Performance Outcomes and Success Factors of Vendor Managed Inventory (VMI)[1]

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Summary

Vendor Managed Inventory (VMI) often does not achieve the benefits claimed in theory. This paper empirically investigates both performance outcomes of VMI and its enablers. Survey data from buyers was analysed using PLS, a structural equation modelling method. The study reveals that 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 quality of the information shared. The results furthermore show that VMI leads to three performance outcomes: higher customer service levels, improved inventory planning and, to a lesser extent, cost reduction.

Keywords: Vendor Managed Inventory, Supply Chain Management, PLS

Educator and practitioner summary

The results of this study show that purchasing managers who invest in the relationship with the supplier and a good IT infrastructure are more likely to get better results from a VMI implementation. Furthermore, our results suggest that VMI is often implemented with wrong expectations about the benefits; most managers expect major cost reductions when implementing VMI. Instead, VMI often does result in some cost reductions, but more benefits can be expected from improved service levels and improved supply chain control.

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 actual sales figures made available by the retailer (Cachon, Pisher, 1997). Today, the concept of VMI has spread to other industries outside retailing (Cachon, Pisher, 1997; Tyan, Wee, 2003). When implementing VMI, the supplier becomes responsible for managing the inventory at the customer's site (Kuk, 2004). In order for the supplier to be able to manage this inventory, information about inventory

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levels, expected demand, promotional activities, and product related costs should be exchanged (Barratt, 2004a; Kumar, Kumar, 2003). This information enables the supplier to take optimal replenishment decisions based on total supply chain costs, and to prevent sub-optimisation, resulting from both players trying to optimise their own profits.

Supply chains are becoming more fragmented as a result of an increase in outsourcing, which is taking place across many industries (Van Weele, 2005). Longer lead times and sub-optimisation are negative side-effects of this outsourcing trend (Christensen, 2001). VMI can help alleviate such problems since it enables companies to reduce lead times while at the same time reducing supply chain overall costs.

Regardless of how promising the theory of VMI may appear, actual results of VMI implementations are often disappointing (Muckstadt et al., 2001). Aichlmayr (2000) 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” (p. 66). A number of studies has looked at these disappointing results, and some important success factors underlying VMI implementations have been identified (Barratt, 2004b; Peterson et al., 2005). Quantitative studies into the performance outcomes of VMI are scarce, however (Vereecke, Muylle, 2006).

Against this background, the aim of this paper is twofold: 1) to compare theory and practice about performance outcomes, and 2) to identify enabling factors underlying successful VMI implementation. We will first describe 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 five exploratory case studies. Using the inputs of both case studies and the literature, 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.

VMI and expected benefits

Benefits of VMI have been discussed in various places, and consist roughly of cost reductions, service improvements and creating transparency in the supply chain. This paragraph will provide an overview of the advantages of VMI mentioned in literature. Most authors agree that benefits can be divided into three categories: Benefits for the supplier, benefits for the buyer, and benefits for the supply chain as a whole. Most benefits are either cost related, or service related.

The most important benefit for suppliers is that they are better able to align their production processes to customer demand (Dong, Xu, 2002; Tyan, Wee, 2003; Waller et al., 1999). Since information about actual demand and forecasted demand is available in an early stage, fluctuations can easily be smoothened over time and suppliers can respond proactively instead of reactively. Furthermore, as VMI presupposes that the supplier becomes responsible for determining the replenishment schedule, the supplier becomes more flexible. Another advantage for the supplier is the potential reduction in transportation costs. 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). Finally, an important advantage for the supplier is the establishment of a long trustworthy relationship with the customer resulting into loyal customers and thus secured sales (Vergin, Barr, 1999; Xu et al., 2001).

The customer benefits from a reduction in administration costs because material requirement planning and purchase orders have become obsolete (Aichlmayr, 2000; Kumar, Kumar, 2003). And since there will be no backorders and returns anymore, administration costs will decrease even more (Holström, 1998). Furthermore, the customer benefits from a lead time reduction (Daugherty et al., 1999; Kaipa et al., 2002; Simchi-Levi et al., 2000; Waller et al., 1999). And finally, the customer will benefit from better service levels (Kaipia et al., 2002; Kumar, Kumar, 2003; Tyan, Wee, 2003).

The improvements for the entire supply chain are a reduction of inventory costs, since the stock point of finished goods at the suppliers' site has become obsolete (Dong, Xu, 2002; Kumar, Kumar, 2003; Tyan, Wee, 2003). In addition, handling costs can decrease, but more importantly, sub-optimisation can be prevented. In the traditional supply chain, the customer decides about the date and the amount of a replenishment. This decision is based on the customer's own inventory and handling costs and does not take into account the transportation costs and the costs for flexible capacity of the supplier. VMI provides the supplier with all information about stock level and demand, and in most cases all supply chain costs, and in this way, optimal decisions for the entire supply chain can be made which will result 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, Towell, 2003; Disney et al., 2004; Reiner, Trcka, 2004). The bullwhip effect is an increase in oscillation upstream the supply chain, which is caused by uncertainty of demand, or interrupted information flows for instance due to batch sizes. The bullwhip effect almost always results in excessive inventory and longer lead times.

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, individual 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 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, Oliveira, 2001; Cottrill, 1997; Frohlich, 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, Kumar, 2003; Tyan, 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;
- 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, Lee, 2000; Tyan, Wee, 2003). The compatibility of information systems has also been emphasized as an enabling factor (Aichlmayr, 2000; Kaipia et al., 2002; Tyan, 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

To investigate the differences between the ways in which VMI is described in the literature and actual VMI implementations, five case studies have been conducted. The goal of these case studies 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 case studies focussed on issues like control, information, the buyer-supplier relationship, IT-systems, and results. The five cases were selected to cover smaller and larger organisations in a variety of industries. Our key informants were purchasing managers at buying companies and supply chain specialists at supplier companies, and all interviews were complemented with document analysis. The data were analyzed using cross-case synthesis, a method that compares the case study findings in a conceptually clustered matrix to identify differences (Yin, 2003).

The case studies showed that VMI can be implemented for a diverse range of products and demand patterns. Different situations lead to different VMI designs. We have found that if VMI was implemented for strategic products, buyer involvement and the willingness to share information with the supplier were higher. On the other hand, in those cases were VMI was implemented for commodity products, buyer involvement was lower and the supplier was expected to take full control of the entire chain. Another observation on VMI design is that in all five cases, inventory costs were paid by the least powerful partner. Finally, a striking observation was that all buyers imposed inventory limits on their suppliers. In two out of five cases, lower limits were set, while in the other three cases both upper and lower limits were defined. The difference between those limits differed as did the penalty costs should those limits be exceeded. These limits indicate that buyers do not entrust their suppliers with full inventory and replenishment control.

The information that was shared between buyer and supplier varied from nothing more than production schedules to every bit of information 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.

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 unrelated. This buyer had set very tight limits with high penalty costs, which is indeed an indication of a low level of trust. It should be noted that setting such tight limits is not in line with the core ideas underlying true VMI.

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 the suppliers) or the collection of information (in case of the buyers) ERP systems like SAP were mentioned as core ICT platforms enabling VMI.

All suppliers mentioned that VMI helped to secure their sales. However, to realize improvements in capacity planning, it appeared that it is important 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 a reduction in incorrect orders. Both buyers and suppliers mentioned the advantage of the increased supply chain control. In three out of five cases an increase in the sales margin for the supplier could be noticed. With respect to costs, many differences appeared, 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. These five case studies are limited in number, and they do not represent more than a qualitative exploration, yet, the findings provided further support for the importance of the enablers as they were identified from literature, and they presented additional insights into the expected benefits of VMI.

Research model and hypotheses

Based on the conclusions from the case studies and the findings from our literature review, 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 exploratory case studies, we have identified four key enablers for VMI success: Quality of ICT systems, quality of information, intensity of information sharing, and relationship quality. We hypothesise:

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

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

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

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

Our review of the literature, in combination with the five case studies, revealed three main categories of expected VMI outcomes: Reduction of costs, improvements in customer service levels, and improved supply chain control. We hypothesise:

H5: The higher the perceived VMI implementation success, the more cost reductions are achieved.
H6: The higher the perceived VMI implementation success, the more customer service level improvements are achieved.
H7: The higher the perceived VMI implementation success, the more supply chain control improvements are achieved.

Insert Figure 1 about here

Research methods

Measures
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. 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). The scale for quality of ICT systems was self-developed on the basis of Sarkis and Talluri (2004). 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 1. 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 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).

Sample and procedure
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. 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 total sample size, i.e. the number of companies that was effectively reached, thus was 629. Of these, a total of 139 rejections were received from buyers who were not familiar with the concept of VMI. 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 %. Respondents come from a variety of industries, notably from the retail sector (17%), the service sector (17%), metal-work industry (13%), chemical industry (12%), machine building industry (10%), and others (32%).

Data analysis

The hypothesized model was tested with the use of PLS. The SmartPLS package version 2.0.M2 was used. PLS is a variance based latent variable structural equations modelling technique, which uses an estimation approach that places minimal demands on sample size and residual distributions (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, Higgins, Thompson, 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. Earlier PLS studies have shown that stable results can be obtained with samples of this size and smaller (Cool et al., 1989; Venkatesh, 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

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 modelled using reflective indicators. A first estimation showed that three items had a loading lower than the suggested minimum of .70 (Chin, 1998; Fornell, Larcker, 1981). These items were dropped and the model was re-estimated. All loadings in the new model were .704 or greater, showing adequate item reliability (see Table 1).

Insert Table 1 about here

All composite reliabilities were at least .848, well above the recommended minimum of .70, indicating adequate internal consistency. For each construct, the average variance extracted (AVE) was at least 0.644, well above the recommended minimum of 0.50 to show convergent validity (Fornell, 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, Larcker, 1981). All constructs satisfy this criterion, see Table 2.

Insert Table 2 about here

Test of the structural model

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 summarised in Table 3. The hypothesis that quality of ICT systems has a positive impact on VMU 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, Wee, 2003).

The coefficient of the path between information quality and 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 2 do show however, that there is a strong positive correlation between information quality and 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 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 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% of the variance in buyer-perceived VMI success (see Table 2).

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 2), we see that VMI can only explain 9% of the variance in cost reductions, but it explains 18% of the variance in supply chain control, and 31% of variance in customer service levels. This suggests that cost reduction is not the most salient benefit of a VMI implementation, but that benefits should be sought primarily in service levels and improved supply chain control.

Insert Table 3 about here

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. An explanation could be found in what Disney and Towell (2003) call the two-stage programme of VMI implementation. The first stage is characterised by the vendor taking responsibility for the inventory and replenishment. At this stage, customer service levels will improve, but total costs may even increase. In the second stage, the vendor takes full “pipechain control”. Disney and Towell (2003) make clear that it is not self-evident that VMI is implemented properly and that the vendor is granted full pipechain control. Using all VMI-related data effectively can be quite a challenge for the vendor (Angulo et al., 2004). Our results suggest that many VMI implementations have not reached the second stage of full vendor pipechain control.

Our case studies seem to corroborate this explanation. What we have observed is that arrangements made between buyer and supplier allow for a lot of slack. This slack is the result of the upper and lower limits for the inventory levels that are imposed by the buyer. In many cases, these arrangements are static (fixed for a year) rather than dynamic as suggested in the literature. And both limits are accompanied by penalty costs. When deciding on the limits, many buyers ensure that sufficient safety stock is present. Such limits and penalties are not in line with the true VMI concept that favours dynamic optimisation of inventory levels and replenishment schedules. As a result of these limits, suppliers will still not 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. Moreover, the slack in the supply chain will help attain high customer service levels, but cost benefits will lag behind.

Future research could look into different forms of VMI, particularly in light of the stages of VMI implementation suggested by Disney and Towell (2003). Such a study could found our observations with more empirical evidence. Of particular interest would be future research that links different forms of VMI and different levels of VMI sophistication to different outcomes. VMI with a low level of sophistication would be characterised by the vendor being made responsible for inventory control, while the buyer remains in strict control using upper and lower inventory limits and penalties for breaking these limits. Trust is expected to be low in this situation, and information sharing relatively limited. VMI with a high level of sophistication would be characterised by a vendor having full pipechain control, with extensive data sharing and a material availability target without inventory limits. This situation would require high levels of mutual trust. Based on this study, our assumptions would be first, that VMI implementations with a low level of sophistication would be related to low levels of cost reductions and a non-significant impact of information quality, and second, that in situation of high VMI sophistication, information quality would be more important for success, and the impact of VMI on cost reductions would be positive and significant.

This study is not without its limitations which should be mentioned here. First if 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 buyer-imposed inventory limits and penalties, there seems sufficient potential for further improvement of this widely advocated concept.

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Table 1: Summary of measurement scales

Constructs Items	**Mean**	**St. Dev.**	**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	1,7519	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		
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. †	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		

† This item was deleted from the measurement model.

Table 2: 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**

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 3: 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	n.s.	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

Figure 1: Research model