Research paper

Performance outcomes and success factors of vendor managed inventory (VMI)

Marloes J.T. Claassen
IG&H Management Consultants, Woerden, The Netherlands

Arjan J. van Weele
Department of Technology Management, Eindhoven University of Technology, Eindhoven, The Netherlands, and

Erik M. van Raaij
RSM Erasmus University, Rotterdam, The Netherlands

Abstract

Purpose – The purpose of this paper is to seek to investigate performance outcomes of vendor managed inventory (VMI) from a buyer's perspective and enablers for its successful application.

Design/methodology/approach – Structural equation modelling through Partial Least Squares (PLS) is used to identify relationships between four enablers (information systems, information sharing, information quality, and relationship quality), perceived VMI success, and three outcomes (cost reductions, customer service, and supply chain control).

Findings – Buyer-perceived VMI success is impacted by the quality of the buyer-supplier relationship, the quality of the IT-system and the intensity of information sharing, but not by the actual quality of the information shared. Furthermore, VMI leads to three performance outcomes: higher customer service levels, improved supply chain control and, to a lesser extent, cost reduction.

Research limitations/implications – Although theory stipulates a positive impact of high quality information on the success of VMI, this study shows that the effect of information quality is limited in practice.

Practical implications – The results of the survey show that purchasing managers who invest in the relationship with their suppliers and a good IT infrastructure are more likely to get better results from a VMI implementation. Furthermore, this paper shows that while most managers expect major cost reductions when implementing VMI, benefits primarily come from improved service levels.

Originality/value – The study provides empirical evidence of why VMI in practice does not achieve all the benefits claimed in theory.

Keywords Vendors, Buyer-seller relationships, Supply chain management, The Netherlands

Paper type Research paper

Introduction

Vendor managed inventory (VMI) originated in the early 1980s with mass retailers demanding vendors to take up the responsibility for inventory replenishment based on sales figures made available by the retailer (Blatherwick, 1998; Cachon and Fisher, 1997). Today, the concept of VMI has spread to industries outside retailing as well (Cachon and Fisher, 1997; Tyan and Wee, 2003). VMI promises a win-win situation for both buyer and supplier. In a true VMI setting, the supplier is given the freedom to plan its own production and decide upon the replenishment schedule as long as the agreed customer service levels are met. This enables suppliers to stabilize their production and to optimize the transportation costs (Waller *et al.*, 1999). For the buyer, administration and inventory costs can be decreased. Enhanced collaboration between both supply chain partners should reduce lead times and minimize the risk of demand amplification in the supply chain (the so-called "bullwhip effect") (Disney *et al.*, 2004; Reiner and Trcka, 2004).

Regardless of how promising the theory of VMI may appear, actual results of VMI implementations can be disappointing (Dong *et al.*, 2007; Muckstadt *et al.*, 2001; Sabath and Fontanella, 2002). Aichlmayr (2000, p. 66) interviewed seven executives in the field of Supply Chain Management and quotes one of these managers saying: "Out of 10 VMI implementations, three or four achieve great benefits. Three or four have some benefits, but not as much as anticipated, and two or three do not get any benefits". A number of studies have looked at these disappointing results, and some important success factors underlying VMI implementations, such as trust and information exchange, have been identified (Barratt, 2004b; Peterson *et al.*, 2005). Quantitative studies into the performance outcomes of VMI are scarce, however (Vereecke and Muylle, 2006).

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Against this background, the aim of this paper is twofold:

1 to compare theory and practice about performance outcomes related to VMI; and
2 to identify enabling factors underlying successful VMI implementation.

We will first further expand on what VMI is and what the expected benefits of VMI are. Then, we will review what the literature offers in terms of enablers for a successful implementation of the VMI concept. Following this review of the literature, we present the outcomes of a set of exploratory interviews. Using the inputs of both the literature and the interviews, we develop a conceptual model, which is subsequently tested with a survey amongst buyers in The Netherlands. We discuss the outcomes of the survey in light of the literature, and identify implications for supply management practice.

The concept of Vendor Managed Inventory (VMI)

The basic principle of VMI is that the vendor, or supplier, becomes responsible for managing the inventory at the customer's site (Kuk, 2004). In contrast to buyers who often manage a broad portfolio of purchased items, suppliers are usually responsible for a more limited range of products of which they have more specific knowledge, and therefore should be better in forecasting and managing the flow of their products through to the end consumer. Making the supplier responsible for replenishment should result in inventory and logistics costs being reduced throughout the total supply chain (Blatherwick, 1998). In order for the supplier to be able to manage this inventory, information about inventory levels, expected demand, promotional activities, and product related costs should be made available to the supplier by the buyer (Barratt, 2004a; Kumar and Kumar, 2003). This information enables the supplier to make better replenishment decisions based on total supply chain costs, and prevent local sub-optimization when both players would try to optimize their own profits individually. Early availability of such information enables the supplier to be pro-active (Kaipia *et al.*, 2002), which should result in reduced lead times. Effective implementation of VMI thus requires a cross-functional and inter-organizational approach. Accurate and timely demand information needs to be shared between the marketing and supply functions of the buyer as well as with the planning function of the supplier.

With the implementation of VMI, one echelon of demand forecasting and ordering is effectively removed from the supply chain (Disney and Towill, 2003b). The role of the customer changes from one of inventory management into providing the supplier with all information which could aid the supplier in making optimal decisions for both echelons as soon as it becomes available. Removing an echelon in a supply chain can result in considerable benefits because it eliminates delays in information and material flows and removes one source of uncertainty and distortion in supply chain decision-making (Wikner *et al.*, 1991). In order to protect product availability for the buyer, VMI is often implemented with minimum and maximum limits of stock levels (Disney and Towill, 2003a). In the absence of a buyer's trust in the supplier's capabilities to replenish just-in-time, the buyer may set tight min-max limits. The tighter such minimum and maximum levels however, the less leeway for the supplier to decide upon the optimum replenishment schedule (Kaipia *et al.*, 2002).

VMI and expected benefits

Benefits of VMI have been discussed in various places, and consist broadly of cost reductions, service improvements and greater transparency in the supply chain (cf. Angulo *et al.*, 2004). This paragraph will provide an overview of the advantages of VMI mentioned in literature. The most important benefit for suppliers is that they are better able to align their production processes to customer demand (Dong and Xu, 2002; Tyan and Wee, 2003; Waller *et al.*, 1999). Since information about actual demand and forecasted demand is available at an early stage, fluctuations can easily be smoothed over time and suppliers can respond proactively instead of reactively. Furthermore when VMI is implemented on a large scale, the flexibility in the replenishment schedules enables the supplier to create full truck loads, which will result in a reduction of transportation costs (Lee, 2004; Waller *et al.*, 1999). Another advantage for the supplier is a reduction of inventory costs. Because uncertainty is reduced considerably, obsolescence of safety stocks at the supplier is reduced (Dong and Xu, 2002; Kumar and Kumar, 2003; Tyan and Wee, 2003). Finally, an important advantage for the supplier is the establishment of a long trustworthy relationship with the customer resulting in more loyal customers and thus secured sales (Vergin and Barr, 1999; Xu *et al.*, 2001).

The customer benefits are related to a reduction in administration costs because extensive materials requirement planning is not necessary anymore, whereas individual purchase orders are replaced by blanket purchase orders (Aichlmayr, 2000; Kumar and Kumar, 2003). Since there will no longer be backorders or returns, administration costs will decrease even more (Holström, 1998). Furthermore, the customer benefits from better service levels (Kumar and Kumar, 2003; Tyan and Wee, 2003) due to a higher level of collaboration and better insight in each others needs.

Taking the entire supply chain into account, there are some additional benefits. Most importantly is the prevention of sub-optimization. In the traditional supply chain, the customer decides about the date and the volume of the replenishments to be made by the supplier. These decisions are based on the buyer's actual inventory and handling costs and do not take into account the transportation costs and the costs for maintaining flexible capacity by the supplier. This results in suboptimal decisions (Cousins and Spekman, 2003). VMI provides the supplier with all information about stock levels and demand, and in most cases all supply chain costs, which enables him to make better decisions for the entire supply chain, resulting in a higher overall margin. The early and continuous exchange of information between buyer and supplier should also result in a reduction of the bullwhip effect (Disney and Towill, 2003b; Disney *et al.*, 2004; Reiner and Trcka, 2004). The bullwhip effect is a phenomenon observed in forecast-driven distribution channels, caused by uncertainty of demand or interrupted information flows between supply chain partners. Inaccuracies in forecasts and the tendency to build safety stocks result in variations between production and demand and these variations are amplified as one moves upstream in the supply chain, i.e. away from the final customer. The bullwhip effect generally results in excessive inventory, increased costs, and longer lead times in the supply chain.

Enablers for successful VMI implementation

In the literature, enablers of VMI are determined based on both qualitative and quantitative research. Barratt (2004b) has conducted 32 interviews across six companies to identify enablers and inhibitors of collaborative planning approaches, which includes VMI. All enablers and inhibitors identified by Barratt could be clustered into two main areas. First, the importance of the relationship was stressed, leading to the identification of enablers such as mutual interdependency, openness, trust, honesty, chemistry between both partners, the frequency of interaction, and commitment. Commitment was described by willingness of both partners to invest in a long term relationship. Not only management commitment is important, but commitment at multiple levels of the organizations involved. The second cluster identified by Barratt (2004b) revolves around information as a key for the success of a VMI implementation. Information was broken down into: information sharing, availability, completeness and reliability. The effect of relationship quality and information quality on collaborative planning has also been investigated by Peterson *et al.* (2005). They surveyed 169 purchasing managers and concluded that trust and information quality both had a positive influence on the planning process. Information quality was broken down into accuracy, timely, completeness, consistency and ease of access. Furthermore they noticed that information shared through linked information systems had a larger impact on collaborative planning effectiveness than information shared in more traditional modes.

Other articles also present information as an important enabler. A difference has been made between the extent of information sharing and the quality of the information that is shared. Sharing information about, for instance, common goals and objectives, can help create a common understanding, thereby enhancing supply chain decision making and activities (Barratt, 2004b; Barratt and Oliveira, 2001; Cottrill, 1997; Frohlich and Westbrook, 2002). Furthermore, by sharing information about exceptions like promotions and campaigns, better forecasts can be made, which is essential for the success of VMI (Blatherwick, 1998). Lastly, two-way exchange of information between buyer and supplier is critical to create the necessary transparency in the relationship (Kumar and Kumar, 2003; Tyan and Wee, 2003).

The quality of information systems has also been forwarded as an enabler for VMI. According to Simchi-Levi *et al.* (2003), the objectives of IT in supply chain management and thus VMI are:

- providing information availability and visibility;
- enabling a single point of contact for data;
- allowing decisions based on total supply chain information; and
- enabling collaboration with supply chain partners.

The quality of information systems consists of the need for a broad communication interface and clearly identified and direct communication channels (Clark and Lee, 2000; Tyan and Wee, 2003). The compatibility of information systems has also been emphasized as an enabling factor (Aichlmayr, 2000; Kaipia *et al.*, 2002; Tyan and Wee, 2003). To summarize, four important enablers can be defined from the literature: Relationship quality, information quality, information sharing, and the quality of information and communication systems.

VMI in practice: a qualitative exploration

In preparing for our quantitative survey, exploratory interviews were conducted with three buyers and three suppliers. The goal of the interviews was to investigate whether statements about VMI outcomes, enablers for success, and the design of VMI itself as found in the literature, also held in practice. The interviews focused on issues like control, information, the buyer-supplier relationship, IT-systems, and VMI outcomes. The six interviewees were selected to cover smaller and larger organizations in a variety of industries (retail, chemical, construction, equipment, and electronics). Our informants were purchasing managers at the buying companies and supply chain specialists at the supplier companies, and all interviews were complemented with an analysis of relevant documents, such as reports and presentations describing the setup of the VMI systems.

The interviews confirmed that VMI can be implemented for a diverse set of products and demand patterns. We have found that different situations lead to different VMI designs. If VMI was implemented for strategic products, the buyer was highly involved and willing to provide the supplier with all necessary information. However, if VMI was applied for commodity products, the buyer expected the supplier to take responsibility of the entire chain without a lot of buyer involvement. We also observed that inventory costs were always paid by the least powerful partner. A surprising finding in this qualitative exploration was that almost all buyers provided their supplier with unexpectedly tight upper and lower limits for the inventory level. This is at odds with the theory of VMI, and significantly reduces the level of replenishment flexibility for the supplier. The distance between those limits differed between cases as did the penalty costs should those limits be exceeded.

The information that was shared between buyer and supplier varied from detailed production schedules to information that was only slightly related to inventory control. Most commonly, the information shared included inventory levels, demand forecasts, production schedules and promotional activities. Inventory levels were shared once a day or once a week and forecasts were shared once a week or once a month. In all cases, the information was shared through linked ICT-systems. In the majority of cases, EDI linkages were used for buyer-supplier communication, and often investments were made in an additional customized ICT tool. For the internal processing of information (in case of suppliers) or the collection of information (in case of the buyers) ERP systems like SAP were mentioned as core ICT platforms enabling VMI.

With respect to the buyer-supplier relationship, all participants, except one, mentioned that trust was extremely important. The one exception was a buyer who mentioned that VMI and trust were not related. It appeared however that this buyer set very tight limits with high penalty costs, which explains why trust played no role in this case. At the same time, setting such tight limits is not in line with the core ideas underlying true VMI.

All suppliers mentioned that VMI helped to secure their sales. However, to realize improvements in capacity planning, it is important for a supplier that VMI is implemented with a large number of customers. Not all suppliers had accomplished this yet. All buyers were enthusiastic about the improved service levels. There were less emergency orders and the number of incorrect orders was reduced. Both buyers and suppliers mentioned the advantage of increased supply chain control. In three cases an increase in the sales margin for the supplier could be noticed. With respect to costs, our findings were mixed. Some had the advantage of reduced transportation costs while others benefited more from reduced inventory costs. Only one buyer mentioned a reduction in administration costs. The interviews confirmed the importance of the enablers found in the literature, and provided us with added insights into the expected benefits of VMI.

Research model and hypotheses

Based on the findings from our literature review and the conclusions from the interviews, a research model was developed as depicted in Figure 1. Our model links buyer-perceived success of VMI implementation to outcomes on the right hand side of the model, and to enablers on the left hand side. From our literature review and our interviews, we have identified four key enablers for VMI success: quality of ICT systems, quality of information, intensity of information sharing, and relationship quality. We hypothesize:

H1. The higher the quality of ICT systems, the higher the buyer-perceived VMI implementation success.

H2. The higher the quality of the information that is shared, the higher the buyer-perceived VMI implementation success.

H3. The more extensive the information that is shared, the higher the buyer-perceived VMI implementation success.

H4. The higher the quality of the buyer-supplier relationship, the higher the buyer-perceived VMI implementation success.

Our review of the literature, in combination with the interviews, revealed three main categories of expected VMI outcomes: reduction of costs, improvements in customer service levels, and improved supply chain control. We hypothesize:

H5. The higher the buyer-perceived VMI implementation success, the more cost reductions are achieved.

H6. The higher the buyer-perceived VMI implementation success, the more customer service level improvements are achieved.

H7. The higher the buyer-perceived VMI implementation success, the more supply chain control improvements are achieved.

Research methods

For the measurement of the latent variables in the model, multiple items were used, based largely on previously published scales. To measure relationship quality, items from the relationship quality scale of Walter *et al.* (2003) were adapted and used. We chose this source because of its explicit focus on business-to-business relationships and its thorough approach to the development of a scale for relationship quality. The extent to which information is shared between buyer and supplier is measured using a set of items developed on the basis of Lee and Whang (2000) and Li *et al.* (2005). In order to measure information quality, we used the five items supplied by Li *et al.* (2005). We used the work by Li *et al.* (2005) as our guiding framework because of its specific focus on information exchange between supply chain partners. The work by Lee and Whang (2000) was used to develop items asking for specific types of information shared between supply chain partners. The scale for quality of ICT systems was self-developed on the basis of Sarkis and Talluri (2004). The work of Sarkis and Talluri (2004) specifically focuses on the evaluation of inter-organizational information systems from a supply chain perspective. The scales for perceived VMI success and the performance indicators have been developed based on our review of the literature. All items are presented in Table I. VMI success and the four enablers were measured with statements where respondents had to indicate their extent of agreement, measured on a seven point Likert-type scale, ranging from "absolutely disagree" (1) to "absolutely agree" (7). VMI benefits in terms of cost reductions, customer service and supply chain control were measured

Figure 1 Research model

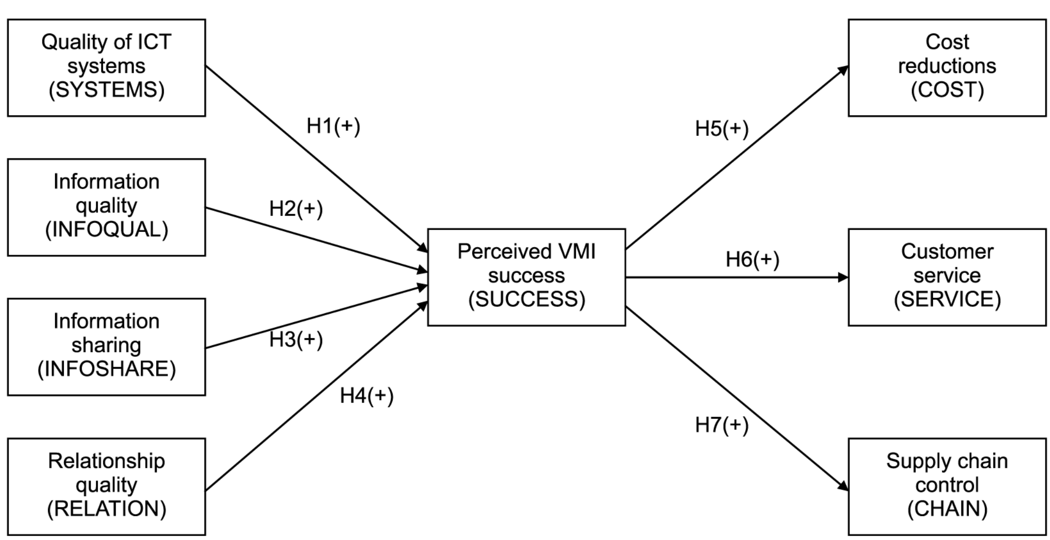

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Table I Summary of measurement scales

Constructs Items	Mean	SD	Item loading	CR	AVE
Quality of ICT systems (SYSTEMS)				0.910	0.669
The communication system we use for VMI is compatible with existing IT systems	3.906	1.806	0.863		
Our IT systems are compatible with the supplier's systems	3.609	1.658	0.857		
Our information can readily be entered in the supplier's systems	4.063	1.435	n/a		
Our communication system is easy to use	4.297	1.388	0.799		
We are satisfied with our communication system	4.375	1.558	0.856		
Our information system is up-to-date	4.484	1.512	0.704		
Information quality (INFOQUAL)				0.930	0.769
The information we provide is timely	4.953	1.350	0.877		
The information we provide is accurate	4.922	1.429	0.865		
The information we provide is complete	4.797	1.394	0.868		
The information we provide is adequate	4.859	1.446	0.897		
The information we provide is reliable†	5.240	1.752	n/a		
Information sharing (INFOSHARE)				0.879	0.644
We inform our supplier of demand changes	5.344	1.417	0.804		
We exchange information which enables us both to perform better	5.563	1.220	0.775		
We make actual usage/sales data available to our supplier	5.141	1.798	0.785		
We make inventory data available to our supplier	5.141	1.807	0.844		
Relationship quality (RELATION)				0.923	0.707
Compared to the ideal situation, we are satisfied with our supplier's performance	4.938	1.082	0.843		
In general, we are very satisfied with this supplier	4.984	1.120	0.859		
We can count on this supplier's support when it comes to important needs and requirements	5.313	1.111	0.821		
We are convinced this supplier will live up to all deals and agreements	4.922	1.349	0.856		
Our view of this relationship conforms with the supplier's view.	4.922	1.059	0.824		
Perceived VMI success (SUCCESS)				0.926	0.863
The implementation of VMI was a good idea	5.719	1.076	0.935		
For me, VMI has more advantages than disadvantages	5.531	1.272	0.923		
Cost benefits (COST)				0.845	0.578
Effect of VMI on inventory costs	5.125	1.047	0.718		
Effect of VMI on transportation costs	4.672	1.070	0.792		
Effect of VMI on administration costs	5.000	1.155	0.784		
Effect of VMI on materials handling costs	4.781	1.119	0.745		
Service benefits (SERVICE)				0.886	0.721
Effect of VMI on customer responsiveness	4.641	1.146	0.790		
Effect of VMI on flexibility in the supply chain	5.188	1.022	0.864		
Effect of VMI on customer service levels	5.328	1.009	0.890		
Supply chain control (CHAIN)				0.852	0.742
Effect of VMI on demand forecasting accuracy[a]	4.688	0.990	n/a		
Effect of VMI on the occurrence of the bullwhip effect	4.656	0.946	0.849		
Effect of VMI on the number of stockouts	5.125	1.134	0.873		

Note: [a] This item was deleted from the measurement model

with statements, where respondents had to indicate what the effect of VMI was on that performance indicator, ranging from "very negative" (1) to "very positive" (7).

A questionnaire was developed and pre-tested with two purchasing managers. This questionnaire was e-mailed to all members of the NEVI, the Dutch purchasing association. Since not all members would be involved in a VMI implementation, a low response rate was anticipated. Only companies with more than 100 employees were targeted, and the NEVI database consisted of 591 companies with 101-400 employees, and 498 companies with more than 400 employees. Of this total set, 168 companies were removed from the database, because due to their business activity (such as financial services or local government) it was not likely they would have implemented VMI. Undeliverable messages were returned from 153 e-mail addresses. The number of companies that was effectively reached, thus was 768. Of these, a total of 139 rejections were received from buyers who were not familiar with the concept of VMI. Hence, the actual sample of companies familiar with VMI was 629. After one reminder, the total response was 101, out of which 37 did not complete the whole survey. All in all, 64 useful responses were received, which amounts to a response rate of 10.2 percent. The respondents represented a variety of industries, including retail, chemicals, metalwork, and services.

The hypothesized model was tested with the use of Partial Least Squares (PLS), a structural equation modeling technique. The SmartPLS package version 2.0.M2 was used (Ringle *et al.*, 2005). PLS is a variance based latent variable structural equations modeling technique. Unlike factor-based covariance fitting approaches such as Lisrel, EQS, and Amos, PLS places minimal demands on measurement scales, residual distributions and sample size (Chin, 1998). As a generally accepted guideline, ten times the number of predictors in the most complex relationship of the model is stated as a minimum requirement for sample size determination (Barclay *et al.*, 1995; Chin, 1998). In our model, the largest block consists of VMI success with four antecedents: ICT systems, information quality, quality of information sharing, and relationship quality. Thus, application of the aforementioned guideline would yield a minimum sample size of 40 for our research. With 64 observations, our sample satisfies this requirement. Earlier PLS studies have shown that stable results can be obtained with samples of this size and smaller (Cool *et al.*, 1989; Venkatesh and Davis, 2000). The evaluation of the model fit was conducted in two stages (Chin, 1998; Hulland, 1999). First, the measurement model was assessed, in which construct validity and reliability of the measures are assessed. Second, the structural model with hypotheses was tested.

Results and discussion

The measurement model, consisting of all constructs depicted in Figure 1 with their respective measurement items, was tested first. The test of the measurement model includes the estimation of internal consistency and the convergent and discriminant validity of the constructs. All constructs were modeled using reflective indicators. A first estimation showed that three items had a loading lower than the suggested minimum of 0.70 (Chin, 1998; Fornell and Larcker, 1981). These items were dropped and the model was re-estimated. All loadings in the new model were 0.704 or greater, showing adequate item reliability (see Table I).

All composite reliabilities were at least .845, well above the recommended minimum of .70, indicating adequate internal consistency. For each construct, the average variance extracted (AVE) was at least 0.578, above the recommended minimum of 0.50 to show convergent validity (Fornell and Larcker, 1981). Finally, in order to show adequate discriminant validity, the square roots of each construct's AVE need to be higher than the correlations of that construct with all other constructs (Fornell and Larcker, 1981). All constructs satisfy this criterion, see Table II.

The research hypotheses are tested by assessing the direction, strength and level of significance of the path coefficients (gammas) estimated by PLS, using a bootstrap resampling method with 250 resamples. The results of the hypothesis testing are summarized in Table III. The hypothesis that quality of ICT systems has a positive impact on perceived VMI success is confirmed by a positive and significant path coefficient between the two constructs ($\gamma = 0.27$). This supports the notion that a compatible, high quality information system is an important enabler for VMI (Tyan and Wee, 2003).

The coefficient of the path between information quality and perceived VMI success is non-significant. This means that our second hypothesis, that information quality has a positive impact on VMI success, could not be supported by our data. The latent variable inter-correlations in Table II do show however, that there is a strong positive correlation between information quality and perceived VMI success. This suggests that information quality is related to VMI success, but it has no positive effect on VMI success over and above the positive effects of high quality information systems, intensive information sharing, and a high quality buyer-supplier relationship.

Hypothesis three is supported with a positive significant path coefficient between information sharing and perceived VMI success ($\gamma = 0.40$). The more extensively information is shared between buyer and supplier, the more successful the implementation of VMI is. The fourth hypothesis, stipulating that relationship quality has a positive impact on perceived VMI success, is also supported by the data with a significant, positive path coefficient ($\gamma = 0.39$). Relationships based on trust and commitment increase the chances of a successful implementation of VMI. Taken together, the four enablers explain 51 percent of the variance in buyer-perceived VMI success (see Table II).

Buyer-perceived VMI success, in turn, has statistically significant positive effects on all three types of benefits. First of all, VMI leads to cost reductions in administration, transportation, inventory and materials handling ($\gamma = 0.34$). Furthermore, our data show that VMI translates into improved customer service levels ($\gamma = 0.56$). Finally, VMI also leads to improved supply chain control ($\gamma = 0.42$), in terms of less stockouts and prevention of the bullwhip effect. Of these three outcome effects, it is striking that the impact on cost reductions is the weakest of the three. Moreover, looking at the levels of explained variance (see Table II), we see that VMI can only explain 9 percent of the variance in cost reductions, but it explains 18 percent of the variance in supply chain control, and 31 percent of variance in customer service levels. This suggests that cost reduction is not the most salient benefit of a VMI implementation, but that its benefits should be sought primarily in service levels and improved supply chain control.

Implications, limitations, and concluding remarks

Of the seven hypotheses tested in this study, six hypotheses were supported. It seems surprising that information quality does not have a significant impact on VMI success while information sharing does. This finding is however in fact quite similar to that of Angulo *et al.* (2004), who find that VMI is still beneficial, especially from a buyer's perspective, even if there are information inaccuracies. The second surprising finding is that of the three performance outcomes, the effect of VMI on cost benefits (much touted in the literature) is the weakest.

If we look at the combined findings of the interviews and the survey, our findings support the notion of what Disney and Towill (2003b) call the two-stage programme of VMI implementation. The first stage is characterized by the vendor taking responsibility for ordering, inventory management, and replenishment. At this stage, significant improvements in customer service levels can be achieved, but total costs generally do not improve yet. In fact, they may even increase

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Table II Discriminant and convergent validity of the constructs

	R^2	1	2	3	4	5	6	7	8
1. SYSTEMS	n/a	*0.818*							
2. INFOQUAL	n/a	0.422	*0.877*						
3. INFOSHARE	n/a	0.344	0.599	*0.802*					
4. RELATION	n/a	0.355	0.340	0.326	*0.841*				
5. SUCCESS	51%	0.492	0.335	0.518	0.566	*0.929*			
6. COST	9%	0.262	0.011	0.013	0.218	0.296	*0.760*		
7. SERVICE	31%	0.185	0.146	0.349	0.251	0.559	0.237	*0.849*	
8. CHAIN	18%	0.076	0.087	0.100	0.232	0.421	0.316	0.351	*0.818*

Notes: For adequate convergent validity, the square root of the average variance extracted (AVE) for each construct (on the diagonal) should exceed 0.707. For adequate discriminant validity, the square root of the AVE should exceed all correlations with the other latent variables (reported off-diagonal). These conditions are satisfied for all constructs

Table III Summary of findings

	Independent variable	Dependent variable	Path coefficient	Sig.	Supp.?
H1(+)	SYSTEMS	SUCCESS	0.270	$p < 0.01$	Yes
H2(+)	INFOQUAL	SUCCESS	−0.141	not sign.	No
H3(+)	INFOSHARE	SUCCESS	0.401	$p < 0.01$	Yes
H4(+)	RELATION	SUCCESS	0.390	$p < 0.01$	Yes
H5(+)	SUCCESS	COST	0.338	$p < 0.01$	Yes
H6(+)	SUCCESS	SERVICE	0.560	$p < 0.01$	Yes
H7(+)	SUCCESS	CHAIN	0.422	$p < 0.01$	Yes

(Gustafsson and Norrman, 2001). This first stage is comparable to what Holweg *et al.* (2005) have termed vendor managed replenishment (VMR). In the second stage, the vendor takes full pipeline control. Only in this second stage, significant cost reductions can be achieved without sacrificing service levels. According to Holweg *et al.* (2005), this is true vendor managed inventory. The problem is that in common parlance, both types of collaboration are termed "vendor managed inventory". Disney and Towill (2003b) make clear that it is not self-evident that true VMI is implemented properly and that the vendor is granted full pipeline control. Using all VMI-related data effectively can be quite a challenge for the supplier (Angulo *et al.*, 2004). Our results suggest that many so-called VMI implementations are in reality vendor managed replenishment (VMR) implementations, which have not reached the second stage of full vendor pipeline control. Unfortunately we did not measure VMI maturity to prove the last statement.

Our findings from the interviews seem to corroborate this explanation. What we have observed in the interviews is that arrangements made between buyer and supplier put constraints on the optimization of replenishment decisions. These constraints are caused by upper and lower limits for the inventory levels imposed by the buyer, where lower limits were quite high and both limits were accompanied by penalty costs. High lower limits and penalties are not fully in line with the true VMI concept which favors dynamic optimization of production and replenishment schedules. As a result of such limits, suppliers cannot fully consider total supply chain costs when making replenishment decisions. Against the background of such practices, it seems logical that quality of information has little impact on buyer perceived VMI success.

Another side effect of imposing a high lower limit is that buyers ensure availability of safety stocks causing slack in the supply chain. This slack would explain our finding of high customer service levels, but limited cost benefits of VMI. In order to prevent such slack-inducing, ineffective implementations of VMI, Chin *et al.* 2004 recommend that personnel at different levels, from different functions within both organizations should be involved in the design and management of a VMI system. Information related to demand (e.g., planned promotions) needs to flow from the buyer's marketing department through the buyer's supply operations to the supplier. Moreover, the supplier should be represented in a cross-functional team which is tasked to develop suggestions and feedback for continuous improvement of the system. This could help prevent a strong buyer perspective in VMI decision-making.

This study is not without its limitations which should be mentioned here. First of all, our sample is limited in size. Although we have attuned our method of analysis to the relatively small sample size, it would be beneficial to strive for larger sample sizes in future studies. As is common to survey research, all measures are perceptions of enablers, VMI success, and outcomes. In order to reduce common method bias, future studies could include objective measures of outcomes as well. Moreover, we have focused on buyer-perceived VMI success. As a complement to the current study, it would be instructive to focus on supplier-perceived success of VMI as well.

With this study, we have been able to confirm the role of ICT systems, information sharing, and buyer-supplier relationship quality in attaining VMI success. We have also shown that the effects of VMI on customer service and supply chain control are stronger than those on cost reductions. As we are under the impression that many VMI implementations are not of a very sophisticated kind and are still guarded by tight, buyer-imposed inventory limits and penalties, there seems sufficient potential for further optimization of this widely advocated concept.

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Corresponding author

Erik M. van Raaij can be contacted at: eraaij@rsm.nl