind of supply chain VMI is suited has focused on responsive or efficient supply chains and innovative versus functional products as described by Fisher (1997). The arguments encompass all possible constellations and it is impossible to identify any main lines.

In Semini et al. (2004) a tool for profiling value chains is outlined. The profiles are developed for seven categories of value chain aspects, market, product, control strategy, procurement, manufacturing system, distribution and relations. The Market and Product categories are lists of aspects characterizing different value chain situations. For this work, aspects from these categories are further examined to identify product and market characteristics typically valid for VMI relationships.

3.4.7 Summarising on claimed success criteria

This section has discussed success criteria under five headings according to Simchi-Levi et al. (2000) and a sixth heading is identified. The issues falling into the area of Top management commitment are identified as management aspects fundamental in any re-engineering process. Therefore, inter-organizational relations refer to both Top management commitment and Trust. In order to limit the scope of this research, these aspects are not further outlined in this work. Managers' ability to handle organizational issues is considered a prerequisite and will be referred to as such.

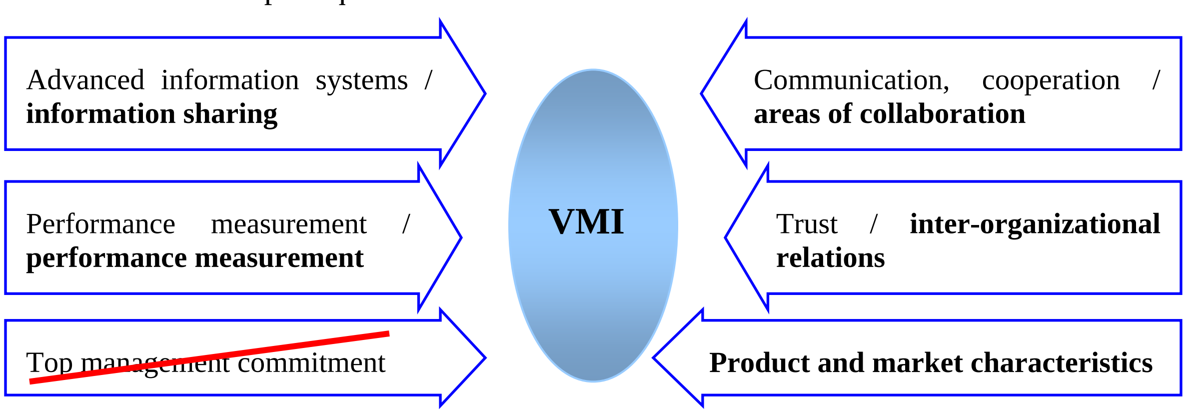


Figure 3-2, conforming aspects identified in literature to related areas of research proposed in the research question.

In Figure 3-2 it is indicated that the area of Top management commitment, for reasons already discussed will not be further explored in this study. These five remaining areas now conform to the elements of the research question.

The findings on success criteria in this section have briefly been summed up under each of the five headings referring to the elements of the research question and to consolidate on the main elements the claimed success criteria and diverging opinions are briefly summarised below.

Advanced information systems, electronic data transmission and collection, highly integrated with online inventory levels, production planning and control. Claimed vital by Simchi-Levi et al. (2000) and Pohlen & Goldsby (2003), claimed important but not vital by others (Mattson 2002, Kaipia et al. 2002, Ellinger et al. 1999, Waller et al. 1999, Holmström 1998).

What information to share include stock levels, incoming orders, promotions, stock withdrawals, production schedules, POS data, Sales forecasts, Delivery schedules and Performance metrics as summarized in Table 3-4.

Accuracy, precision and reliability of information shared whether shared electronically or by less integrated means (Simchi-Levi et al. 2000, Kulp 2002,)

Supplier's ability to use the new type of demand information for advanced production planning and the dampening of bullwhip effect. (Småros et al. 2003, Kulp 2002, Harrison & van Hoek 2002, Lapide 2001)

Collaborative forecasting, is claimed important by Ellinger et al. 1999 and Simchi-Levi et al. 2000. De Toni & Zamolo (2005) describe a case where the customer develops forecasts which are transferred to supplier who integrates the forecasts in the production planning process. Likewise, Achabal et al. (2000) suggest that forecasting is done by customer and transferred to supplier for improved planning purposes.

Trust is considered vital by all who included it in the discussion, (e.g. Pohlen & Goldsby 2003, Kaipia et al. 2002, Simchi-Levi et al. 2000, Hoyt & Huq 2000, Waller et al. 1999)

Demand variability is widely discussed and is claimed both important (e.g. Disney et al. 2001, Harrison & van Hoek 2002) and unimportant (e.g. Kulp 2002).

These elements will be further examined in the five cases of this study. This work will therefore provide support to some of the researchers reviewed and simultaneously argue against some of the others.

3.5 A fundament for data collection

The summary of success criteria creates a fundament for a structured data collection process. With the five aspects identified and summarized in Figure 3-2 as main headings this section will present what elements will be mapped in the data collection process and discuss why they are included. Further, these elements are used in the construction of the interview guide presented in appendix A.

3.5.1 Information sharing

With respect to what data should be sent from customer to supplier there were seven suggestions found in literature as summarized in Table 3-4.

Inventory level was the type of data most frequently recommended in the literature review. The basis of VMI collaboration is that the supplier should resume responsibility for inventory at the customer's premises or somewhere on his behalf, and keeping track of inventory levels is therefore a most essential activity.

Incoming orders and *stock withdrawals* are events of the same demand action. Stock withdrawals follow incoming orders and the time elapsing between the two events can be short if the customer is a wholesaler or a retailer and longer if the customer is a manufacturer. If the customer is a wholesaler, the time gained from using incoming orders rather than stock withdrawal to indicate a replenishment demand can be marginal. This is particularly true if the customer's policy is to respond to orders instantly or within hours. It is still recommended to transfer incoming orders because these give a direct picture of actual demand disregarding actual stock levels. In case of a stock-out there will be no stock withdrawal and lost sales at the customer side will not be observed by the supplier. An incoming order would still be registered even if the customer was not able to serve the order.

A *production schedule* will also indicate a future need for replenishment. If the production schedule is made available to the supplier he can act on expected rather than actual withdrawals. This will extend the supplier's time window for replenishment planning. As it was also argued that incoming orders are preferable to stock withdrawals one can discuss whether production schedules or incoming orders represent the most valuable advance demand information. This issue is discussed by Pohlen & Goldsby (2003) who indicate that the decision is usually determined by the location of the supply chain decoupling point, i.e. where there is a shift from independent to dependent demand for finished goods. They claim that the decision is determined by the customer's market interaction strategy (make-to-stock or make-to-order).

The main benefit of transferring *Point of sale* data is reduced bullwhip (e.g. Disney & Towill 2003, Småros et al. 2003, Lee et al. 2000). Actual demand is observed along the supply chain which offers upstream suppliers an extended time window for replenishment planning. While being based on more uncertainties, *sales forecasts* will offer similar time benefits (Achabal et al. 2000).

From studying the pilot it was learned that other elements would also affect inventory levels and the three following will be further mapped:

- *Goods in transit* refer to goods being shipped between the customer's warehouses. It is applicable where the customer has more than one warehouse. Mapping goods in transit is important to assure the supplier has full information on all products available in the customer's inventory system. It is not about goods being shipped from supplier to customer as the supplier is indeed aware that goods are shipped. Information on inventory movements will indicate to the supplier whether goods have arrived.
- *Backorders* and *returns* were listed in the interview guide because these too will have a direct effect on inventory levels but such movements will not be picked up by traditional stock withdrawal registrations.

From supplier to customer

Transfer of information from supplier to customer is found more limited. From the summary in Table 3-4 it is observed that only delivery schedule is suggested. A delivery schedule will act as an assurance to the customer that goods will be available and it is often materialized in the format of an *Advance Shipment Notice* (ASN).

It is assumed in this study that there is a fundamental difference between the VMI and the VMR solution as discussed in the introduction (Mattson 2002). The assumption is that in the VMR solution it is important for the customer to be notified what is shipped while in the VMI solution the customer does not need to know because the goods are still the responsibility of the supplier.

It is assumed that the main benefit derived from an ASN for the receiving warehouse is improved operations planning, i.e. allocation of resources and preparing for receiving the shipment. It is also assumed that the customer would benefit from receiving an ASN for control purposes and for being assured that goods is in transport and can be expected to arrive shortly.

Mapping of ASN has two purposes.

- To study whether it is used or not. The purpose of this was to study whether ownership is an important determinant for when an ASN is required, and to see what benefits would derive from receiving warehouse's advance knowledge on incoming shipments.
- What is the content of an ASN.

<u>Transfer means and frequency</u>

Technology and means used for information storage and transfer set conditions for the integration level of the information sharing. In order to map how automated and frequent the transfer process is, the alternative elements mapped are use of *barcodes or RFID*, use of *track-and-trace* systems, use of *EDI, XML, internet* or other automated technology, use of manual exchange systems like *phone, fax or e-mail* and whether exchange is *online, by regular intervals* or whenever a change in status occurs (*by activity*).

Two characteristics of integration emerged, electronic vs. manual data transfer and registration and online vs. batch transfer.

Benefits of automated information systems relate to the automatic transfer from the sending party and the automatic update of receiving party's information system. The automatic computerized actions offer two main benefits.

- They reduce man hours needed and offer cost savings that have particular importance in countries where labour costs are high.
- There will be less errors and delays caused by manual data entry. Data accuracy subsequently affects required safety margins and it is found that use of integrated electronic information sharing offer opportunities for reduced safety stock, improved inventory turnover rates and reduced obsolescence, (Kulp 2002, Yu et al. 2001, Simchi-Levi et al. 2000, Cachon & Fisher 2000).

Holmström's (1998) case shows that VMI implementation without employment of automatic information transfer is possible. However, the probability that the automatic data transfer systems offers additional cost saving opportunities in several logistic related activities is considerable.

Judging by some opinions in literature, and literature on bullwhip in particular, it looks like continuous and online information is the ultimate solution for VMI (e.g. Småros et al. 2003, Lapide 2001, Simchi-Levi et al. 2000). Mattson (2002) suggested that update frequency should be adjusted to facilitate individual needs. One objective of this study is therefore to reveal what these individual needs can imply in real life.

Mapping of elements under the heading Advanced Information Systems are summarized in Table 3-6 which represents the interview guide section 1.

Table 3-6, mapping of what data to transfer, transfer means and frequency

Information sharing		
Data collection and transfer	**Aspects of data transfer**	**Level of integration**
	Data collection	Bar-coding/RFID
		Track-and-trace
	Transfer means	Electronic integration: EDI/internet
		Manual integration: fax, phone, e-mail
	Transfer frequency	Online
		Batch
		By activity
Transferred data	**From supplier to customer**	**From customer to supplier**
	Advance shipping Notice (ASN) incl.	Inventory levels
	– Product descriptions	Incoming orders
	– Quantities	Goods in transit
	– Delivery date	Stock withdrawals
	– Destination	Sales data (Point-Of-Sale)
		Production schedule
		Back orders
		Returns

3.5.2 Performance measurement

Performance measurement is both about using indicators or scorecards to monitor operational performance and to measure output of processes for evaluation of changes. The literature review shows that the customer can measure the supplier's performance by using a wide selection of indicators while the supplier rarely measures the customer's performance. Further, the review indicates that there are many expected benefits of VMI implementation and in this study, case specific improvements are mapped.

<u>Supplier performance</u>

In VMI programs the supplier is often supposed to replenish inventory within some maximum and minimum inventory levels. Measuring *Inventory level* is then a means to control whether the supplier performs as agreed. Inventory level is listed by almost all of the reviewed literature that discusses information sharing, but it is equally important to use this information to assess the supplier's ability to perform within the agreed inventory limits. Similarly, *Service level* and *stock-out level* are both measures of the supplier's ability to assure product availability. While Service level takes a positive perspective focusing on ability to perform, stock-out level takes a negative perspective focusing on failing to perform.

Inventory turnover rate can be measured before and during the collaboration program both to check whether the supplier is doing a better job managing the customer's inventory than the customer did, and to cross check on the effect of change in product availability to average inventory level. Low inventory turnover rates can be used to initiate a discussion on smaller lot sizes or reduced maximum inventory level. The inventory turnover rate can also be a more sophisticated way to measure supplier's performance as it indicates the freshness of the goods. By maintaining a stable inventory turnover rate the supplier shows ability to adjust replenishment to sales.

Replenishment lead time was included because the sharing of advance demand data should reduce uncertainty and enable the supplier to prepare for future demand. Measuring replenishment lead time would therefore indicate whether the supplier has been able to improve responsiveness from this information.

Service level towards next tier customer was included in the study to see if a supply chain perspective was brought into the dyadic relationship. However, if this should be at all a fair measure, the supplier's delivery performance must have direct effect on the availability towards the customer's customers. This would only be true when the customer in the VMI dyad is a wholesaler or retailer. If the customer performs any additional processing, the cause of failure to perform could just as well be with the customer. Solely blaming the supplier would bring no benefits to the collaboration program.

Customer performance

In a VMI relationship the sharing of responsibility often includes that the supplier delivers the goods and the customer delivers demand information. Supplier is measured on the quality of his product supplies, and therefore the customer should be measured on the quality of the data supplied. *Information precision* and *information reliability* was discussed by Kulp (2002) and they have also been pursued in this study. Precision refers to the absolute correctness of information, where for instance forecasts are accompanied by standard deviations, or to what extent the data is still valid when reaching the supplier. Reliability refers to the extent of which the sender and receiver are uniform in the interpretation.

Effects of VMI implementation

Based on the literature review a list of possible benefits from VMI implementation is made.

*Extended time window for production and distribution plannin*g is obtained from advance demand information and decision authority. Improved control opportunity increase flexibility and enables *priority of orders*, increased *inventory control* and *distribution planning*.

Smoothed production is obtainable as planning can be based on anticipated demand further ahead in the future and as a result *capacity buffers* to cope with sudden changes can be reduced.

Increased control can improve inventory turnover rate which can lead to reduced inventory levels, storage costs and capital employment, reduced obsolescence and faster EOL removal from system.

Reduced administration was mapped because for the customer the purchasing activity is reduced. However, there is a risk that monitoring and controlling the supplier's performance engage administrative staff more than relieving work load on the purchasing department. The implementation of more electronic and automatic information exchange is likely to *reduce paper handling*.

Demand information sharing offer better conditions for forecasting and *improved forecasting* often lead to *reduced demand uncertainty* and *reduced safety stock levels*.

Improved performance in part of the supply chain can have a *further downstream* positive effect on *service level*. *Reduced total costs* and *increased sales* can be obtained.

Mapping of elements under the heading Performance Measurement is summarized in Table 3-7 which represents the interview guide section 2.

Table 3-7, mapping of supplier and customer performance, and effects of VMI

Performance measurement		
KPI's for operation management	**Supplier performance**	**Customer performance**
	Service level (Product availability) Replenishment lead time Inventory levels Inventory turnover Stock-out level Order fill rate towards next tier customer	Information precision Information reliability
Effects for program evaluation	**Effects**	**Subsequent effects**
	Smoothed production	Reduced capacity buffers required
	Extended time window for production and distribution planning	Increased flexibility – Priority control – Inventory balancing
		Reduced distribution costs
	Increased inventory turnover rate	Reduced obsolescence
		Faster end-of-life product removal
		Reduced inventory levels
		Reduced storage costs
		Improved capital employment
	Reduced administration	Reduced paper handling
	Increased service levels throughout the value chain	Reduced value chain costs
		Increased sales
	Improved forecasting	Reduced demand uncertainty
		Reduced safety stock levels

3.5.3 Areas of collaboration

The literature review indicates that collaboration is an important ingredient in VMI. However, there are limited descriptions of what areas should be subject to collaboration at the different phases of the VMI program. In this work collaboration is defined as initial and continuous collaboration to differentiate on program phases.

Initial collaboration is indicated to be of vital importance because this is where the general framework conditions and allocation of responsibilities are settled. Decisions made in the initial stages of the collaboration program are important determinants for the possibility for success to evolve in the execution. Continuous collaboration during the contract period is discussed with respect to maintaining or improving the performance of the collaboration program.

Initial collaboration

According to Simchi-Levi et al. (2000) initial collaboration should include discussions on ownership issues, credit terms, ordering responsibilities and performance measures. Setting up a VMI contract is time consuming, especially when it is done for the first time for an actor. According to McBeath (2003) agreements on clearly defined liability, product freshness and title transfer are time consuming decisions. If there is little or no collaboration in this area, it is presumed that the terms have been dictated by one of the parties. This can cause shortcomings in comprehension at the later stages of the program.

Information standardization is studied because it is of vital importance to have compatible computer systems that interpret data similarly. *Service levels, inventory levels* and other performance measures are studied because it is important that the parties know what performance they have contracted to conform to. It is important that the parties understand the consequence in selecting point of *ownership transfer*. It is equally important to build a solid comprehension of the value of information sharing.

Continuous collaboration

Continuous collaboration is about building a collaborative environment for maintaining and refinement of the program. The focus in this research was on elements that influence future demand, such as *forecasting*, *promotions*, *new product introduction* and decisions regarding *product mix* and *End OF Life (EOL)* decisions. The supplier's participation in these decisions is assumed to offer benefits from early warnings and adjustment opportunities.

Mapping of elements under the heading Performance Measurement is summarized in Table 3-8 which represents the interview guide section 3.

Table 3-8, mapping of collaboration areas in phases of the program

Areas of collaboration		
Initial and continuous collaboration	**Time perspective**	**Collaboration areas**
	Continuous collaboration	Forecasting
		Promotion planning
		New product development and introduction
		Product range management (product mix)
	Initial collaboration	Information standardization
		Service levels
		Inventory level goals (safety stock included)
		Lead time goals
		Pre-defined performance measurement levels
		Information sharing, type and frequency
		Ownership issues

3.5.4 Inter-organizational relations

It has been stated by multiple authors that successful VMI rests on a certain level of trust, (e.g. Pohlen & Goldsby 2003, Kaipia et al. 2002, Thoben & Jagdev 2001, Simchi-Levi et al. 2000, Hoyt & Huq 2000, and Waller et al. 1999). Trust was described in chapter 2 as calculative or relational (Rousseau et al. 1998). Parallels were also drawn to contractual, competence and goodwill trust (Childe 1998). *Calculative trust* was described as when exchanges are likely to be terminated once violation occurs (paralleled to contractual and competence trust,) and *Relational trust* was described as a resilient trust that survives a violation, especially if an effort is made to restore the good faith (paralleled to goodwill trust).

Duration of relationships was an element in the development of trust and partners are expected to move from a calculative to a relational trust if they both prove their performance capabilities over the contract period.

Trust is discussed to establish the relative importance of trust in VMI replenishment. The presumption made for this study is that when trust is limited and calculative each party will attempt to safeguard against violations by focusing on internal improvements. When trust is relational, the actors will focus on supply chain improvements.

Mapping of elements under the heading Trust is summarized in Table 3-9 which represents the interview guide section 5.

Table 3-9, mapping of trust and other regulatory mechanisms

Trust	
Additions to trust	**Regulation mechanisms**
	Power relations **Willingness to depend on another party (risk and vulnerability analysis)** **Governance mechanisms and contracts** – **Incentive mechanisms** – **Sanctions**

3.5.5 Product and market characteristics

The literature review revealed that many authors have discussed supply chain conditions as criteria for success. There was divergence in opinions and therefore a selection of market and product characteristics are mapped for the purpose of comparing case specific characteristics to effect of VMI.

Volume is mapped because some researchers indicate that a *minimum volume* is required before setting up VMI is advantageous and some have discussed the effect of VMI when only a *portion of the products or the customers* are involved.

Lead time is mapped because it has been argued that responsive suppliers with short lead time do not gain as much from VMI as less responsive suppliers.

Demand variation is mapped because it has been argued that VMI is not good for *seasonal products*. VMI is said to be a means to reduce demand uncertainty, hence *general variations* and *variation predictability* is mapped.

The supplier's relative *production capacity* is mapped because it is argued that VMI offers more benefits for suppliers running on close to maximum utilization level.

Price fluctuation was mapped because in one of the cases this was discussed as a criterion for selection of what products to include in a VMI program.

Planning cycle was mapped to identify coherence between planning and information transfer frequency. It would also be included in the discussion regarding responsiveness and benefits related to the replenishment lead time discussions.

Monetary density was mapped because inventory control policies and priorities often differ with costs of overstock versus cost of stock-outs.

Product *customization level* was mapped in order to see whether any of the case companies had explored the opportunities of reassignment of products to more urgent orders. This opportunity is lost if the products are customized.

Competitive situation was mapped because it can influence the power relation between the parties and thereby also the contract terms.

Geographical distance between customer and supplier was mapped because global sourcing is emerging and this was not discussed in any of the reviewed references.

Mapping of elements under the heading Product and market characteristics is summarized in Table 3-10 which represents the interview guide section 4.

Table 3-10, mapping of product and market characteristics

Product and market characteristics		
	Aspects	**Characteristics**
Product and market characteristics	Volume	High or low volumes, share of product range, share of customers involved
	Lead time	replenishment lead time (manufacturing can be included)
	Demand variation	Seasonal or general variations, variation predictability
	Production capacity	Limited or well buffered manufacturing capacity at supplier
	Price fluctuation	Stable or fluctuating
	Planning cycle	Short or long supplier production replanning cycles
	Monetary density	High or low value goods
	Level of customization	Highly customized or off-the-shelf component
	Competitive situation	Monopoly, market leader or free competition
	Geographical distance	Distance between supplier and customer's warehouse

3.6 Summary

It is apparent that VMI collaboration rest heavily on the sharing of advance demand information. The ability to trust and apply this information is essential. Demand information sharing is a means to reduce demand uncertainty which allows for lower safety stock and increased product availability. The supplier's ability to adjust production and shipments to other constraints of his operation facilitates smoothed production and reduced transport costs. For the customer purchasing is no longer an operational matter but a strategic decision based on long term relations. The main limitations to VMI involvement are related to reluctance to sharing of information and relinquishment of control, and some economic obstacles are found. It is also relevant to discuss under what supply chain conditions VMI is most suited.

In recognition of the discussion on divergences in interpretation of the term VMI to be outlined in the next chapter, the authors referred to in this chapter are identified to take views very similar to the interpretation used in this work.

4 Methodology, design and research procedure

The research question posed for this work aims to identify important parameters for succeeding in establishment of a collaboration program between two autonomous business organizations. One major assumption in this work is that findings will differ with circumstances, they will differ over time and they will be very sensitive to human intervention. One essential consequence of this assumption is that there is no “one size, fits all”, and what worked out well in one collaboration program will not automatically be successful if copied to another program. One can still argue that the more examples are found where one particular parameter is important, the more it is likely that this particular parameter is of importance in general.

The ontological perspective and epistemological assumptions of this research as they are outlined above has defined clear distinctions for selection of approach to knowledge creation applied in this work. According to Oliver (2004) there should be a logical sequence and connection between ontology, epistemology and methodology in research. This chapter outlines on approaches to knowledge creation in general, and as the systems approach is identified to be suitable this work the theory of case studies is further described.

The second part of this chapter includes the research procedure of the work. It is argued that a case study depends on a proper design, and in particular it is essential that the data collection process is sound and thorough, well structured and documented in order to be testable, verifiable and valid. An interview guide is therefore developed, followed by a description on how the interviews were initiated and completed, and how the data will be analyzed and presented. The chapter closes with a brief introduction to the cases and selection criteria, and some prevailing similarities and differences between the cases.

4.1 Approaches to research

A frequently referred to textbook in knowledge creation is Arbnor & Bjerke (1997). They identify and make detailed descriptions of three approaches to the development of knowledge, the analytical approach, systems approach and the actor approach.

Examples of analytical approaches are statistical analyses and surveys. These are ideally objective and potential sources of bias are handled in questionnaire design and weighting of replies. The research variables can be considered independent and the total equals the sum of its parts. Analytical approaches aim at explaining objective reality as fully as possible.

In a systems approach, reality is assumed to consist of mutually dependent components. The elements cannot be summed up. The circumstances where the unit of analysis is a part must be considered. There are empirical settings that will affect the actual situation, the research variables cannot be isolated and the results of the study are influenced by the conditions under which the findings are observed. The systems approach takes a problem oriented perspective to the development of knowledge.

In the actors approach one does not assume some objective reality. Reality is a social construction created by the relationship between the participants. The construction is dynamic and the truth is only true under specific circumstances. If relations between some of the participants change, so does the truth. Every truth is relative to a specific situation, dependent on perspective. Based on relations, the actors approach is a means to create understanding for why actors choose to act the way they do in the specific situation studied.

From this very brief description of approaches it is clear that the systems approach will facilitate knowledge creation in the ontological perspective and epistemological assumptions taken for this research. An analytical approach is not suitable because the variables cannot be considered independently, for instance will cost reductions in distribution be influenced by changing freight rates just as much as the opportunity to increase utilization of available load volumes. An actors approach is insufficient because it is the effect of process changes that is at focus, not specific human interventions. Despite the assumption that the importance of variables studied might differ with circumstances they are still assumed to be of general validity and truth.

4.2 Case studies as a system approach

Case methodology is a system approach to research (e.g. Gammelgaard, 2004), and it is a methodology for generalization based on comparisons and identification for causality (Eisenhardt 1989a, Andersen 1997). With reference to the description of the systems approach above, case studies is a complex method of research but it is valuable when enough data for sufficient statistical analyses are inappropriate, unavailable or too expensive to collect (Andersen, 1997). Yin (2003) proclaims case studies to be the right research strategy when studying something that is or has recently been going on and the research variables cannot be controlled.

Case studies can be used for different research purposes, they can be descriptive, exploratory or explanatory (Yin 2003:3). They can be used for theory building, theory testing and theory refinement (Voss et al. 2002). Choice of design strategy must reflect the purpose of the study.

Stake (2000) presents three types of case studies, intrinsic, instrumental and collective case studies. The *intrinsic* case study is when the case in itself is of interest. The purpose of studying this particular case is not to come to some generic conclusions or to build theory, the main purpose is to understand the case for the sake of the particular case and not what it is a case of. Andersen (1997) calls these *A-theoretical* case studies.

When the purpose of a study is to provide general insight into a subject and the case itself is of secondary interest Stake (2000) calls it *instrumental*. Though the particular case is studied in depth, it plays only a supportive role to facilitate the understanding of whatever the case is a case of. The particular case is an instrument to general knowledge and building hypotheses is a common outcome. These are called *interpretive* case studies by Andersen (1997)

A *collective* case study is an instrumental case study extended to more than one case. The comparison of several cases of the same is believed to substantiate the findings, and a small collection of cases could improve the understanding of even larger numbers of similar cases. Andersen (1997) applies the term *comparative* case study and indicates that this methodology is good for hypothesis testing and refinement of theory when the purpose is to generalise.

4.2.1 Case studies for generalisation

A frequent motive for conducting case studies is to generalise. The analysis methodology applied is pattern matching by attempting to identify independent variables' effect on a predefined outcome. The outcome is the result of a process and the aim is to identify how this particular outcome prevailed. An independent variable's effect on an outcome could be positive, negative or neutral (no effect), i.e. appearance or non appearance of the independent variable in the process caused a positive or a negative outcome or did not affect the outcome at all. In an exploratory case study it is vital to identify independent variables that could have an effect on the outcome and by analyzing each case specific appearance/non appearance compared to outcome one can identify a likely effect by the independent variable to the outcome. Though findings from a single case can be used to develop hypotheses, it can rarely be argued that because a specific causality is observed in one case it has general validity. If similar findings can be observed in other cases, the hypothesis is supported and the probability of general causality is larger. Using a sufficient number of cases to obtain statistical significance is neither attainable nor necessary, methods for case design and criteria for case selection can be used to strengthen the propositions.

In Stake's (2000) view, case studies for generalization would be instrumental or collective. Andersen (1997) claim that case studies can be used to identify causalities as in the identification of what causes what. It is therefore a methodology for answering research questions focusing on HOW things happen. In particular, the HOW question is answered for the actual case studied while the main purpose of a study is often to predict future outcomes as well. The prediction can be based on existing theory and empiric results depending on what is available. A comparative case study where multiple cases of the same are compared will add to the generalization of the patterns found (Eisenhardt, 1989a) For the purpose of generalization to bring more empiric results to the board a multiple case study is therefore suggested.

In case studies there is the ever returning question of how many cases are required, but there is no standard answer to what is the ideal number. With a low number of cases one can increase depth of observations but ability to generalise increases with numbers. It is important to stop collecting samples when there is enough data to address the research question or when new samples offer very little new information to the study (Voss et al. 2002).

4.2.2 Analyses

In a multiple case study for generalisation it is important to analyse data in two steps. First it is important to do an internal analysis. This is important for two reasons (Eisenhardt 1989a): it is important to become familiar with each case as a single entity and it is essential to identify causalities. Second step is to search for cross-case patterns. One should not perform cross-case analyses without performing the internal analysis first.

When searching for key parameters and requirements it is essential to separate between casual coincidence and causal coherence. Casual coincidences are situations where there is coherence between the variables studied, but the connection should be ruled out as a determinant because a causal connection cannot be verified. In order to identify causalities it is essential to relate the connections to a context. Causes and effects must be analyzed in a context to propose general presumptions on case specific observations.

4.2.3 Validity and reliability of case studies

The validity and reliability of case studies rest heavily on the correctness of the information provided by the interviewees. Replies are most likely biased by the respondent's own perceptions and opinions rather than purely reflecting a neutral, accurate and unbiased description of the situation in question. Yin (2003:34) offers a set of tactics for controlling validity and reliability of the data collection process. These include the use of multiple sources of evidence, to have key informants to review the case report, search for patterns, build explanations and address rival explanations, use theory in the design phase and build a proper protocol and database. It is important to make sure the cases meet the sample criteria and those cases that do not fit into the study should be discarded (Voss et al. 2002).

Essential in the work of identifying causalities is to relate the variables to a context (Arbnor & Bjerke, 1997). It is therefore important to get a rich picture of the system or organization being studied to be able to interpret the outcomes soundly. As a researcher one cannot possibly get the complete and full picture because in a social setting the limits of the system or organization are difficult to define (Goode & Hatt, 1952). A case study will still attempt to keep together the characteristics relevant for the problem being studied and validity can be assured by using multiple sources or by looking at data in multiple ways (Eisenhardt 1989a, Yin 2003).

Case studies and interviews are approaches gaining ground in logistics research (Halldorsson & Aastrup, 2003) and has become an accepted approach in this field. A further validation of this particular study is included in the concluding section of the thesis.

4.3 Why case study in this work

The application of case studies methodology in this particular work is collective (Stake 2000). This methodology was selected due to the nature of the problem being studied. Firstly, it has been argued that one of the main purposes of this work is to contribute to the practitioners' knowledge on key elements of a VMI collaboration program. One of the most powerful instruments to build confidence among practitioners is to provide real life examples of VMI applications, accompanied by the involved parties' perception of effects and successfulness of these applications. This is also expressed by Stuart et al. (2002:431) who call for coherence between methodology and end customer understanding of the results.

Every case and context is unique. A case study is an iterative process where new leads are pursued by follow up questions and both researcher and interviewee must contribute actively to the discussions. Often the interview is a reflection of what the interviewee wants to talk about and it is the researcher's task to ensure that the proposed questions are answered (e.g. Stuart et al. 2002). However, while every case is unique in some matters, there are also commonalities. Commonalities are essential in comparative case studies. Without commonalities the cases would not be comparable and a multiple case study would not be feasible. The value of comparability becomes clearer as the work proceeds. During the interpretative stages of the work the researcher will acquire deeper insight into the subject and thereby be able to elaborate on certain issues being raised during the interviews. Eventually the interviewees will benefit from the researcher's general knowledge on the subject and therefore participating in a case study is rewarding for the studied object (e.g. the case company) as well as the researcher.

A survey approach could be taken in order to identify coinciding states and variables, a questionnaire can be designed to capture changes over time and thereby identifying sequences of changes. While a survey is useful for comparing results within the same context, it is less appropriate for extensive comparisons across companies or organizations where context differ (Stuart et al. 2002). Moreover, a survey would trigger less interaction between researcher and respondent, the response would be biased by the respondent's opinion and perception, and the researcher would lose the opportunity to capture the operational environment of the unit of analysis. The context and other possible connections are more difficult to capture when the data collection is conducted by a questionnaire where the process rarely is iterative. A survey is not feasible when a large amount of data from each respondent is required (Andersen 2003, Stuart et al. 2002). Furthermore, responding to a questionnaire is less rewarding and it is more likely to be completed in a left-handed manner.

Additionally, considering the already recognized limited number of possible research objects, it would be difficult to obtain statistical significance required to validate a quantitative approach.

The main design parameter of this work is theory refinement. The main objective has been to generalise and to se where the theory applies, furthermore it has been important to compress the findings in order to make them available to practitioners. However, the early stages of the study held elements of theory building as one of the objectives was to identify key variables and patterns of causalities.

The approach taken in this study is further described below. The five cases studied are cases of VMI based supply chain collaboration. The aim of the study is to reveal causes of success or failure of VMI collaboration, and both criteria for being VMI and a selected definition of success are described in the introduction of this thesis. Possible independent variables are pursued within the five areas presented in the research question and in order to capture the context of the case the status of these variables is mapped. The variables' possible effect on the outcome is discussed and analyzed, both with respect to theory and case company's perceptions. Finally the elements discussed are compared for all the five cases studied and recommendations are offered on the basis of these findings. The data is structured in an interview guide developed specifically for this study.

4.4 The data collection process

The data collection was conducted via semi structured interviews directed by an interview guide. The interview guide was developed in order to ensure that the same questions were asked and the same parameters were mapped in all cases. It is essential to design a stringent data collection process to ensure compatibility. This interview guide was built to conform to the elements of the research question and the content was related to the findings of literature review presented in chapter 3. Additionally, the pilot was used to empirically identify elements of VMI collaboration considered important by industrial actors implementing VMI collaboration. The pilot and the planning of the data collection were worked on in parallel and therefore the development of the interview guide has been a combined inductive and deductive process. The interview guide with reading instructions can be found in appendix A. Completed guides for each individual case are also included there.

Interviewees were company representatives holding logistic manager positions or similar. The prime target for data collection was the supplier side of the VMI relationship, however where possibly accessible also representatives from the customer side were interviewed, (for validation, multiple sources of evidence, Yin 2004).

The initial contact was made via telephone. During this telephone conversation a case was established, e.g. a suggested case of VMI collaboration between the contacted party and a supplier or a customer was found to be within the definition of VMI as described in the introduction of this thesis. The telephone conversations were closed by setting a date for an interview meeting.

Prior to the interview, further details of the purpose of this research and subjects to be discussed in the meeting were e-mailed to the interviewees. Accompanying the e-mails was a copy of the interview guide and a note that completing this guide was an activity going to take place by the researcher during the interview, (as recommended by Voss et al. 2002). It was assured at this point that nothing would be published without the approval of the company and if confidentiality was a matter of concern, steps would be taken to hide or make the data anonymous.

The meetings took place at the company's premises and part of the meeting was a tour around the manufacturing facilities if applicable. Tours were not included where the researcher had toured the premises on earlier occasions or where the company had no production facilities at the visited premises. Time spent on each interview was 2-3 hours and each meeting started with a brief introduction of the company in question.

The main purpose of the interviews was to get a clear picture of how the VMI solution was operated. Both physical material flow and information flow were sketched, including transfer means and frequency. It was essential at this stage to reveal the level of electronic integration, to what extent demand information was shared upstream the supply chain and to what extent this information was used for extensive procurement and production planning by the supplier.

Additionally it was of vital importance to reveal the company's perception of the successfulness of the program as a whole, including potential improvement areas and perceived reasons for failure or success. By the end of the interviews it was clarified that follow-up telephones and e-mails were welcomed.

The interview guide was completed by the researcher based on the interview and discussions evolving. The researcher had the chance to rephrase questions to assure the correct understanding of the subjects and the chance of respondent misinterpretation of elements in the interview guide was highly reduced. To further assure common understanding, the researcher prepared minutes that were commented on and finally confirmed by the respondents.

4.5 Sequence of data analysis

As explained above, in a multiple case study data is analyzed by comparing a variable's presence to the outcome of the case, and the more cases are compared the more likely one will separate causal coherence from casual coincidence. The data will be presented in tables where the responses from all five cases are viewed for easy comparison. It is important to note that though the data is presented in tables and some of the data take the format of numbers or values, the nature of the study is qualitative and the data are not being subject to statistical analyses.

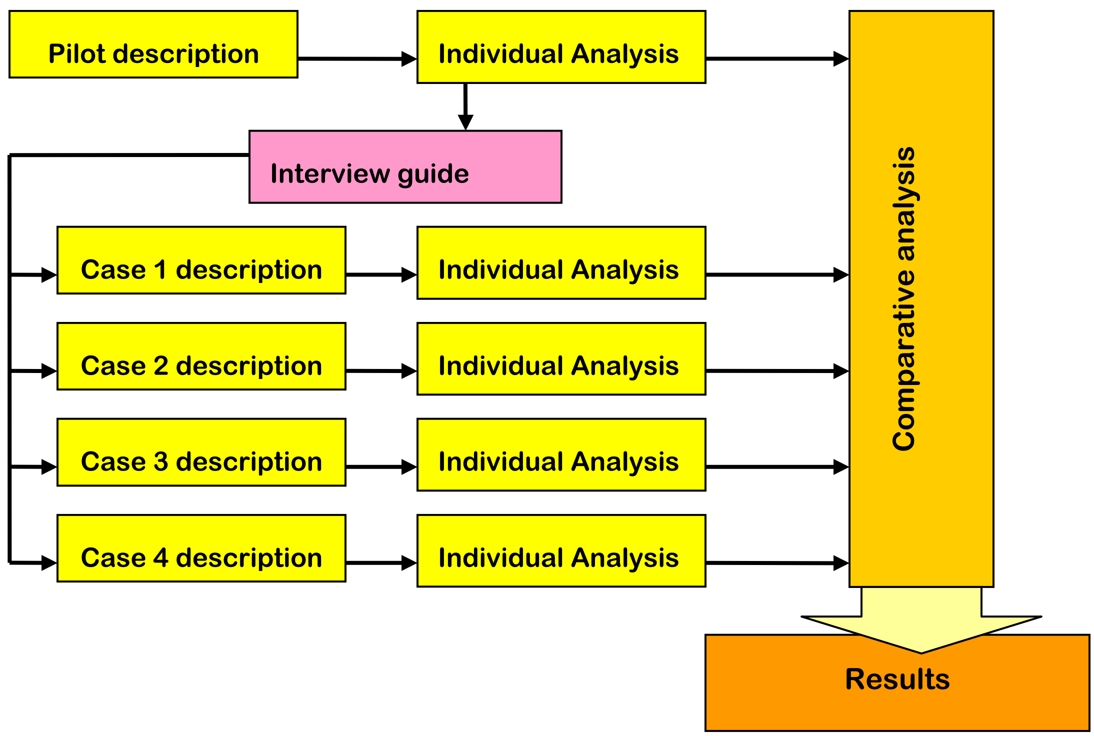


Figure 4-1, the overall analysis structure

The analysis follows the two steps recommended by Eisenhardt (1989a). First all cases are studied internally. All cases are described with respect to material and information flow and how the VMI program in question is constructed and carried out. This forms the context of the programs studied. Each case description is followed by a discussion on lessons learned about VMI from the case and how the case corresponds to the research question. Next the cases are compared to each other and to literature in order to identify the most likely key parameters in a general perspective. Figure 4-1 illustrates how the five cases are analysed, first separately in order to identify case specific parameters, then in comparison to identify general parameters. It also shows that the pilot analysis was first used in the development of the interview guide and then how the guide was used to describe the other cases.

4.6 The cases

The following is a brief introduction to the cases used in this work arguing why these specific cases are studied. More detailed case descriptions are found in the case descriptions to follow.

4.6.1 The pilot case

The pilot case is the establishment of a Vendor Managed Replenishment (VMR) relationship between a manufacturer of damped boring bars, Teeness ASA and the distributor, Sandvik Coromant. This particular case was chosen for three main reasons,

The project was still in the planning phase, which gave the researcher the ability to follow the whole process of negotiations, planning, and implementation. The distributor is the manufacturer's only customer and the manufacturer is the distributor's only supplier of this product. This makes the case very transparent and there is no risk of results being influenced by the actions of other actors in the supply network.

The relationship between the two parties has evolved over more than 30 years of interaction and mutual trust is present.

4.6.2 Case 1

Case 1 is the VMR relationship between a manufacturer of cardboard packaging, Smurfit Norpapp and Pipelife Norge who is a manufacturer of a wide range of pipes and accessories for water, gas and electrical installation. The VMR program has been working successfully since January 2004 and it is now considered routine by both parties. The main reason for choosing this case for discussion is that it differs from the pilot case on product and market characteristics.

The two companies were doing business with each other prior to the establishment of the collaboration program and the case thus offers a good opportunity to identify before and after implementation performance for comparison.

4.6.3 Case 2

Case 2 is from the automotive industry, the VMI relationship between the manufacturer of aluminium control arms for wheel suspensions, Raufoss Chassis Technology (RCT) and the car manufacturer, General Motors (GM) Opel. The VMI program terminated after 16 months of operation. The main reason for choosing this case was to include in the research a case with a different outcome than the pilot.

There are three states of affair available in this case, performance prior to establishment of VMI, performance under VMI conditions and performance after abandoning VMI. This case therefore offers excellent opportunities for comparison.

4.6.4 Case 3

Case 3 is the VMI relationship between Tingstad, a supplier of attaching parts and tools for general assembly, and Kverneland Klepp, a manufacturer of ploughs, harrows and other agriculture and farming equipment. Tingstad has undertaken total responsibility for replenishment of attaching parts consumed by Kverneland Klepp supplied by themselves as well as multiple sub-suppliers. The program was established in early 2001 and has been constantly developed ever since. The main reason for choosing this case was its high complexity. Similar to the pilot case the number of SKUs involved is high, but where as the pilot case only represents one supplier and one stock location, this case includes sub-suppliers and multiple satellite stock points.

Due to the major changes involved when entering the VMI program, identifying before and after implementation performance for comparisons is not possible in this case. The case does however show how shortcomings in certain perceived success criteria have reduced the successfulness of the program.

4.6.5 Case 4

Case 4 is also from the automotive industry. This is the VMI relationship between Hydro Aluminium Structure Raufoss (HARA) and GM Opel. Here the customer is the very same organization that was the customer in case 2. However, in this case a different assembly location is involved. HARA manufactures aluminium bumpers and crash boxes for a wide number of car models and they have in total seven VMI contracts with different customers. The relationship with Opel was selected because it was said to be the most successful form of VMI relationship HARA is involved in.

4.6.6 Roles in the supply chain

Table 4-1 outlines the roles of the actors involved and thereby basic supply chain structure of the cases can be drawn. The column *Customer industry* shows what type of industry the customer is involved in, the column *Customer supply chain activities* shows what kind of supply chain activities the customer is performing (i.e. OEM, distributor, retailer etc.), and the column *Type of goods from supplier* shows what kind of input the supplier offers to the customer.

Table 4-1, outline of case specific supply chain structures

Case	Customer industry	Customer supply chain activities	Type of goods from supplier
P	Machining industry	Manufacturer and distributor of finished goods	Finished goods
1	Water installation	Manufacturer of finished goods	Packaging
2	Automotive	Assembler of finished goods	Component, wheel extension
3	Agriculture machinery	Manufacturer of finished goods	Attachment parts, screws, nuts etc.
4	Automotive	Assembler of finished goods	Components, bumpers

4.6.7 Case commonalities

Some elements are common in all cases. These elements make the cases comparable.

~ In all cases the products are customized to the specific customer involved.

~ All the suppliers perform their replenishment planning in their own computer systems, thus the option outlined by Mattson (2002:356) using online communication and planning directly in the customer's computer system is not applied.

~ All the customers perform some kind of further processing on the goods replenished and can be characterized as Original Equipment Manufacturers (OEM's) of the value chain. In the pilot case the customer performs no further physical processing of the goods, but the products are frequently included in complete product packs assembled by the customer.

4.6.8 Case differences

Several elements differ between the cases and these differences represent variations that can be identified as causes of different outcomes. Some of the most prevailing differences are outlined below.

Competitive situation

In cases 2, 3 and 4 the continuation of the relationships depends heavily on the performance of the suppliers. There are multiple competitors ready to take the suppliers' place and the suppliers are forced to focus on customer service and cost efficiency comes second.

In the pilot and case 1 the suppliers are not constantly threatened by serious competitors. There is no monopolistic situations and the continuation of the relationships certainly rely on the suppliers' performance but the actors can concentrate on developing a system beneficial to both parties without competitors breathing down their neck.

Share of total production

In the pilot and case 2 all or a major part of the supplier's production is shipped to the VMI customers.

In cases 1, 3 and 4 the suppliers also serve multiple other customers and only a small share of their production is included in the relationship discussed.

Monetary density

In the pilot case the products are high technology and expensive whilst in the other cases the goods are mostly low value or low to medium value products.

4.7 Summary

This chapter has outlined the methodological decisions of this work. The ontological perspectives and epistemological assumptions are derived from the type of research question posed and choice of knowledge building approach is founded on research question complexity.

Based on in inductive/deductive process of literature reviews and a pilot an interview guide was developed. This is used to assure data consistence in a series of semi-structured interviews in four other cases. The selection criteria and some specificities of the cases are outlined and detailed case descriptions follow in part II of the thesis.

Part II

Case descriptions

This part includes descriptions of all the five cases of VMI collaboration studied. Each description has three purposes.

First the companies and the VMI relationship in question is presented. This is considered the facts about each case as they represent the fundament for the data analysis.

Second, the facts are compared to the research question. This is built on the researcher's interpretation of the responses and is used to highlight the findings.

Third, a reflection on lessons learned about VMI is presented. This is a further elaboration on the companies' experience and represents the researcher's identification of causalities.

5 Pilot case, case description Teeness ASA – Sandvik Coromant AB

The pilot in this study is the Vendor Managed Replenishment (VMR) relationship between a manufacturer (Teeness ASA) and a distributor (Sandvik Coromant) of high technology damped boring bars. The VMR program has been developed during the research period and the researcher has been observing the development process. A total of four meetings, three phone conversations and approximately six e-mail exchanges form the fundament of the data collection process in this case. The communication is listed chronologically in Table 5-1.

Table 5-1, Communication for the pilot case

Date	*Communication*	*Purpose*
Oct 04	Meeting	Interview with Teeness,
Oct 04	e-mail	Follow-up on interview and case description
Nov 04	Telephone	Follow-up on case description
Nov 04	e-mail	Case description Teeness
Jan 05	Meeting	Interview with Sandvik Coromant
Jan 05	e-mail	Case description Sandvik Coromant
June 05	e-mail	Follow-up on progress and status
July 05	Meeting	Progress and implementation status
Oct 05	Telephone	Follow-up on progress and performance
Nov 05	e-mail	Follow-up on progress and status
April 07	Meeting	Implementation status and present research results
April 07	Telephone	Follow-up on progress and experience
April 07	e-mail	Follow-up on status and distribute publication

The initial meeting was held at Teeness' premises, participants were Karl Ove Nilsen, assistant director Teeness, Lars Skjelstad, researcher Sintef and Astrid Vigtil, researcher NTNU. The meeting was closed with a tour around the production facilities.

The second meeting was held at Sandvik Coromant's premises in Sandviken Sweden. Participants were Ulf Lundahl, head of purchasing department Sandvik Coromant, Mona Persson, purchaser Sandvik Coromant and Astrid Vigtil, researcher NTNU. This meeting started with a presentation of the company and included a visit at their exhibition and productivity center in Sandviken.

Two follow-up meetings with the supplier to discuss implementation progress and experience have been held.

5.1 The supplier

Teeness ASA is a manufacturer of damped boring bars located in Trondheim Norway. The company was founded in 1897, starting as a nail factory. In 2004 they had 70 employees, and with an annual turnover on NOK 80 mill. (2004) they are the world leading supplier of high technology damped boring bars. They hold a standard selection of close to 20 product lines, and based on differences in dimensions and technical specifications around 450 standard product variants are manufactured in a total number of more than 40 000 pieces annually. The standard products represent about 85% of Teeness' annual turnover. Additionally they develop customized bars on request at an annual average rate of 250 pieces. The average working life of a boring bar is 4 to 5 years and the average product line life cycle is 5 to 10 years. Popular product lines are usually reengineered and upgraded for improved performance and prolonged life cycle. In earlier years, bars had a life cycle of around 20 years, however technology development has halved the expected life cycle. Teeness' intention is to have all standard products manufactured to order, production lead time is 4-6 weeks. Realistically they have found it necessary in some instances to initiate production independent of orders to handle experienced demand variations. The picture in Figure 5-1**Error! Reference source not found.** shows one type of a standard damped boring bar, the Coromant Capto finishing tool.

Figure 5-1, the Coromant Capto Finishing tool

5.2 The customer

Sandvik Coromant is a Swedish manufacturer of cutting tools for the metalworking industry. Their product assortment includes more than 25 000 products they serve customers throughout the metalworking field including the world's major automotive and aerospace industries, the die and mould industry and general engineering industries in more than 60 countries world wide.

Sandvik Coromant was established as a daughter company of the Sandvik Group in 1942 when Sandvikens Jernverks AB in Sandviken decided to enter the field of cemented carbide. The cemented carbide products were given the trade name Coromant. The first element from **Coro**na, the name of a high-speed steel grade for metal cutting that the company had been producing for years. The second element comes from the Swedish word for diamond (dia**mant**). During the decades that followed, Sandvik Coromant played a most important part in the international development of carbide tools and accessories for metal cutting operations.

Sandvik Coromant headquarter is located in Sandviken, 190 kilometers north of Stockholm. Their main production unit is in Gimo and the R&D facilities are located in Västberga.

Sandvik Coromant supplies their customers from three stock-points, a central warehouse in Schiedam, Netherlands, a warehouse in Singapore for the Asian market and a warehouse in Kentucky for the US market. From these warehouses they aim at supplying their customers on a 24 hour delivery service. The warehouses are not specific to Sandvik Coromant, they are common to all business areas of the Sandvik Group. Sandvik

Coromant's product stream is coordinated with the main stream of the Sandvik Group in order to take advantage of scale benefits. Figure 5-2 illustrates the material flow between the different locations in Sandvik Coromant's distribution network. From the Sandvik Group 2006 annual report it can be read that 55% of the product volumes go to the European market, 25% to the US and American market and 20% to Far East markets.

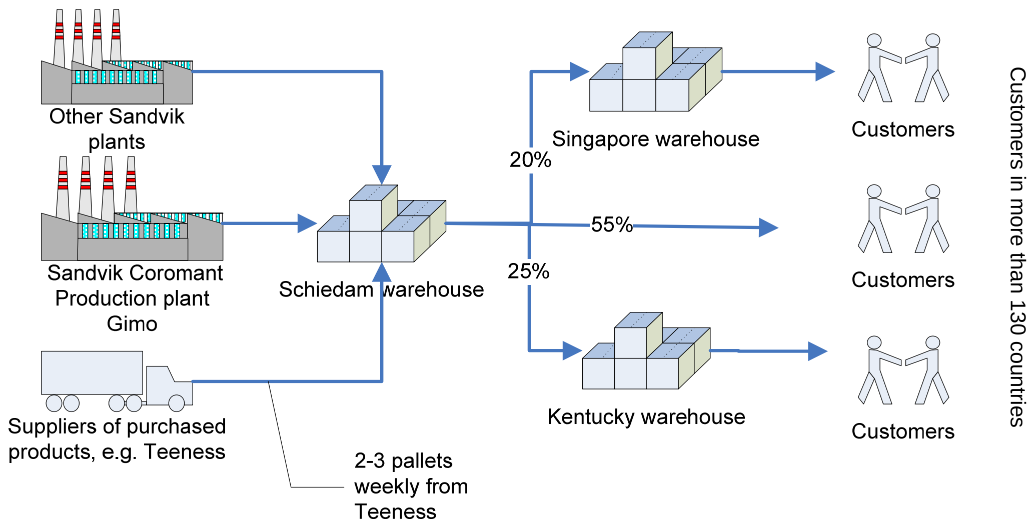


Figure 5-2, material flow between Sandvik Coromant locations

5.3 The connection between Teeness and Sandvik

Teeness uses the brand Silent Tools™ to sell their boring bars and they are distributed exclusively via the Sandvik Coromant subsidiaries in more than 30 countries around the world. When they are sold they are accompanied by cutting blades and inserts for the drill head manufactured by Sandvik Coromant.

The boring bars are shipped to the Sandvik Group's warehouse in Schiedam. Shipments usually contain 1 – 2 pallet loads and they leave the Teeness facilities 2-3 times a week. The shipment agreement is Ex works and is handled by a third party carrier who consolidates goods from several transport customers for shipment from Norway to Central Europe. Ex works is a standard Incoterm trade agreement between a supplier and a customer where the customer assumes responsibility for transport with respect to both transport charges and risk of damages (Grønland 2002).Transportation lead time is about one week, from leaving Trondheim to registration at the warehouse. Teeness only ships to the Schiedam warehouse. Internal shipments between the warehouses are handled by the Sandvik Group as depicted in Figure 5-2.

The responsibility for replenishing standard boring bars to the Schiedam warehouse is now being undertaken by Teeness on a VMR basis. This is indicated in the Sandvik Coromant value chain depicted in Figure 5-3 below.

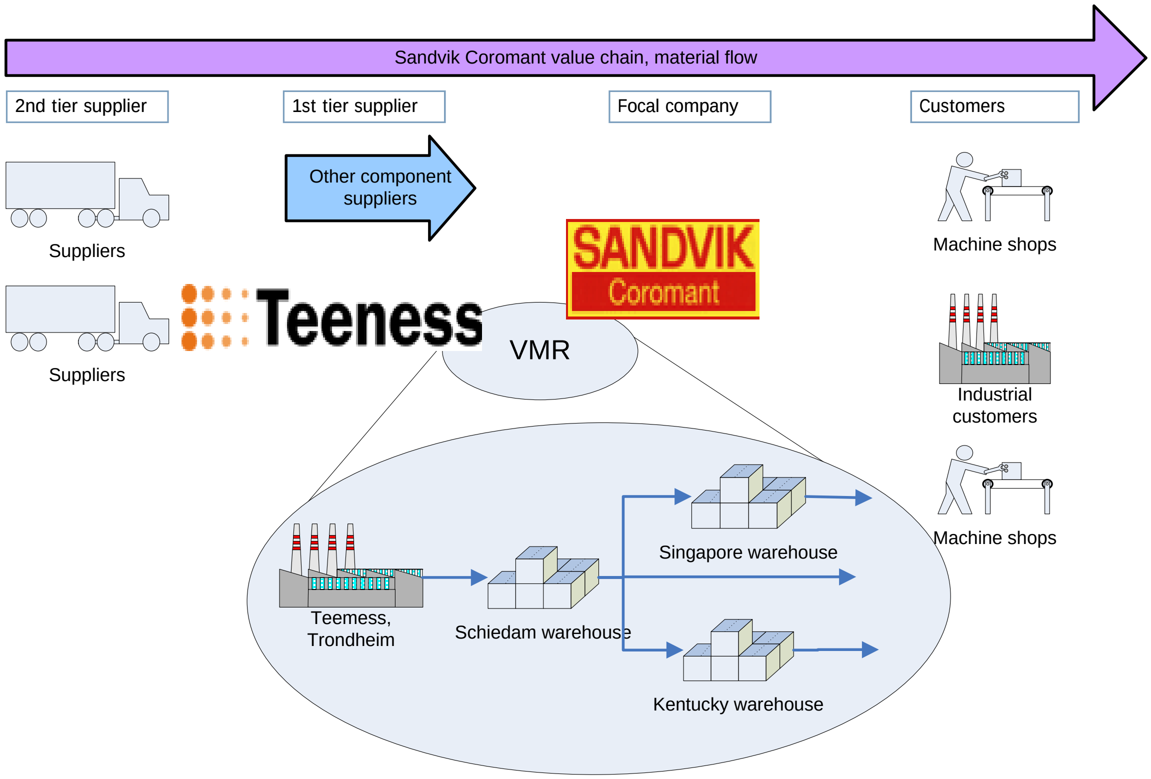


Figure 5-3, Sandvik Coromant value chain

5.4 Relationship characteristics

The standardized damped boring bars represent 85% of the Teeness' turnover, but they represent only a small part of Sandvik Coromant's wide product range. The boring bars are however strategically very important to the customer. Silent Tools™ are patented products and Teeness is the sole manufacturer. The rights to include these patented boring bars in Sandvik Coromant's machining packages open new markets for their inserts and it makes Teeness a strategically important supplier. They have been collaborating since 1971 and a long term relationship is established.

5.4.1 Logistic challenges

There were two logistic challenges of specific interest identified in this relationship. Firstly, the customer experienced high stock-outs because they had no routines to stock up on standard products prior to holidays and high selling seasons. To restock on sold-out items, large orders were sent to the supplier to who experienced a typical example of the Bullwhip effect. An even flow of goods was interrupted and peaks and valleys in the demand curve were observed. The supplier's focus on smoothed capacity utilization was highly stressed.

The waveform of the demand curve was reinforced by the second logistic challenge identified. The quality of the customer's forecasts used for warehouse replenishment of boring bars was poor. The forecasts were based on demand for the inserts manufactured by the customer. However, though the inserts and the boring bars are complementary, the durability of the two products is very different. A standardized dampened boring bar is complementary to several types of inserts and while a bar can operate for 4 to 5 years, an insert is worn by an average of 15 to 30 minutes of work.

The supplier developed their own forecasting model to predict boring bar demand. These forecasts had over the last five years prior to the initiation of the VMR project proved to be much more reliable than the forecasts used by the customer. The supplier's forecasting model was less nervous and did not overreact on random small fluctuations in demand. The supplier compared these forecasts to the customer's forecasts that were transferred on a monthly basis. The result was that the supplier had to act on orders they knew were not optimal, neither for their own manufacturing nor the customer's warehouse operation in Schiedam. To be able to cope with the erroneous orders they kept an unnecessarily large Work-in-process and in transit stock in Trondheim.

5.4.2 Supplier's objectives

In order to get an even better picture of the customer's demand and the quality of their own forecasts, the supplier asked for daily transfers of inventory status. This was granted by the customer. The supplier expected the suggested VMR program to have a positive effect on both costs and service level towards the end customer. The absolute main purpose of initiating this project was to find a way to be allowed to act on own forecasts rather than the customer's purchase orders. This would reduce the demand variability and dampen the bullwhip effect. Additionally they expected logistic improvements like increased service levels, reduced stock-outs, reduced dead stock (items with a shelf life of more than 1 year), reduced inventory levels and capital employments, and a controlled end-of-life removal from product assortment. In manufacturing they expected a levelled production that would give smoothed workload and improved and smoothed capacity utilization. This would reduce manufacturing costs due to reduced use of overtime, and it would reduce uncertainty for the workforce due to reduced risk of temporary layoffs.

5.4.3 Customer's objectives

The customer became increasingly aware of this untraditional demand knowledge, and they decided to enter project discussions with the supplier. They saw both strategic and logistic opportunities in the prospects presented by the supplier.

They wanted to take advantage of the supplier's demonstrable better forecasting model and thereby improve their own service level towards their customers (reduced stock-outs) and reduce transhipments between their three stock-points. They wanted to use this project as a pilot to learn more about VMI collaboration for the purpose of inviting other suppliers to collaborate on the same model. They also wanted to upgrade the work tasks for purchasing staff, from traditional ordering routines to participate in taking more strategic purchasing decisions.

Their prime target was to increase product availability from 95% via 96% to 98% without affecting the throughput time.

5.5 VMR project implementation

The implementation of the VMR project was following a three step process.

1) Step one was a formalization of what was already happening. Every 24 hours (10.00 pm) a file was transferred from the customer to the supplier containing updates on incoming orders and inventory levels. The supplier used this information to validate their own forecasts. Orders were still issued by the customer.

2) Step two included that the supplier prepared a purchase proposal based on the information transferred. The customer reviewed the proposals and confirmed them before the supplier issued a shipment order. At this step the collaboration program was analogous to a CRP (continuous replenishment) program described in the theory section of this thesis.

3) Step three included that the purchase proposal was replaced by an advance shipment notice (ASN) issued by the supplier. At this stage the collaboration program was turning into a VMR program, the replenishment decision was totally in the hands of the supplier and the customer was just notified on what products at what volumes were due for shipment.

The ownership of the goods was transferred to the customer upon dispatch at all stages of the implementation process. This was also the intention from the start due to the characteristics of the warehouse. It was found more convenient that the goods were owned by the customer as the warehouse was also used by other companies within the Sandvik Group. There was a well functioning system for combined shipments to the two other warehouses. Additionally it was found that the capital costs would be relatively large for the supplier while not representing a particular difference to the customer, a cost the customer was prepared to undertake. A fourth step and a further integration would include that ownership of the goods remained with the supplier until stock withdrawal, but this has not been considered a relevant move.

5.5.1 Process changes

The change in replenishment strategy only concerned standard product lines previously replenished on customer orders, and not customized bars manufactured directly to end customer’s order.

The main process change when entering step 3 was that the customer terminated the ordering process. The supplier handled replenishment based on his own forecast model and daily updated inventory and sales data. The point of invoicing was not changed, shipments were still Ex. works and ownership of the goods was transferred to the customer when leaving supplier’s facilities. The termination of the ordering process reduced the work done by the customer’s purchasing staff but as the supplier’s production planners were already using their own forecasts for control purposes no significant changes in work tasks and knowledge requirements were experienced.

5.5.2 Initial collaboration

The initial part of the new replenishment program was subject to collaboration in multiple areas. A major effort was put into information standardization and a clean-up in existing inventory volumes and product codes.

Discussions were held on replenishment lot sizes. The common trade-off between lot sizes, unit costs and storage costs was sorted out jointly.

Also the type of information to be shared was subject to discussions. The customer appreciated his obligation to support the supplier in his new responsibilities and was prepared to offer the supplier the information asked for. In return, the customer required advance shipment notice (ASN) on initiated shipments.

Performance measurement was a vital element in the initial discussion. It was agreed that it was important to establish a set of measures that the supplier was able to affect. In this way the supplier's performance would not be influenced by outside elements beyond his control.

5.5.3 Continuous collaboration

Due to long replenishment lead times (4-6 weeks) the supplier's production planning relies on forecasts. Good lead time demand forecasts are important to avoid stock-outs. Forecasting was subject to continuous collaboration. Customer and supplier prepared separate forecasts that were compared and major divergences were discussed. The final replenishment decision was though in the hands of the supplier and stock-out was one of the key supplier performance indicators.

One of the most important collaboration areas was management of product variants. The main focus was on the product end-of-life (EOL) aspect and the main issue was how to maintain a full-assortment customer service while simultaneously reducing excess and dead stock. A program for new product development and introduction was already established, and though there is always room for logistic improvements in the supply process this was not considered a weak point of the variant management process.

5.6 The case control model

To complement the new collaboration scheme, new routines for information transfer were established. The new information flow is simple but it rests on an in depth study of what information is needed for what purposes. Once the type of data needed was settled, the daily data transfer was only subject to technical issues.

The control model applied in this case shows that the supplier makes the replenishment decision based on daily updates of customer inventory levels. The supplier initiates production based on manufacturing lead times and expected demand during lead time. The inventory control technique applied is further described below. The customer is informed about planned shipments, and physical dispatch usually occurs twice or three times weekly. Supplier performance is measured on product availability at the customer's warehouse and service goal is 98%. Figure 5-4 shows the information and material flow.

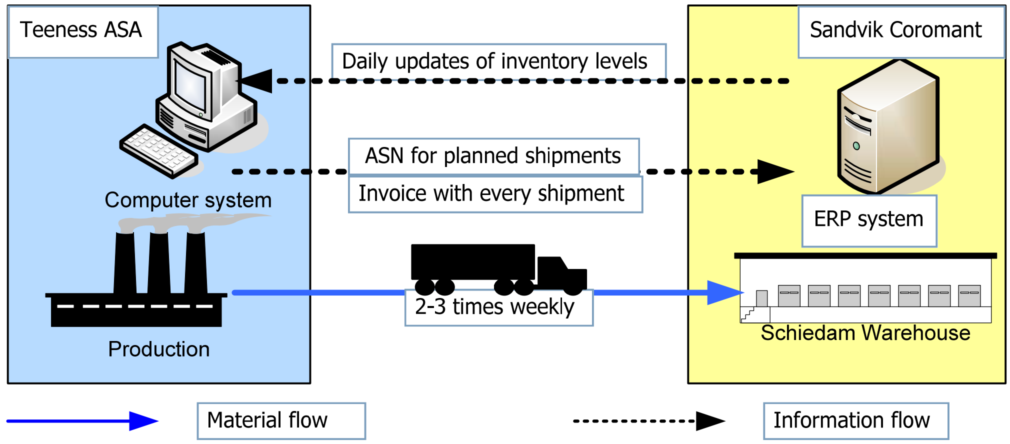


Figure 5-4, material and electronic information flow between Sandvik Coromant and Teeness

Every night updated status on incoming orders, inventory levels, stock withdrawals, backlog and accumulated sales are transferred from the customer's ERP system to the supplier's computer system. Every product is identified by a set of product description codes. A Product description includes:

- A customer system product code,
- A category code referring to the life cycle stage,
- A change date which is a prediction of future change of category code,
- the supplier's product code,
- the customer's EAN barcode
- a code indicating whether the product has been introduced or not

A File Transfer Protocol (FTP) file with all this information is automatically initiated by the customer's ERP system and transferred. The supplier's system is updated and when reorder points are met, production planners are alerted automatically.

From the supplier an advanced shipment notice (ASN) containing product descriptions, quantities and delivery date is transferred prior to every shipment. Every shipment is accompanied by an invoice for the shipped goods.

5.6.1 Inventory control technique

The replenishment decision is based on a simple reorder point methodology. Production of a new lot is initiated once the available to promise level reaches a predefined reorder level for each product. The available to promise level for each product is calculated by the formula shown in Figure 5-5.

Physical inventory	*Physical inventory*: aggregated current stock level
+ Goods in transport	*Goods in transport:* the goods being shipped from Teeness but not yet arrived at Schiedam.
- Allocations	*Allocations*: the goods promised to a customer but not yet withdrawn from stock
- Backlog	
Available to promise	*Backlog*: shortages at one of the warehouses to be supplied from another warehouse (internal matter).

Figure 5-5, formula calculating available to promise

The reorder level is defined by the expected demand for the product over the expected replenishment lead time including safety stock.

5.6.2 Investments required

The customer had to upgrade their internal ERP system to handle the data collection and transmission required in the VMR program. It was however of strategic interest to make the solution generic as this would ease future establishments of new VMR programs towards other suppliers. The costs incurred were justified by future opportunities.

The supplier spent the project period developing their computerized planning and control system. The system was tailor-made to their specific needs by an in house multi-skilled programming expert and they had no extra costs incurring by hiring external consultants.

5.7 How the case corresponds to the research questions

The initial preparations and step one lasted for 18 months and step two lasted for 12 months. The move to step three was delayed because the customer was changing their ERP system and the supplier spent much time standardizing product codes and preparing for the move. The implementation process and the operation of the VMR program is now considered successful by both parties. The following is a summary on how the case corresponds to the different elements of the research question posed for this work.

5.7.1 Information sharing

The supplier receives information about inventory levels, incoming orders, stock withdrawals, backlog and accumulated sales on a 24 hour basis.

The customer receives ASNs including information about product types, volumes and due dates whenever a shipment is planned. This ASN is issued after production is initiated but before the shipment is ready for dispatch.

All information is sent electronically. Regular updates are sent via the internet and special notifications and alerts, for instance priority changes that affect already communicated due dates, are sent by e-mail.

5.7.2 Performance measurement

Customer is not measured on the quality of his forecasts. This is based on the realization that the supplier has the best forecasting model and forecasting is subjected to collaboration.

The supplier is measured on inventory levels, inventory turnover and stock-out levels. Monitoring inventory levels is important in this program because the goods belong to the customer when stored. Turnover rate is measured for each SKU to monitor product life cycle and to make sure the supplier doesn't stock up on products facing soon forthcoming removal from product range. A stock-out will not cause production delays for the customer. Therefore a certain stock-out level is accepted. It is still important that the supplier maintains a balance between a low inventory level and a low stock-out level for each SKU.

5.7.3 Communication and cooperation

None of the parties had any experience in VMI collaboration. The initiation process was long and most of the contract terms were subject to discussions and mutual openness in order to build a solid collaboration program. Initial discussions included required service and inventory level, performance measures, ownership issues and information sharing with respect to what to transfer, transfer means and frequency, and data standardization.

On a continuous basis, collaboration focuses on maintenance of product range with respect to both product introductions and removals, and promotions and forecasting. Recent refinement includes an expansion of products managed via the VMR system. Originally only the standard product sizes were managed this way, now the supplier is managing special orders as well.

5.7.4 Product and market characteristics

The products manufactured by the supplier are high value goods. Demand variation is moderate and predictable and though the supplier has patented their high quality products there are substitutes available in the market. The products are not highly customized but they are prepared to facilitate use in combination with the customer's products in order to build a complete tooling package to the end consumer. The customer has exclusive rights to distribute the product, and therefore neither party has other competitive relations. Prices are stable and manufacturing lead times are fairly long. Stabile supplies are therefore vital to reduce safety stock levels.

5.7.5 Trust and contract regulations

Trust has been a major element of this project. It was the customer's great confidence in the supplier's capabilities that made them believe in the idea of leaving replenishment responsibility with the supplier. Trust was one of the main reasons this particular relationship was selected a pilot for VMI collaboration by the customer.

The contract has built in incentives for revenue and risk sharing and flexibility to allow for temporary low performance. There was commitment from top management with both companies, and reciprocal openness and discussions on practical solutions has been considered one of the most important success factors of this process.

5.8 Lessons learned

In order to capture the lessons to be learned from this case, the following summarizes on the two parties' experience with the VMR program.

5.8.1 Improved working conditions

One very early effect of the new collaboration scheme was the appearance of a new atmosphere and enthusiasm to work among the supplier employees. They were no longer operating within the trade-off between producing for expected demand and shipping for actual customer orders which was short of congruence. The new enthusiasm was built on the supplier's eager to prove their performance capabilities on an indicator they believed in.

The supplier still have to build inventory prior to holiday seasons but this inventory can be built by an even increase in production over several weeks allowing them to operate within regular capacity limits. Additionally, this build-up and its cause is both known to and accepted by the customer. Conclusively, operating on fair terms is found more rewarding and satisfactory to the supplier.

5.8.2 Collaborative data specification and clean-up

In order to facilitate integrated electronic information sharing it was vital to standardize product codes. A major data clean-up was performed which resulted in improved structure and reduced data volumes in the supplier's computer system. In conjunction with the data clean-up they also entered discussions on prices and lot sizes for each product.

Collaboration on product mix management is important when inventory level is a key performance indicator. In order to make this a fair measure, the supplier must be able to control the factors affecting inventory levels. An increase in number of variants imposes an increase in total stock level, a continuous monitoring of demand levels for each product and product line is vital in order to find the right time to start the EOL process. Reaction to demand reduction can be followed by three changes, a reduction in manufacturing frequency, reduction in lot size or a combination of these. Maintaining the lot size means increased storage life and a rise in inventory costs. Reducing lot size causes an increase in average unit manufacturing cost. Increased product shelf life reduces the supplier performance measure while increasing manufacturing costs reduces the product's contribution to gross margin. Selecting the right action is a trade-off between the cost of keeping the product within the product range and the benefits of sustaining a full assortment customer service.

5.8.3 Make to stock or make to order

As already indicated, the supplier wanted to act on their own forecasts rather than the customer's purchase orders. Manufacturing on own forecasts per se could have been achieved by moving from make to order (MTO) to a make to stock (MTS) strategy. This would disconnect sales and production, and they could have continued shipping on customer's purchase orders while producing on own forecasts. While this is a move they were very reluctant to do, it was in reality how they were already operating. The main difference was that the goods manufactured on anticipated demand was defined to be awaiting transport rather than finished goods inventory.

VMI is realistically MTS but as opposed to regular MTS where manufacturing is performed in anticipation of future demand, in VMI this anticipation is strongly directed towards one specific customer with a long term standing order. VMI can therefore be described as MTS in an open order environment.

5.8.4 Quality of forecasts

In this case it was obvious to the supplier that the customer's forecasts were not good. When acting on customer's forecasts the supplier knew their operation was less than satisfactory. When the supplier was able to present a better forecasting model the customer could understand the extra costs and operation inefficiencies being the consequences of his bad forecasts. This evidence made it easier to talk him into the idea of leaving replenishment responsibility with the supplier.

It is vital that the customer is aware of the effect of forecast quality and understands how bad forecasts have a negative effect on supplier's performance. With this knowledge the customer is likely to make an effort improving forecast quality.

5.8.5 Long term dedication

The implementation process was long and several years passed from the supplier initiated the new replenishment routines until effects were observed. It is essential that both parties spend time to build confidence in the new replenishment scheme, systems and solutions must be prepared for the new operation. It is therefore important to build this type of relationship with a supply chain partner with long term perspectives. However, it is also important to keep the process going so that results can be observed within fairly reasonable time.

5.8.6 Standardized computer systems

The customer spent time and resources on selecting an ERP system that facilitate VMI collaboration. One of the prerequisites made by the customer was that the system developed was capable of including other suppliers on similar replenishment programs. This would make the investment less transaction specific and it would open opportunities for simpler and more cost efficient implementation of later replenishment programs.

This is a typical example to show how reduced transaction specificity will reduce risks and open for future opportunities.

5.9 Concluding remarks

This case of VMR establishment and implementation has embraced multiple aspects of VMI theory found in literature. A deep sense of commitment to the project is found with both parties and there is a genuine interest in making this a successful collaboration program. The project is supported by top management with both parties and most important of all, the establishment of routines and operational details rests on in depth discussions and collaboration in order to select the solutions most suitable for both parties.

The comprehensiveness of this case made it suitable for a pilot study. The bullwhip effect was visible and the case show how demand was smoothed by improved forecasts and information sharing, and how VMI allowed for production smoothing. It has highlighted the importance of collaboration in the initial stages of a VMI program and it has opened some subjects for continuous collaboration. It is detailed in information sharing and it offers some very interesting opportunities to study how performance measurement should be applied dynamically and related to the life cycle of a product. Waller et al. (1999) indicated that a minimum volume of transactions is required to establish VMI. This case shows that a minimum of long term perspective is equally important.

The case has been a major source of input to the development of the interview guide used for data collection in the other cases, and it played an important role in the task of comparing causes of outcomes.

6 Case description Smurfit Norpapp – Pipelife Norway AS

Case 1 is the Vendor Managed Replenishment (VMR) relationship between Smurfit Norpapp and Pipelife Norway AS. Smurfit Norpapp manufactures cardboard boxes and supplies Pipelife Norway on a VMR contract. When the interviews were performed the collaboration program had been working for about one year. A total of two meetings, four telephone conversations and approximately eight e-mail exchanges form the framework for the data collection in this case. In Table 6-1 the communication is listed chronologically.

Table 6-1, communication for case 1

Date	*Communication*	*Purpose*
Feb 05	telephone	Establish contact and get appointments for interviews
Feb 05	e-mail	Set dates for appointments
Feb 05	Meeting	Interview with Smurfit Norpapp
March 05	e-mail	Case description Smurfit Norpapp
March 05	Meeting	Interview with Pipelife
March 05	e-mail	Case description Pipelife
April 05	e-mail	Clearing up on details
Nov 06	telephone	Specification of data exchange process
Dec 06	e-mail	New data on inventory levels
Jan 07	telephone	Details regarding new inventory level data

In this case, representatives from both the customer and the supplier were interviewed. The first interview was held at Smurfit Norpapp sales office in Trondheim, participants were Gunnbjørn Uglem, regional Sales manager, Smurfit Norpapp and Astrid Vigtil, researcher, NTNU. There was no tour around the premises as the factory is located some 400 kilometres from the sales office in Trondheim. Additional follow-up e-mails have sorted out some details.

The second interview took place at Pipelife Norway’s premises in Surnadal, participants were Kjetil Fagerholt, logistics manager Pipelife and Astrid Vigtil, researcher NTNU. The interview started with a tour around the factory and follow-up e-mails have sorted out details.

6.1 The supplier

Smurfit Norpapp (SN) is a manufacturer of corrugated cardboard boxes for packaging. The company history goes back to 1929 and it is now a part of the Jefferson Smurfit Group, a world wide leading supplier of fibre based packaging.

SN has one production plant in Norway, at Hensmoen by the city of Hønefoss. Additionally they have five sales offices in the south of Norway. SN offers a large spectre of both standardized and customized products. Standardized products are distributed via a wholesaler that also manages the warehousing facilities used by SN throughout Norway.

The customized boxes are tailored with respect to paper quality, dimensions and print, and they are made to order.

The manufacturing is based on batch production principles and batch sizes are frequently determined by Economic Order Quantity (EOQ) calculations. When the boxes are finished, they are palletized and shipped to wholesalers or customers respectively.

6.2 The customer

Pipelife Norway AS is a manufacturer of pipes and parts for in house and outdoor sewage and electrical installations. In 1969 a company called Mabo was established in Surnadal, Norway by the entrepreneur Martin Botten. Mabo quickly became market leader in manufacturing of in house pipes and parts for draining and sewage systems and in 1999 the Mabo group became a part of the Pipelife group. Pipelife was founded in 1989 as a Joint Venture of Solvay (Belgium) and Wienerberger (Austria) with activities in Austria, France and Germany. Following more than a decade of expansions, Pipelife is now represented world wide.

Pipelife has two production plants in Norway, one at Stathelle and one in Surnadal. The Stathelle plant is specially designed to manufacture large dimension PE pipes for export, and the original Mabo plant in Surnadal manufacture small dimension pipes and parts for in house installations. These products are made to stock and distributed via wholesalers. The connection between SN and Pipelife

Pipelife's small dimension parts manufactured in Surnadal are packaged in cardboard boxes supplied by SN. The boxes come in 7 different sizes and they are all printed with Pipelife's logo. The replenishment of these boxes is managed by SN on a VMR contract.

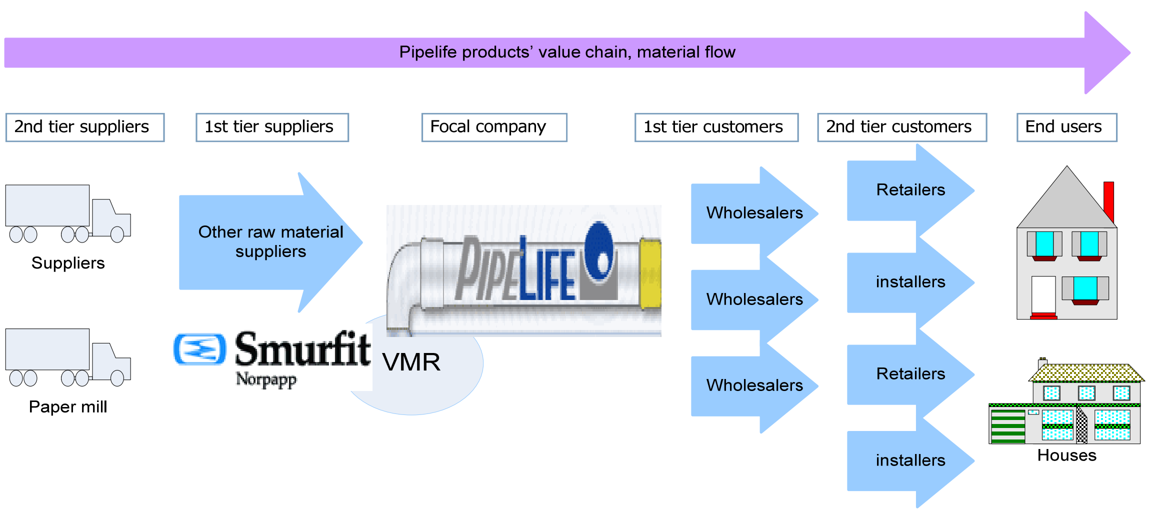


Figure 6-1, Pipelife's value chain where Smurfit Norpapp is 1st tier supplier

A maximum inventory level and a reorder point for each box size is defined by Pipelife, and daily updates of current inventory levels are communicated to SN who makes the replenishment decision. The ownership of the goods is transferred to Pipelife when the boxes arrive at their facilities in Surnadal. Pipelife's value chain is depicted in Figure 6-1 and SN is identified as a 1st tier supplier.

6.3 Relationship characteristics

The VMR relationship was initiated by Pipelife in 2003. After a few months of preparation the new replenishment scheme was enrolled on January 1st 2004 and it has been considered a success by both parties from day one. The data transfers were closely monitored the first two months but the program is now established routine. None of the parties had any previous experience in such form of supply chain collaboration.

6.3.1 Customer objectives

The customer's primary objective was to attain some experience in the field of VMI collaboration. They had a general interest in this type of supply chain collaboration and wanted to further expand the use of VMR programs to other supply chain partners. Their two secondary objectives for this specific VMR collaboration were to improve trade terms for cardboard boxes and to relieve work load on purchasing staff. Their prime objective was strategic, their secondary objectives were financial.

The customer had two suppliers of cardboard packaging, both proven to be solid and trustworthy. A single sourcing strategy would offer the opportunity for both the supplier and the customer to obtain scale advantage while the nature of the product as easily substitutable placed little risk upon the customer. Large volumes, few variants and high transaction frequency offered potential positive effects of a VMI replenishment system. A request for tender was opened to both suppliers and SN was chosen because they were the only party showing genuine interest in the suggested collaboration scheme.

6.3.2 Supplier objectives

SN's positive response to the customer's request was motivated by a general interest in modern logistic operation. The request was considered an opportunity to gain competitive advantages. Their main objective was to demonstrate their capabilities as a modern and dynamic supply chain collaboration partner. Additionally they wanted to secure customer retention, which was considered very important in a highly competitive market situation. Establishment of electronic communication to reduce manual paper handling, speed up communication and eliminate manual delays was important. Reduced distribution costs by use of established rail links and improved capacity utilization of regional distribution trucks were expected benefits. Finally, production planning improvements were also expected. Their main objective was strategic, other objectives were financial.

They decided to respond to the tender. They were not afraid to make an effort as the customer has previously shown interest in modern ICT-solutions for logistic operation. The customer's share of the supplier's total volumes are low (0,3-0,4 % of total production), but is still a relatively large single customer of large volumes and few variants. This makes remote inventory control less complicated and it was found of particular importance as the supplier had no previous experience in this type of operation. The supplier used to have a warehouse close to the customer in Surnadal but this had recently been closed for the purpose of reducing warehousing and distribution costs and to exploit existing rail capacity at the main route between Hønefoss and Trondheim, and the supplier identified this as an opportunity to improve their logistic operation in the region.

6.3.3 Investments

Both parties were originally fairly well equipped with ICT, both regarding hardware and software. Some man hours were spent on enabling electronic information sharing and the establishment of software compatibility. Except from this, no investments were required.

6.4 The case control model

The control model shows the material and information flows and what inventory indicators trigger replenishment actions. The control model applied in this case is depicted in Figure 6-2. The supplier operates a regional warehouse in Trondheim which is the CODP in the supply chain. Both the material flow and information flow in this program are two-stepped where step one concern the replenishment of the regional warehouse and step two concerns serving the customer.

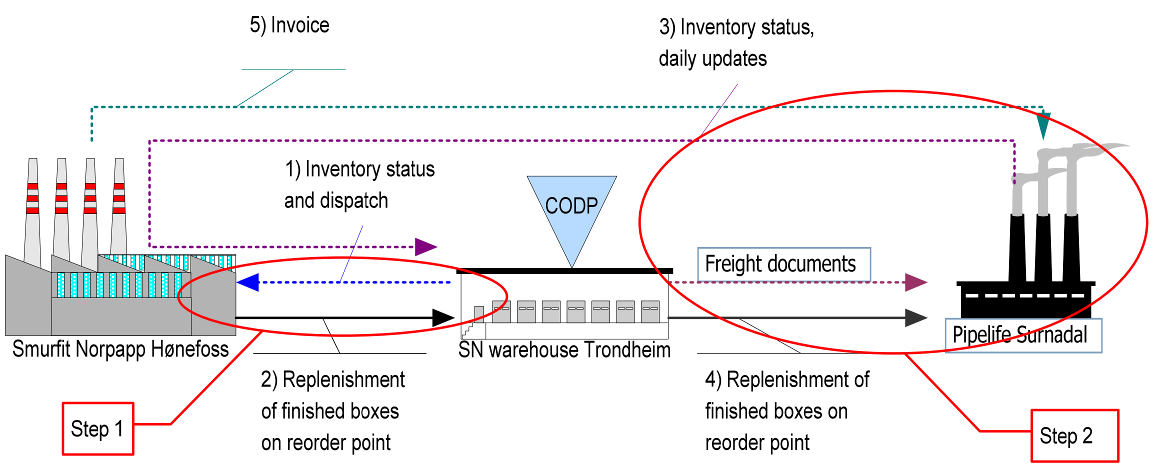


Figure 6-2, Material and information flow between Smurfit Norpapp and Pipelife

Step One:

– Inventory status is communicated from the warehouse to the production facility (1)

– replenishment is on reorder point (2)

Step two:

– Daily updates of customer's inventory levels are communicated from customer to the supplier's central computer system in Hønefoss (3).

– These updates are forwarded to and viewed by an operator at the Trondheim warehouse who makes daily replenishment decisions based on reorder points and maximum levels (4). The customer's requirements are combined with orders from other customers in the area and optimal truck loads are prepared.

– Dispatch from the Trondheim warehouse is communicated back to the central planning system (1)

– an invoice is prepared (5)

6.5 Performance measurement

The new collaboration scheme was enrolled 15 months prior to the interviews and during this period there had never been a stock-out at the customer's warehouse. Customer's goal achievements include that they have gained positive experience in VMI collaboration, purchaser spends almost no time on cardboard box replenishment and purchase prices on the cardboard boxes are reduced.

Supplier's goal achievements include that they have reduced their distribution costs in the region, they have increased use of electronic communication and documentation has speeded up communication and reduced paper handling, work load and errors. Additionally, they have increased flexibility in production planning.

Table 6-2 shows how performance is measured and respective observations. Customer performance is measured on number of stock-outs and average inventory level. Stock-out level is zero while average inventory level has increased. The supplier measure their own performance on resources spent on customer follow-up and throughput time in the Trondheim warehouse. Both are reduced after VMR. The increase in average inventory level is further discussed in section 6.7.1.

Table 6-2, success measures and observations

Company	Measure	Observation
Pipelife	Number of stock-outs	0
	Average inventory level	Increased (aprx. 10%)
Smurfit Norpapp	Resources spent on customer follow-up	Reduced
	Throughput time at the warehouse in Trondheim	Reduced

6.6 How the case corresponds to the research question

The VMR collaboration is considered a success by both parties. They indicate that they are happy with the new replenishment model and both argue that their goals are achieved. The following is a summary on how the case corresponds to the different elements of the research question posed for this work.

6.6.1 Information sharing

The supplier receives information about inventory levels electronically every 24 hours. This information is used for replenishment and distribution planning from a regional finished goods warehouse. The information is not directly used for production planning purposes, but production is smoothed by decoupling production and demand.

The customer receives paper copies of shipment documents when goods are received. This information must be manually re-entered into the customer's ERP system in order to update inventory levels. This solution is timely and subject to typing errors, but for the time being, the volumes are considered to low to justify further investments. Electronic transfer of incoming shipments will be pursued in the future. No other information is transferred from supplier to customer.

The integration level between the parties is low. There is little data transmitted, some type of data is not transferred electronically and what is transferred electronically is not used in a decision support system.

6.6.2 Performance measurement

The performance measure considered most important in the program is stock-out level. The customer finds it essential that boxes are always available. Inventory levels are measured to assess the supplier's ability to keep inventories within the predefined maximum and minimum limits, and inventory turnover is measured by the customer to calculate inventory costs and to compare these costs before and after VMR. These measures can also be applied to adjust maximum and minimum inventory limits.

6.6.3 Communication and cooperation

At the initial stage of the collaboration program the parties agreed on what information to share, how to share it and transfer frequency. They also agreed on transfer of ownership and point of payment. For continuous collaboration, annual forecasts and planned product development are communicated.

6.6.4 Product and market characteristics

The product is customized but can easily be supplied by any cardboard box manufacturer. The product is cheap and if stored correctly the risk of deterioration is low. Obsolescence occurs only if the customer decides to change dimensions, paper quality or print. Prices are stable, demand is predictable and demand variation is low.

6.6.5 Trust and contract regulations

The business relationship is regulated by a contract specifying each party's responsibilities and duties. There are no incentives to improvement but financial sanctions are used in case of breach of contract (e.g. stock-outs). There was an initial calculative trust (Rousseau et al. 1998) between the parties. Additionally they had already some history of business and a minimum level of relational trust was present. As months passed without contractual violations relational trust has developed. The parties are more relaxed about the program but contractual regulations are not altered.

6.7 Lessons learned

In order to capture the lessons to be learned from this case, the following shows how performance measurement can be used to visualize mechanisms of logistics and identify effects of VMI with examples from this case. Further, this section summarizes on the two parties' experience with the VMR program.

6.7.1 Filling level effect on demand

After the VMR relationship was established, the customer made a minor change to their filling procedures. In order to improve the volume efficiency of outgoing shipments, they increased the number of items going into each box. Size, quality and number of box variants were not affected by the change.

Other things being equal, this will reduce the total demand for boxes and cause a momentary reduction in turnover rate.

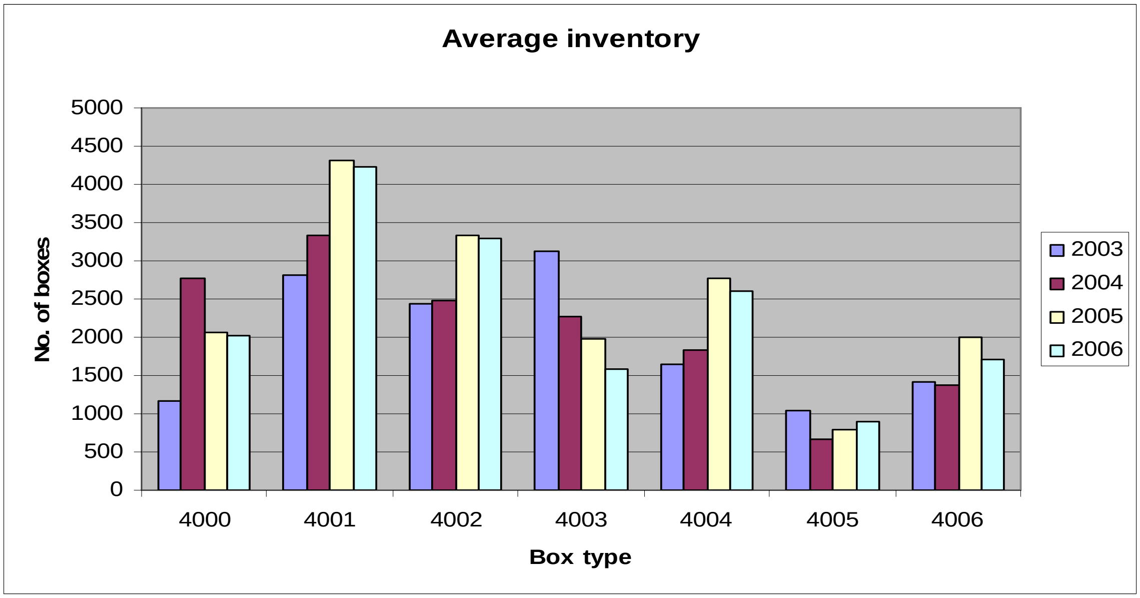


Figure 6-3, average inventory before and after VMR

An approximately 10% increase in inventory level was experienced. This was considered a consequence of allowing the supplier to manage the replenishment and no further action was taken to address this issue. The probability that this was due to the improved filling was not considered by the customer. Figure 6-3 depicts the differences in average inventory for each box type over the last four years from 2003 to 2006. 2003 was the last year prior to VMR collaboration. Measures are approximate and will not be subjected to calculations used for in depth studies and quantitative decisions, just for examples.

It is observed that average inventory levels increased after implementation of VMR. Initially this is bad news but it must be seen in conjunction with other performance measures like stock-out level, total demand and turnover rate.

6.7.2 Example of performance calculations

The inventory turnover rate was measured and found satisfactory by the customer. This feeling of satisfaction was not based on relevant benchmarks or comparisons to the performance of other packaging suppliers, but on comparisons to the customer's products. This is probably not a relevant benchmark in this situation but for this example turnover calculations are used to identify cost reduction opportunities.

Individually, the turnover rates for each box vary. For this turnover rate calculation, data on average inventory levels found in Figure 6-3 are used. The formula used to calculate turnover rate (TR) is total purchases (TP) divided by average inventory (AI).

$$TR = \frac{TP}{AI}$$

For the seven box sizes the rates span from 2 to 38 in 2004, from 3 to 23 in 2005 and from 3 to 26 in 2006, se Table 6-3 for results.

Table 6-3, turnover rates for each box type at Pipelife's warehouse first three years of VMR

Year\box	4000	4001	4002	4003	4004	4005	4006
2004	2	15	16	22	38	14	18
2005	3	11	13	7	23	12	15
2006	3	11	15	10	26	12	16

Example:

Box type 4000 shows a turnover rate of 2, 3 and 3 which implies that average inventory equals 6 months demand in 2004 and 4 months demand in 2005 and 2006. This indicates that maximum inventory level probably is set too high. If maximum level was reduced, average inventory levels would most likely go down and thereby increase the turnover rate and reduce inventory carrying costs. This decision is however, influenced by demand patterns, seasonal variations, lot size prices and purchase costs.

Figure 6-4 is a bar chart of Table 6-3 that shows how the turnover rate has changed over the VMR period for the seven box types. It shows that turnover rate was reduced in 2005 but is slowly increasing in 2006.

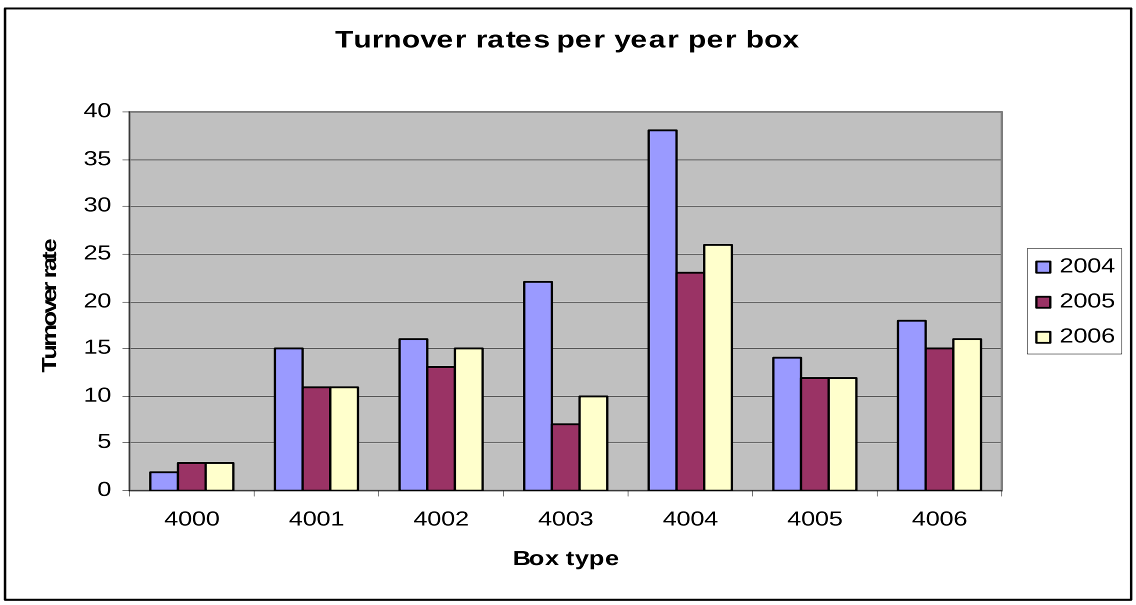


Figure 6-4, changing turnover rates over the three first years of VMR

Despite decreasing turnover rates the customer is satisfied. From the customer's perspective the VMR collaboration scheme was considered an important pilot but facing limited resources and the relatively low impact of inventory carrying costs, refining the operational aspects of the relationship has not been prioritized.

6.7.3 Customer's experience

The customer had three main purposes for the VMR implementation. Firstly, they wanted to attain experience in the field of VMI collaboration and it is very likely that they have gained much more experience by running a pilot themselves than what they could have done simply by observing and studying others.

Secondly, they wanted improved trade terms for cardboard boxes. While price negotiations in general and by adopting a single sourcing strategy in particular could have offered the same outcome, the VMR program's contribution to improved trade terms is obvious in this case.

Thirdly, they wanted to reduce work load on purchasing staff. The work load on purchasing staff is reduced by the elimination of purchasing activity. Decisions on timing and volumes for replenishment and communication regarding purchasing, delivery terms, volumes and price negotiations are no longer performed. The establishment of electronic communication and automatic paper handling has further reduced the administrative work in the purchasing department. However, as shipping documents are not transferred electronically inventory status must be manually updated when supplies of boxes arrive. The opportunity to take further advantage of ICT is observed but not exploited.

6.7.4 Supplier's experience

The supplier's main purpose was to demonstrate their capabilities as a modern and dynamic supply chain collaboration partner. By the time of the interviews the program had been running successfully for 15 months, and this is an indication of their successive effort in obtaining these capabilities. The fact that they were able to develop routines for VMR collaboration could also indicate that they would be able to enter other types of collaboration schemes upon request.

The supplier also wanted to secure customer retention, which was found very important in their highly competitive market situation. Supply chain collaboration in general is a means to develop long term relationships and increase likelihood of customer retention. Long or medium term contracts would have this effect. The nature of the VMR program where the customer does not actively purchase but where the supplier continues supplying is an excellent means to retain customers, and the supplier became the only supplier of boxes to the customer when they engaged in VMR. The VMR program is considered a very important contributor to customer retention.

The supplier wanted to establish electronic communication to reduce manual paper handling, to speed up communication and to eliminate manual delays. The establishment of electronic communication is by several authors considered an enabler for VMI collaboration (e.g. Mattson 2002, Kulp 2002, Waller et al. 1999). Entering the VMR program could justify the investments required. Reduction of manual paper handling, speeding up communication and elimination of manual delays could be achievable by establishing electronic communication without entering the VMR program. It is however vital to be aware that ICT for the sake of ICT rarely offer much value. The information that is transferred and the receiver's ability to utilize this data are essential, and ICT is just the enabler (Mason-Jones & Towill 1997). Under the VMR program, requirements for information sharing and utilization were set and it is very likely that reduction of manual paper handling, speeding up communication and elimination of manual delay are achieved because ICT is used in the context of VMR.

One of the expected benefits of the VMR program was reduced transport and distribution costs by use of established rail transport links and capacity utilization of regional distribution trucks. They experienced reduced distribution costs because their updated information on customer inventory levels enables improved capacity utilization of the distribution lorry supplying from the Trondheim warehouse. These cost reductions evolved because the VMR program allowed flexible shipments. The reorder point in Trondheim is adjusted to allow cost efficient high volume shipments from the production plant to the warehouse, and the VMR and the use of a regional warehouse in Trondheim allowed them to serve the customer despite the closedown of the local warehouse in Surnadal.

The supplier claims that due to the VMR program they have increased their flexibility in the production planning. Their production planning is however restricted to the reorder point at their warehouse in Trondheim and no advance demand data from the customer is used in the planning phase. The Trondheim warehouse is a buffer between the customer’s low volume demand and the supplier’s focus on economic production batches which enables them to reduce the unit cost. The improved production planning and smoothed manufacturing is therefore a result of applying a warehouse to handle the disruption caused by demand variability.

In this case advanced demand data is not incorporated into production planning, thus some potential benefits of VMR are not exploited. This observation indicates that when products are cheap and production and transport are important cost drivers it is more important to apply production and distribution strategies to gain economies of scale than to use advance demand data to tailor supplies to demand.

6.8 Concluding remarks

The Smurfit Norpapp – Pipelife case is an example of successful VMR collaboration. Material and information flow is simple and well structured. It is a low risk program to both parties as there are little investments made, the products are common, they will not perish while price and risk of obsolescence is low. The benefits of electronic communication are observed but not fully exploited. Both parties have benefited from the program. The supplier has reduced distribution costs and assured future sales while spending less time and resources on selling activities. This pays off the reduced item selling price. The customer has reduced purchase prices on boxes and at the same time they spend less resources on purchasing.

This case shows that VMI is feasible for products where demand is predictable and risks are low. It also shows that VMI is a means to secure customer retention and increase sales and obtain cost reduction in distribution. Additionally, the case supports the statement that electronic information exchange and increased level of integration is an important element in a VMI collaboration program, and it shows how performance measurement can be used to reveal improvement areas.

7 Case description Raufoss Chassis Technology ASA–General Motors Opel

Case 2 is the VMI relationship between the supplier, Raufoss Chassis technology ASA (RCT) and the customer, General Motors, Opel. RCT used to supply Opel with front end control arms on a VMI contract for a period of approx 16 months, then the replenishment routines were changed to direct deliveries. One meeting, two telephone conversations and five e-mail exchanges form the framework for the data collection in this case, and the communication is listed chronologically in Table 7-1.

Table 7-1, communication for case 2

Date	*Communication*	*Purpose*
April 05	telephone	Establish contact and get appointment for interview
June 05	e-mail	Documents for interview
June 05	Meeting	Interview with RCT
June 05	e-mails	Case description and comments

The main interview was held at Raufoss Industrial Estate, participants were Arne Horten, former logistics manager at RCT and Astrid Vigtil, researcher, NTNU. An initial phone interview was held to prepare for the interview. The researcher had on a previous occasion toured the premises and a new tour was not required.

7.1 The supplier

Raufoss Chassis Technology ASA (RCT) makes aluminium control arms for wheel suspensions and is located in Raufoss, approximately 120 kilometres north of Oslo, the capital of Norway. In 2004 RCT and its two subsidiaries in Canada and USA were acquired by Austrian Neuman Aluminium. Since 1981 RCT has designed and manufactured aluminium chassis components for the European automotive industry, and in 1999 they were nominated the sole supplier of control arms for the new General Motor’s European Epsilon platform. Consequently, a parallel nomination for the North American Epsilon platform was appointed in year 2000. The European customers are supplied by the Raufoss factory while a green field factory established in Quebec, Canada in 2003 supplies the North American market.

Figure 7-1, front end control arm

RCT makes two main components, front and rear end control arms for wheel suspension. The front arms come in two designs, one for the right hand side and one for the left hand side wheel suspension, and one is a reverse of the other. Figure 7-1 shows the right hand side front end control arm, Figure 7-2 shows the rear end control arm and Figure 7-3 shows how the control arms are fitted on to the wheel suspensions.

Figure 7-2, rear end control arm

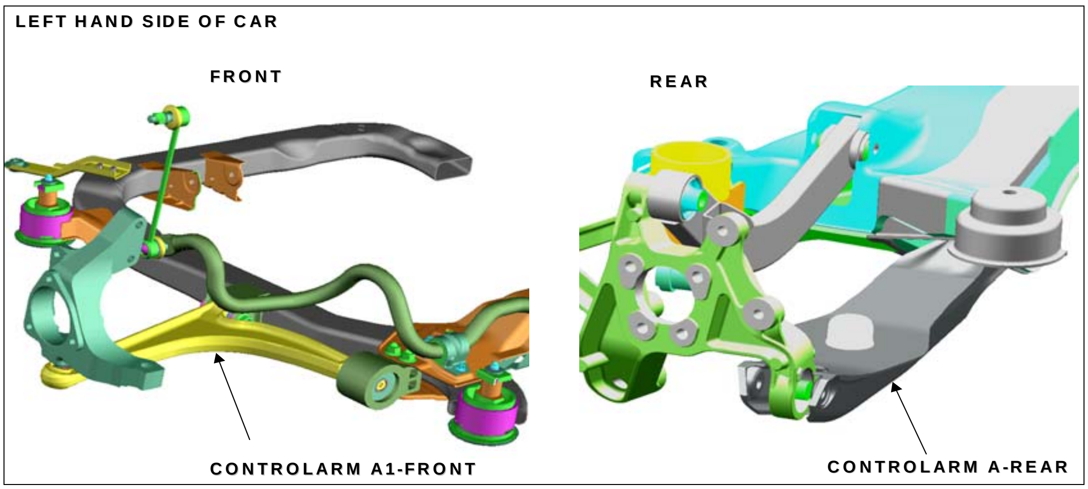


Figure 7-3, control arms fitted to wheel suspension

The production process is highly automated and based on batch production principles. One production line is designed to manufacture front end control arms and every second control arm is a right hand and a left hand arm. Due to customer requirements they are however loaded into separate containers. A second production line is designed to manufacture the rear control arms. All products are manufactured to stock in anticipation of future demand.

RCT have three main customers in Europe, Saab, Opel and Vauxhall. The Opel and Vauxhall components are identical but there is a slight modification in the final assembly of the Saab version, thus logistically RCT manufacture 6 different products, approx. 80% of total volume being Opel/Vauxhall specified and 20% Saab specified components.

Front and rear end control arms are shipped to Saab by three destinations in Sweden (Trollhättan, MagnaSteyr and Nyköping) and by four destinations to Opel/Vauxhall (Ruesselsheim, Kaiserslautern, Ellesmere and Bochum). Figure 7-4 illustrates this flow.

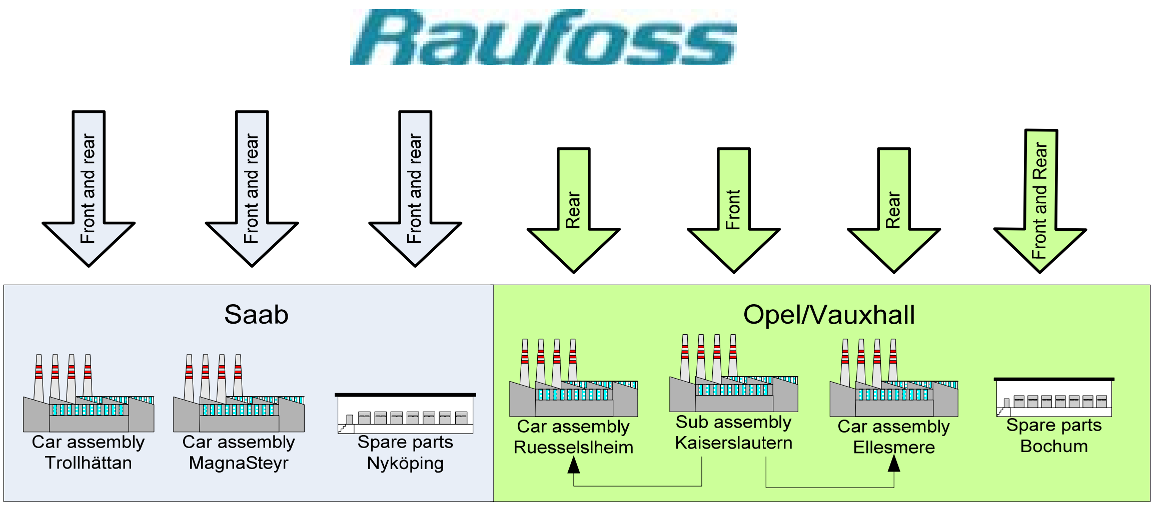


Figure 7-4, Finished goods flow from RCT Raufoss to Saab and Opel locations

7.2 The customer

Opel is a brand under the General Motors Corporation (GM), a world wide car manufacturer. GM was founded in 1908. They are the world's largest automaker and have been the global industry sales leader since 1931. GM employs about 324,000 people around the world (2005 figures). They have manufacturing operations in 32 countries and their vehicles are sold in 200 countries. In 2004, GM sold nearly 9 million cars and trucks globally, up 4 percent and the second-highest total in the company's history. GM's global headquarters are at the GM Renaissance Center in Detroit.

In addition to Opel, GM's other automotive brands are Buick, Cadillac, Chevrolet, GMC, Holden, HUMMER, Pontiac, Saab, Saturn and Vauxhall.

Today's cars are built on platform design. An automobile platform is a shared set of components common to a number of different automobiles. It is also referred to as vehicle architecture. It represents a standardized base used for different vehicle models and it simplifies manufacturing and logistics by e.g. reducing component variation. The concept of platforms has different meanings to different manufacturers: for VW, the platform is an "element with no impact in the exterior design of the vehicle, constituted as a chassis comprehending as much as 65 % of the total of the vehicle's components"; for GM, the platform consists of a "group of parts for a line of models composed of components such as engines, gear boxes, axes and suspensions but not dashboards" (WP1, D1.1, MOMENT project, 2003).

The 2003 Opel Vectra is built on the Epsilon platform, an architecture developed by American, German and Swedish engineers to be used on mid size front wheel driven automobiles. Other cars built on the Epsilon platform are the 2003 Saab 9-3, 2003 Vauxhall Vectra, 2004 Chevrolet Malibu, 2004 Opel Signum and 2005 Pontiac G6. A new version of the Epsilon platform, Epsilon 2 will be launched in year 2008.

The Opel Vectra is assembled in Germany. The front cradle sub frame is assembled in Kaiserslautern and shipped 90 kilometres north, to Ruesselsheim for final assembly.

Cars are assembled on highly automated assembly lines on mass customization principles. All vehicles are based on the epsilon platform and share the same basis components, but each individual vehicle has its own component list with respect to e.g. engine, interior, safety equipment, textiles, body colours and other finishing that is subject to customer specification. Figure 7-5 depicts roughly the material flow at Opel for the vehicle assembly.

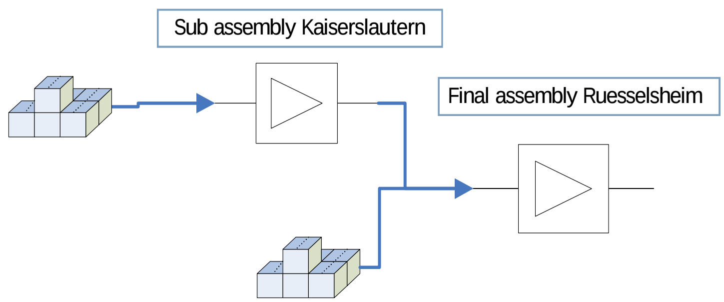


Figure 7-5, material flow, stock-points and assembly locations for Opel Vectra

7.3 The connection between RCT and Opel

RCTs control arms are standard components within the Epsilon platform, thus all cars built on this platform are equipped with control arms manufactured by RCT. The front end control arms enter Opels value chain at the sub-frame assembly in Kaiserslautern and the rear end control arms enter the value chain upon final assembly in Ruesselsheim. Shipments from RCT thus have different destinations based on content (which was also illustrated in Figure 7-4). Figure 7-6 illustrates the total vehicle value chain with the car manufacturer Opel as the focal company.

The inventory of front end control arms prior to the sub-frame assembly in Kaiserslautern was subject to VMI replenishment for about 16 months, from January 2002 through April 2003. The warehouse was located next to Opels sub-frame assembly plant and was operated by a third party. Opel paid for the third party warehouse operator’s services and the ownership of the goods remained with RCT until withdrawal from the warehouse. The relationship was characterized as a Vendor Managed Inventory (VMI) program. Maximum and minimum inventory levels were set by the customer, max. 8 days demand and min. 3 days demand. Replenishment within these limits was completely in the hands of the supplier, however with a strict responsibility of advance notification in case of expected supply shortages; whether due to strikes, raw material shortages or other reasons for plant downtime. Transport time from Raufoss to Kaiserslautern was 2-3 days on regular shipments, 12-14 hours in case of express. Transport was paid by the supplier.

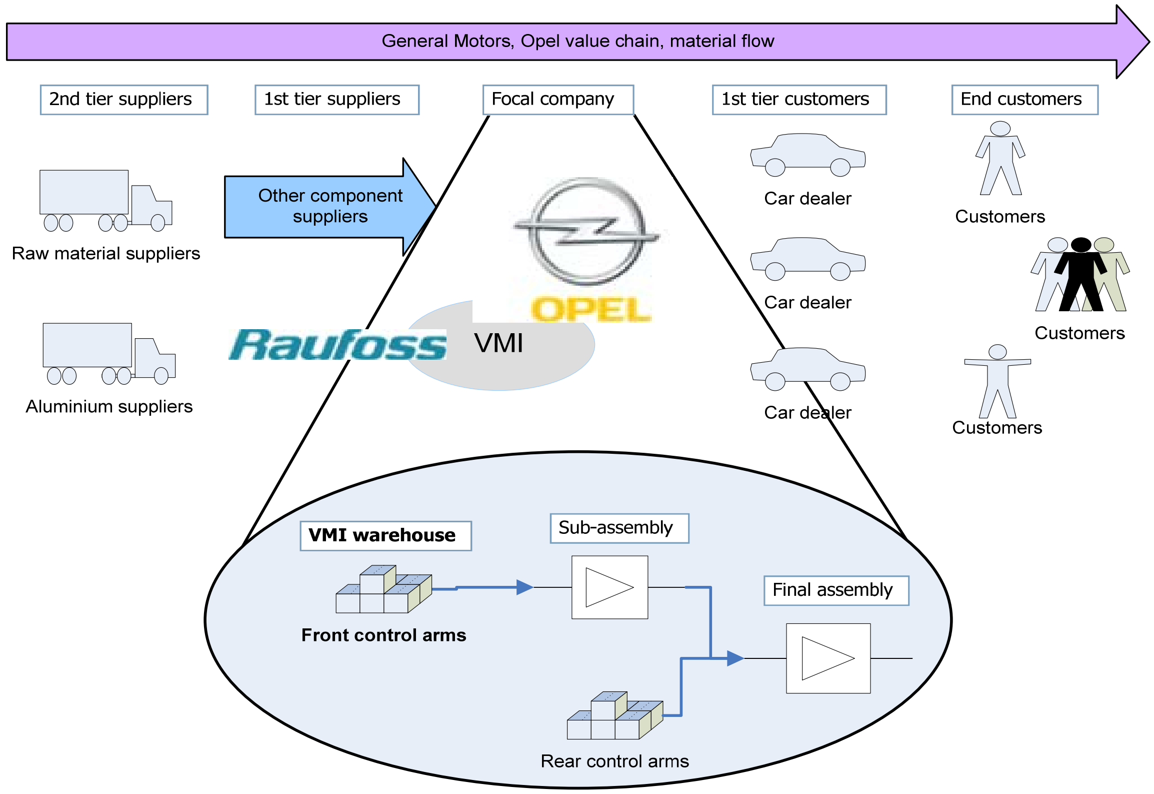


Figure 7-6, Opel Vectra value chain

7.4 The case control model

The control model in this case shows that material flows from supplier via a VMI warehouse close to the customer to the assembly plant. Replenishment of the VMI warehouse is triggered by inventory levels and the supplier was measured on the ability to maintain the inventory level within the predefined interval. Five types of information were exchanged on a regular basis between the three actors, RCT, Opel and the 3rd party warehouse operator.

1. Daily updates on stock withdrawals, inventory status and expected arrivals were sent from the 3rd party warehouse operator to RCT. Exchange means: First 7 months by fax, last 9 months by EDI
2. Advanced Shipment Notification (ASN) was sent from RCT to the warehouse operator prior to every dispatch. Exchange means: EDI
3. Weekly updates of two week demand based on production schedules and 6 months production forecasts from Opel to RCT. Exchange means: EDI. The weekly updated demand was MRP demand calculations including one week lead time, thus the assembly plant's actual production schedule was not known to RCT
4. Hourly stock withdrawal requirements from assembly line to VMI warehouse. Exchange means: Kanban

5. Monthly invoice from supplier to customer based on withdrawals reported from 3rd party warehouse operator.

Daily stock withdrawals and weekly production schedules were used to develop production and shipment plans at RCT. The control model is depicted in Figure 7-7, dotted red arrows indicate information flow and solid black arrows indicate physical material flow.

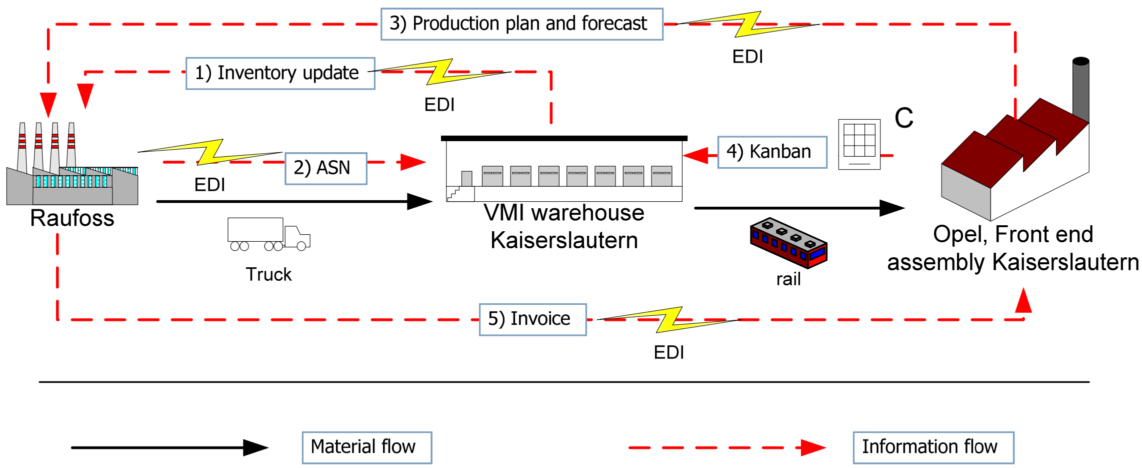


Figure 7-7, information and material flow between RCT, 3rd party warehouse and Opel sub-assembly plant

7.5 Relationship characteristics

The relationship was established on a take it or leave it basis. The new replenishment model was imposed on the supplier by the customer, presumably based on trends in the automotive industry where increased competition has caused massive efforts in cost reduction initiatives. The customer was establishing a 3rd party warehouse close to their sub-frame assembly in Kaiserslautern and several suppliers were required to use this warehouse for VMI purposes. RCT had no previous experience in VMI collaboration.

7.5.1 Investments required

The supplier made no other investments than the EDI links with the customer and the 3rd party warehouse operator. The link to the warehouse operator was established later in the project period and the investment never broke even before the program terminated. The customer made some investments in the relationship with the 3rd party warehouse operator but these investments were related to multiple suppliers required to apply the warehouse facilities for VMI replenishment.

7.5.2 Customer objectives

Due to the circumstances of the case, it has not been possible to interview representatives from the customer. One can only make presumptions of customer's objectives based on indications from the general trends in the industry and specific objectives are not identified.

7.5.3 Supplier objectives

The supplier chose to take the opportunity of VMI replenishment rather than leaving it. By leaving the opportunity they would probably exclude themselves as suppliers of control arms for the Epsilon platform, meaning they would go out of business completely. Their main objective for taking the challenge was to sustain their position as supplier of control arms for the Epsilon platform. Additionally they realized the inherent opportunity to smooth their own manufacturing and transport operation by using the demand information for production planning.

Taking the challenge had both positive and negative impact on their operation. Positive impacts found are:

~ *Finished goods inventory reduction at Raufoss*, when the VMI program was in operation they had a maximum of one truck load in stock at Raufoss, frequently goods were shipped directly from manufacturing to the warehouse in Kaiserslautern. Post VMI inventory status at Raufoss is an average of three full truck loads.

~ *Reduced distribution costs*, RCT was able to maximize capacity utilization on distribution trucks and experienced an approximately NOK 200.000,- of annual cost savings.

~ *Improved production planning*, the access to the customer's production plans offered RCT the opportunity to smoothen and adjust their own production plans.

Negative impact:

~ *Increased data entry work load*. On the first 6-7 months of operation daily updated inventory levels, stock withdrawals and arrivals were transmitted by fax from the 3rd party warehouse operator. This data had to be manually entered into RCTs own ERP system and the less integrated means of data transfer exploded the data entry work load.

7.5.4 Trust

RCT had been a supplier to the Saab automobiles for a long time. Saab representatives were part of the group developing the Epsilon platform and it was stated that choosing RCT as sole supplier of control arms to the Epsilon platform was, in addition to price, directly affected by the long term successful relations to Saab. An initial form of contractual trust (Childe 1998) was thus apparent while the customer's relatively strong position in the relationship definitely forced the supplier to put an effort into conforming to the obligations put on them.

7.5.5 Demand variation

Demand for finished cars is unstable but still to a certain extent predictable. Seasonal variations on ± 30% from high to low selling seasons are observed.

Additionally the supplier experienced a somewhat illogic difference in demand for the right hand side and the left hand side control arms. Bearing in mind that each car needs one front end control arm of each type one would assume that there was an even stock withdrawal of the two components, but this was not true. Different feeding lines are assembling the right hand side and the left hand side of the front cradle, and the feeding of these lines is not coordinated. On an annual basis the demand is evened out but on weekly periods the difference could reach as much as six containers (equals two kanban cards, 420 components!).

7.5.6 Supplier's effects of VMI

The supplier's production line was constructed to manufacture front end control arms for both Opel and Saab. The control arms are slightly different for the two car models. When the line was new they experienced some initial problems causing capacity constraints and the VMI inventory gave RCT the flexibility to perform longer runs before set-up. When the line was stabilized they were able to reduce safety stock. Facing reduced demand and increased capacity this benefit was however found of less importance.

The inventory also gave RCT the flexibility to make priorities between the two customers and to buffer up for planned maintenance and vacation downtime.

7.5.7 Performance measurement

Supplier's performance was controlled by two main indicators,

1. number of stock-outs at the warehouse (never to occur) and
2. warehouse inventory level (min. 3 days, max. 8 days)

Most important was avoiding stock-outs. Inventory levels below 3 days initiated a red alert and express shipments where required. Inventory levels above 8 days were supposed to incur extra warehouse charges but due to high capacity with the warehouse operator this was never practiced. Applying this would however make an efficient incentive for the supplier to avoid exceeding the limit, but this was never an issue.

7.5.8 Program termination

The VMI replenishment program was terminated after 16 months. Similar to the way the VMI program was imposed on the supplier, they were now notified that the customer would abandon the program and demanded direct deliveries instead.

One possible cause of this instant change in replenishment strategy was suggested by the supplier. The 3rd party warehouse services were paid for by the customer. The control arms in fact being quite voluminous would occupy much warehouse space and be relatively expensive to store. It is likely that the VMI program was terminated due to high warehousing costs.

The reason why this is assumed to be the cause rests with the fact that the customer has indeed not abandoned the use of VMI replenishment in general. Multiple other suppliers apply the warehouse for VMI replenishment but these are actors supplying less voluminous components.

It is the supplier's opinion that this program was terminated too soon and that the system never reached a state of maturity. The manufacturing processes are now well trimmed and the supplier would at this point be able to reduce the average inventory volumes. However, with the Direct Deliveries replenishment strategy currently applied the customer has retained responsibility for the replenishment, and while only full truck-loads are still shipped and at approximately the same frequencies and volumes as before, the new strategy has somewhat reduced the supplier's flexibility to play with stock and manufacturing priorities.

7.6 How the case corresponds to the research question

The following summarizes on how the case corresponds to the different elements of the research question.

7.6.1 Information sharing

Information was exchanged by several means and levels of integration. The supplier received weekly production schedules on EDI from customer and daily updates on stock withdrawals and inventory status from warehouse operator on EDI (first 7 months by fax).

Warehouse operator received an ASN on EDI from the supplier prior to every dispatch. Withdrawals from stock to production line were made by kanban. The customer was also informed about expected arrivals and inventory levels.

The customer and supplier used different ERP systems and initially the integration level between them was low, but along the contract period technical barriers were overcome to increase integration level. An EDI link established between supplier and warehouse operator increased integration level between the two parties. This new EDI link offered major improvements in resources spent on information updating.

7.6.2 Performance measurement

Supplier was measured on inventory levels and the ability to maintain these within the predefined maximum and minimum limits. Supplier was also measured on number of stock-outs which was expected never to occur. Customer performance was never measured.

7.6.3 Communication and cooperation

In this case the terms were dictated by the most powerful party. Neither at the initial stage nor further along the contractual period there was much cooperation. The supplier learned to deal with the conditions offered. In cases of unexpected events and situations where the supplier had delivery problems (e.g. strikes), he was obliged to inform the customer. Together they could take actions to reduce the damages. The supplier was notified via the regular production schedule updates when demand changed.

7.6.4 Product and market characteristics

The product is customized with respect to design but standard materials are used. It is not a high technology product and value is considered medium, meaning it is expensive enough to have an effect on capital employment costs but not enough to justify expensive distribution solutions. RCT is market leader in aluminium control arms but the products can easily be substituted by similar products made from other materials and the competitive situation is considered free market. The product will not deteriorate and there is no risk of obsolescence during the contract period as long as the contract is not cancelled by any of the actors. There is also a spare parts market to serve. In a long term perspective the main challenge will be to make small and cost efficient series of spare parts. Demand variation is considered medium to high, yet fairly predictable.

7.6.5 Trust and contract regulation

It has been indicated that the supplier was selected based on previous performance in contract with one of the parties responsible for the Epsilon platform. Calculative trust was supported by a certain level of relational trust (Rousseau et al. 1998). Along the collaboration program the suppler was entrusted replenishment responsibility but the customer used public scoreboards to enforce high quality performance. The customer's relative power gained from being the supplier's absolutely largest customer was used to bring forward a set of terms suiting the customer where supplier's needs were not so much acknowledged. Further collaboration for mutual benefits was therefore not pursued.

7.7 Lessons learned

The collaboration program was terminated, presumably due to high warehouse costs experienced by the customer. It is therefore the overall conclusion that the program was unsuccessful and a discussion on this is outlined at the end of this section. The section also reflects on how the supplier has experienced and coped with the changing logistic challenges of the two recent replenishment strategies, the VMI solution and the direct deliveries strategy currently applied.

7.7.1 Supplier's experience and reflections

When the VMI program was running, there were on average four full truckloads of goods in the supplier's system. There were on average 3 truckloads at the warehouse and one in transit. Today there are on average three truckloads stored at the supplier premises awaiting a delivery call and one truckload in transit. The volume of goods in the system is very much the same, it is however moved from a warehouse close to the point of consumption to a point close to production which increases the strain on the transportation process and poses an extra risk on the customer. The customer has undertaken more of the responsibility for the replenishment and it has reduced the supplier's flexibility in inventory balancing and production planning. The loss of this flexibility would however have a much larger impact if the production process was more complex and they would need the opportunity to play around with more product variants to more customers.

Being able to plan for full truck loads was the most important cost reduction element of the VMI solution. Full truck load deliveries are however incorporated into the new replenishment deal as well and this will not represent a difference between the two solutions.

Demand data was transferred on a weekly basis from customer to supplier. This demand data was based on production plans and represented an MRP calculation of net demand for control arms taking into consideration the incoming inventory ordered from the VMI warehouse by the kanban system. The demand data was not sell-through data but the supplier was still able to use the customer's production plans for their own production planning. They had an idea of what to produce the next week by calculating back on demand and stock levels and they had the flexibility to ship the goods to the warehouse when it suited their own operation.

The current one week in advance pick-up sheet represents almost the same advanced demand information. They know what to produce over the next week based on how much the customer wants delivered. The major difference is that the goods are stored at the supplier location awaiting shipment when it suits the customer rather that being forwarded to the VMI warehouse.

The main drawback of the current solution is that the one week in advance pick-up sheets do not represent the final delivery plan. Extra deliveries are frequently required and the supplier is forced to have a safety stock at their own premises and at their own costs to respond to urgent requirements.

To summarize, the benefits from the VMI solution experienced by the supplier were:

– the ability to plan for full truckloads,

– the ability to smooth production,

– balance between the two products on the line

These benefits were however not so inevitable compared to the Direct deliveries strategy when the volumes were large, frequency fairly high, demand fairly stable and when production capacity was no constraint. These conclusions are in line with the findings presented by e.g. De Toni & Zamolo (2005), Småros et al. (2003), Kaipia et al. (2002) and Waller et al. (1999) who indicate that VMI will facilitate production smoothing and that VMI offers more benefits when production capacity is limited and demand variation is high.

It appears that the performance of the current Direct Deliveries strategy is at a satisfactory level and returning to the VMI solution is not something the supplier aims at.

7.8 Concluding remarks

Deciding whether this case is a success or a failure is a discussion related to time. It is indicated that the reason for termination was high warehouse costs at the customer side of the relationship. Other less than optimal performances were related to the startup inefficiencies of the production line causing irregular shipments and warehouse volumes. Instability of the production process at the supplier side made a substantial contribution to the high warehouse costs at the customer side that at that point in time reduced the successfulness of the collaboration program.

However, knowing what they knew two years later, the supplier's production line had stabilized and provided the supplier with excess capacity. This enabled the supplier to reduce the safety stock levels, and it is presumed that the new performance level of the production line would have offered a correlating opportunity to reduce warehouse volumes and costs in the VMI program. It is not unlikely that the program, provided that it was continued, could have been considered a success.

This case is one more support to the statement that electronic information exchange and increased level of integration improves the performance of a VMI program and that VMI can be a means to reduce distribution costs.

The contribution of this presumption to the overall subject of VMI success is that regularity and certainty of supplies appears to have an effect on VMI successfulness and should be further addressed.

8 Case description Tingstad – Kverneland Klepp

Case 3 is the VMI relationship between Tingstad and Kverneland Klepp where Tingstad has resumed full responsibility for replenishment of fasteners for attachment solutions applied in Kverneland Klepp's manufacturing of ploughs for agriculture and farming. The program had been running for four years when the interviews were performed. One meeting, four telephone conversations and five e-mail exchanges form the fundament of the data collection in this case and the communication is listed in Table 8-1.

Table 8-1, communication for case 3

Date	*Communication*	*Purpose*
May 05	Telephone	Establish contact and get appointment for interview
June 05	Meeting	Interview with Tingstad
July 05	Telephone	Clearing up on details
July 05	e-mail	Case description Tingstad
August 05	Telephone	Clearing up on details on case description
August 05	Telephone	Interview with Kverneland Klepp
August 05	e-mails	Case description and clearing up on details

The main interview was held at Tingstad's head office in Breivika outside Ålesund, participants were Ronny Furstrand, Logistics and supply solutions manager at Tingstad and Astrid Vigtil, researcher, NTNU. Follow-up phone calls were directed to Øyvind Søyland, Tingstad's representative at Kverneland Klepp. Additionally, a phone interview with Sem Ueland, production manager at Kverneland Klepp was held to discuss the customer side of the relationship.

8.1 The supplier

The company Koppernæs was established in Ålesund in 1884 as a wholesaler supplying consumption equipment to fishing, ship-owners and shipbuilding industry. The Koppernæs family was pioneers in many aspects of fishing and shipping and the company gradually expanded to own fishing-boats, fishmeal and fish oil production and development of safety equipment for ships.

In parallel, the company Tingstad was established in Oslo in 1935 and they quickly became a global market leader within fasteners and tools for attachment and assembly processes. Tingstad's core competence was in global sourcing and they have contacts around the world.

In 2000 Tingstad was acquired by Koppernæs. The Koppernæs Group was split in three divisions; Brude, the safety equipment division, Vedde, the fishmeal and fish oil division and Tingstad, the fastener and tool division. The Tingstad name was selected because this was a well known world wide established brand.

All together the Koppernæs group had an annual turnover on NOK 600 millions in 2005, 250 of these being produced by the Tingstad division and their 120 employees.

Tingstad have administration and central warehouses in Ålesund and Oslo, five regional sales offices and four collaborating partners around Norway. Their largest customers are in the maritime and oil industry but they also supply furniture manufacturers and metal working industry.

Tingstad operate in a market characterized by fierce competition from local and global actors and their strategy is to compete on value adding activities supporting the physical products. They undertake total responsibility for replenishment of a wide selection of fasteners, tools and other consumption products, their value chain integration strategy includes replenishment systems based on a two-bin system and they prepare packages of screws, nuts and bolts for on location assembly at end customer premises. Two-bin systems are applied at approx 70 customers and with 15 of these Tingstad have resumed some level of replenishment responsibility. In 2005 they launched the pilot of a web-based customer access point offering log-in access to customer specific statistics, purchasing history and on-line ordering.

The earlier Tingstad core competence in global sourcing is focused on Far East sourcing where component manufacturing on special request can be performed at low price. However, facing very strict quality requirements from customers and long transport lead times this is a challenging operation, and as will be seen in this case study it has caused inefficiencies in their value chain strategy initiative.

8.2 The customer

The history of Kverneland Group dates back to 1879 when the company was first established as a small plough producer in the village of Kvernaland in Norway. The first production activity was forging of scythes, and with a freshly designed water powered spring hammer they used mass production principles to outperform their competitors who still used manual production methods. The product spectre grew to include ploughs and harrows and after more than 125 years in business and a constant search for growth and acquisitions the Kverneland Group is now one of the largest manufacturers of farming equipment with a turnover in 2004 on EUR 500 million and a total number of more than 2800 employees.

Still located in Kverneland but heavily expanded, at Kverneland Klepp they manufacture ploughs, soil packers, disc and power harrows, rotary tillers and all purpose forks. Their core competence is in metal working (hardening and forging technology) and they design and manufacture most of the components in house. On average they produce 5000 units per year and more than 90% is for export. The manufacturing process is complex, high technology and time consuming but in an overall picture there are three main steps involved, component production, sub-assembly and final assembly (see Figure 8-2). All ploughs are manufactured on order and the average lead time for a standard plough is approx. 4 weeks.

8.3 The connection between Tingstad and Kverneland Klepp

Kverneland Klepp used to have a large central warehouse at their premises and though the pallets were piling up they tended to be out of the specific part needed. The warehouse building was urgently required for production facilities rather than storage and they wanted to change the inventory structure of the factory. They also realized the urgent need to improve the inventory control function. The current structure was inefficient, employing between 20 and 30 persons operating the warehouse and supplying the production lines. Small stock-points close to each assembly line was expected to be the most efficient structure but inventory management was not Kverneland Klepp's core competence and they decided to outsource this management activity.

As part of Kverneland Klepp's effort in restructuring their inventory systems, they initiated a supplier collaboration project to establish satellite stock-points assigned to each assembly process. The initial planning involved another supplier, but when the other supplier withdrew from the project, Tingstad stepped in.

Tingstad now supplies Kverneland Klepp with fasteners, screws, nuts and bolts etc. on a VMI contract. They have resumed full replenishment responsibility, and ownership of the goods remains with the supplier until the components are withdrawn from stock.

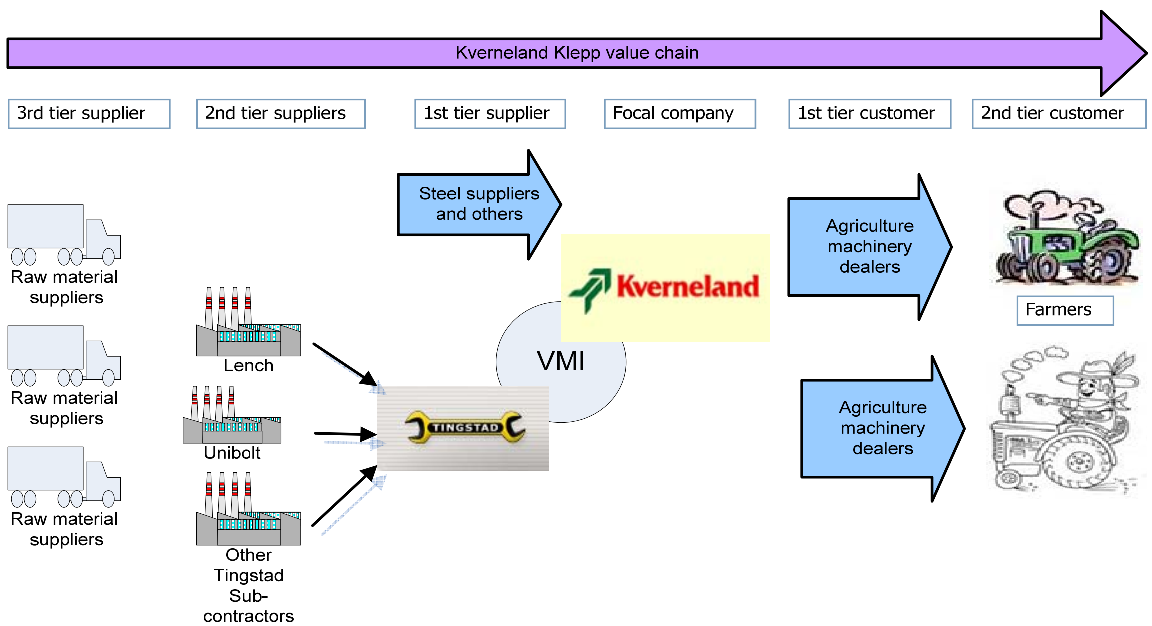


Figure 8-1, Kverneland Klepp value chain

Kverneland Klepp wanted to have one single contact point and Tingstad was assigned the responsibility to administer the relationship with more than 10 other suppliers. Many of these used to be 1st tier suppliers to Kverneland Klepp, now they are sub-suppliers administered by Tingstad. The supply chain illustration in Figure 8-1 where Kverneland Klepp is viewed as the focal company indicates that Tingstad is the 1st tier supplier and wholesaler, and resumes full responsibility for supplies from multiple sub-suppliers to replenish on customer's (focal company) demand.

In early 2001, 39 satellite stock-points, each dedicated to a certain operation area, were established on a two-bin system. After four years in operation the number of satellites had increased to 44. Tingstad supplies approximately 600 different SKU's and because many components are stored in several parallel satellites they manage some 5.000 different storage units. Every storage unit is represented by two boxes and a total of 10.000 boxes are in operation. Tingstad is responsible for refilling empty boxes and return them to their correct stock-point.

The fasteners enter the manufacturing at the sub-assembly and final assembly processes. Figure 8-2 depicts the customer's main process steps and where in the process the components from the supplier enter the value chain. This figure shows that component manufacturing lead time is about 14 days and the total production process lead time is about 30 days.

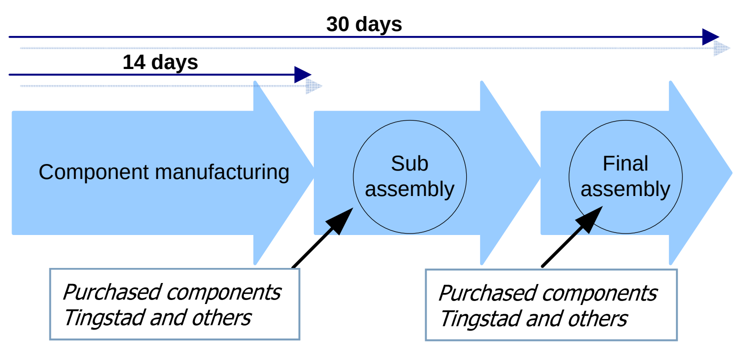


Figure 8-2, Process step sequence at Kverneland Klepp

Kverneland Klepp had no past experience with the Koppernæs Group but had long relations to Tingstad from prior to the Koppernæs acquisition.

Most of the conditions for the new collaboration scheme were set by the customer. An absolute availability of parts is required and a delay in Kverneland Klepp's plough production due to a shortage in bolt supplies is unacceptable. If Tingstad cannot supply from their regular channels, expensive rush orders are initiated at Tingstad's expense. *Product availability* is the main performance measure applied and nothing less than 100% is accepted.

The fasteners and products supplied are customer specific with respect to e.g. dimensions and required steel and surface treatment quality. The technology used to manufacture the products is however general and switching supplier is easily possible.

Nuts and bolt production is found very inflexible. Mass production and long set-up times offer little room for responsiveness. Long lead times and large lot sizes force the supplier to purchase large lots and store them at a central warehouse from where they supply the customer.

8.4 The case control model

The establishment of the 39 satellite stock-points, to find their optimal location and to furnish them with appropriate shelves and racks was a huge job. Two boxes for each part stored at each satellite were purchased. Hand held bar code scanners and terminals for data collection compatible with the supplier's ERP system were also required.

The control model shows that the supplier makes periodic reviews of inventory levels and replenishment is triggered by identification of empty boxes. This demand is communicated back to the supplier's central warehouse or directly to sub suppliers. The supplier uses forecasts from the customer to plan restocking of his central warehouse.

Once a week all empty boxes are scanned by a supplier representative using a hand-held scanner. Included in the bar-code information is the content id, full volume and assigned stock location. An empty box indicates that a reorder point is reached and once the scanned data is docked into the supplier's ERP system the demand information is treated as a customer order. The information and material flow related to the physical replenishment is as follows:

1. Scanned empty box information is loaded into the ERP system.
2. Based on the consumed parts an invoice is prepared and sent to the customer.
3. Replenishment orders are issued to the respective sub suppliers
4. Order confirmation and invoice from sub suppliers to Tingstad
5. Goods are shipped from the supplier's central warehouse in Oslo or directly from sub-supplier to the customer where a supplier representative distributes the goods to the empty boxes respectively. The dotted arrow indicates a temporary material flow that is established because one of the sub-suppliers initially did not perform up to the expected level on delivery reliability. The supplier established an intermediate stock-point on their own behalf outside the VMI warehouse to be able to fulfil their obligations. The main flow of goods is not directed via this warehouse. The warehouse holds a minimum safety stock and is located close to the customer.
6. Future expected demand is sent from customer to supplier

Most sub-suppliers deliver their goods to the supplier's warehouse in Oslo where they further distribute the goods as required. Two sub-suppliers deliver such high volumes that shipments are directed straight to the customer. All information in this cycle is transferred by electronic means and the information and material flow is depicted in Figure 8-3.

The physical inventory levels are controlled by the supplier and the control process is well functioning. The sharing of future expected demand is however facing some inefficiency.

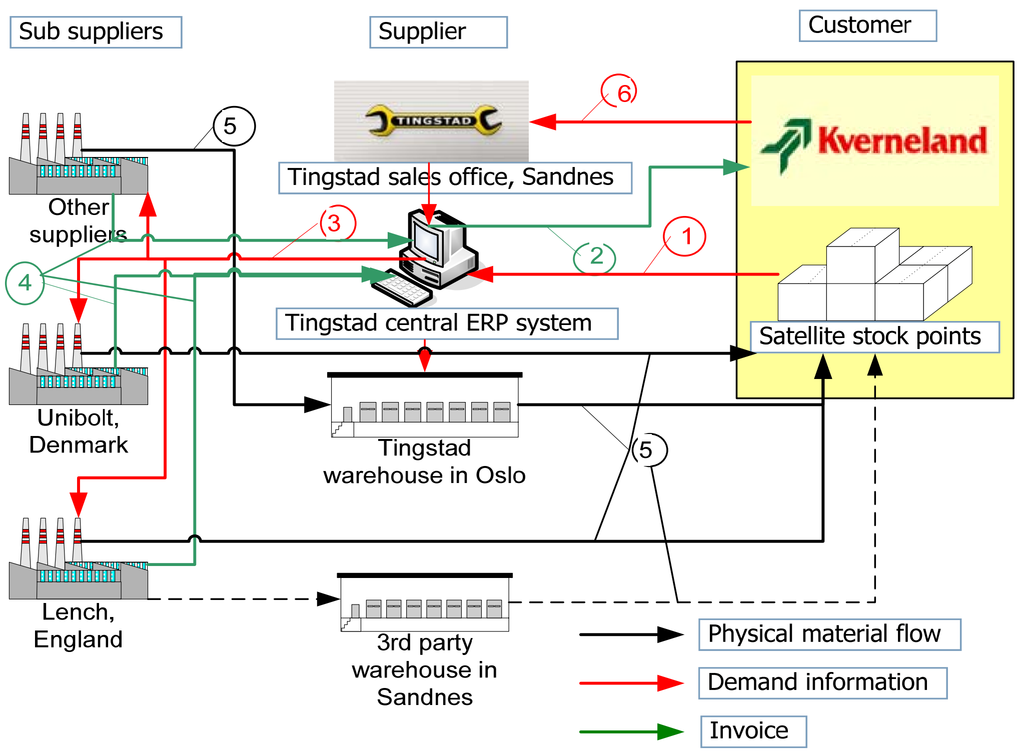


Figure 8-3, Information and material flow

The customer's future demand expectations are submitted to the supplier on three different levels,

1. annual sales forecasts,
2. semi annual updates of these forecasts and
3. monthly updated scheduled and opened orders

The last type of information has however turned out to be transmitted on slightly irregular intervals and due to end customer's opportunity to make last minute changes to his order and a demand for shorter delivery times of ploughs in general, this demand information is uncertain. Here it is appropriate to note that the cause of this uncertainty is not due to the customer's unwillingness to prepare good forecasts but the characteristics of the demand variation. The quality of demand information at this level is found insufficient and actions have been taken to improve this. The solution being worked on is outlined in section 8.7.1 New routines for demand information sharing below.

Routines for notifying the supplier when large orders are acquired are not established. This information is currently picked up by the supplier representative by occasion. The benefits of communicating this to the supplier are acknowledged by the customer and efforts to establish such routines are made.

The demand information transferred from the customer is processed manually at the supplier's local sales office and transformed into forecasts. These are used by the supplier's purchasing department. The forecasts are also forwarded to the two major parallel sub-suppliers.

Every 6 months there are follow-up meetings to discuss problems and future developments related to the collaboration program.

8.5 Objectives

The customer and the supplier had certain objectives for entering this agreement. The customer wanted to simplify the procurement and storage of consumables while the supplier wanted to increase market shares and assure customer retention.

8.5.1 Customer objectives

The customer's primary objective in this process was to assure 100% availability of fasteners and components on location when needed and they wanted someone to handle this on their behalf.

The customer's warehouse restructuring strategy included the establishment of decentralized satellite stock-points in order to

- → Make premises used for warehousing purposes available for expansion of production capacities, and
- → Improve operator efficiency by improving internal transportation,

As part of this strategy they wanted to outsource the replenishment and warehousing operation. The outsourcing strategy was the main purpose for initiating this collaboration program. This was expected to

- → Relieve the work load at the purchasing department, and
- → Reallocate warehouse operators to undertake tasks in manufacturing.

8.5.2 Supplier objectives

The supplier's prime objective for developing their value adding strategy was to assure customer retention and to keep competitors at arm's length. Also they aim at expanding the product spectre sold to each customer. Their objectives for entering this collaboration program were mainly strategic and related to their effort in making value added logistic services their competitive head,

- → to strengthen their bonds to a major customer,
- → subsequently increase the product assortment delivered to this customer,
- → Build more experience in performing value added logistic activities towards customers in general.
- → Obtain advance demand information to improve their forecasts and delivery performance.

A good VMI solution could reduce the total volume of goods at the warehouse. However, reducing the total number of items in each box is not an issue. The costs of stock-outs will by far outweigh the cost of storing the low value screws, nuts and bolts.

8.5.3 Achievement of objectives

The customer achieved their objectives. When turning the supplier into their single point of contact and making them responsible for more than 10 other suppliers, they removed multiple trading partners and experienced reduced workload in the purchasing department. The coinciding establishment of electronic communication links has also reduced the workload. In parallel, when outsourcing the warehouse operation they were able to remove all warehouse operator positions and reallocate these resources to production lines in need of operator capacity.

In general, the customer is very happy with the services offered by the supplier. They find the solution very satisfactory and product availability is by far the best they have ever experienced. The presence of the supplier representative makes possible problems being taken care of at an early stage. The supplier is also encouraged by the customer to look for external suppliers of components that are currently manufactured in house. The engagement in this sort of collaboration program made the customer more concerned about their logistics and material flow in general and they have become more open to changes and new obligations to obtain logistic improvements.

The supplier was not too happy about the state of the collaboration program and claims that though the program is strategically important the success is conditional. Their achievements include

→ strengthening their bonds to a major customer,

→ increase in product assortment and volumes sold to this customer

→ they have built on this experience to develop more favourable contracts with other customers

However, obtaining advance demand information to improve their forecasts and delivery performance has not been successful. It is indicated that the main reason for the missing benefits is the poor quality of the future demand information shared by the customer. This observation supports Kulp (2002) who claims that when information is not reliable VMI is not better than traditional replenishment models.

The establishment of electronic communication links is stated to be the main cause of improved order handling efficiency and future demand information sharing accessed by internet based links is assumed to further improve the supplier's replenishment planning process.

8.6 How the case corresponds to the research question

The case is considered a success by the customer and the supplier is prepared to continue the relationship and to improve the operational terms in order to make it financial viable for strategic reasons. The following summarizes on how the case corresponds to the research question.

8.6.1 Information sharing

Weekly updates of emptied boxes is electronically collected and transmitted to the supplier's ERP system. Information on planned and initiated production is supposed to be transmitted to supplier on a monthly bases but this has not been working satisfactory. Information about large projects and incoming orders are usually picked up by supplier representative on location before it is transmitted by official means. Annual and semi annual forecasts are transferred manually. There is no regular transmission of information from supplier to customer, but supplier is expected to notify customer in case of delivery problems.

8.6.2 Performance measurement

Supplier is measured on stock-out level. Customer performance is not measured.

8.6.3 Communication and cooperation

Initially there were discussions on the terms of the contract but in general the supplier agreed to the terms suggested by the customer. Along the contract period there are regular meetings for assessment and refinement of the collaboration program where both forecasts and product developments are discussed. Product development includes both improving existing parts and finding other suppliers to make parts currently being made in house by the customer.

8.6.4 Product and market characteristics

Some of the products are standard fasteners but many of the products have special requests with respect to steel quality. Prices are low, particularly by far east manufacturers, but replenishment lead times are long due to large lot sizes and long shipment distances where sea transport is the only feasible option. Products are easily substitutable and supplier can easily be switched. Prices are stable, and demand is unpredictable and subjected to seasonal variations.

8.6.5 Trust and contract regulation

The agreement is regulated by a contract resting on incentive mechanisms and sanctions. If the supplier comes up with solutions and products beneficial to the customer the sales volumes will increase as the number of services and products provided by the supplier is increased. If the supplier cannot deliver as required he is expected to take actions on his own expenses.

There was history of earlier business between the customer and a company being acquired by the supplier but no earlier relations was built between the customer and the new supplier organization. Calculative trust was present but relational trust was not built prior to the initiation of the contract.

8.7 Lessons learned

This case represents a complex and extensive VMI relationship where products, stock points and sub suppliers are multiple. Advance demand information is uncertain, product requirements are absolute and replenishment lead times are long. It has shown difficult to make the program financially beneficial to the supplier but yet the supplier has spent time and resources to work out improvements. Objectives and accomplishments in this case are already outlined and the following sections reflect on the coming changes and opportunities of the collaboration program.

8.7.1 New routines for demand information sharing

Demand information sharing is currently not at the preferred level and discussions regarding a new computerized solution are undertaken. The new solution is expected to represent a new forecasting tool for the supplier purchasing department that would ease the planning and coordination job considerably. Substantial cost reductions are expected from:

→ Reduced manual planning,

→ reduced express shipments,

→ reduced numbers of extraordinary purchases and

→ other fire fighting activities

It is also assumed that improved forecasts will support the sub-suppliers' performance.

The outlined solution is simple. The supplier is granted read-only access to the customer's ERP system to view incoming and opened orders that will indicate future demand. The supplier's replenishment lead time is longer than the customer's production lead time, and the incoming orders must be used for development of forecasts only. Inventory must be held to supply empty boxes. An extended update of Bills of Material (BOM) and some man hours for making the technical aspects of information sharing are required. Further details of this solution remains to be settled. These changes will allow the supplier to act more quickly on demand changes because the system assures notification. The changes do not change the uncertain nature of the demand information caused by the end customers' opportunity to make last minute changes.

Learning from the ongoing collaboration program, the customer has realized the importance of correct and updated BOMs. Routines for notifying the supplier whenever a redesign involves substitution of components supplied by them are established.

8.7.2 Little economic benefits

After four years of operation the economic benefits the supplier expected to see from participating in this collaboration scheme have not prevailed. Some main reasons are suggested:

→ The customer has a complex production structure where all products are customized. This offers no scale benefits and opportunities to tranship and flex between different customers' demand.

→ Long replenishment lead times and inflexible production increases the supplier's response time. Combined with less than optimal demand information, inventory levels grow.

→ Larger than expected variation of demand has added to the previous point,

→ The customer's demand for high quality components has reduced the supplier's opportunity to source in the Far East. Only 2/3 of expected Far East volumes have been realized.

However, accepting that a VMI relationship is a long term commitment of continuous development has eventually made the effects more favourable to the supplier, and experience gained from this project is used to develop more fruitful engagements with other customers.

8.7.3 Performance measurement

The only performance measure used in the collaboration program is component availability, and the supplier is prepared to take expensive actions to maintain the required service level of 100%.

Demand information has been discussed and found to be a major cause of less than expected cost reductions. Increasing awareness of the importance of advance demand information has initiated an improvement project. The customer was never measured on the quality of this demand information, which can be a reason why four years passed before the problem was attended to.

8.7.4 Demand uncertainty and responsiveness

In order to reduce costs the supplier wants to increase Far East sourcing volumes. Limitations are long lead times and unsatisfactory quality of the material available in that region. The quality of the material is given by nature and cannot be overcome by logistic solutions but for those components where the quality is satisfactory a proper logistic solution would find the optimal sourcing volumes.

Facing long lead times and inflexible production systems there are two means to improve the delivery performance,

→ reduce uncertainty of demand and

→ establish a responsive supply chain

Supply chain responsiveness is characterized by the ability to respond fast to changing customer needs (Lee, 2002). Build or assemble to order are typical production strategies. Mass production of nuts and bolts is not typical for responsiveness. The supplier's ability to increase the responsiveness of their Far East suppliers at an acceptable cost is rather unlikely. A possible strategy is using Far East suppliers for base demand and local suppliers for uncertain demand (see e.g. Harrison & van Hoek 2002:171).

Demand uncertainty can be reduced by using sell-through information for purchasing and forecasting (e.g. Lee et al. 2000, Småros et al. 2003). As previously described, sell-through information is when the customer's sales or incoming orders are transmitted to the supplier to indicate future demand.

Supplier access to sell-through information is as already outlined being worked on. The solution is based on extended use of ICT and judging by the perceived causes and circumstances it appears to be an important step in the right direction to make the VMI collaboration program beneficial to the supplier.

8.7.5 New production strategy at customer

The plough market requirements have changed radically over the last 5-10 years. 10 years ago, on time delivery of a finished plough was achieved in 50% of the sales on average, and this was the state of the business in general. Today the customers require 100% on time delivery and in parallel the required delivery time has shortened dramatically. The customer has therefore made considerable efforts to improve their delivery performance. They face fierce competition and even though their ploughs represent high quality and new technology they need to cut costs to lower their prices.

This challenge is met by standardization. They have reduced their selection of ploughs and they aim at combining orders to obtain benefits of batch production. This new standardization strategy is in line with modern trends in production management.

The customer's move towards standardization and coordinated batch assembly is indicated to have both benefits and disadvantages to the supplier's two-bin system due to changing demand pattern.

- → The main benefit is the reduced number of component variants that offer scale opportunities.
- → The main disadvantage experienced is the periodic variation of demand, i.e. the large demand for components used in the plough type being produced and the zero demand for components not needed. The supplier found the two-bin system to be less appropriate under such demand conditions and more responsive min-max solutions are applied at some satellites.

The change in demand pattern is a move from an uncontrolled random demand based on incoming orders to a controlled high or low demand based on planned production. The random demand is historically more evenly distributed between the various components while the controlled demand will cause larger demand variations.

The two-bin system and the max-min model are described in the inventory control technique chapter of this thesis and difference in flexibility lies within the determination of the reorder point and reorder volume.

In a two-bin system the reorder point is reached when one box is empty and the content of the box is not viewed during consumption. Deciding box volume is based on two determinants. Firstly, the minimum volume must be large enough to cover expected demand during replenishment lead time and to cover for safety stock decisions. Secondly the replenishment volume is affected by lot size policies which might exceed this minimum. The second determinant can be controlled by the supplier but the first one set definite standards for volume decisions and the two-bin system is inflexible with regard to changing volume demands.

When demand over the replenishment lead time changes, the parameters for calculating minimum box volume change. An increase in demand cannot be covered by increasing order volume because the order volume is determined by the box capacity, neither is increasing box throughput speed an option because this speed is determined by the replenishment lead time. The change can only be handled by increasing the capacity of the box (implicitly increasing reorder volume). The longer the lead time the more the change will impact on the performance of the replenishment system.

The new production environment is also expected to cause temporary decrease of demand, and when demand decreases the volumes in the replenishment systems will be found unnecessary high. This will have more effect on the inventory costs when the component or product is expensive. One way to deal with this is to reduce box capacity. This will reduce reorder volumes, improve throughput time and reduce total volumes in stock. However, altering between small and large boxes is likely to cause confusion. Deciding when to use small and large boxes could be a managerial issue absorbing more resources than abandoning the two-bin system and implementing a more flexible solution.

In a max-min model the replenishment decision is not dependent on the physical presence of an empty box and both replenishment volume and frequency can more easily be adjusted to suit real demand whether going up or down. However, moving to a max-min model requires a new inventory management system. The two-bin system is a manual system where actual inventory level within each box is never known. To run a max-min model it is vital to have absolute control over current inventory levels and computerized systems for stock control is frequently required.

This section has outlined why a two-bin system in theory can be found less appropriate in a manufacturing environment based on batch production principles. This is also described by Arnold & Chapman (2004:416) who claim that large lot sizes and long replenishment lead times are critical conditions causing problems for reorder point systems. The discussion has only been described from a theoretical perspective and not supported by empirical evidence. Neither has it been discussed how large the demand variations must become before changing box capacity in the two-bin system is necessary. The subject does however provide an interesting contribution to the issue of what inventory control models apply under different production and demand conditions.

8.8 Concluding remarks

Lessons learned from this case includes that it is important for the supplier to know the real requirements of the customer to ensure that products with the right quality are supplied. It is important to know the quality of the advance demand data available and it is recommended to establish routines for electronic and automatic data exchange to secure regular transfer. This case is therefore one more support to the statement that electronic information exchange and increased level of integration is an important element of VMI.

The case shows that VMI can be a tool to reduce operational work load for the customer and an opportunity to reallocate resources to other value adding activities. The case also shows that VMI can be a tool for increased customer retention and increased sales.

It is shown that insufficient demand information is a limitation to success as this will reduce the supplier’s ability to gain bullwhip reduction. Mass production and long replenishment lead times from sub suppliers appear to enhance the negative impact.

Performance measurement should be applied to reveal improvement areas and communication is important to assure a common understanding for the challenges and opportunities of the relationship.

Last but not least, the case shows that a VMI collaboration program is a long term commitment and one must expect some time to reach maturity. Therefore it is a strategic decision to involve in VMI collaboration. The payoffs are likely to come, both in the relationship in question and in the development of new relationships where experience helps avoiding the pitfalls.

9 Case description Hydro Automotive Structures Raufoss (HARA) - General Motors Opel

Case 4 is the VMI relationship between the supplier Hydro Automotive Structures Raufoss (HARA) and General Motors, Opel. The customer in this relationship is the very same customer that terminated the VMI relationship with RCT as described in case 2 and a general introduction to Opel is not repeated in this section. One meeting, two telephone conversations and four e-mail exchanges form the background to the data collection in this case and the communication is listed in Table 9-1.

Table 9-1, communication for case 4

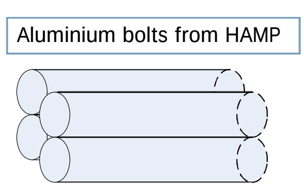
Date	*Communication*	*Purpose*
May 05	Telephone	Establish contact and get appointment for interview
July 05	Meeting	Interview with Hydro Aluminium structures
September 05	Telephone	Clearing up on details
October 05	e-mails	Case description and comments

The main interview was held at HARA's main office in Raufoss industrial estate, participants were Roy Jakobsen, Logistic manager HARA, Jan Marlow Beck, HARA and Astrid Vigtil, researcher NTNU. There was no tour around the production facilities as the researcher had toured the premises on an earlier occasion. The meeting was succeeded by a follow up phone meeting between the same three persons.

9.1 The supplier

Hydro Automotive Raufoss (HARA) is a plant of Hydro Aluminium Structures, a division of Hydro, a large Norwegian international corporation. HARA is located at Raufoss, in the same industrial estate as RCT from case 2. HARA manufactures aluminium bumpers and crash boxes for a wide number of car models. Their products are shipped to some 110 destinations and their customers are car manufacturers around the world, Opel, Toyota, Renault, Volvo, Audi, Nissan and Jaguar to name a few.

HARA's manufacturing process is highly automated and the three main processes involved are extrusion, shaping and surface treatment. Aluminium bolts are supplied by another Hydro plant (HAMP) situated in the same industrial estate.



- The first process is extruding these bolts to profiled beams (3 parallel lines).
- The second process is the shaping of these beams into bumpers (six parallel lines)
- The third process is surface treatment, aging.

75% of the products are ready for dispatch after heat treatment but the remaining bumpers need further processing. An overview of HARA's current processes and material flow is sketched in Figure 9-1. There are three parallel lines.

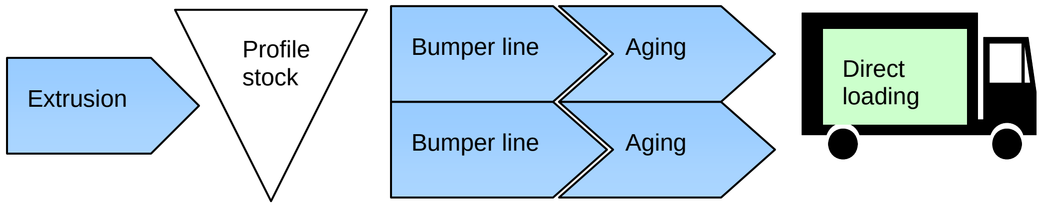


Figure 9-1, processes at HARA

The product structure is heavily expanding. The extrusion bolts come in 20 variants, they are processed to 140 different profiles and the total number of different bumper variants is 1200. Figure 9-2 illustrates this expansion. Gross manufacturing lead time is on average 35 days. This number varies with WIP inventory levels and an overall goal is to get down to 32 days. They manufacture approximately 5 million bumpers annually and their maximum capacity is 7 million.

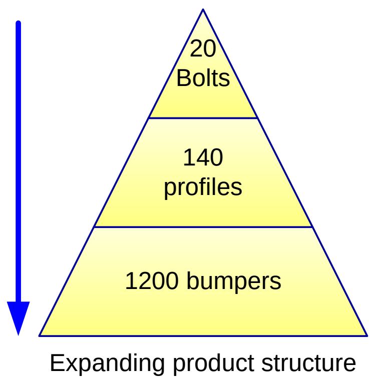


Figure 9-2, HARA's expanding product structure

The manufacturing process is considered inflexible. The six parallel production lines are highly specialized and once tooled up they can only produce a limited number of product variants. Setup time to change between these variants is 30 minutes and though it has been improved from 2 hours they aim at going down to 15 minutes.

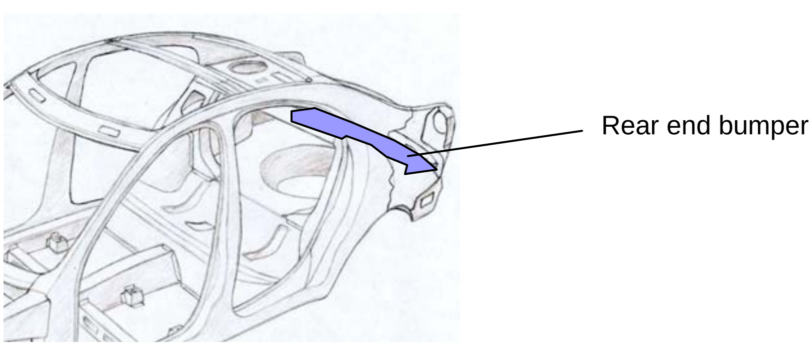


Figure 9-3 depicts placement of rear end bumper in a car

Figure 9-3, rear end bumper in car

The contract for supplies of bumpers is not nominated for the whole manufacturing life of a platform like in the RCT control arms case. The products are customized with respect to dimensions and shapes but suppliers can easily be switched. The main benefit of using aluminium bumpers is the low weight, but if HARA performs badly in the replenishment process there are multiple competitors ready to take their place.

9.2 The customer and the connection to the supplier

The customer in this relationship is GM Opel, the same customer that terminated the relationship with RCT from case 2. HARA supplies rear end bumpers to the final assembly plant in Ruesselsheim via a third party warehouse operator in Bischofsheim and one important difference between the HARA and the RCT relationship is that while RCT supplied the sub-assembly plant in Kaiserslautern HARA supplies the final assembly plant in Ruesselsheim.

In this relationship in can be discussed whether the relationship is a true VMI relationship or a replenishment program based on fast deliveries from a regional warehouse. The warehouse service is paid for by the supplier and the ownership of the goods remains with the supplier until the customer makes a withdrawal. The products are however customized, there are no other customers accessing the goods and the supplier's opportunity to tranship is not present. Customer orders are replaced by expected demand information sharing and notification of call-offs. It can therefore be argued that this collaboration program conforms to the requirements as outlined in the introduction. Figure 9-4 offers an overview of Opel's value chain where HARA is a VMI supplier.

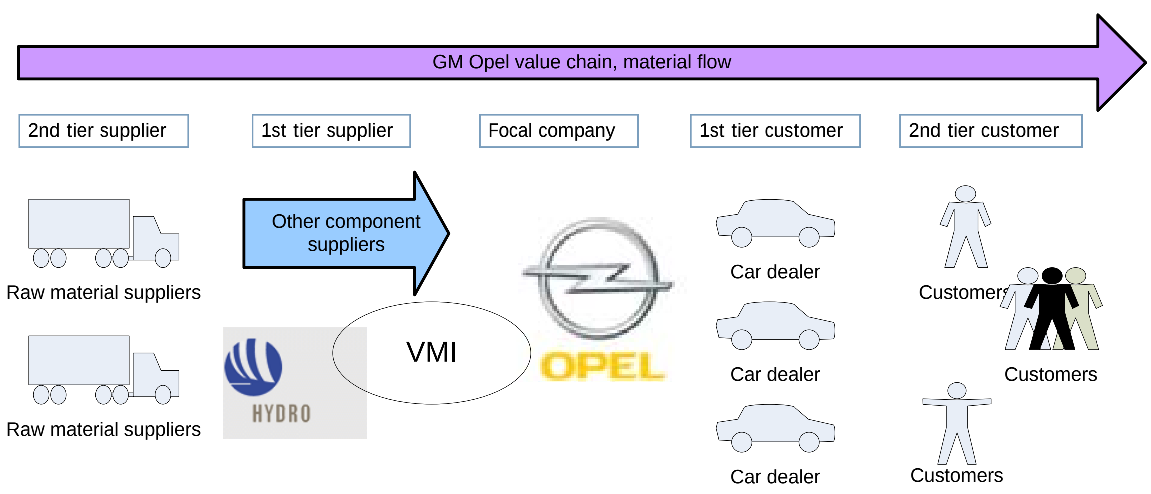


Figure 9-4, Opel value chain depicting Hydro as a VMI supplier

HARA is a VMI supplier in a total of seven replenishment programs. Over these seven programs there are slightly different solutions with respect to ownership and information transfer. Additionally the relationships differ with respect to volumes, frequency, contract period duration, geographic distance etc. HARA are quite happy with the relationship with Opel because they prefer a solution where they can control the goods while not yet being paid for.

9.3 The case control model

The control model applied in this case is very similar to how it was described in case 2, the RCT case. The main difference in information flow is that there is no EDI link established between the warehouse operator and HARA or Opel. The other main difference is that the goods are directed to a warehouse close to the final assembly plant rather than towards the sub-frame assembly plant. Except from these, the supplier plans operation based on weekly production forecasts and inventory level requirements and is measured on ability to maintain inventory levels within predefined intervals.

1. Three types of demand information are transferred from the customer to the suppler. Weekly production plans and call-offs are sent from customer to supplier on EDI. Supporting this information is both 6 and 12 months expected demand forecasts used for long term capacity planning. The information is directly incorporated into the suppliers ERP system,
2. As an immediate response to updated call-offs an invoice for reported stock withdrawals is sent from supplier to customer.
3. Physical stock withdrawals from the VMI warehouse to the production line is initiated by pick-up sheets.
4. In order to keep control of physical inventory level at the VMI warehouse, an excel file containing updated physical inventory levels is transferred from the warehouse operator to the supplier every week. This update is used to cross-check the expected levels calculated in the suppliers ERP system from what is shipped and what is withdrawn by the customer.
5. Accompanying the physical shipment is a paper copy pro forma invoice. A similar pro forma invoice is also forwarded to the customer for customs purposes. These are sent by mail.

This information and material flow is depicted in Figure 9-5 below.

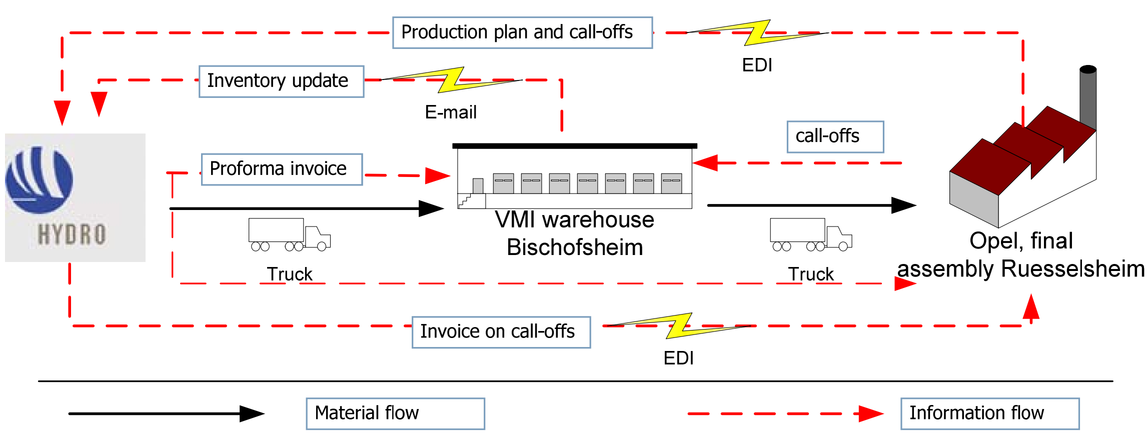


Figure 9-5, information and material flow between customer, supplier and warehouse operator

The weekly updated two week demand information is used for MRP calculations of HARA's production schedule. This MRP calculation includes demand during lead time, safety stock and spares. Advanced demand information supplied by the customer is a prerequisite for efficient production planning and the use of integrated transfer means has automated this process and offered substantial cost savings.

Material flow is well structured. Goods are dispatched from Raufoss by truck and sent to the warehouse in Bischofsheim. On a general basis, one truck load is shipped every week and the average inventory level represents 10 days of demand. Shipments from the warehouse to the customer are handled by a lorry service. This lorry service performs daily milk rounds to pick up replenishment goods from different warehouses in the region to feed the final assembly line in Ruesselsheim.

9.4 Relationship characteristics

The VMI replenishment contract between Opel and HARA was established in 2002 and it was conditional for the nomination of the contract that replenishment would follow VMI principles.

9.4.1 Investments required

The supplier had to establish a relationship with a 3rd party warehouse operator to handle the physical storage and control of the forwarded goods. This operator does not have any electronic communication links and information is transferred by standard means, e-mail and paper copies. In this specific agreement repacking takes place at the warehouse site. The bumpers are shipped from Raufoss in special steel racks that are incorporated into the manufacturing process. The bumpers are stored in these racks prior to the ageing process and they facilitate easy handling and volume efficient transportation. The customer does however require the bumpers to be delivered in another type of rack and repacking is performed by warehouse operators. The HARA racks are folded and returned to Raufoss for further use.

EDI links are established between the customer and the supplier. Both parties had similar links to other business contacts and this establishment was not considered a major investment.

9.4.2 Supplier's objectives

HARA's main objective for entering this agreement was to take the opportunity to operate with a warehouse close to the customer. The main logistic benefit is the opportunity to take cost advantage of full truck loads and this benefit is enlarged by restrictions on the national traffic system in Germany and restriction on delivery time windows at the customer's gate.

A second benefit pursued by the supplier is the opportunity to take advantage of combined shipments, i.e. fill a truck with goods to different customers in the same region to obtain cost benefits.

Thirdly they wanted to gain more experience in developing a VMI replenishment relationship as they saw the trend in the industry coming.

9.4.3 Customer's objectives

Customer representatives have not been interviewed in this specific case. It is therefore not correct to indicate what objectives the customer could have had. One can only make presumptions of customer's objectives based on indications from the general trends in the industry and specific objectives are not identified.

9.4.4 Initial collaboration

The establishment of the relationship between the customer and the supplier were not subject to much initial collaboration. The terms were very much set by the customer and the supplier had to accept these. Both the customer and the supplier had previous history of working together and both parties had experience in VMI replenishment.

9.4.5 Performance measures

The only performance HARA is measured on by the customer is product availability or stock-out level. Stopping the assembly line due to missing bumpers is unacceptable and 100% availability is the required service level. There is no agreement on maximum or minimum inventory levels and HARA's incentive to keep the volumes down in addition to capital employment is an extra warehouse charge from the 3rd party operator if volumes exceed a specified limit contracted between HARA and the operator.

9.4.6 Supplier benefits from VMI collaboration

HARA have found the program beneficial on all their objectives. They only ship full truck loads from the Raufoss plant, they have been able to combine transport to obtain scale benefits on shipments and they manage to maintain the service level required by the customer. Their main cost reduction element is the reduction of transaction costs as the sales process is automated and this effect is enforced by the establishment of electronic communication links.

9.5 How the case corresponds to the research question

The case is considered a success by the supplier and the customer has not reported any fundamental problems to the supplier. The following summarizes on how the case corresponds to the elements of the research question.

9.5.1 Information sharing

Information about production schedules and call-offs are send by EDI from customer to supplier weekly. Production schedules are incorporated into the suppliers production planning. Call-offs are used for invoicing and checked against inventory updates emailed weekly from warehouse operator. No information except from pro forma invoice is sent from supplier to customer.

9.5.2 Performance measurement

Supplier is measured on product availability and the main focus is on stock-out level. Supplier tried to measure the quality of the forecasts supplied by the customer but this did not work out. No other performance measures are applied.

9.5.3 Communication and cooperation

There was little cooperation between the customer and the supplier in the initiation of this program, the customer stated the terms and the supplier had a few comments that were taken into account. In the continuation of the program there is still little cooperation and communication except from regular updates. The supplier has learned to handle the circumstances by applying lean principles in the factory and strict control with the VMI stock.

9.5.4 Product and market characteristics

The product is customized, there is low risk of obsolescence and when stored properly the product will not deteriorate. While the supplier is market leader in aluminium bumpers the product can easily be substituted by bumpers made from other materials. Prices are stable and monetary density is low enough to prioritize cost efficient transport rather than capital employment in stock. Demand variation is seasonal but predictable and supplier is currently working on approximately 70% of maximum capacity.

9.5.5 Trust and contract regulations

The relationship is founded on a contract where the supplier is financially responsible for any economic losses the customer might suffer in case the supplier fails to perform as agreed. Both parties had previous experience in operating VMI contracts and they had been doing business with each other earlier. Calculative trust was present and a certain level of relational trust was developed (Rousseau et al. 1998). The contract appears to be built on calculative trust from the customer to the supplier as sanctions and power is used to enforce performance.

9.6 Lessons learned

This case shows a simple and well structured replenishment system for one product where demand is variable but predictable and where both parties had some previous experience in this type of operation.

The supplier has experienced cost benefits from this collaboration program. The benefits have materialized in reduced distribution and storage costs by enabling shipment of full truck loads and reduced safety stock from improved demand visibility. They have reduced their transaction costs towards this customer by the automated sales process, and they are taking their experience into the development of new VMI replenishment relationships.

It has not been directly stated by the customer that they are happy with the program in general or the supplier’s performance in particular but as the customer is known to take action if they are not happy it is assumed that they find the program beneficial. For the purpose of the analysis of the research, this case is considered a success.

9.6.1 Comparability to case 2

One of the most interesting aspects of this case is the unique opportunity it offers to compare two separate programs (HARA-Opel and RCT-Opel) that have so many similarities but still end up with different outcomes. This specific aspect is pursued conceptually in the discussion of findings.

9.7 Concluding remarks

This case brought two new elements to the study. Firstly, as the supplier had some experience in this type of replenishment they also appeared to manoeuvre more confidently within the opportunities and pitfalls of VMI. They appeared very convincing and seemed to know how they should operate in order to serve the customer as required. Secondly, this case supports some of the assumptions made in case 2 related to customer uncertainties.

Further, this case supports findings and lessons learned from the other cases. It shows that transfer of customer's production schedule is important because it enables the supplier to manufacture on lean principles with reduced set-ups and increased capacity utilization. This allows for full truck loads and reduced distribution costs, which are important solutions when capital employment in stock is less important than product availability.

The case is another example showing that increased level of integration reduces work load and increases data correctness. It also shows that VMI is applicable in cases where the number of different products is low, demand is predictable and access to raw materials and production capacity is stable.

This concludes the case descriptions and lessons learned from the cases. In the last part of this thesis findings from the cases are compared and analyzed in view of case study methodology and existing literature, and responses to the research question are prepared.

Part III

Scientific and Managerial Contribution

This part includes the data analysis and cross-case pattern matching that represents the fundament of the findings of this study. The hypotheses are revisited and it is further highlighted what are the responses to these hypotheses from this work.

Next, the framework for modelling of VMI collaboration is described, and an introduction to the Practitioners' Guide is presented.

The conclusions include a summary of the research process, a quality discussion of the work and suggestions for further research. The finalization of the work is a closure that summarizes on the main findings and results.

10 Data analysis and cross-case pattern matching

In order to identify causalities the cases presented above are subject to cross-case pattern matching. The five main subjects of the research question are discussed on the basis of patterns of replies depicted in the interview guide and the literature review. Each subject is subtracted from the interview guide table and presented individually. The different elements under each heading are isolated and case specific responses are displayed next to each other (see Table 10-1 through Table 10-11) to enable simple and visual comparison of the different cases. With respect to the causalities discussion it is emphasized that case 2 and case 3 have negative outcomes, further details of the individual replies can be found in the case descriptions.

Reflections over the interviews and the data collected have brought forward some ideas and suggestions elaborating the elements discussed during the interviews. They will add to the understanding of what can improve the chances of VMI success and they are included in the discussions.

The interview guide was developed to build a wide comprehension of the cases. The subtracted tables have different purposes and they present different types of data, and therefore they can not be discussed on equal terms. The analyses of information in tables 1 to 5, tables 7 and 9 offer recommendations, tables 6 and 10 presents a list of possibilities and table 8 present facts about case specific conditions and circumstances. The content of each table was presented and discussed in chapter 3.5 and following each table is a discussion of the replies. Every section is closed with conclusions related to each part of the research question.

When completing the tables, boxes ticked with X indicated positive response. Boxes ticked with N/A indicated the question was not applicable to the case. Blank boxes indicated negative response. A copy of each completed interview guide is presented in Appendix A.

10.1 Information sharing

The first area studied to find key parameters to successful VMI replenishment is information sharing and use of information systems. This area encompasses what data is transferred between the two parties (Table 10-1 and Table 10-3) and how this data is transferred (Table 10-2). This subject encompasses questions related to information sharing with respect to what information is shared, by what means and how frequently it is transmitted on an operational basis.

10.1.1 Data from customer to supplier

In the search for what information should be sent from customer to supplier, eight types of data were suggested. These were *inventory levels*, *incoming orders*, *stock withdrawals*, *production schedules*, *Sales data (POS and forecasts)*, *backorders* and *returns*. The objective was to identify what information is sufficient for periodic data update so the supplier can prepare replenishment plans on an operational level. The replies are depicted in Table 10-1. The table does not reflect sharing of annual or semi-annual forecasts.

The case specific replies on what data is transferred from customer to supplier on a regular basis are presented in Table 10-1, and following is an analysis of the replies.

Table 10-1, data transferred from customer to supplier

From customer to supplier	Case P	Case 1	Case 2	Case 3	Case 4
Inventory levels	X	X	X	X	X
Incoming orders	X				
Goods in transit	X	N/A	N/A	N/A	N/A
Stock withdrawals			X		X
Sales data (Point-Of-Sale)	X				
Production schedule			X	Forecasted	X
Back orders	X				
Returns					

The responses show that *Inventory level* is transferred in all the collaboration programs included in this study. This observation was not surprising considering the nature of the form of collaboration studied and the fact that almost all literature state its' importance.

Goods in transit were only applicable in the pilot because this was the only case where the customer had multiple warehouses storing the same products. In cases 1, 2 and 4 there was only one warehouse used for storing the products after they were shipped from supplier. In case 3 the same products were stored at multiple stock-points but the two-bin system offered no opportunity for internal transfer.

The cases show conformity to Pohlen & Goldsby (2003) in the question of using incoming order or production schedule. Incoming orders are considered one of the most important types of data transferred in the pilot where the goods are shipped directly to the customer's finished goods warehouse.

- In cases 2 and 4 the customer makes to stock and the production schedule is considered the most valuable demand input for the suppliers.
- In case 3 the customer manufactures to order and the missing transfer of incoming orders is assumed to be an important cause of the supplier's inability to replenish in a cost efficient manner.
- In case 1 the demand is dependent but variable and according to the discussion above, the type of data to be transferred is the customer's production schedule. However, the supplier is highly responsive and finds stock withdrawals sufficient for replenishment planning. Neither incoming orders nor production schedules are transferred.

If the customer is a manufacturer the value of incoming orders depends on the customer's market interaction strategy. If the customer makes to order an *incoming order* will affect stock withdrawals directly and thereby be a vital input to the supplier's replenishment plan. The time elapsed from order to stock withdrawal depends on e.g. order processing time and manufacturing capacity, and this time window can be substantial. The longer this time window, the more valuable it is as an indication of future demand. The supplier can take advantage of this time window for replenishment planning.

If the customer makes to stock, the link between an incoming order and a withdrawal from the VMI stock is disconnected. Incoming orders could represent valuable information for calculating forecasting quality and to indicate future demand, but the actual stock withdrawals will be affected by the *production schedule*. Therefore it can be argued that if a stock withdrawal is directly related to an incoming order (make to order or customer is wholesaler/retailer), i.e. facing independent demand, it is more urgent to transfer information about incoming orders, (see Figure 10-1). Stock withdrawals can be transferred for control purposes.

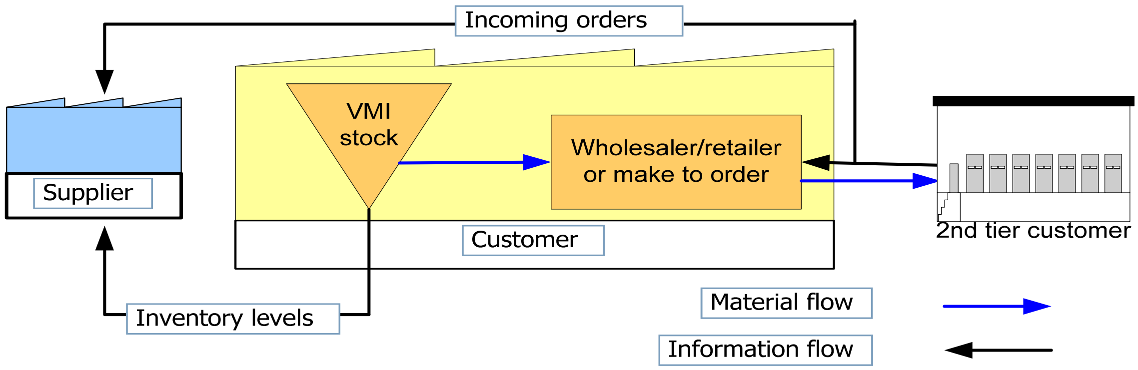


Figure 10-1, information sharing when customer is wholesaler/retailer or when manufacturing is make to order (independent demand)

If stock withdrawals relate to a production schedule (dependent demand) and products are stored to cover future demand, (Figure 10-2) it is more urgent to transfer production schedules and stock withdrawals. Incoming orders can be transferred for forecasting quality calculations. This is in line with Pohlen & Goldsby (2003).

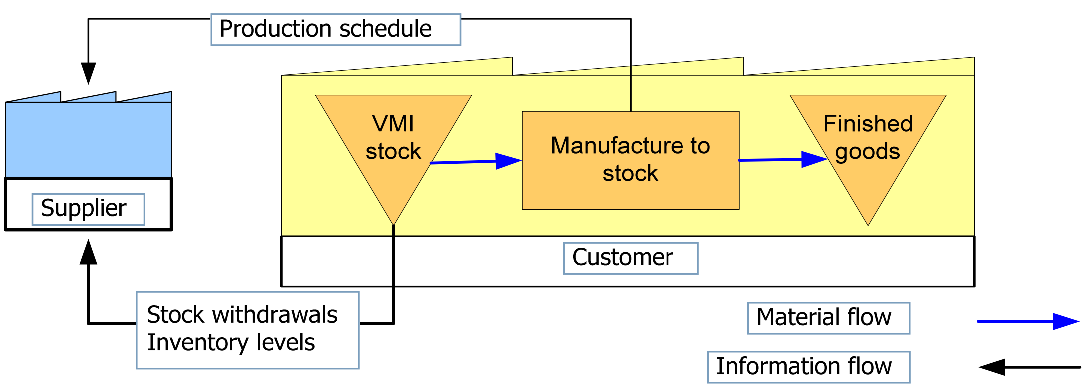


Figure 10-2, information sharing when customer makes to stock (dependent demand)

Point of sale data was transferred only in the pilot. Point of sale is defined as where the final consumer makes the purchase from the last actor in the supply chain and for all except from case 3 this point is two levels down the chain.

In case 3 the end customer is the immediate customer of the customer in the VMI relationship studied. POS and incoming orders would be the same data in this case. Neither POS nor incoming orders are transferred. Information shortage combined with long replenishment lead times on the supplier side is indicated to be a major cause of cost benefits failing to emerge for the supplier in this case. This finding supports the previous discussion on benefits of transferring incoming orders when customer makes to order.

In the pilot the customer's subsidiaries have no local inventories and any orders from end customers to subsidiaries are supplied from a distribution centre owned by the customer of the VMR relationship. Incoming orders and POS data is in reality the same.

– In case 1 POS data was not transferred and it was indicated by the supplier that it was not needed due to their responsiveness.

– In cases 2 and 4 POS data was not transferred. In these cases as well it was indicated that supplier responsiveness towards the customer's production schedule was sufficient for operational planning. Semi-annual forecast updates were applied for medium term planning on the tactical level.

From these findings it can be argued that the importance of POS data transfer is relative to the demand uncertainty and the responsiveness of the supplier. It can also be interpreted from this study that POS data is more important when the customer is a wholesaler or a manufacturer making to order than when he makes to stock to decouple sales and manufacturing.

The last three elements did not show any importance to the subject of this research question. *Sales forecasts* were subject for transfer only by the pilot where the supplier used the customer's sales forecasts to compare to their own and to update production plans. In the other cases sales forecasts was transferred less regularly. Theory on forecasting is not further pursued in this study.

Neither *returns* nor *backorders* were subject to high frequency periodic reviews for cases 1 to 4. The main reason was that such incidents were supposed not to occur and shouldn't be subject to high frequency periodic review. However, if they did occur they would be handled directly and with high priority by both parties and the supplier was expected to take immediate corrective action. In the pilot, backorders were registered to keep track of stock-outs. Even though these elements are not transferred from customer to supplier they can be applied as performance indicators.

10.1.2 How is data collected and transferred

The need for advance computer systems and automatic data transfer has been widely discussed in literature. Here it is called *level of integration* because it relates to time and manual interaction required in the transfer process. The case specific responses to how and how often information is transferred is shown in Table 10-2.

Table 10-2, data collection and transfer

Level of integration	Case P	Case 1	Case 2	Case 3	Case 4
Bar-coding/RFID	X		X	X	
Track-and-trace					
Electronic integration: EDI/internet	X	X	X	X	X
Manual integration: fax, phone, e-mail			X		X
Online					
Batch	X	X	X	X	X
By activity					

<u>Means of data transfer</u>

In all cases EDI or internet is used for information transfer. Both successful and unsuccessful cases apply electronic information transfer. It can therefore be stated that the use of such means is an enabler but not a guarantee for success. Statements from all five cases indicate that the use of integrated communication systems have played a major part in the successfulness of their VMR/VMI programs. The effect of the integrated automatic data transmission solutions are said to offer positive contributions, even in the programs turning out not so favourable.

- In case 1 it is stated that the use of automatic data transfer is the direct cause of cost reductions found in fast and reliable data transfer, causing reduced stock-out levels and reduced manual work load for both parties.
- In case 2 it is stated that the establishment of EDI links improved efficiency and reduced costs considerably with respect to stock withdrawal's effect on production and transportation planning.
- In case 3 it is stated that establishment of online read only access to the customer's ERP system removes the supplier's dependence on customer's routines to manually confirm periodic transmission of updated data.
- In case 4 it is stated that without the use of EDI and highly integrated ERP systems they would never be able to supply their customers on VMI principles. They confirm this statement by comparing their different VMI solutions and strongly insist that their ability to perform properly relies on the level of automation and integration of data transfer.
- In the pilot, for two years they used monthly data transfers that were manually prepared and applied, to confirm that the supplier's forecasts outperformed the customer's. This indicates that in this particular case they might have been able to run a successful VMR program without using a highly automated and integrated computer system. However, upon implementation the applied computer system was both automated and integrated and they never tried to operate the VMR program with the less integrated means.

Level of integration has not been subject to in depth studies in each case. It is however apparent that the benefits of the information systems relate to the automatic transfer from the sending party and the automatic update of receiving party's information system.

This supports Simchi-Levi et al (2000) who state the vitality of advanced information systems. The evidence are however not strong enough to contradict those who indicate that VMI can work with less integrated means (e.g. Mattson 2002, Waller et al. 1999, Ellinger et al. 1999, Holmström 1998). The probability that the automatic data transfer systems offers additional cost saving opportunities in several logistic related activities is considerable.

Transfer frequency

In all cases data transfer is periodic, i.e. 24 hours or weekly updates. This corresponds to alternative b) in the outlined combinations of transfer means and frequencies described in chapter 3.4.1. None of the respondents indicated that a more frequent update than what was applied would offer any benefits to the supplier. It is however argued that the data update should be available for operational production or distribution planning, and this was founded on the realization that unless there is a change in the expected demand pattern there is no need for extraordinary re-planning. The frequency of data transfer should be determined by the need for regular re-planning.

A general interpretation of these findings is that the individual needs (ref. Mattson 2002) would be determined by the need for re-planning of production and distribution which would only occur when actual activities have deviated from planned activities. Important variables would be demand uncertainty and planning cycles.

In order to make Mattsons (2002) suggestions more specific it is hereby suggested that the data update frequency should be equal to or higher than the supplier's re-planning frequency. This contradicts Simchi-Levi et al. (2000) who state that the advanced information systems should be online.

10.1.3 Data from supplier to customer

Table 10-3 shows case specific replies to whether or not advanced shipment data is transferred from supplier to customer or receiving warehouse and what is the information included in the ASN. Recall that the presumption related to this subject was founded on a need for an ASN only when ownership was transferred with transfer of physical location.

Table 10-3, data transferred from supplier to customer

From supplier to customer	Case P	Case 1	Case 2	Case 3	Case 4
Advance shipping Notice (ASN) incl.	X		X		
→ Product descriptions	X		X		
→ Quantities	X		X		
→ Delivery date	X		X		
→ Destination	X		X		

With respect to *ownership* to the goods, in this work the pilot and case 1 are cases of VMR while cases 2, 3 and 4 are cases of VMI. If the assumption is correct, the pilot and case 1 should have similar practices and cases 2, 3 and 4 should have similar practices.

The pilot and case 1 have different practices regarding advanced shipment notice.

- In the pilot the shipment is Ex works and the customer is notified both with respect to supplier's production plans, changes in production plans and final shipment plans. The customer is fully informed about future deliveries. The customer's main intention of requiring an ASN from the supplier was to assure early warnings in cases of delivery problems.

- In case 1 there is no information sent to the customer prior to a shipment. The supplier assumes full responsibility for the shipment and the goods are followed by paper copy freight documents used by the customer to update inventory levels. The volumes are found too low to justify the required computer system investments.

Cases 2, 3 and 4 also differ in ASN practices. They are all cases of VMI but only in case 2 the receiving warehouse was notified about expected arrivals.

- In case 2 the warehouse operator required this information for capacity planning purposes. The customer was notified by a pro forma invoice for customs purposes.

- Case 4 was identical to case 2 in this respect. The customer was informed about shipments by pro forma invoices for customs purposes. But in case 4 the warehouse operator was not notified about expected arrivals.

- In case 3 there are weekly replenishment shipments, contents vary based on what boxes were emptied over last period. A representative from the supplier is in charge of refilling empty boxes and the customer is not involved in the replenishment process at all.

It is hereby stated that the initial assumption regarding ownership and need for an ASN is contradicted, the need for ASN is not determined by time for transfer of ownership.

It is now appropriate to ask what would be the main *benefits of receiving ASNs.*

- In the pilot and case 2 where ASN is applied, the main reason is indicated to be warehouse operation planning purposes.
- In case 3 the need for planning is reduced by regular shipments and advanced notification with respect to content is not required.
- In case 1 it is stated that ASN is not required because the low volumes allow for warehouse handling whenever required.
- In case 4 it was indicated that the warehouse operator's capacity is sufficient to handle shipments when they arrive without any prior notice.

From these case statements it can be assumed that ASN is more important when warehouse operation capacity is limited, but as case 2 is an example of VMI failure despite ASN application it can be argued that the use of ASN is not a guarantee for success. An ASN can also be used for risk reduction purposes when customer wants to monitor supplier's performance.

There are both successful and unsuccessful collaboration programs not applying ASN, thus ASN application is not a requirement for successful VMI collaboration. In general it appears that ASN is not an important issue amongst VMI practitioners. This observation can be a parallel to the apprehension that this subject also has gained little attention in research literature.

10.1.4 Conclusions on information sharing

Key elements of advanced information systems in successful VMI replenishment are summarized as below:

Any information affecting customer's inventory status is valuable for the supplier but most important is *current inventory level*. Additionally:

- When customer is a manufacturer and makes to stock, production schedule and stock withdrawals should be transferred. Incoming orders and POS data could be transferred for improved forecasting.
- When customer is a wholesaler or a manufacturer making to order, information on incoming orders should be transferred. POS data, production schedules and stock withdrawals could be transferred for control purposes.

Point of Sales data is more important when demand is uncertain and when supplier responsiveness is low. When POS data and incoming orders are in reality the same, POS data should be transferred to supplier according to the incoming orders situation discussed above.

Applying electronic integration and automatic data updates is not a prerequisite for successful VMI but it is recommended because the cost saving opportunities and other benefits are found multiple.

Data update frequency should be in tact with the supplier's need for re-planning.

An ASN is particularly important for planning purposes when the receiving warehouse operates with limited capacity and resources.

10.2 Performance measurement

Performance measurement encompasses two types of performance indicators. These are:

– indicators measured to monitor and assess the other party's performance within the terms contracted (Table 10-4 and Table 10-5), and

– internal measures indicating the logistic effect of the collaboration program (Table 10-6)

The term logistic effects are here used to describe changes in logistic performance due to the implementation of the collaboration program and can be exemplified by improved inventory turnover, reduced distribution costs, smoothed production plans etc.

It was argued in chapter 2 that performance measurement is essential because you will always make an extra effort performing well on the elements you are evaluated. Also, choice of performance indicators reflects priorities. The supplier should be measured on the elements found most important for the customer and vice versa.

10.2.1 Supplier performance

Table 10-4 displays case replies on how supplier performance is measured.

Table 10-4, KPI's for operation management, supplier performance

Supplier performance	Case P	Case 1	Case 2	Case 3	Case 4
Service level (Product availability)					X
Replenishment lead time					
Inventory levels	X	X	X		
Inventory turnover	X	X			
Stock-out level	X	X	X	X	X
Order fill rate towards customer's customer					

It is in the nature of a VMI collaboration program that the supplier is given the responsibility for assuring product availability. It was therefore not surprising to observe that measuring supplier's ability to perform in this area is a common control concept. The extensive use of stock-out rather than service level probably reflects the operational purpose of the collaboration program in general but it was observed that the most fierce focus on stock-out level was found where the component replenished by VMI was a cheap but vital component in a manufacturing process where the cost of stocking up on components was substantially lower than the cost of delaying manufacturing due to component shortage.

Inventory level is a measure found particularly important in a VMR program. In the VMR program the supplier has no obvious cost incentive to keep inventory levels down as the ownership, cost and risk are transferred to the customer during shipment. Keeping track of inventory levels can be a means to balance the supplier's urge to avoid stock-out and the customer's need to keep inventory costs down (Figure 10-3).

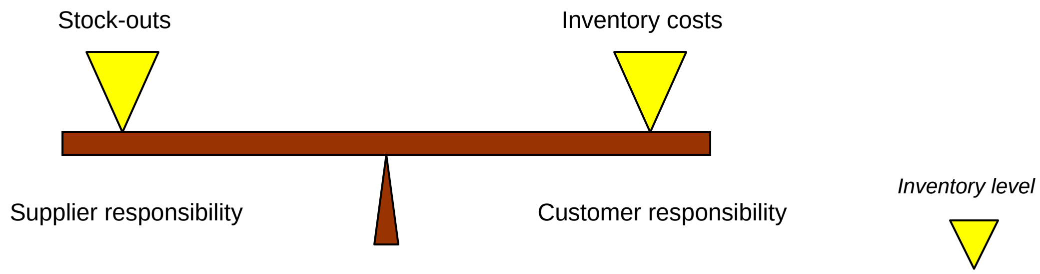


Figure 10-3, measuring inventory level to balance stock-out and inventory costs

Similarly, *turnover rate* is a measure more relevant for VMR programs where it is in the customer's interest to control replenishment volumes. Turnover rate on component level can be used to indicate what parts are fast movers and which are slow movers. The measure could thus be applied to identify opportunities for further improvements where the supplier is responsible for replenishment of multiple components.

Replenishment lead time was not used for performance measurement in any of the cases studied. This was not surprising considering the purpose of the collaboration program. The supplier is responsible for making products available to the customer and it is of secondary interest to the customer how much time the supplier needs to perform his tasks. None of the customers have taken an integrated supply chain approach to the programs.

Service level towards next tier customer is not indicated to be a performance measure in any of the cases studied. Considering the sampling criteria applied in this study, (customer in the dyad is a manufacturer), the observation that this measure is not applied is in line with the presumption. However, it cannot be stated whether this is due to casual coincidence or a firm and conscious decision made during the establishment of the collaboration program.

10.2.2 Customer performance

Table 10-5 shows case specific responses to how customer performance was measured.

Table 10-5, KPI's for operation management, customer performance

Customer performance	Case P	Case 1	Case 2	Case 3	Case 4
Information precision					
Information reliability					

In none of the cases studied, customer performance was measured. Neither those suggested in the interview guide nor other performance indicators were applied. In case 2 the supplier made an attempt to measure the customer on level of forecast error, i.e. the difference between weekly forecasted demand and actual demand. The attempt was however discontinued due to computer system inefficiencies.

In case 3 it was indicated that the non-existence of customer performance measurement has delayed the customer in acknowledging the importance of forecasting quality.

In the pilot it was revealed prior to the establishment of the VMR collaboration program that the quality of the customer's forecasts was less than appropriate. Forecasting is now subject to collaboration.

When forecasting is not subject to collaboration, the supplier is heavily dependent on the quality of forecasts or accuracy of production schedule transferred by the supplier. It is hereby indicated that by being measured on forecast quality the customer is more likely to make a better effort preparing quality forecasts.

10.2.3 Logistic effects of collaboration

In chapter 3 where the concept of VMI was described a long list of benefits and opportunities was presented. Prior to the data collection process it was assumed that the benefits would be reflected by case specific motives for entering the collaboration program and by what performance measures are applied. It was also assumed that there are differences in focus with respect to product and market characteristics. A list of possible logistic effects to the supplier from VMI implementation was included in the interview guide to map benefits observed, (see Table 10-6)

Table 10-6, effects to supplier from VMI implementation

Effects	Case P	Case 1	Case 2	Case 3	Case 4
Smoothed production	X		X	N/A	X
Extended time window for production and distribution planning	X		X		
Increased inventory turnover rate	X				
Increased service levels throughout the value chain	X				
Improved forecasting			X		X
Reduced capacity buffers required	X				
Increased flexibility			X		
Priority control	X	X	X		
Reduced distribution costs		X	X		X
Reduced obsolescence				X	
Faster end-of-life product removal			N/A	X	N/A
Reduced inventory levels					
Reduced storage costs					
Improved capital employment					
Reduced paper handling		X	X		X
Reduced value chain costs					
Increased sales					
Reduced demand uncertainty			X		X
Reduced safety stock levels			X		X

The first reflection evolving from these replies is that in addition to the assumptions on motives and performance measures, the improvements are also relative to the state of the situation prior to the change. Additionally, the reason some of the effects asked for were not observed was because they were not measured, and not necessarily because the effect was not obtained. Some of the observations are outlined here.

Smoothed production was experienced by all three large manufacturing suppliers of the cases (pilot, case 2 and case 4). In case 1 the supplier chose to decouple production and demand by a warehouse and smoothed production was not experienced by the VMR relationship.

Reduced distribution costs were experienced in case 1, 2 and 4, and it was one of the expected benefits failing to emerge in case 3. This was not measured in the pilot where the customer paid for the distribution both prior to and after the VMR implementation. Obviously these costs are recorded for accounting purposes but they were not used actively to measure effects of the VMR program.

Improved forecasting was observed in the two automotive cases supplying an assembly line (case 2 and 4). In the pilot forecasting was not improved, but the VMR project allowed the supplier to act on their own high quality forecasts rather than the customer's erratic ones. In case 3 this was one more of the expected benefits failing to prevail. In case 1 the supplier had not extended the VMR program to encompass forecasting.

Reduced paper handling was experienced when employing electronic means of information sharing, disregarding final outcome of the project. In the pilot they were already exchanging information electronically and the VMR program did not offer further reduction in this area. In case 3 the complexity required manual control that outweighed the reduction gained by the limited use of electronic integration.

In general there are positive effects observed in all cases, disregarding final outcome. Even in case 3 where the project had yet to add to the supplier's surplus, some benefits have still evolved. Interestingly there are more benefits found in case 2, which was considered unsuccessful and terminated by the customer, than in case 1 that is considered a success by both parties. The number of effects found according to the list in Table 10-6 can therefore not be an indication to level of success.

Based on these observations it can be argued that also those collaboration programs being unsuccessful to the supplier can offer some logistic benefits. This reflection suggests that success is in reality a subjective measure relative to the participants' objectives and initial situation. It was not the purpose of this study to question the case specific perceptions of success, Table 10-6 only offers a list of possible benefits worth looking for or aiming at in the process of striving for VMI success.

10.2.4 Conclusions on performance measurement

Performance measurement is an important tool to assure the other party's priority to a desired action. From the six performance indicators presented in section 2.5.5 Inventory performance measurement it appears that only three of them are applied. Inventory carrying costs are used in order to assume an acceptable service level and turnover rate is used regularly in the pilot and occasionally in case 1. Inventory investments, number of items managed by an operator and forecasting accuracy are not applied.

Table 10-7, applied inventory performance indicators

Financial		Productivity		Quality	
~~Inventory investments~~	Inventory carrying costs	Inventory turnover rate	~~No. of items managed by an inventory planner~~	~~Forecasting accuracy~~	Fill rate and service level

Table 10-7 is a copy of Table 2-4 and the performance measures not applied in any of the cases are marked with red x-es.

The following is an advice to what performance indicators should be applied to support the success of a VMI replenishment program.

Measuring supplier's continuous performance

The supplier should be measured on his ability to make products available upon demand. Service level or stock-out level should be measured.

– Stock-out level is the preferred measure in general and should in particular be at focus when availability is vital to supply a production schedule.

Inventory level should be measured when

– The ownership of the goods is transferred to the customer when the goods are shipped (VMR).

– When the supplier has contracted to keep the inventory level within maximum and minimum inventory limits,

Inventory turnover rate can be applied to measure supplier responsiveness and is more important for product differentiation when the supplier is responsible for replenishment of multiple products.

Service level towards next tier customer is automatically derived from stock-out level when the 1st tier customer is a wholesaler or retailer. Applying this measure places the dyadic relationship in a supply chain perspective.

– If service level towards 2nd tier customer is affected by the performance of the 1st tier customer, this way to measure supplier performance should not be applied without reservations.

Measuring customer's continuous performance

Quality of forecasts and forecast deviation should be measured when demand forecasts are developed by the customer alone and forecasting is not subject to collaboration.

Measuring effects of program to evaluate for success

A list of possible benefits is presented in Table 10-6, which ones are obtainable will depend on case specific circumstances and physical conditions.

10.3 Communication and cooperation

Communication and cooperation was identified by Simchi-Levi et al. (2000) as important for successful VMI. This research intended to identify what decisions and activities are subject to collaboration, both initially (Table 10-8) and continuously (Table 10-9).

10.3.1 Initial collaboration

Initial collaboration indicates to what extent the parties have discussed the terms of the contract and come to a mutual agreement on the decisions made. Table 10-8 shows what contract terms were subject to collaboration in the different cases studied.

Table 10-8, initial collaboration

Collaboration areas	Case P	Case 1	Case 2	Case 3	Case 4
Information standardization	X				
Service levels	X				
Inventory level goals (safety stock included)	X	X			
Lead time goals	X				
Pre-defined performance measurement levels	X				
Information sharing, type and frequency	X	X			
Ownership issues	X	X			

In the pilot and case 1 there was collaboration in the initial stages of the programs. For the pilot this collaboration was essential to build inter-organizational faith in the new replenishment program and it was vital for both parties that they could influence the decisions that would affect their future operation.

Case 3 was established by friendly negotiations but they did not rest on collaboration. The customer set the main terms and conditions upon which the supplier presented a solution. One of the main reasons for missing profitability on the supplier side is said to be shortages in establishment of a collaborative environment and the creation of a mutual understanding of the other party’s business environment and requirements. As the collaboration program continues, these shortcomings are improved and the benefits are evolving.

Cases 2 and 4 were established by negotiations. However the customer is a large manufacturer taking high volumes and is an important supply chain actor. His negotiation power was superior to the suppliers and he was able to dictate the requirements to optimize his own operation. The establishment of a suitable replenishment solution was not subject to collaboration.

10.3.2 Continuous collaboration

Collaboration during the contract period is important in order to build a best possible operation environment for the VMI program. Case specific replies are shown in Table 10-9.

Table 10-9, continuous collaboration

Collaboration areas	Case P	Case 1	Case 2	Case 3	Case 4
Forecasting	X	X		X	
Promotion planning	X				
New product development and introduction	X	X			
Product range management (product mix)	X	X	N/A	X	N/A

The replies show that the pilot is subject to a high level of collaboration, case 1 and 3 are partly subject to collaboration while in cases 2 and 4 there is very little collaboration.

The pilot and case 1 rest on collaboration for maintaining and improving program performance. In case 1 this collaboration occurs when the products are subject to occasional changes but in the pilot these are ongoing collaboration activities. The cases differ with respect to comprehensiveness and the pilot is more complex than case 1.

In case 3 they have introduced collaborative forecasting as a step towards supporting the supplier in the replenishment process, an action found valuable to the supplier so far. Additionally, the supplier aids in the customer's make or buy decisions. The supplier is continuously looking for specialized manufacturers being able to make components at a lower price than what can be done in house. The benefit to the customer is component availability at lower cost and the benefit to the supplier is increased sales volumes.

In cases 2 and 4 there was little collaboration concerning indications to future demand. Trade terms were mostly determined by the customer and the suppliers were left with an opportunity they could take or leave. The component demand is dependent on the demand for finished cars, and once the demand for finished cars is forecasted the demand for bumpers and wheel suspensions is automatically derived thereof. The suppliers did not claim to have any market knowledge valuable for the customer in development of forecasts and they did not want to engage in this process. Product mix is not applicable for collaboration in these cases. The contracts only apply to one type of product. A new edition of the end product will induce a new contract for components.

10.3.3 Conclusions on collaboration

It is indicated that neither initial nor continuous collaboration are prerequisites for successful VMI operation. However, collaboration is found more fruitful when products are multiple, when demand is more uncertain and when the whole collaboration program is more complex and comprehensive. A comprehensive program involving multiple stock-points and/or multiple products is difficult to build in detail prior to implementation. Therefore it is recommended to establish a forum where the parties meet regularly to discuss improvement opportunities.

Collaboration in general is found valuable for two reasons:

– First, agreements are based on negotiation and sub-optimizations can be avoided.

– Second, the parties develop a deeper understanding of each other's businesses, requirements and challenges in general and can support each other when new questions rise.

When demand for the replenished component is directly dependent on the demand for the end product there is less need for collaborative forecasting.

10.4 Product and market characteristics

Practitioners want to learn if VMI is suitable for their supply chain and therefore product and market characteristics are studied. The purpose has been to map case specific product and market characteristics in order to identify situations and circumstances where VMI collaboration is particularly beneficial or particularly difficult to embrace. Table 10-10 shows what characteristics are mapped and respective case replies. In the following discussion it is indicated to what extent the elements appear important judged by the different replies. This discussion takes particular reflection to the conclusions that the pilot and cases 1 and 4 have positive outcomes while cases 2 and 3 have negative outcomes.

Table 10-10, product and market characteristics

Aspects	Characteristics	Case P	Case 1	Case 2	Case 3	Case 4
Volume	High or low volumes	Low	Medium	High	High	Medium
	share of product range	80%	0,4 %	2 of 6	1%	5%
	share of customers involved	100%	1	1 of 7	low	low
Lead time	replenishment lead time	4-6 weeks	24 hours	Cont p, 3 days tr.	1 week, 3 weeks	1 week + 3 days
Demand variation	Seasonal or general variations,	Medium	low	seasonal	seasonal	seasonal
	variation predictability	High	high	medium	medium	high
Production capacity	Limited or well buffered manufacturing capacity at supplier	Limited	90% of max	Well buffered	N/A	70% of max
Price fluctuation	Stable or fluctuating price	Stable	stable	stable	stable	stable
Planning cycle	Supplier production replanning cycles	daily	daily	1 week	1 week	1 week
Monetary density	High or low value goods	High	low	Medium	low	medium
Level of customization	Highly customized or off-the-shelf component	Customized	customized	customized	customized	customized
Competitive situation	Monopoly, market leader or free competition	Free competition	Free competition	Free competition	Free competition	Free competition
Geographical distance	Distance between supplier and customer's warehouse	Northern Europe	2 hours by road	Europe	Northern Europe	Europe

Several of the characteristics mapped were similar to all the cases. The selection of similar cases was made for the purpose of making the cases comparable on a limited number of variables. This was explained as "most similar cases" in chapter 4.

10.4.1 Volumes

Volume of goods being shipped was mapped to study the comprehensiveness of the relationship from the supplier's perspective. It includes what volumes are shipped between the supplier and this particular customer, it includes how large the share of the supplier's total volumes is sent to this particular customer, and how many of the supplier's total number of customers are involved in VMI replenishment programs. This was studied because some authors (e.g. De Toni & Zamolo 2005, Waller et al. 1999) claim a certain "minimum volume" is required before setting up a VMI relationship is beneficial.

For *transferred volumes* it is observed that both unsuccessful cases encompass relatively high volumes. This can indicate that VMI is less beneficial when volumes are high, but that is contradictive to what is found in literature (e.g. De Toni & Zamolo 2005, Småros et al. 2003, Waller et al. 1999) and to theory related to scale economies. This is therefore not assumed to be a cause of failure but it can be an amplifier in cases being unsuccessful in the first place.

When analyzing *share of product range* there are no trends observed to indicate the relevance of this element. Both high and low shares are observed in both successful and unsuccessful cases.

The *share of customers involved* reflects how many customers with whom the supplier has established VMI agreements. Småros et al. (2003) study how a supplier can benefit when only parts of his customer base are VMI customers, and Waller et al. (1999) claim that VMI is more beneficial the higher the share of customers are VMI customers. In cases 1, 3 and 4 there is a low share customers involved in VMI collaboration, but in the pilot the supplier has only one customer and in case 2 the largest out of a few customers is involved. Neither in this element is any trend observed to indicate its relevance.

This study can therefore not conclude on volume related characteristics as key elements to successfulness in VMI collaboration.

10.4.2 Replenishment lead time

Replenishment lead time was mapped to compare supplier responsiveness and VMI benefits. Disney and Towill (2003a and b) show that VMI reduces demand uncertainty. Therefore it is interesting to study responsive suppliers that have reduced their reliance on forecasts by increased flexibility. De Toni & Zamolo (2005) perform a discussion on potential VMI benefits of a flexible vs. an inflexible manufacturing system. They state that if supplies are flexible and responsive, the time benefits obtained by advance demand information sharing and improved predictability have less effect. An assumption is made that responsive suppliers should obtain less cost benefits from VMI collaboration than suppliers relying on forecasts. It is a difference between suppliers being responsive due to VMI and those being responsive by flexibility.

In this study the pilot is the case where the supplier has the longest replenishment lead time and should benefit most from VMI according to the assumption. The program is considered a success and the improved forecasting has brought benefits to production planning and inventory levels.

Case 1 has the most responsive supplier. According to the assumption this supplier should not depend on forecasts and therefore should not gain VMI benefits. The interviews confirm that due to the responsiveness the supplier can base replenishment on actual inventory levels rather than forecasts. From Table 10-6 it is observed that the benefits to the supplier are few and they relate to priorities and paper handling rather than other logistic benefits. This observation supports the assumption, and it also supports Kaipia et al. (2002) who suggest that conditions like those found in case 1 will not gain substantial benefits from VMI collaboration.

In cases 2 and 4 the suppliers ship goods to the VMI warehouse several times during the planning period. They both considered themselves fairly responsive, yet their production smoothing and reduced distribution costs depend highly on the customer's production schedule. Their responsiveness is built on advance demand information and their logistics benefits gained are related to this.

In case 3 the supplier operates with a one week replenishment lead time and for most of the components the goods are shipped from a central warehouse. In this case the challenge is not the relation between unpredictable demand and replenishment lead time because stock levels at the VMI stock will buffer for variations. The main challenge here is the lead time from sub-suppliers for restocking the central warehouse. When facing long re-stocking lead times the supplier would benefit just as much to quality forecasts as he would when facing long replenishment lead times. It is indicated that the long re-stocking lead times enforce the negative effect of the supplier's inability to dampen demand uncertainty. When the supplier is stuck between demand uncertainty from his customer and long re-stocking lead times from his suppliers he can safeguard from stock-outs by carrying high inventories and buying from more responsive and more expensive suppliers. Either way his costs will increase. Figure 10-4 illustrates difference of re-stocking and replenishment as applied in this discussion.

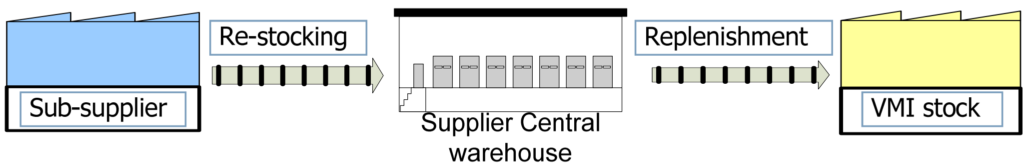


Figure 10-4, Case 3, restocking to central warehouse and replenishment of VMI stock at customer's premises

None of the cases contradict the assumption that responsive suppliers gain less logistic benefits from VMI. On the other hand, neither is responsiveness a limitation to successful VMI.

10.4.3 Demand variability and predictability

Demand variability and the predictability of variations were mapped to elaborate on conflicting opinions found in literature. Disney et al. (2001) indicated that slow moving products suffering from bullwhip are most suitable for VMI collaboration, and while Kulp (2002) indicates that Fisher (1997) suggests VMI is most suitable for products showing stable demand she herself claims the issue will not affect the benefits from VMI replenishment.

- In the pilot the demand is fairly stable and the collaboration program is initiated on the basis that demand is actually more stable than the supplier's forecasting model used to predict.
- In case 1 the demand is considered fairly stable. Actions have been taken to standardize product assortment and demand has stabilized even more.
- In case 2 it is indicated that demand was predictable though subject to seasonal variations.
- In case 3 the demand is unpredictable and to some extent instable. The instability is related to seasonal variations and general market variations and the unpredictability is directly related to the end customer's ability to make last minute changes to the order. The cause of failure is considered to be more related to the unpredictability rather than instability.

- In case 4 it is indicated that demand was predictable and fairly stable though seasonal.

These results indicate that demand variability is not an important determinant for VMI success. Predicted variations are handled with surplus production capacity, changing priorities or advance building of stock.

Kaipia et al. (2002) claim that VMI offer more benefits to products suffering from instable demand because these products tend to have longer throughput time. They indicate that success is more rewarding when demand is unstable. The cases studied here indicate that it is more difficult to establish a successful VMI program under such conditions.

Predictability appears to be an important element. If demand is unpredictable it is vital to establish communication links and collaboration routines to counteract demand uncertainty. Additionally, supplier responsiveness adds an element to this discussion. If the supplier suffers from long manufacturing lead time or long replenishment lead time from his own sub suppliers, and further actions to reduce this response time are fruitless, the supplier have to rely on high safety stocks. High safety stocks reduce the expected cost benefits and the program appears less successful.

In case 3 it is suggested that the supplier has failed to dampen the bullwhip effect due to *unreliable demand information*. Kulp (2002) investigated the effect of information reliability on VMI performance and she concluded that for unreliable systems a traditional replenishment model is just as successful as a VMI solution. Case 3 supports Kulp’s (op.cit) findings by being an example of a relationship where demand information is unreliable and where VMI has little success.

10.4.4 Production capacity

Production capacity maps the level of capacity utilization with the supplier. Waller et al. (1999) claim that VMI is more beneficial when the supplier is running close to maximum capacity because improved planning enables smoothed manufacturing.

- The pilot is a good example thereof. The main reason the supplier initiated the VMR project was the inherent possibility to smooth production due to limited capacity and one of the reasons the project is considered a success is the fact that this is accomplished.
- In case 1 the supplier is running on 90% of regular available capacity. The supplier has however decoupled manufacturing and replenishment with a regional warehouse that enables the supplier to smooth manufacturing independent of the customers demand.
- In case 2 the supplier had temporary limited capacity in the concurrent start-up period of the production line and the VMI program. The instable manufacturing process created a need for high safety stock and it was assumed that the high warehouse costs were the reason for program termination from the customer side. In this case the limited capacity caused high inventory costs. Therefore one of the findings from this case was that regularity and certainty of supplies and manufacturing process is an element of importance and should be further addressed.

- In case 3 the supplier is a distributor and does not perform any manufacturing. This question was thus not applicable to this case. Both case 2 and 3 are living examples of how need for safety inventory increases with supplies uncertainty as described in general theory on inventory calculations under uncertainty (e.g. Chopra & Meindl 2007:316-318).
- In case 4 they run on approximately 70% of absolute maximum capacity and the sharing of production schedule is an important input to the supplier’s production planning.

The pilot is a good example supporting Waller et al. (1999) but the results on this element are too inconsistent to offer any indications as to whether production capacity is a relevant variable for VMI success. Supply uncertainty effect on VMI has been outlined but no conclusions are drawn. This should be an issue for further discussion and research.

10.4.5 Price fluctuation

Price fluctuations were brought up under the proposition that VMI would work only when prices are stable. When prices fluctuate and purchasing is subject to trading and market analyses there is no incentive for the supplier to trade on behalf of the customer.

None of the cases were representatives cases of high price fluctuation, thus this proposition could not be tested.

10.4.6 Supplier replanning cycle

The supplier’s replanning cycle was mapped in order to support the discussion on supplier responsiveness and to compare replanning cycle to demand information receiving frequency. Conclusions on the relation between information sharing and replanning cycle were discussed in section 10.1.4. Discussion regarding responsiveness and VMI was presented in section 10.4.2.

10.4.7 Monetary density

Monetary density is a description of the volume and value of the goods. The purpose of mapping monetary density was to study how product value affected the priorities. It is assumed that it is more important to focus on inventory level reductions when value is high because inventory levels will affect capital employment. It is also assumed that when monetary density is low, cost reductions are sought in scale operation.

The replies indicate that there is a difference in cost saving focus with respect to the value of the goods. None of the suppliers of low value goods were concerned about inventory levels, the focus was on product availability and cost savings were sought in transport, for instance full truck loads and combined deliveries. The suppliers of more expensive products were more focused on reducing inventory levels to reduce costs. In all cases they acted as expected according to traditional theory on cost savings opportunities.

This observation conforms to the assumption. High value goods employ more capital when stored, and larger cost reductions can be achieved from reducing inventory levels. Transport costs are not directly affected by the value of the goods. In the trade-off between transport costs and inventory carrying costs, one should choose to reduce transport costs for low value goods and inventory carrying costs for the high value goods.

The pilot is a case of high monetary density, cases 2 and 4 of medium and cases 1 and 3 of low monetary density. Monetary density as such does not give any indications on likely success or failure.

10.4.8 Level of customization

One benefit of VMI as outlined by Waller et al. (1999) is the supplier’s ability to play with the goods and reassign deliveries to more critical orders. This will encompass both prioritizing resources and finished goods and it is called Priority control. Level of customization was mapped for the purpose of studying the relation between cost savings and priority control. If redirection of finished goods should at all be an option the products must be standardized, and customized goods remove one source of potential benefits.

All the cases studied encompass customized products and this subject could not be studied, but as there are both successful and unsuccessful cases included it can be argued that customization is not a determinant of success.

10.4.9 Competitive situation

This element was included to describe the competitive situation for the supplier. There were no assumptions following this element but the purpose of mapping the competitive situation was to study correlations between the customer’s possibility to select alternative suppliers and attitude towards the supplier in the collaborative environment.

All suppliers were operating in a market where competitors were ready to take their place. These particular suppliers were selected by the customers because they had a product or a service strategy that was found valuable and important.

In the pilot the supplier manufactures special products that are of strategic importance to the customer. Alternative products with similar functionality but of lower quality are available but not so competitive in the end customer market. The customer is therefore very interested in maintaining the business with the supplier.

In cases 1 and 3 the suppliers were selected because they had the interest and ability to serve the customers on a strategic level in addition to offering general but yet customized products. The established routines are likely to enforce the relationships as switching supplier will include some practical hassle. However, these hassles would be undertaken if the supplier fails to perform.

In cases 2 and 4 the customer have multiple alternative suppliers, however these particular suppliers were selected due to their excellence in designing and manufacturing the relevant components in a preferred material. The customer is likely to offer any competitor the same business terms.

All the suppliers studied operate in a competitive environment but the customers’ attitudes towards the relationships differ. The main difference observed is related to the extent the customer is involved in the ongoing decision process. Some customers take advantage of the competitive situation to ensure supplier priority. This appears in particular where alternative suppliers are multiple and switching costs are low. Higher level of dependency increases level of collaboration.

Competitive situation is not a key determinant for VMI success but it is of secondary importance as level of competitiveness appears to have an influence on the commitment from the customer.

10.4.10 Geographical distance

Geographical distance was included for the purpose of studying the relation between physical distance between the actors and the outcome of the replenishment program. The observations find no trends indicating any correlation and upon direct question none of the interviewees assumed this would be an issue. However, in a global perspective all cases encompassed dyads where geographical distance is short. General conclusions of geographical distance in a global perspective cannot be drawn from this study alone.

10.4.11 Conclusions on product and market characteristics

None of the mapped elements of product and market characteristics is in isolation identified as essential for successful VMI replenishment but some of the variables lead to different priorities and constructs of a program. The following summarises on the main lines drawn from the analysis of product and market characteristics.

- No volume related characteristics are identified as prerequisites or limitations to VMI success. It was however stated by several of the interviewees that a certain minimum trading volume was required to bother establishing the collaboration program.
- When demand is more instable and unpredictable it is more important to establish communication links and routines for demand information sharing. The more instable and unpredictable the more challenging is establishment of VMI collaboration, yet the potential benefits are higher. If predictability cannot be increased the costs are not removed from the supply chain, just pushed upstream.
- VMI collaboration appears more beneficial to the supplier when replenishment lead time is long.
- When production capacity is limited, efforts should be made to reduce set-up and smooth production volumes. VMI will facilitate both.
- When monetary density is high the focus should be on reducing inventory levels. When monetary density is low the focus should be on scale economies in production and distribution.
- When products are customized it is more important to focus on responsiveness and resource priority.
- When the replenished product is subject to free competition, the customers' engagements in VMI are motivated by opportunities to reduce workload and costs rather than to secure product availability.
- Geographical distance between customer and supplier facilities is no apparent limitation to VMI success.

10.5 Trust

It was suggested from the literature review that trust is essential in VMI and that mechanisms for governing of contracts can replace relational trust. Trust and government mechanisms are mapped (see Table 10-11), and duration of relationship was specified in the case descriptions.

Table 10-11, trust and other regulatory mechanisms

Regulation mechanisms	Case P	Case 1	Case 2	Case 3	Case 4
Power relations			X		X
Willingness to depend on another party	X				
Governance mechanisms and contracts	X	X	X	X	X
~ Incentive mechanisms	X			X	
~ Sanctions		X	X		X

Trust is indicated by all interviewees to be important in their relationship. The different interviewees' perception of trust was not subject to in depth questioning but it was indicated that the trust needed is some kind of fundamental calculative trust that every collaboration program will require.

– In the pilot a long term relational trust is developed. The good relation between the parties has been an important element in the discussions and development of the VMR program. Trust was the main reason why the customer selected this particular project to be a pilot for VMI implementation. The customer's willingness to share inventory and demand data was an important criterion when the supplier initiated the collaboration program. During the development phase the supplier was never denied access to any relevant data needed to establish the new routines.

– In case 1 the VMR program was established on calculative trust. The partners had some previous history of interaction and the relationship is developing towards relational trust. The contract is built on calculative terms offering both parties the opportunity to leave the relationship in case the other party fails to conform to his obligations. Neither party is vital to the other. The relationship is built on a genuine interest in developing efficient operation and gaining competitive advantages.

– In case 2 the VMI program was established on a take it or leave it basis where the supplier was likely to go out of business if choosing to turn the offer down. The relationship was calculative and power was superior to trust. The customer disclosed all their suppliers' performance on a web page and they realistically put bad performing suppliers in a public pillory. Though the daily operational communication was based on a collaborative environment aiming for operation efficiency, the driving force was an underlying struggle to obtain internal cost savings rather than a search for mutual benefits.

– In case 4 both the customer and the supplier had earlier relations and they had previous experience in VMI collaboration. The selected 3rd party warehouse operator had similar experience in doing business with the customer. The customer in this case applies the same public pillory methods as was the situation in case 2 and it is also seen in this case that the supplier aims at optimizing own operation rather than seeking mutual benefits. However, this relationship appears more resilient.

- In case 3 the parties had little previous history of interaction and there was no relational trust developed. The customer had some level of calculative trust in the supplier from the supplier's long term history of being a competitor in the supplier market. The supplier had a similar calculative trust in the customer. Over the years the supplier has proved his trustworthiness and the collaboration program is slowly developing to offer benefits to both parties.

The findings indicate that the longer the pre-VMI history of the relationship, the more successful the relationship appears. It is also indicated that the longer the VMI relationship has lasted the more successful it appears, whether based on mutual trust or power. This indicates that the more knowledge the parties have gained about each other's business, conditions and challenges the better they can develop a collaboration program offering mutual benefits, of which case 3 is a typical example.

The presumptions stated regarding trust are partly supported by all cases. In the pilot relational trust was developed prior to the VMR establishment and this process was highly integrated and focused on mutual benefits. The replenishment program in case 4 was developed by experienced VMI partners. Still there is little focus on mutual benefits. Cases 1, 2 and 3 were also established on calculative trust. The case 1 relationship was operating successfully on arms length and while the supplier proved his capabilities no further integration was embraced. The case 2 relationship was not founded on mutual benefits and cost benefits from improvements made by the suppler were not shared with the customer. The case 3 relationship was initiated on strict terms but as time passed and the supplier demonstrated effort in making the program work, the customer also helped in the improvement process and results were shared.

The first part of the presumption is supported as when only calculative trust is present the parties are more likely to focus on internal benefits and results. The second part of the presumption indicating that further improvements come with relational trust is not supported. The cases indicate that relational trust is required to move from internal to supply chain focus but it is not indicated that a move towards relational trust induces increased integration and supply chain thinking.

10.5.1 Conclusions on trust

The importance of trust as a contribution to success in a replenishment program based on VMI principles is summarized below:

- Some minimum level of calculative trust must be present. This calculative trust can be based on previous interaction or the actors' reputation.
- This trust is related to the perception that the other party can and will perform according to certain requirements and standards.
- Trust develops over time and further refinement of the collaboration program can grow from history of good performance.

10.6 Revisiting the hypotheses

The first five sections of this chapter have analyzed each of the five aspects of the research question based on cross-case analysis and comparison to existing literature. It is now about time to show how these results respond to the corresponding hypotheses. From the introduction it is recalled that the hypotheses of this research was:

There are at least five aspects of supply chain collaboration that will have an influence on the effect of a VMI program. These are

H 1. The way ICT is used to support communication and information exchange
H 2. How performance is measured
H 3. To what extent the parties collaborate initially and during operation
H 4. There are production, product and market characteristics that affect the appropriateness of VMI.
H 5. To what extent the parties trust each other

Further it is presumed that in cases where these properties are not in such state that they support the VMI program, logistic performance will suffer, costs will rise and the actors will look for alternative options.

This was illustrated by a figure which is copied to Figure 10-5 below:

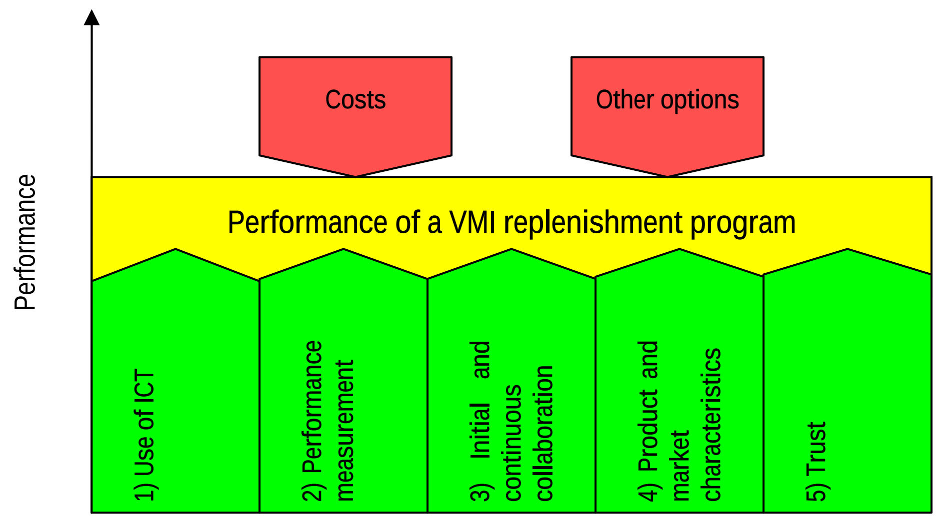


Figure 10-5, five aspects of supply chain collaboration that will influence VMI effect

Hypothesis 1

1. *The effect of a VMI program will be influenced by the way ICT is used to support communication and information exchange*

This hypothesis is supported by all cases because it is evident that where less integrated means are used (for instance e-mail or paper copies), transaction time is slower, office clerk work load is not reduced and timeliness and correctness of data is lower. This is supported by many researchers who have indicated that use of highly integrated information systems is required (e.g. Simchi-Levi et al. 2000). However, the evidence is not strong enough to state that use of highly integrated ICT is a requirement for success and the findings support for instance Mattson (2002), Waller et al. (1999) and Holmström (1998) who indicate that less integrated means can be applied.

Hypothesis 2

2. *The effect of a VMI program will be influenced by how performance is measured*

This hypothesis has two parts. First it concerns the measurement of each party's conformance to obligations, and second it concerns measuring the logistic effect and improvements of a program.

With respect to choice of performance indicators all cases support the hypothesis because there is consensus between product value and accepted stock-out level as a trade-off to reduce capital employment.

With respect to performance improvements this hypothesis is supported by case 3 because the customer improved their data quality when the supplier realized quality was unsatisfactory and made the customer aware of the consequences. In case 1 the inventory levels increased, but the supplier was never notified and hence actions were not taken.

Hypothesis 3

3. *The effect of a VMI program will be influenced by the extent the parties collaborate initially and during operation*

This hypothesis also has two parts. First it concerns collaboration in the planning phase, and second it concerns collaboration in the operational phase.

The hypothesis is supported by all cases on continuous collaboration because in those cases where collaborative improvement initiatives were pursued, benefits evolved (pilot and case 3). In those cases where there was no collaboration initiatives observed (cases 1, 2 and 4) benefits of minor improvements were kept in house.

On initial collaboration this is supported by all cases except case 4. In the pilot and case 1 there was initial collaboration and both cases are considered successful. In cases 2 and 3 there was little collaboration initially and the cases are considered not successful. The part is not supported by case 4. The case is considered a success despite little initial collaboration. The contract was signed by skilled negotiators with VMI experience from both parties. It can therefore be stated that the hypothesis is supported only under the conditions that one or both of the parties are inexperienced in establishment of VMI.

Hypothesis 4

4. *The effect of a VMI program will be influenced by production, product and market characteristics.*

This is supported because the study has revealed characteristics of production, product and market that will influence the effect of VMI. Those characteristics identified to reduce VMI effect are low demand predictability, high supplier responsiveness, high supplies uncertainty and product customization. Additionally, it is recommended that a certain volume is needed over a certain period

Monetary density will not influence VMI effect directly but experienced or missing cost savings will be proportionally enlarged by high monetary density.

Hypothesis 5

5. *The effect of a VMI program will be influenced by the extent the parties trust each other*

This is supported by the pilot and case 1 because in both cases a growing confidence in the system and move towards a relational trust reduced the desire to monitor and control the supplier's performance. Reduced control efforts reduced costs. The other cases are not contradictive to the hypothesis. In cases 2 and 4 the customer continued monitoring supplier performance and put it on public display. This was a chosen strategy and had not so much to do with the confidence in the specific suppliers.

To summarize on the hypotheses it is argued that:

- Hypothesis 1 is supported by all cases
- Hypothesis 2 is supported by all cases on the part of logistic effects and supported by case 3 on performance indicators
- Hypothesis 3 is supported conditionally as collaboration both initially and continuously is found important when the parties are inexperienced.
- Hypothesis 4 is supported and supporting elements are identified in all cases
- Hypothesis 5 is supported by the pilot and case 1, and it is not contradicted by the remaining cases

10.7 Summary

The purpose of this chapter has been to find responses to the hypotheses based on an analysis of the cases studied. The analysis method applied was cross case pattern matching and comparisons to literature aiming to find support to presumptions about some subjects expected to be central in VMI.

It has not been the ambitious goal of this analysis to identify prerequisites for success. The purpose has merely been to understand some of the operational mechanisms that affect the conditions of a VMI relationship.

The next chapter presents a framework for modelling of a VMI collaboration program. This framework is built on the results of this analysis and it will represent the scientific result of this study. Additionally, a practitioners' guide is developed in order to make the outcomes available to practitioners who want the results in an applied rather than a scientific perspective.

11 A Modelling Framework for Vendor Managed Inventory

This chapter presents a framework for VMI modelling. This framework contemplates the scientific contribution of this research. The recommendations are built on research that identifies mechanisms and logistic effects of different solutions applied in a VMI context. The purpose is to highlight the important parameters that will build a solid and resilient VMI collaboration program.

Next, these results are applied to develop a practitioner's guide to VMI. The guide is a set of general advices and a set of guidelines. The advices focus on understanding the practical implication of VMI replenishment, and at the same time they summarize on the conclusions presented for each of the five areas studied in the analysis. The guidelines will aid in the initial stages of establishment of VMI and they can be applied for refinement purposes.

11.1 A framework for VMI modelling

This framework shows the applicability of the scientific outcomes of this research. With reference to the theoretical framework presented in chapter 2, this modelling framework shows how the design components influence the development process but the scope of the framework encompasses only the control components. The framework is shown as a three level flow chart in Figure 11-1 and further described below.

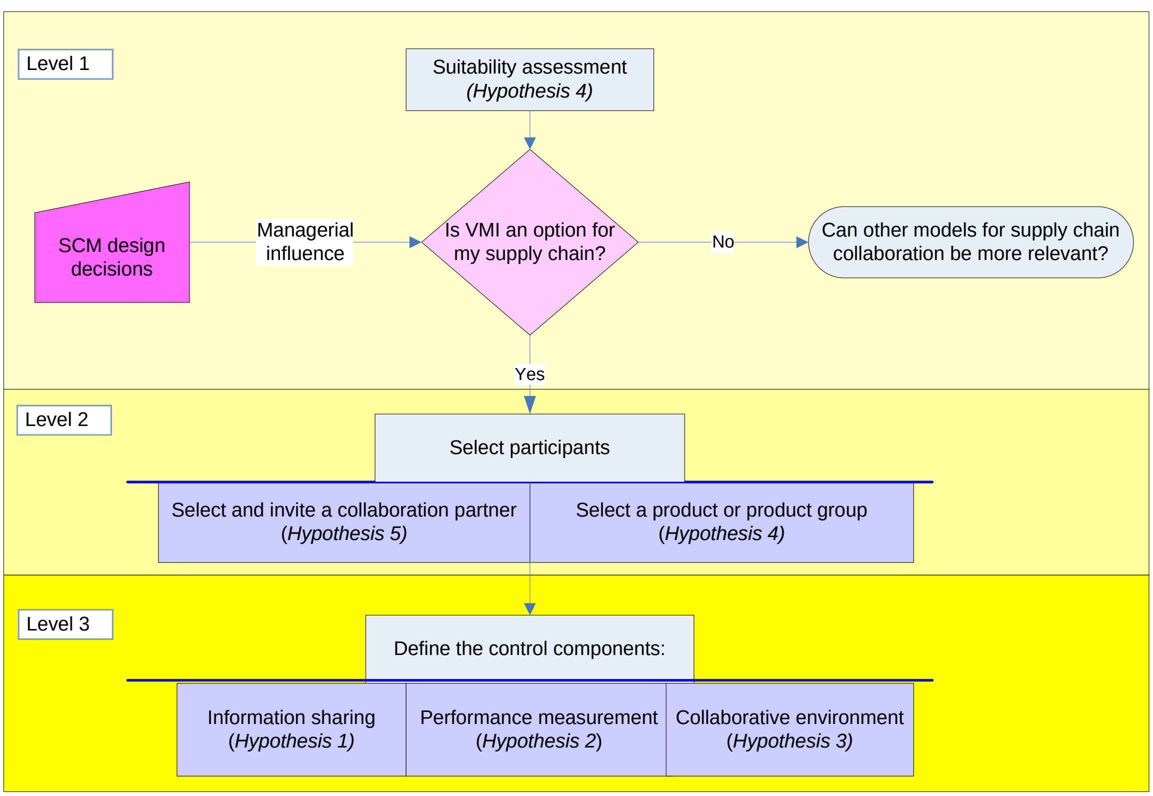


Figure 11-1, a framework for modelling VMI

11.1.1 Level 1 - Define objectives and purposes

The modelling process starts with deciding whether *VMI is an option for the supply chain*. This decision should be based on a suitability assessment and a managerial acceptance to assure conformity to the overall business strategy.

- Based on the analysis of product and market characteristics and study of success criteria in literature it is recommended that some basic characteristics of the supply chain are observed. These recommendations can be used for the initial suitability assessment.
    - The bullwhip effect should be evident in the supply chain. The main benefit of VMI is based on the inherent mechanisms' ability to reduce bullwhip, and if there is no bullwhip observed there are little potential cost savings by introducing this model (pilot, case 1, Harrison & van Hoek 2002).
    - Demand predictability should be medium to high because high uncertainty that cannot be reduced by improved forecasting, communication or extended response time only pushes costs and risk upstream the supply chain (pilot, case 3, Kulp 2002, Simchi-Levi et al. 2000).
    - Facilities for establishing communication links must be available. Computer systems must have functionality for information exchange (pilot, case 1, case 2, case 3, case 4, Roberts 2003, Kaipia et al. 2002, Simchi-Levi et al. 2000, Pohlen & Goldsby 1999).

  Other characteristics identified to have an influence on VMI effect but not being vital are included in selection of partner and product.
- Managerial decisions will influence the response to whether VMI is an option. In many instances it is a take it or leave it decision based on a request from a customer (Case 2, McBeath 2003). Suitability should still be analyzed in order to identify where extra effort should be made to build appropriate solutions.

If the answer to the question is "no", i.e. VMI is not an option, it is recommended that other collaboration models are studied or that other means to improve transparency and demand visibility along the supply chain are exploited.

If the answer is "Yes" it is essential that it includes a clear definition of goals, purposes and methods. This is a fundament for approaching the next step which is to decide what products/product groups to include and what supply chain partner to invite.

11.1.2 Level 2 – Select participants

Level 2 is about selecting participants to the VMI program. This concerns both supply chain actors and products. Decisions on what partners and products to include are central in order to identify where potential cost savings and other benefits are high. These decision processes are alternating because

- Some times a product is first selected and supply chain partner is selected from a base of possible suppliers or customers.

- Sometimes the partner is selected first and selection of possible products is limited to what is already or can be included in the product assortment.
- Sometimes these decisions are very simple because they are already made by the supply chain partner.

In selection of supply chain partner and product or product group the following recommendations are based on responses to hypotheses 4 and 5

- If the purpose is to reduce work load in the purchasing department high volume products should be included (pilot, case 2, case 3, de Toni & Zamolo 2005, Roberts 2003, Waller et al. 1999). Automation of high frequency transactions will cause higher work load reduction than low frequency transactions.
- If the purpose is to increase service level, products with long replenishment lead time should be included (pilot, de Toni & Zamolo 2005, Kaipia et al. 2002). Advance demand information will expand supplier response time window. Flexible and highly responsive suppliers will not benefit the same way from advance demand information (case 1).
- Select a product or product group for which production capacity is limited. This is where the potential benefits of increased flexibility and extended response time window are higher (pilot, case 1, case 2, Waller et al. 1999).
- It is important to select a partner with high SCM skills. A partner must be able to provide accurate and timely information (pilot, case 3, Kulp 2002), A customer must be able to provide best possible forecasts (pilot, case 2) and a supplier must be able to apply forecasts for planning purposes (pilot, Småros et al. 2003, Lapide 2001).
- Select a trustworthy partner. VMI increases interdependency and in a competitive environment where both parties do business with other actors as well, it is essential to maintain confidentiality and integrity (pilot, case 1, case 2, case 3, case 4, Pohlen & Goldsby 2003, Kaipia et al. 2002, Simchi-Levi et al. 2000 and others).

Decisions regarding what partners and products/product groups to include ought to be made from these recommendations. However, they must also be in line with managerial instructions to suit the overall business and competitive strategy.

11.1.3 Level 3 – Define the control components

When supply chain partners have agreed to start contract negotiations it is time to define the planning and operational parameters of the collaboration program. These decisions are important because they form the fundament of the daily operation and they include decisions regarding:

1. information sharing,
2. performance measurement and
3. sharing of responsibilities

The recommendations presented below are based on the analyses and responses to hypotheses 1, 2 and 3 respectively.

Information sharing

For the subject of information sharing it is underlined here that these recommendations only relate to information to be transferred frequently and for operational purposes. Exchange of annual or semi annual forecasts are not encompassed by these recommendations. These will follow in the section for sharing of responsibilities. The following results on information sharing are also published in "*International Journal of Physical Distribution & Logistics management*", Vol. 37, No. 2, 2007, pp 131-147 and is referred to as Vigtil 2007.

Three basic questions regarding information sharing are identified (Vigtil 2007). These are:

1. what information should be sent from customer to supplier,
2. what should be sent from supplier to customer, and
3. by what means and frequency information should be exchanged

<u>1. Information from customer to supplier:</u>

- Current inventory status (all cases and e.g. de Toni & Zamolo 2005, Angulo et al. 2004, Harrison & van Hoek 2002, Christopher 1998, Holmström 1998)
- Production schedule when customer makes to stock (case 2, case 4, Vigtil 2007, Kulp 2002, Thoneman 2002)
- Incoming orders, particularly important when customer makes to order but also valuable when customer makes to stock (Pilot, case 3, Vigtil 2007, de Toni & Zamolo 2005, Harrison & van Hoek 2002)
- Stock withdrawals (pilot, Vigtil 2007, Kulp 2002)

<u>2. Information from supplier to customer:</u>

- Advance shipment notice (ASN) (pilot, case 2, Angulo et al. 2004)
- Invoice (case 2, case 4)

<u>3. Transfer means and frequency:</u>

- Highly integrated means are recommended but not absolutely required. Automatic updates reduce office clerk work load and risk of typing errors and delays (pilot, case 1, case 2)
- Frequency of update from customer to supplier should be coordinated with the supplier's replanning frequency (Pilot, case 2, Vigtil 2007)
- Frequency of ASN from supplier to customer should be coordinated with frequency of actual shipments.
- Frequency of invoice should be related to business agreements and payment terms.

Performance measurement

Performance measurement in VMI has received limited attention in earlier work. Performance monitoring and measurement is an important means to control the other party's compliance to responsibilities, and it is an important tool for evaluation of the actual VMI program.

The supplier can be measured on a number of parameters related to product availability and inventory costs. Choice of parameters should reflect the customer's priorities and supplier can be measured on:

- *Inventory levels*, ability to maintain inventory levels within predetermined limits (pilot, case 2, case 4, de Toni & Zamolo 2005)
- *Service level*, number of stock-outs (pilot, cases 1, 2, 3, 4, Kaipia et a. 2002, Harrison & van Hoek 2002)
- *Turnover rate*, ability to adjust inventory levels to changing demands (pilot, Kaipia et al. 2002)

In VMI the customer has relinquished inventory management responsibility to the supplier. His responsibilities are limited and adequate performance measures are few. His main responsibility is to supply high quality demand information and therefore his performance should be evaluated by measuring

- *Information precision*, minimum deviation between transferred and true information, e.g. updated BOM, inventory counts (pilot, case 2, Kulp 2002)
- *Information timeliness*, information must still be invalid when finally made available to supplier

The performance of the VMI program can be evaluated by measuring cost savings and logistic improvements. The measures must be related to the goals set out for the program, but it is important to study measures over time and related to similar measures before the initiation of the program. Typical evaluation measures are:

- *Smoothed production* and *reduced overtime*, often experienced by supplier due to increased flexibility (pilot, case 2, de Toni & Zamolo 2005, Kaipia et a. 2002, Disney et al. 2001)
- *Reduced distribution costs*, because full truck loads can be planned and excess capacity on other shipments heading the same direction can be utilized (case 1, 2, 4, Pohlen & Goldsby 2003, Mattson 2002, Somchi-Levi et al. 2000)
- *Improved forecasting*, obtainable due to increased focus on forecasting quality and access to new demand information (Pilot, case 2, 3, 4, de Toni & Zamolo 2005, Pohlen & Goldsby 2003, Simchi-Levi et al. 2000, Achabal et al. 2000)
- *Reduced paper handling*, because information is exchanged electronically (pilot, case 1, case 2)
- *Reduced capital employment*, because inventory control is improved (pilot, case 3, Pohlen & Goldsby 2003, Mattson 2002)

A well managed VMI program can offer improvements in many if these and other areas.

Sharing of responsibility

Sharing of responsibilities and roles in the program is essential. Both parties must have a clear vision of their obligations. For inexperienced VMI partners a joint establishment is essential. Partners with VMI experience might be able to build this vision with less joint efforts (pilot, case 3, case 4). Collaborative initiatives should be taken both initially and during the operational stages of the program.

Initial collaboration is important because it is essential that both parties are confident with the contracted obligations. Recommended subjects for initial collaboration are:

- *Standardization of data* to enable computer system compatibility (pilot)
- *Required information sharing*, type and frequency (pilot, Simchi-Levi et al. 2000)
- *Who prepare forecasts* (pilot, Simchi-Levi et al. 2000)
- Predefined *performance measures*, including service level, inventory level or other performance indicators to be applied (Simchi-Levi et al. 2000)
- *Time for transfer of ownership* to the goods (McBeath 2003, Mattson 2002, Simchi-Levi et al. 2000)
- *Contingency*, responsibility for corrective actions in case of unexpected incidents (Case 2, 3, 4)

Continuous collaboration is important because an arena for problem solving and further refinement and expansion of the program are important parameters for long term success (pilot). Suggested topics for continuous collaboration are:

- *Product mix management* and *new product development* are important parameters because it is essential that there is consistency between customer consumption and supplier production (pilot). Inconsistency will cause high inventory levels and stock-outs.
- *Promotion planning* is important because a campaign will influence demand pattern. The supplier should at least be notified when promotions are planned (pilot, Ellinger et al. 1999).
- *Forecasts* can be developed jointly provided the supplier has the required market knowledge (pilot, Ellinger et al. 1999). When the customer is an OEM, the component suppliers rarely have sufficient market knowledge about the end product. Forecasts should be prepared by the customer and shared with the supplier (case 2).

11.2 An introduction to the Practitioners' Guide to VMI

The modelling framework described above is a scientific contribution of this work. It is built on a scientific fundament of literature and empiric studies. In order to make the results easily available to practitioners who want the advice without studying the scientific perspective, a Practitioners' Guide to VMI is developed. This guide is the managerial contribution of this work.

The guide is applicable to practitioners being in the process of establishing new VMI collaboration and to those in the process of improving and refining an existing program. It takes a particular focus on relationships where the customer is a manufacturer. Engaging in supply chain collaboration is a long term strategic decision and the process of establishing a well functioning solution is time consuming and resource demanding. This guide will aid in the development process, provide decision support and reduce the risk of entering an unfavourable agreement.

The guide includes a set of advices and a guideline.

- The set of advices are related to the five focus areas studied in the research question and they are developed to support in the design phase of a planning process
- The guideline reflects a set of decisions to be made prior to and during establishment of a VMI program.

When applying this guide it is recommended that the user reflect around the advices before making the decisions set out in the guideline.

The guideline follows a planning structure starting with defining the overall content of the program, defining goals and purposes and selecting products and collaboration partners. Further it approaches the details of the program and guides in practical solutions. Finally it suggests how to follow up and support continuity of the program. The ten decision areas are:

1) Define goals and purposes
2) Select a product or a product group
3) Select a collaboration partner
4) Understand your partner
5) Think simple
6) Define demand information
7) Prepare for electronic data exchange
8) Define operational parameters
9) Define performance measures
10) Establish a forum for collaboration.

Decision area 1) is related to level 1 in the modelling framework. Decision areas 2), 3) and 4) are related to level 2 and the remaining six decision areas are related to level 3.

11.2.1 The guideline in short

The guideline is summarized in a table format, see Table 11-1. The table has three columns.

~ The left hand column presents the general decisions to be made.

~ The middle column presents the decision from the supplier perspective. If the user intends to be the supplier in the replenishment program he should pay special attention to the suggestions presented here. The user is however encouraged to reflect on the recommendations presented for the customer as well.

~ The right hand column presents the decision from the customer perspective. If the user intends to be the customer in the replenishment program he should pay special attention to the suggestions presented here. The user is however encouraged to reflect on the recommendations presented for the supplier as well.

Those recommendations that are similar for the customer and the supplier are described in cells covering both the supplier and the customer columns of the table.

The full Practitioners' Guide is presented in Appendix B

Table 11-1, Guideline for establishment of VMI

Decision	When your company is a supplier	When your company is a customer
1) Define goals and purposes	State your goals and define your purposes of establishing a VMI replenishment program. Use the goals to guide in the decisions required further down the establishment process.	
2) Select a product or product group	Select products subjected to characteristics where advance demand information offer particular benefits to your planning process.	Select a product or product group with long term demand perspectives.
3) Select a collaboration partner	Select a customer from which advance demand information is very valuable to your planning. Select a customer where expansion of product spectre is possible.	Select a supplier that is trustworthy with respect to capabilities and product quality. A supplier with an established business relationship is beneficial but do not exclude alternative suppliers.
4) Spend time to get familiar with the other party's business area, markets and challenges	Make sure you understand the customer's business and market situation, and make sure the customer understands yours	Make sure the supplier understands your quality and availability requirements, make sure you understand the supplier's capabilities, limitations and restrictions
5) Think simple	Establish a pilot and start with one product or product group. Prepare for step-wise implementation	
6) Define demand information	Be clear on what kind of demand information you need to improve your planning	Be clear on what kind of demand information you can provide and the quality of this information.
7) Prepare for electronic data exchange	Focus on information standardization to assure system compatibility and to assure that information is interpreted similarly by both parties. Automate data transfer and update if possible. Prepare generic transfer files.	
8) Define operational parameters	Determine what data to share and update frequency. Define ownership transfer, shipment regulations and invoice routines. Define targeted performance levels and agree on a lot size/price policy if applicable. Identify collaboration areas, e.g. forecasting, product development, product mix and life cycle management, introduction and promotion planning.	
9) Define performance measures	Select performance indicators that reflects your priorities, purposes and goals	
	Measure customer on the quality of the demand data and correctness of other information being transferred.	Measure supplier on ability to perform within targeted performance levels and ability to respond to expected demand.
10) Establish forum for collaboration	Establish a schedule for regular collaboration meetings with representatives from both parties. Define agenda and purpose based on long term collaborative development and improvement of program. Use forum to build human relations	

12 Conclusions

The main topic of this thesis has been inter-organizational collaboration for supply chain management, and the collaboration model studied here is the concept of Vendor Managed Inventory (VMI). The concept is not new, it has more than 20 years of history and its benefits and success stories in retailing are well documented. It has been indicated that in the US retail industry more than 75% of the actors are involved in VMI replenishment (RIS 1999).

The scientific contribution of this work is a Framework for modelling of VMI, and as a managerial contribution the results are presented in a Practitioners' Guide to VMI. Some more general descriptions of the outcomes are presented along this concluding chapter.

12.1 Storyline

The main purpose of establishing this work was to build comprehension on how VMI can be a tool for improved supply chain operation, how the expected benefits would develop and to identify important focus areas for establishment of a VMI collaboration program. This purpose was motivated by the realization that much theory on expected benefits, particularly in the retail industry is available but little work has been done to study VMI from the practitioners' perspective further upstream the supply chain.

The first part of the work was to study the theoretical aspects of VMI. Benefits and opportunities related to costs and customer retention were identified, and they could primarily be related back to improved information sharing and improved material flow.

This study also revealed that there are numerous terms and interpretations applied in industry and theory describing this concept. An attempt was made to identify patterns in use of terms and to clarify different interpretations. To identify cases to be studied in this work the term VMI was not used, but a set of criteria for falling into the scope of the study was developed.

12.1.1 Research question

In the view of the objective set out for this work, the research question posed and pursued was:

> *What are key parameters for successful VMI operation in the areas of information sharing, performance measurement, collaboration areas, inter-organizational relations and other product and market characteristics?*

The selection of these five areas was founded on the extensive literature review on supply chain collaboration and VMI, and the early interviews made in the establishment of a pilot case.

12.1.2 Research methodology

The methodology selected for this work was to perform a combined literature review and a multiple case study. As the desire was to study VMI in practice, a case study was the most adequate methodology. A case study can tell how things happen and offers an opportunity to identify causes and effects.

First a pilot was established. This particular case was selected because the supplier and customer in question was in the process of establishing a VMI replenishment program and this offered a unique opportunity for the researcher to study the initial stages of the process. Additionally, this case was complex and comprehensive on several aspects and would be an essential contributor to the identification of important elements within the five areas outlined in the research question. Another four cases of VMI collaboration were selected and interviews were arranged.

For the purpose of planning and structuring the interviews an interview guide was developed. It was applied in the data collection process and formed the basis for the subjects discussed in the interviews. The interview guide was based on literature reviews and the pilot case, and it encompassed elements from all the five areas outlined in the research question. One main objective was to reveal key parameters in each area.

When the data collection process was completed the data was analyzed. The five main areas from the research question were analyzed separately and case specific replies were compared to each other and to theory. Important criteria for the analysis were the perceived positive or negative outcome of the VMI program and to what extent the elements in question were believed to have influenced this outcome in any way.

The outcome of the analysis was compared to the hypotheses and produced the answers to the research question.

12.2 Research outcomes

The outcomes of this work include a presentation of elements that affect the successfulness of a VMI program and some elements that do not affect likelihood of success. Further, this work also shows some conditions where VMI will be a good replenishment solution and what conditions are not critical determinants for choosing VMI or some other replenishment solution.

More specifically related to the research questions, these outcomes include

- recommendations to information sharing as in what information to share on a frequent basis, and means and frequency for this transfer
- recommendations for performance measurement towards both the customer and the supplier
- recommendations to initial and continuous collaboration, referring to what issues should be subject to collaboration initially and during the contract period
- the need for trust and contractual regulations like incentives and sanctions. The work shows how incentives can be used to encourage improvement initiatives while sanctions and power can be used as an alternative to trust to monitor and ensure performance

12.2.1 Contribution to science

The primary objective of this work has been to identify key elements in successful VMI collaboration programs. In order to reach this objective, two supporting objectives were stated:

- to identify and describe how a VMI collaboration program affects the material and information flow of a company, and
- to identify and describe the benefits, limitations and pitfalls of VMI collaboration

The outcomes of the work are discussed in the cross case comparison and data analysis in chapter 10. They are also structured, applied and presented as a framework for modelling of a VMI collaboration program in chapter 11.

Some findings are supportive to existing theory and literature and thus represent further support to the propositions made. These are for example:

- the basic need for a certain level of trust,
- the need for information sharing in general and
- the need to transfer inventory levels and demand forecasts in particular

This study is also supportive to those who argue that VMI can be used to reduce the bullwhip effect and that reduced bullwhip is a characteristic of a successful VMI program.

The indication that there is a certain critical minimum volume required is supported as all interviewees indicated that going through this process properly required so much resources that they wouldn’t bother if the possible benefits were small. Additionally, this work supports those who argue for the importance of a long term perspective.

On some of the elements studied, the findings are not as conclusive as the proponents wish to argue. The proposition that highly automated and integrated ICT systems with online communication are required has been challenged. The evidence from this work indicates that the use of integrated electronic communication will offer substantial cost reductions and increase data timeliness and accuracy, but it is not indicated from this work that this is an absolute requirement for VMI success.

Yet other findings are building theory as they are conclusive on elements that are not discussed in literature at all or where literature is weak on propositions. This is in particular the finding indicating that what is the most important data depends on customer market interaction strategy. There are also discrepancies in the discussion of whether online communication is required or whether transfer should be on an “as needed” frequency. This work concludes that online communication is not required and the “as needed” frequency is as needed for regular re-planning.

It has been argued that the opportunities of VMI are larger for products suffering from Bullwhip (typically B and C products in an ABC analysis). This work supports this statement, but it also shows that it is the complexity of the program as a whole that offers these potential opportunities.

Performance measurement in VMI is scarcely discussed in literature. Supplier performance can be paralleled to inventory performance in general. Customer performance must be related to the customer’s contribution to the operation which very often is forecasts. This work indicates that the customer should be measured on the quality of his forecasts.

12.2.2 Contribution to practice

Observations along the interviews revealed a lack of familiarity with the subject of VMI amongst the logistics personnel applying the concept. Though they all showed great confidence in the replenishment model they had adapted, they still appeared to have involved in something they weren't completely familiar with prior to the establishment. Most of the discrepancies were related back to their uncertainties and missing experience at the initial stages of the establishment process. Those actors being involved in more than one VMI replenishment program were happier with their later establishments because they knew the pitfalls.

Based on this observation it is suggested that one of the reasons Norwegian industry appear reluctant to establish VMI replenishment programs is a general lack of knowledge and experience on this particular subject among business managers. It was therefore found appropriate to make the findings from this study available to the industry. These should include a set of advice and guidelines applicable to suppliers and customers considering establishment of a VMI replenishment program, and for actors working on redesigning and improving an existing replenishment agreement.

The advices were prepared to increase the user's comprehension of VMI replenishment as a complex and dynamic relationship between a supplier and a customer because knowledge is important to make the right decisions. The guidelines following the advice indicated what decisions should be made when establishing a VMI replenishment program. The user should prior to applying the guidelines have made reflections around the advices presented to support a fundamental comprehension of the consequences of the decisions made.

12.3 Evaluation of work

A systems approach was selected for this work because the research question was multifaceted and encompassed several elements of supply chain collaboration. It is recognized that supply chain collaboration is a complex and comprehensive task where the solution is important but where there is not just one correct solution design. What is the right design depends on the characteristics of the situation and the competence of the actors involved.

The interviews reported in this work reflect the ideas and comprehension available at the time of the interview. It is possible that responses can differ if the cases were revisited some years later. Some respondents would have gained more experience in the field of VMI collaboration and some respondents have left the company. It is not unlikely that programs are terminated when contract periods are out. Neither is it unlikely that the contract terms have changed as the collaboration programs have matured. Reproducing a particular case study can be difficult but refreshed interviews with the same respondents are likely to offer the same conclusions.

12.3.1 Possible sources of errors

Case studies suffer from statistical conclusion validity, statistical generalizability and replication but they are strong in realism and internal validity (Mentzer & Flint 1997). The validity and reliability of case studies rest heavily on the correctness of the information provided by the interviewees. There is also a risk that the indicated perception of the successfulness of the VMI program in question is coloured by the interviewees' personal opinion rather than depicting the general perception. These risks were met by triangulation, i.e. interviewing representatives from both the customer and the supplier where possible, both parties being aware that the other party was also participating in the data collection process.

Case studies build theory on identification of causalities. In single cases there is always a risk that a casual coincident is interpreted as causal coherence. In multiple case studies this can be controlled by comparison, either to other cases or to literature. In this work some causality are identified, and while some have been comparable to other cases, others are not. This might indicate that the attempt to build a comparative case study has failed and that the five cases studied must be considered separate single case studies where casual coincident cannot be controlled in the same way.

However, while it is realized that not all cases are comparable to each other in all matters they are all in some way comparable to the pilot and to some of the other cases. All possible causalities identified are therefore discussed with respect to some of the other cases and to literature.

There might have been other causalities than those identified. Some might have been lost because of some presumptions made or that some elements are left out of the study. Such lost causalities will represent a limitation to the comprehensiveness of this work. It is, however, unlikely that any of the lost opportunities would have made a difference to the ones identified.

An attempt was made to identify more cases to include in the study. This would enrich the picture further and probably offer more examples to support causalities. There were, however, none identified that would offer new settings. For example, one more case of appliances supplied on a two bin system was identified but it was not included in the study. While it was very comparable to case 3, studying a two bin system was not a prime objective of this work. Neither was the case particularly extensive or exciting with respect to the other elements of the research question. This case was therefore not included in the study.

One possible source of error in this work is the fact that the customer was not interviewed in cases 2 and 4. This customer is a large actor in the automotive industry with much VMI experience. An experienced representative from this customer could have contributed on several issues, and this can be considered a lost opportunity of this work. On the other hand, this customer is considered very powerful and he has shown only limited understanding to the supplier side of the relationships discussed. His contribution to supply chain thinking and mutual comprehension might therefore have been limited anyway.

12.3.2 Limitations

From this work it is realized that supply chain collaboration in general and the application of VMI replenishment in particular is a complex action. The perspective selected for this work is related to logistic effects and the question of success has been related to logistic improvements. However, it is observed that some programs with little logistic improvements are continued while other programs are terminated despite the observation of benefits coming through. This proves that there is more to the decision of applying VMI than pure logistic effects.

Not surprisingly this work shows that the topic studied is interdisciplinary. One cannot find one absolute correct answer to what is the ultimate recipe for successful VMI collaboration. This question cannot be answered without discussing managerial issues like for instance supply chain strategy, customer relations management (CRM) and supplier relations management (SRM), relational contracting and trust, inter-firm dependencies, power structure and conflicts in relationships. They are observed as limitations to success like reluctance to relinquishment of responsibility and control, reluctance to sharing of possible sensitive information, lack of top management commitment and allocation of resources, the use of power to enforce unfair contracts, lack of mutual business comprehension etc.

The importance of these managerial, relational and other external factors must not be underestimated because they can be central causes of program inefficiencies disregarding the logistic solutions developed. The purpose of this work has still been to attract the attention to the logistic solutions, because in either way, if a program shows logistic inefficiencies it is bound to be unsuccessful.

The mission has been to build a framework for the development of a VMI replenishment program built on logistic efficiency, mainly reduced production, transport and storage costs and improved material and information flow. The framework assumes there is a genuine interest among the participants to make the program work but though the framework does not offer recommendations on contract regulations and other specific managerial issues it is still recognized that the participants usually are autonomous organizations facing separate financial goals. Precautions and means to maintain control are therefore discussed.

Without forgetting that the successful operation of a VMI replenishment program also rests on multiple managerial and organizational aspects outside the discipline of logistics this work offers a structured set of advice and guidelines to how VMI should be built to gain logistic efficiency.

12.4 Further research

It has been argued in this concluding chapter that despite some limitations the goal of this study has been accomplished. As the work has proceeded some questions have been raised and some issues have been opened that were not pursued in this work. While the concept and ideas are not new and have been subject to multiple analytical and empirical studies it is reassuring to observe that there are always new issues and problems to be solved. The following is a brief summary of some opened issues that would be highly interesting to pursue for further research.

12.4.1 VMI and different control models

In case 3 it was found that the two-bin system did not perform very well when demand was highly variable, and this raised the question on what inventory control models are best suited under different production conditions and demand patterns. Chapter 3 outlined on some of the most common inventory control models but this work has not aimed at finding what model should be applied under different demand conditions. This discussion should initially be held irrespective of who is responsible for controlling inventories but VMI could be included as an element in the discussion to study how advance demand information can improve the performance of the different inventory control models discussed.

12.4.2 VMI and SMI revisited

During the course of this work the main focus has been on manufacturing industry and to what extent VMI is applied by manufacturers. The focus has deliberately been taken off the retailer side of the supply chain.

It has been observed that companies being OEM’s will typically have multiple VMI relationships towards the different suppliers while component manufacturers are more likely to be suppliers in a VMI relationship. The bullwhip effect is known to amplify upstream the supply chain and VMI is argued to be a means to reduce bullwhip. Hence, the opportunities ought to be better for farther upstream suppliers.

A basic difference between being an OEM and being the supplier to an OEM is demand characteristics. The OEM will face independent demand for his finished products whilst the supplier will face dependent demand. While it was argued in the introduction to this thesis that there will not be made a difference between VMI and SMI as claimed by Pohlen & Goldsby (2003), this might be an opportunity to revisit this claim. A possible subject for a research domain can be why VMI is not exploited among upstream suppliers when these are the ones facing bullwhip, and whether volumes, complexity or demand patterns are important characteristics.

12.4.3 The role of ICT in multi echelon VMI relationships

An even further elaboration on collaboration and integration level can be subject to further research. The use of ICT was recommended but not considered necessary for VMI success in this work. Also, the application level found in the cases studied is somewhat traditional. Simchi-Levi et al. (2000) have been referred to several times during this work, and their statement that use of advanced computer systems is required has been toned down.

The use of ICT in the cases studied has mainly automated, secured, speeded up and improved the quality of existing activities and processes. What is equally interesting is to study how the use of highly advanced ICT systems and real time data can make changes to the processes in order to further reduce costs and improve the material flow. This might also include an expansion of the relationship between a customer and a supplier. Major advantages can develop by including more supply chain actors in the collaboration program. VMI in a multi echelon supply chain is scarcely discussed in literature. Building a truly integrated VMI supply chain in practice will most likely be even more difficult than building a dyadic VMI, and it would probably rest more heavily on the use of ICT to support information sharing. Possible subjects for a research domain can be what are the benefits, opportunities and obstacles to developing an extended VMI relationship and how can the use of modern ICT solutions support this new relationship.

12.5 Closure

To close this thesis the following is a summary of the key points and main contributions of this study.

The framework for modelling of a Vendor Managed Inventory collaboration program is a methodological and step wise presentation of decisions to be made by business managers when establishing VMI collaboration.

The modelling approach encompasses three decision levels where detail level increases with decision level and the framework includes guidance and recommendations for decision support based on the findings of this study.

VMI can be applied for most products and in most business relationships between a supplier and a manufacturer. Recommended conditions are:

- There must be a minimum volume of business interaction over time to justify the costs and efforts made in the establishment process
- The bullwhip effect should be evident in the supply chain
- Facilities for establishment of electronic communication links must be available
- The supplier must be able to apply advance demand information to improve his own operation
- A certain level of trust and confidence must be evident between the business partners
- The supplier must have access to inventory status information
- When the customer makes to stock the supplier must have access to the customer's production schedule
- When the customer makes to order the supplier must have access to the customer's incoming orders
- Information transfer frequency must be adjusted to the supplier's planning frequency
- Required service level must be related to the trade-off between carrying and stock-out costs
- The parties must understand each other's market and business environment
- The collaborative environment must be reinforced by a forum for regular discussions and problem solving

The scientific content of the framework is transformed into a Practitioners' Guide to VMI. This is developed to support those practitioners who want the applied version of the advice.

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Interviewees

- ~ Karl Ove Nilsen, Teeness ASA
- ~ Ulf Lundahl, Sandvik Coromant
- ~ Mona Persson, Sandvik Coromant
- ~ Gunnbjørn Uglem, Smurfit Norpapp
- ~ Kjetil Fagerholt, Pipelife Norge
- ~ Olav Bolseth, Pipelife Norge
- ~ Arne Horten, RTIM, ex Raufoss Chassis Technology
- ~ Ronny Furstrand, Tingstad AS
- ~ Øyvind Søyland, Tingstad AS
- ~ Sem Ueland, Kverneland Klepp AS
- ~ Roy Jakobsen, Hydro Automotive structures
- ~ Jan Marlow Beck, Hydro Automotive Structures
- ~ Bo Terje Kalsaas, Høgskolen i Agder, HiA

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- ~ The MOMENT project, Mobile extended Manufacturing Enterprise,
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Appendix A

Blank interview guide

Completed interview guide Teeness ASA – Sandvik Coromant AB

Completed interview guide Smurfit Norpapp – Pipelife Norway

Completed interview guide Raufoss Chassis technology – GM Opel

Completed interview guide Tingstad AS – Kverneland Klepp AS

Completed interview guide Hydro Aluminium Automotive Structures – GM Opel

Interview guide, blank

This is the interview guide applied for the semi structured interviews conducted to map the five cases studied. The guide can be read as follows:

The guide has five main sections conforming to the five elements of the research question. Under each top heading there are sub headings (vertical text) that specify the focus of the information sought. The third level of headings further specifies what aspects are mapped and under each of these third level headings the elements mapped are listed.

Information sharing		
Data collection and transfer	**Aspects of data transfer**	**Level of integration**
	Data collection	Bar-coding/RFID
		Track-and-trace
	Transfer means	Electronic integration: EDI/internet
		Manual integration: fax, phone, e-mail
	Transfer frequency	Online
		Batch
		By activity
Transferred data	**From supplier to customer**	**From customer to supplier**
	Advance shipping Notice (ASN) incl. – Product descriptions – Quantities – Delivery date – Destination	Inventory levels Incoming orders Goods in transit Stock withdrawals Sales data (Point-Of-Sale) Production schedule Back orders Returns
Performance measurement		
KPI's for operation management	**Supplier performance**	**Customer performance**
	Service level (Product availability) Replenishment lead time Inventory levels Inventory turnover Stock-out level Order fill rate towards next tier customer	Information precision Information reliability
Effects for program evaluation	**Effects**	**Subsequent effects**
	Smoothed production	Reduced capacity buffers required
	Extended time window for production and distribution planning	Increased flexibility – Priority control – Inventory balancing
		Reduced distribution costs
	Increased inventory turnover rate	Reduced obsolescence
		Faster end-of-life product removal
		Reduced inventory levels
		Reduced storage costs
		Improved capital employment
	Reduced administration	Reduced paper handling
	Increased service levels throughout the value chain	Reduced value chain costs
		Increased sales
	Improved forecasting	Reduced demand uncertainty
		Reduced safety stock levels

Areas of collaboration		
Initial and continuous collaboration	**Time perspective**	**Collaboration areas**
	Continuous collaboration	Forecasting
		Promotion planning
		New product development and introduction
		Product range management (product mix)
	Initial collaboration	Information standardization
		Service levels
		Inventory level goals (safety stock included)
		Lead time goals
		Pre-defined performance measurement levels
		Information sharing, type and frequency
		Ownership issues
Product characteristics		
Product and market characteristics	**Aspects**	**Characteristics**
	Volume	High or low volumes, share of product range, share of customers involved
	Lead time	replenishment lead time (manufacturing can be included)
	Demand variation	Seasonal or general variations, variation predictability
	Production capacity	Limited or well buffered manufacturing capacity at supplier
	Price fluctuation	Stable or fluctuating
	Planning cycle	Short or long supplier production replanning cycles
	Monetary density	High or low value goods
	Level of customization	Highly customized or off-the-shelf component
	Competitive situation	Monopoly, market leader or free competition
	Geographical distance	Distance between supplier and customer's warehouse
Trust		
Additions to trust	**Regulation mechanisms**	
	Power relations Willingness to depend on another party (risk and vulnerability analysis) Governance mechanisms and contracts – Incentive mechanisms – Sanctions	

It has not been at focus to make the guide intuitive. This is because the guide was not supposed to be completed by the interviewees but only to be completed during the interview by the interviewer who knew the complexity and structure of the guide.

Interview guide pilot case, Teeness – Sandvik Coromant

Information sharing

	Aspects of data transfer	Level of integration	
Data collection and transfer	Data collection	Bar-coding/RFID	X
		Track-and-trace	
	Transfer means	Electronic integration: EDI/internet	X
		Manual integration: fax, phone, e-mail	
	Transfer frequency	Online	
		Batch	X
		By activity	

	From supplier to customer		From customer to supplier	
Transferred data	Advance shipping Notice (ASN) incl.		Inventory levels	X
	– Product descriptions	X	Incoming orders	X
	– Quantities	X	Goods in transit	X
	– Delivery date	X	Stock withdrawals	
	– Destination	X	Sales data (Point-Of-Sale)	X
			Production schedule	
			Back orders	X
			Returns	

Performance measurement

	Supplier performance		Customer performance
KPI's for operation management	Service level (Product availability)		Information precision
	Replenishment lead time		Information reliability
	Inventory levels	X	
	Inventory turnover	X	
	Stock-out level	X	
	Order fill rate towards next tier customer		

	Effects		Subsequent effects	
Effects for program evaluation	Smoothed production	X	Reduced capacity buffers required	X
	Extended time window for production and distribution planning	X	Increased flexibility – Priority control	X
			– Inventory balancing	
			Reduced distribution costs	
	Increased inventory turnover rate	X	Reduced obsolescence	
			Faster end-of-life product removal	
			Reduced inventory levels	
			Reduced storage costs	
			Improved capital employment	
	Reduced administration		Reduced paper handling	
	Increased service levels throughout the value chain	X	Reduced value chain costs	
			Increased sales	
	Improved forecasting		Reduced demand uncertainty	
			Reduced safety stock levels	

Areas of collaboration		
Initial and continuous collaboration	**Time perspective**	**Collaboration areas**
	Continuous collaboration	Forecasting X
		Promotion planning X
		New product development and introduction X
		Product range management (product mix) X
	Initial collaboration	Information standardization X
		Service levels X
		Inventory level goals (safety stock included) X
		Lead time goals X
		Pre-defined performance measurement levels X
		Information sharing, type and frequency X
		Ownership issues X
Product characteristics		
Product and market characteristics	**Aspects**	**Characteristics**
	Volume	High or low volumes, Low share of product range, 80% share of customers involved 100 %
	Lead time	replenishment lead time (manufacturing can be included) 4-6 weeks
	Demand variation	Seasonal or general variations, medium variation predictability high
	Production capacity	Limited or well buffered manufacturing capacity at supplier limited
	Price fluctuation	Stable or fluctuating stable
	Planning cycle	Short or long supplier production replanning cycles daily
	Monetary density	High or low value goods High
	Level of customization	Highly customized or off-the-shelf component Customized
	Competitive situation	Monopoly, market leader or free competition free competition
	Geographical distance	Distance between supplier and customer's warehouse Northern Europe
Trust		
Additions to trust	**Regulation mechanisms**	
	Power relations Willingness to depend on another party (risk and vulnerability analysis) X Governance mechanisms and contracts – Incentive mechanisms X – Sanctions	

Interview guide Case 1, Smurfit Norpapp - Pipelife

Information sharing

Data collection and transfer

Aspects of data transfer	Level of integration	
Data collection	Bar-coding/RFID	
	Track-and-trace	
Transfer means	Electronic integration: EDI/internet	X
	Manual integration: fax, phone, e-mail	
Transfer frequency	Online	
	Batch	X
	By activity	

Transferred data

From supplier to customer	From customer to supplier	
Advance shipping Notice (ASN) incl. – Product descriptions – Quantities – Delivery date – Destination	Inventory levels	X
	Incoming orders	
	Stock withdrawals	
	Sales data (Point-Of-Sale)	
	Production schedule	
	Back orders	
	Returns	

Performance measurement

KPI's for operation management

Supplier performance		Customer performance
Service level (Product availability)		Information precision
Replenishment lead time		Information reliability
Inventory levels	X	
Inventory turnover	X	
Stock-out level	X	
Order fill rate towards next tier customer		

Effects for program evaluation

Effects	Subsequent effects	
Smoothed production	Reduced capacity buffers required	
Extended time window for production and distribution planning	Increased flexibility – Priority control – Inventory balancing	X (Priority control)
	Reduced distribution costs	X
Increased inventory turnover rate	Reduced obsolescence	
	Faster end-of-life product removal	
	Reduced inventory levels	
	Reduced storage costs	
	Improved capital employment	
Reduced administration	Reduced paper handling	X
Increased service levels throughout the value chain	Reduced value chain costs	
	Increased sales	
Improved forecasting	Reduced demand uncertainty	
	Reduced safety stock levels	

Areas of collaboration

Initial and continuous collaboration

Time perspective	Collaboration areas	
Continuous collaboration	Forecasting	X
	Promotion planning	
	New product development and introduction	X
	Product range management (product mix)	X
Initial collaboration	Information standardization	
	Service levels	
	Inventory level goals (safety stock included)	X
	Lead time goals	
	Pre-defined performance measurement levels	
	Information sharing, type and frequency	X
	Ownership issues	X

Product and market characteristics

Product and market characteristics

Aspects	Characteristics	
Volume	High or low volumes, share of product range, share of customers involved	High Small 1
Lead time	replenishment lead time (manufacturing can be included)	24 hours
Demand variation	Seasonal or general variations, variation predictability	Low High
Production capacity	Limited or well buffered manufacturing capacity at supplier	10% spares and extra shift in high seasons
Price fluctuation	Stable or fluctuating	stable
Planning cycle	Supplier production replanning cycles	24 hours
Monetary density	High or low value goods	low
Level of customization	Customized or off-the-shelf component	Customized
Competitive situation	Monopoly, market leader or free competition	Free competition
Geographical distance	Distance between supplier and customer's warehouse	2 hours by road

Trust

Additions to trust

Regulation mechanisms	
Power relations	
Willingness to depend on another party (risk and vulnerability analysis)	
Governance mechanisms and contracts	X
– Incentive mechanisms	
– Sanctions	X

Interview guide Case 2, Raufoss Chassis technology (RCT) - General Motors (GM) Opel.

Information sharing

Data collection and transfer	Aspects of data transfer	Level of integration	
	Data collection	Bar-coding/RFID	Bar codes
		Track-and-trace	
	Transfer means	Electronic integration: EDI/internet	EDI
		Manual integration: fax, phone, e-mail	Fax
	Transfer frequency	Online	
		Batch	over night
		By activity	

Transferred data	From supplier to customer		From customer to supplier	
	Advance shipping Notice (ASN) incl.		Inventory levels	X
			Incoming orders	
	– Product descriptions	X	Goods in transit	N/A
	– Quantities	X	Stock withdrawals	X
	– Delivery date	X	Sales data (Point-Of-Sale)	
	– Destination	X	Production schedule	X
			Back orders	
			Returns	

Performance measurement

KPI's for operation management	Supplier performance		Customer performance
	Service level (Product availability)		Information precision
	Replenishment lead time		Information reliability
	Inventory levels	X	
	Inventory turnover		
	Stock-out level	X	
	Order fill rate towards next tier customer		

Effects for program evaluation	Effects		Subsequent effects	
	Smoothed production	X	Reduced capacity buffers required	
	Extended time window for production and distribution planning	X	Increased flexibility	X
			– Priority control	X
			– Inventory balancing	
			Reduced distribution costs	X
	Increased inventory turnover rate		Reduced obsolescence	
			Faster end-of-life product removal	
			Reduced inventory levels	
			Reduced storage costs	
			Improved capital employment	
	Reduced administration		Reduced paper handling	X
	Increased service levels throughout the value chain		Reduced value chain costs	
			Increased sales	
	Improved forecasting	X	Reduced demand uncertainty	X
			Reduced safety stock levels	X

Areas of collaboration

Initial and continuous collaboration

Time perspective	Collaboration areas
Continuous collaboration	Forecasting
	Promotion planning
	New product development and introduction
	Product range management (product mix) N/A
Initial collaboration	Information standardization
	Service levels
	Inventory level goals (safety stock included)
	Lead time goals
	Pre-defined performance measurement levels
	Information sharing, type and frequency
	Ownership issues

Product characteristics

Product and market characteristics

Aspects	Characteristics
Volume	High or low volumes, High share of product range, 2 out of 6 share of customers involved 1 out of 7
Lead time	replenishment lead time (manufacturing can be included) continuous production
Demand variation	Seasonal or general variations, Seasonal variation predictability medium
Production capacity	Limited or well buffered manufacturing capacity at supplier High
Price fluctuation	Stable or fluctuating Stable
Planning cycle	Short or long supplier production replanning cycles 1 week
Monetary density	High or low value goods Low/ Medium
Level of customization	Highly customized or off-the-shelf component Customized
Competitive situation	Monopoly, market leader or free competition Free
Geographical distance	Distance between supplier and customer's warehouse 3 days, 12 hours by express shipment

Trust

Additions to trust

Regulation mechanisms	
Power relations	X
Willingness to depend on another party (risk and vulnerability analysis)	
Governance mechanisms and contracts	X
– Incentive mechanisms	
– Sanctions	X

Interview guide case 3, Tingstad – Kverneland Klepp

Information sharing

Data collection and transfer

Aspects of data transfer	Level of integration	
Data collection	Bar-coding/RFID	X
	Track-and-trace	
Transfer means	Electronic integration: EDI/internet	X
	Manual integration: fax, phone, e-mail	
Transfer frequency	Online	
	Batch	X
	By activity	

Transferred data

From supplier to customer	From customer to supplier	
Advance shipping Notice (ASN) incl.	Inventory levels	X
	Incoming orders	
– Product descriptions	Goods in transit	N/A
– Quantities	Stock withdrawals	
– Delivery date	Sales data (Point-Of-Sale)	
– Destination	Production schedule	Forecasted
Historic purchase statistics	Back orders	
	Returns	

Performance measurement

KPI's for operation management

Supplier performance		Customer performance
Service level (Product availability)		Information precision
Replenishment lead time		Information reliability
Inventory levels		
Inventory turnover		
Stock-out level	X	
Order fill rate towards next tier customer		

Effects for program evaluation

Effects	Subsequent effects	
Smoothed production	Reduced capacity buffers required	
Extended time window for production and distribution planning	Increased flexibility – Priority control – Inventory balancing	
	Reduced distribution costs	
Increased inventory turnover rate	Reduced obsolescence	X
	Faster end-of-life product removal	X
	Reduced inventory levels	
	Reduced storage costs	
	Improved capital employment	
Reduced administration	Reduced paper handling	
Increased service levels throughout the value chain	Reduced value chain costs	
	Increased sales	
Improved forecasting	Reduced demand uncertainty	
	Reduced safety stock levels	

Areas of collaboration

Initial and continuous collaboration	Time perspective	Collaboration areas	
	Continuous collaboration	Forecasting	X
		Promotion planning	
		New product development and introduction	
		Product range management (product mix)	X
	Initial collaboration	Information standardization	
		Service levels	
		Inventory level goals (safety stock included)	
		Lead time goals	
		Pre-defined performance measurement levels	
		Information sharing, type and frequency	
		Ownership issues	

Product characteristics

Product and market characteristics	Aspects	Characteristics	
	Volume	High or low volumes, share of product range, share of customers involved	high 600 out of 60000 15
	Lead time	replenishment lead time (manufacturing can be included)	1 week, 2-3 weeks for sub-suppliers
	Demand variation	Seasonal or general variations, variation predictability	medium seasonal medium
	Production capacity	Limited or well buffered manufacturing capacity at supplier	N/A
	Price fluctuation	Stable or fluctuating	Stable
	Planning cycle	Short or long supplier production replanning cycles	1 week
	Monetary density	High or low value goods	low
	Level of customization	Highly customized or off-the-shelf component	customized
	Competitive situation	Monopoly, market leader or free competition	free competition
	Geographical distance	Distance between supplier and customer's warehouse	Denmark, England, Norway

Trust

Additions to trust	Regulation mechanisms	
	Power relations	
	Willingness to depend on another party (risk and vulnerability analysis)	
	Governance mechanisms and contracts	X
	– Incentive mechanisms	X
	– Sanctions	

Interview guide case 4, Hydro Automotive Raufoss – GM Opel

Information sharing

Data collection and transfer	**Aspects of data transfer**	**Level of integration**
	Data collection	Bar-coding/RFID
		Track-and-trace
	Transfer means	Electronic integration: EDI/internet X
		Manual integration: fax, phone, e-mail X
	Transfer frequency	Online
		Batch X
		By activity
Transferred data	**From supplier to customer**	**From customer to supplier**
	Advance shipping Notice (ASN) incl. – Product descriptions – Quantities – Delivery date – Destination	Inventory levels X
		Incoming orders
		Goods in transit
		Stock withdrawals X
		Sales data (Point-Of-Sale)
		Production schedule X
		Back orders
		Returns

Performance measurement

KPI's for operation management	**Supplier performance**	**Customer performance**
	Service level (Product availability) X Replenishment lead time Inventory levels Inventory turnover Stock-out level X Order fill rate towards next tier customer	Information precision Information reliability have tried but cannot control this
Effects for program evaluation	**Effects**	**Subsequent effects**
	Smoothed production X	Reduced capacity buffers required
	Extended time window for production and distribution planning	Increased flexibility – Priority control – Inventory balancing
		Reduced distribution costs X
	Increased inventory turnover rate	Reduced obsolescence
		Faster end-of-life product removal
		Reduced inventory levels
		Reduced storage costs
		Improved capital employment
	Reduced administration	Reduced paper handling X
	Increased service levels throughout the value chain	Reduced value chain costs
		Increased sales
	Improved forecasting X	Reduced demand uncertainty X
		Reduced safety stock levels X

Areas of collaboration

Initial and continuous collaboration

Time perspective	Collaboration areas
Continuous collaboration	Forecasting
	Promotion planning
	New product development and introduction
	Product range management (product mix) N/A
Initial collaboration	Information standardization
	Service levels
	Inventory level goals (safety stock included)
	Lead time goals
	Pre-defined performance measurement levels
	Information sharing, type and frequency
	Ownership issues

Product characteristics

Product and market characteristics

Aspects	Characteristics
Volume	High or low volumes, Medium share of product range, low share of customers involved low
Lead time	replenishment lead time (manufacturing can be included) 1 week production, 3 days transport
Demand variation	Seasonal or general variations, seasonal variation predictability predictable
Production capacity	Limited or well buffered manufacturing capacity at supplier approx 70% of max
Price fluctuation	Stable or fluctuating stable
Planning cycle	Short or long supplier production replanning cycles 1 week
Monetary density	High or low value goods low/medium
Level of customization	Highly customized or off-the-shelf component Customized
Competitive situation	Monopoly, market leader or free competition free competition
Geographical distance	Distance between supplier and customer's warehouse Europe

Trust

Additions to trust

Regulation mechanisms	
Power relations	X
Willingness to depend on another party (risk and vulnerability analysis)	
Governance mechanisms and contracts	X
– Incentive mechanisms	
– Sanctions	X

Appendix B

A Practitioners' Guide to Vendor Managed Inventory

Appendix B presents the Practitioners' Guide to Vendor Managed Inventory. This guide is the applied version of a framework for modelling of VMI that was built on the findings of a PhD research project aiming to identify key points for successful Vendor Managed Inventory.

This Guide was developed for practitioners who want the advice without studying the scientific perspective required for a PhD. It is applicable to practitioners being in the process of establishing new VMI collaboration and to those in the process of improving and refining an existing program. It takes a particular focus on relationships where the customer is a manufacturer.

The guide includes a set of advices and a guideline applicable to suppliers and customers considering establishment of a VMI replenishment program. It can also be applied when redesigning and improving an existing VMI agreement.

- The set of advices refers to five focus areas in the design phase of a planning process.
- The guideline reflects a set of decisions to be made prior to and during establishment of a VMI program.

When applying this guide it is recommended that the user reflect around the advices before making the decisions set out in the guideline.

Engaging in supply chain collaboration is a long term strategic decision and the process of establishing a well functioning solution is time consuming and resource demanding. This guide will aid in the development process, provide decision support and reduce the risk of entering an unfavourable agreement.

Advice for design of VMI replenishment

The following are general advice aiming at increasing the user's comprehension of VMI replenishment as a complex and dynamic relationship between a supplier and a customer. The intention for application is that the user should reflect around the elements presented with respect to how they relate to the characteristics of the relationship being considered or reviewed. First the user should be aware that these elements are subjects needing attention. Second it is the user's task to make decisions around these subjects that suit the particular situation in question. Therefore the advices are purposely generic and not specified to a particular industry.

~ *Information sharing*

Information should be transmitted electronically and automatically in predefined and regular intervals. These intervals are determined by the supplier's re-planning frequency.

An advance shipment notice (ASN) to receiving warehouse is particularly important when receiving warehouse operates on limited capacity. An ASN can also be used as an advance notification to reassure the customer that products will be available.

The types of data transferred to the supplier in the predefined intervals are inventory status and indications of future expected demand (stock-withdrawals, incoming orders, POS-data and production schedule). When the customer is a manufacturer that makes to stock, the production schedule is essential.

~ *Performance measurement*

Performance measures must reflect priorities and they must be fair. The supplier should be measured on what is found most important and valuable for the customer and vice versa. Each party must have the ability to control the parameters he is measured on.

Possible measures of supplier performance are service level, inventory level, stock-out level and inventory turnover rate. Possible measures of customer performance are forecast accuracy and data timeliness.

Key performance indicators for monitoring collaboration program performance should also be applied. Selection of KPI's should reflect the purpose of entering the collaboration program.

~ *Areas of collaboration*

Collaboration in the initial stages of the agreement is important for setting the terms and conditions for the collaborative environment. It is vital that both parties agree to terms they know they can conform to (e.g. type and means for data transfer, time for transfer of ownership, prices, inventory levels, product availability, lot sizes). Every establishment and improvement of a VMI collaboration program should be based on detailed negotiations.

The relationship should be subject to continuous collaboration for ongoing refinement, improvement and extension of collaboration areas (e.g. improve type and means of data transfer, change type and number of product variants to be encompassed by replenishment program, lot sizes, forecasting if required).

The more complex and comprehensive the relationship, the more effort should be put into collective understanding of the business as a whole.

~ *Trust and Inter-organizational relations*

Building a VMI replenishment program implies building a collaborative relationship with a supply chain partner. This is a strategic decision. A certain level of calculative trust is required when selecting supply chain partner for VMI collaboration.

Establishing a forum for problem solving, e.g. regular meetings to handle inefficiencies, irregularities and other strategic questions is required. Whether developed in collaboration or not, annual and/or semi-annual forecasts should be transferred to the supplier and should be a subject for discussion in this forum.

The more complex and comprehensive the relationship, the more important is trust.

~ *Product and market characteristics*

Certain product and market characteristics set different premises for priorities in VMI. The list below presents both characteristics that will require special attention and characteristics that are of no special criticality to establish a successful VMI program. The expression “of less importance” indicates that this particular characteristic is no determinant for probability of success.

→ When replenishment lead time is long the supplier will find advance demand information more valuable.

→ Demand predictability is essential. High demand uncertainty requires high quality forecasting and extended advance demand information exchange.

→ Demand variation is of less importance.

→ Monetary density set criteria for cost saving focus.

→ When supplier’s production capacity is limited, the supplier will benefit more from advance demand information and flexibility in the replenishment schedule.

→ When products are customized the opportunity to tranship is lost.

→ Supplier’s competitive situation is of less importance.

→ Geographical distance between supplier and customer is of less importance.

→ The more complex and comprehensive the relationship, the more challenging it is to make it work - but the more rewarding it is to find it working.

After reflecting around these advices it is time to focus on the process of negotiating a collaboration model with a potential supply chain partner.

Guideline for decision support

The guideline is a decision support tool in the sense that it indicates what decisions should be made when establishing VMI replenishment. Prior to applying the guideline the user should have reflected around the advices presented. This is to build a fundamental comprehension of the consequences of the decisions made.

The guideline is a ten step process suggesting ten decision areas. For each suggested decision area there are recommendations to aid in the decision process. For some of the decisions the recommendations are specified as to whether the company is a supplier or a customer in the relationship. The sequence of decision areas reflects a general recommended sequence of attention but the user is not requested to strictly follow it. Making decisions can be an iterative process as the decision makers learn to understand the concept and consequences. In some instances one or several of the suggested decision areas are already settled.

The guideline follows a planning structure starting with defining the overall content of the program, defining goals and purposes and selecting products and collaboration partners. Further it approaches the details of the program and guides in practical solutions. Finally it suggests how to follow up and support continuity of the program. The ten decision areas are:

1) Define goals and purposes
2) Select a product or a product group
3) Select a collaboration partner
4) Understand your partner
5) Think simple
6) Define demand information
7) Prepare for electronic data exchange
8) Define operational parameters
9) Define performance measures
10) Establish a forum for collaboration.

Each of these decision areas are further described in the following.

Define goals and purposes

State your goals and define your purposes of establishing a VMI replenishment program. Your perception of success will be related to these goals. Use these goals to guide in the decisions required further along the establishment process. A general goal can be to increase supply chain integration level, but these goals must be more specific.

When your company is a supplier

Typical goals and purposes:

- Assure customer retention and gain market shares
    - Become a single supplier or increase product specter
- Improve customer service
    - Improve product availability and other value adding services
- Acquire advance demand information to improve own operation planning
    - Better planning can improve utilization of resources

When your company is a customer

Typical goals and purposes:

- Reorganization of purchasing staff or inventory structure
    - Motivated by initiatives to reduce costs
- Improve incoming material availability
    - Maintain component availability to assure continuous operation without increasing inventory costs

Select a product or a product group

Select a product or a group of products to be encompassed by the program. This group of products should have a set of common characteristics.

When your company is a supplier

Select products subject to characteristics where advance demand information offer particular benefits to your planning process. These characteristics could be:

- Long replenishment lead times
- Availability is critical
- High demand uncertainty (*only when advance demand information is available and will be helpful to your operation, otherwise you are left with both responsibility, risk and costs*)
- Expensive products
- High volume products

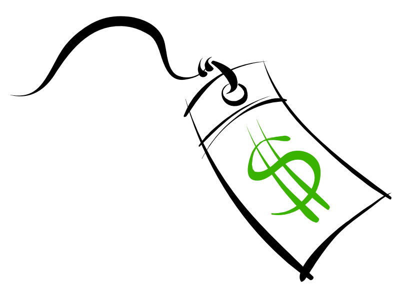
When your company is a customer

Select a product or a product group with long term demand perspectives. The demand should be expected to last for several years and could be related to:

- One particular product or component
- New editions and continuous development of a product or component
- The function of the product or the component

Select products subjected to high frequent purchases that will benefit from being automatic.

It can be wise to start with a less important component until experience in VMI collaboration is gained.



Select a collaboration partner

Select a collaboration partner that is genuinely interested in being your partner and who will assure you receive the required attention. Select a partner with relevance to your product decisions, one you deal with on a regular basis or one who is of strategic importance to your business. You should not rule out an actor just because you are not currently doing business with him. Select a partner that is considered trustworthy and solid. Avoid companies at the edge of bankruptcy.

When your company is a supplier

Select a customer:

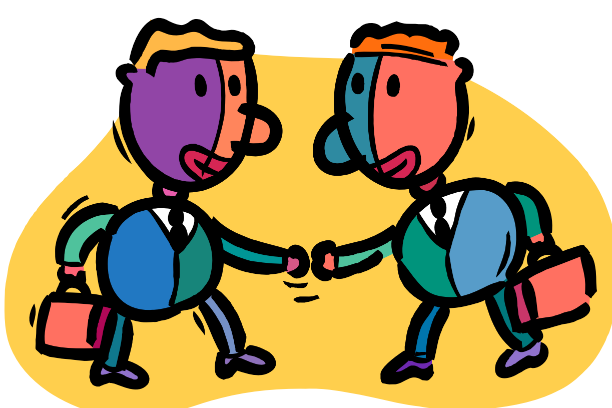
- who can offer advance demand information that is very valuable to your production and distribution planning
    - aim for smoothed production and combined transport
- who might need more of what you can provide and there are opportunities for expansion of business
    - aim for becoming a single supplier and try to expand your service

When your company is a customer

Select a supplier that you trust with respect to:

- production and delivery capabilities
- product quality

Select a supplier who can expand his service specter if he does well.



Understand your partner

Spend time to get familiar with the other party's business area, markets and challenges. When you know his special requirements and capabilities you can better understand the opportunities and limitations of the interaction. Do also make sure the other party understands your special requirements and capabilities. Both parties must understand each other's business. Then contract terms that offer mutual benefits are more easily identified and accepted.

When your company is a supplier

Make sure you understand the customer's

- market situation,
- demand uncertainty,
- product quality requirements
- availability requirements
    - your chances of understanding what the customer actually require from you and why, increase

When your company is a customer

Make sure you understand the supplier's capabilities and limitations of the:

- production planning process
- production system
- lead times
    - your chances of understanding how you can help the supplier perform his tasks will increase

Think simple

Establish a pilot and start with one product or product group and one supply chain partner. Standardize the administrative processes without jeopardizing flexibility and dynamics of the collaborative environment. Prepare for step-wise implementation. Start carefully and open for expansions as the processes and program develops and experience is gained.

Define demand information

Exchange of demand information from customer to supplier is considered the most important feature of VMI. Information replaces inventory in the supply chain. It is important to establish what kind of demand information is available, for instance incoming orders, sales data, sales forecasts, production schedule, inventory levels, a stock withdrawal plan etc. Information can be defined as facts or results.

- *Facts* are pure observed values like incoming orders, inventory levels and Point of sales data.
- *Results* are output from calculations, for instance a production schedule and sales forecasts.

It is important to think both long term and short term. Define what information is static and what information is dynamic and changes frequently. It is important to agree on who is responsible for preparing the various plans.

When your company is a supplier

Be clear on what kind of demand information you need from the customer to prepare your operation and improve your planning. Include both static and dynamic information.

– Inventory status is one of the most important types of information

– If the customer makes to stock the production schedule or stock withdrawal schedule is important

– If the customer makes to order incoming orders and production forecasts are important

When your company is a customer

Be clear on what kind of demand information you can provide and be explicit on the quality of this information. Examples of limitations to data applicability are:

– Sales data can be late

– Forecasts can be subject to high uncertainty

– Inventory level information can be inexact

– Bills of material can be inaccurate

These sources of error highly reduce the information's value to the supplier.

Prepare for electronic data exchange

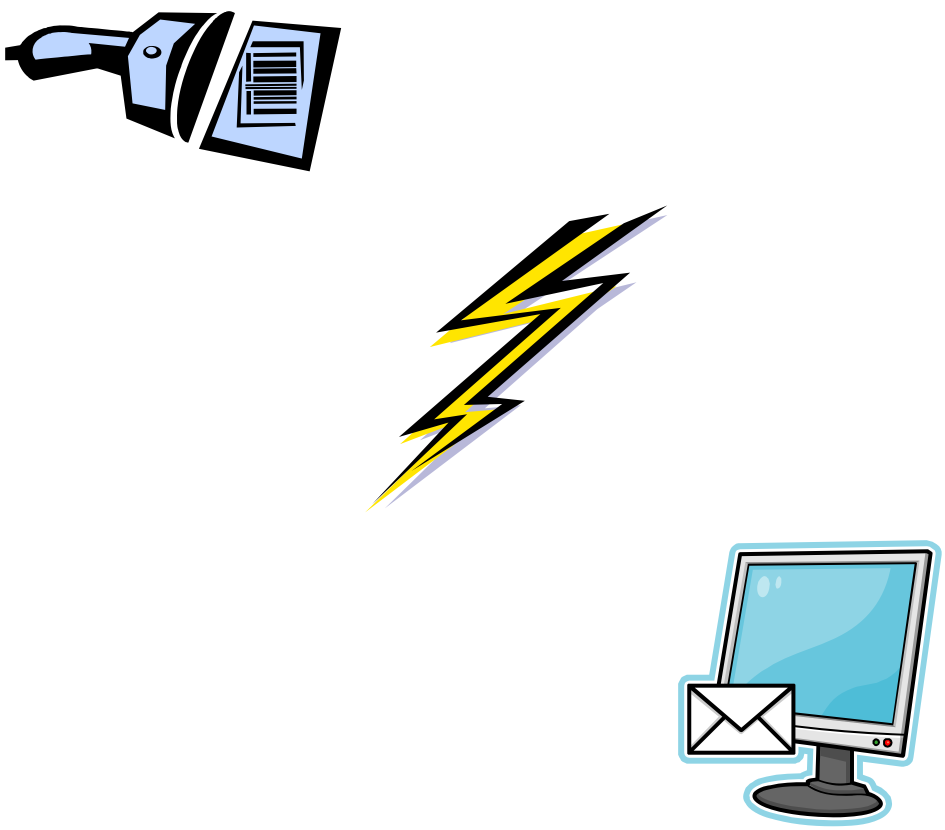
Electronic data exchange will speed up information exchange. More integrated transfer means will automate data transfer, reduce risks of data entry errors and reduce data entry workload.

Information must be standardized to assure system compatibility and to assure that both parties interpret the data alike.

Some investments in hardware and software will often be required. Many new ERP systems have VMI features included or available from the system supplier but older business systems might need special and customized add-ons. EDI, FTP or XML solutions are often required

Think ahead and build generic solutions so that

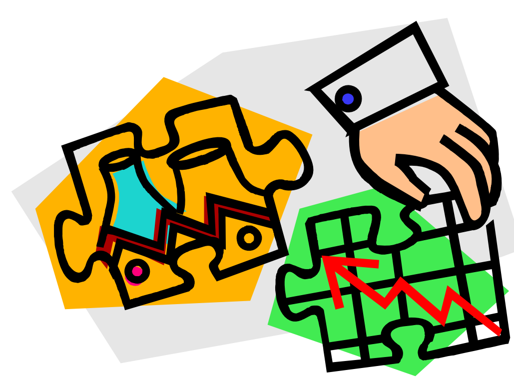
– new features can be included as the relationship develops
– the same system can be applied towards other VMI partners



Define operational parameters

When you have determined what information is available and how information can be transferred it is essential to define the operational parameters of the collaboration program.

- If not already done you must define what data to share and frequency of update. Update frequency should be related to the supplier's need for replanning.
    - Supplier could receive inventory status, production plans and incoming orders
    - Customer could receive an Advance Shipment Notice including shipment content and expected time of arrival
- Agree on time for transfer of ownership, shipment regulations and invoice routines.
    - The goods can belong to the customer or the supplier when in customer's store
    - Shipment responsibilities can be regulated by common Incoterms
    - Invoice can be issued periodically or by call-offs
- Define targeted performance levels, e.g. minimum and maximum inventory levels, service levels or turnover rates
    - Inventory level intervals is a flexible solution to the supplier as long as determined levels are appropriate
    - Service level, stock-out level or other measures indicating product availability are more definite measures. Desired service level should be reflected by the trade-off between holding costs and stock-out costs
    - Turnover rates can be used when demand is variable and physical inventory level is an inappropriate indicator for future availability
- Agree on a lot size/price policy if applicable
    - Lot size and unit price is one of the most common dilemmas in logistics. If lot size variation has a huge impact on unit price this should be included in the inventory level decision.
- Identify what decisions should be subject to collaboration, e.g. forecasting, product development, product mix and life cycle management, introduction and promotions
    - all decisions that influence future demand should be discussed prior to execution.



Define performance measures

Your choice of performance indicators reflects your priorities and they should be related to the goals and purposes for entering the VMI agreement.

When your company is a supplier

Measure customer performance on

- Quality of demand data, e.g. forecast errors
- Correctness of other information transferred, e.g. bill of material or inventory levels
    - By measuring the quality of the data and information received, the supplier improves the quality of the decisions made on the basis of the received information

When your company is a customer

Measure supplier performance on his ability to perform within targeted performance levels, e.g.

- Stock out level
- Service level
- Inventory turnover rate
    - Sanctions, fines or other required corrective actions should be agreed on and included in the collaboration contract

Establish a forum for collaboration

Set a schedule for regular collaboration meetings with representatives from both customer and supplier. The main purpose of this forum should be to discuss long term collaborative issues and improvements. Build human relations between the partners and maintain an open environment for discussion of initiatives and ideas. This forum should not be used for urgent operational matters.

Suggested frequency is semi annual or quarterly. Frequency can be higher in the earlier stages of the program and it can be reduced over time. Possible issues for discussion are:

- Expansion of the program, incorporating new products or product groups
- Changes of responsibilities
- Process changes
- Trend analyses, challenges and not urgent problems