Effectiveness of vendor-managed inventory in the electronics industry: determinants and outcomes

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Abstract

This study used the extended limits-to-value model to frame four research hypotheses related to the effects of organizational size, employee involvement, and logistics integration on the expected and perceived values of vendor-managed inventory (VMI) as implemented in the electronics industry. Most of the findings supported the hypotheses. Specifically, that supply chain members working for organizations with high levels of employee involvement and logistics integration were more likely to realize the potential values of VMI. However, contrary to the notion that large organizations have more slack resources in technology adoption and implementation, VMI benefited small organizations most.

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Keywords: Vendor-managed inventory; Limits-to-value; Logistics integration; Employee involvement; Organizational size

1. Introduction

Vendor-managed inventory (VMI) is a tool used to improve customer service and reduce inventory cost [1,11,27]. It is a supply initiative where the supplier assumes the responsibility of tracking and replenishing a customer’s inventory. The concept was first successfully implemented between Wal-Mart and Procter & Gamble in the late 1980s. Since then, other companies such as Shell Chemical, Campbell Soup, and Johnson & Johnson have followed suit [7]. To date, it has become one of the key programs in the grocery industry’s pursuit of “efficient consumer response” and the garment industry’s “quick response” [32].

In a VMI partnership, the suppliers generate orders for the customers based on the actual warehouse withdrawal at the customer distribution centers, and product usage and consumption at customer stores. The key to its success is good connectivity between the customer and the supplier through which the suppliers have direct access to consumption information in order to make better forecast and better respond to the customers’ inventory needs in terms of quantities to ship and locations to replenish. The replenishment decisions made by the supplier are then more likely to be accurate and the orders generated for the customers are more likely to meet the true demand in the marketplace. The reliance on consumption information effectively minimizes the so-called bullwhip effect that occurs when time lags coupled with batch orders from the buyers, tend to amplify demand fluctuations as they go up the supply chain [22,23]. It is generally accepted that VMI can result in lower incidences of stock-out situations and hence an increase in the levels of customer services, and cost
reduction due to an increase in inventory turns and a decrease in the levels of safety stock [13].

Although VMI has advantages, many anecdotes suggest otherwise [9,31]. Among the limitations are: an increased level of details required for planning, high administration costs, ineffective ordering and fulfillment processing, particularly for distribution centers, and a high incidences of failure on the part of the supplier to harness the customer specific data for planning and manufacturing production. In some cases, priority treatment by reserving finished goods to a few customers has caused shortages to others. These problems have increased the number of cancellation and failures of VMI initiatives.

This paper explores some of the underlying factors that might affect the effectiveness of VMI on service improvement and cost reduction, and argues that the initial success of VMI in the garment and retailing industries might not be generalizable to others. To frame the present research questions, we use the extended limits-to-value model of Chircu and Kauffman [8] to examine the role of VMI in improving the connectivity between the suppliers and customers.

2. Research hypotheses

Despite the huge and continuing growth in IT investment, it is often claimed that the actual benefits of IT are disappointing, and that IT expenditure has failed to yield significant productivity gains [34]. A prime area of concern is that IT investments often involve major changes to processes, ingrained working practices and authority relationships. A very large percentage of information systems fail to deliver benefits or to solve intended problems because the process of organizational change was not properly addressed [18]. Brynjolfsson and Hitt [6] found it increasingly important to organize in ways that leverage the value of IT through restructuring and changing work practices. Against this, the firms have concomitantly to invest in co-specialized resources that complement the IT investment. Chircu and Kauffman argued that the realization of IT investment benefits is limited by two specific “limits to value” discounting factors: valuation barriers and conversion barriers. These block value flow and create limits to the potential return that IT investment may realize over time.

The valuation barriers consider how compatible the proposed technology is to industry standards and the firm’s existing IT infrastructure. The conversion barriers consider the availability of supporting resources to ensure smooth implementation.

In terms of valuation barriers, the basic components of VMI technology, such as electronic data interchange, barcoding, and scanning technology are readily available and their technical aspects are almost routine, and their implementation cost is low. This is particularly true in retailing, where the point-of-sales data are captured and analyzed. However, in sectors such as the electronics industry, these types of technology and their levels of implementation are more mature as information exchanged among supply chain partners goes beyond point of sales data and includes product and engineering design, and inventory and cost data. Technologies such as advanced online messaging, data retrieval systems, product identification technology, and decision support systems become essential [14,32].

From a resource-based perspective, large organizations have more slack resources at their disposal [10,25] and thus deploy VMI. Compared with their smaller counterparts, large organizations can afford to experiment with new technologies, absorb any failures, bear the cost of implementing innovative technologies, and develop core competencies and internal resources [21,35]. It is likely that slack resources have provided large organizations the competitive edge over their small counterparts through the deployment of state-of-the-art VMI technologies. Therefore, we propose the following hypothesis.

**H1.** The larger the organization, the greater the expected and perceived value of VMI in terms of information quality enhancement, service improvement, and cost reduction.

According to the limits-to-value model, the Achilles’ heel for many IT initiatives is a lack of co-specialized resources to ensure smooth implementation and user acceptance. In multiple channel integration, the resource barriers are closely linked to the effectiveness of organizational capabilities in human resources management [3,26]. Firms that dedicate the required human capital and resources to it are likely to benefit from the VMI initiatives, whereas firms that only invest in technology and ignore the difficulties of
the implementation are likely to be disappointed and have a gap between the perceived and expected values of VMI initiatives. Taken together, we give the following hypotheses.

**H2a.** In contrast to organizations with low employee involvement, supply chain members belonging to firms with high employee involvement in the VMI implementation will report higher expected and perceived values of VMI.

**H2b.** In contrast to organizations with low employee involvement, supply chain members belonging to firms with high employee involvement in the VMI implementation will report a smaller gap between the perceived and expected values of VMI.

The limits-to-value model also stipulates the significance of knowledge barriers in maximizing the potential values of VMI. In supply chain management, the consuming organizations often do not have distribution and logistics knowledge. They have to make a strategic choice of external distribution and logistics specialists. The decision hinges on three performance goals of outsourcing [24,30]. If the emphasis is about cost minimization, the consuming organizations will normally attempt to find the lowest price and use many vendors. This is the least formalized and committed arrangement. A slightly more formalized method is to use third party logistics providers, with a third party warehouse as a hub for inventory storage. This provides the consuming organizations with flexibility, especially when customers prefer the warehouses to be located near their factory. The most formalized type of strategic alliance is by having the consuming organizations sign an integrated service agreement with their suppliers. This entitles the consuming organizations to customized services pertaining to transportation, warehousing, and order fulfillment. The arrangement adds value through a continuing high supply. Increasingly, more organizations, especially those overseas, are combining both the third party hub and integrated service arrangements. The combination gives organizations both added value and flexibility. Thus, in considering the potential impact of various levels of integration, we propose the following hypothesis.

**H3a.** Members who use integrated services will expect the highest returns, whereas those with a third party arrangement will expect the least.

**H3b.** Members who use integrated services will have the smallest gap between perceived and expected values compared to a third party arrangement.

VMI initiatives are information intensive and require effective database linkages among supply chain partners to facilitate information flow. The underlying philosophy is that effective use of information can replace extensive commitment to inventory holdings [20,33]. In today’s business environment, reorder decisions are made frequently and for smaller quantities. Poor decisions are likely to result in stock-outs and production line disruption. To avoid the former situation, technology has to ensure that information exchanged among supply chain members is accurate and timely. Investment in technical capability and technological know-how is essential to attract and maintain business with the right partner. Han [17] suggests that the most promising relationships are
where the two partners use a similar technology. Compatible technology is likely to foster mutual understanding and lead to a greater satisfaction, since the exchange cost is lower while incompatible technology is likely to lead to an increase in conflict. Thus, technology that improves information flow and connectivity is likely to win supply chain members’ approval. This leads to the following hypothesis.

**H4.** Supply chain members who find that the technology capability of VMI is improving the quality of information flow will report a smaller gap between its perceived and expected values.

Taken together, Fig. 1 represents the interrelationships among the testing variables, specifically the enabling role of technology in improving connectivity and the quality of information flow among supply chain members.

### 3. Methodology

Tests of the four hypotheses were conducted on VMI programs implemented in the electronics industry. A short survey was developed and piloted on a sample of six supply chain members. Based on the participants’ feedback, two amendments were made. First, participants found an open-ended format for the three independent variables particularly difficult and suggested an alternative of providing a list of options for ticking/checking. Second, the definition of VMI was added, as companies employed different terminology, e.g. supplier owned inventory (SOI) and supplier managed inventory (SMI), though they were generally considered to be VMI programs. After these amendments, the survey was sent to another group of six respondents. This time the pilot testing went smoothly and no further changes were required.

#### 3.1. Measures

Independent variables included the number of employees involved actively in the tactical operations of the VMI (five levels: less than 25, 25–49, 50–74, 75–99, and 100 or more), organizational size in total number of employees (five levels: less than 100, 100–999, 1000–9999, 10,000–99,999, 100,000 or more), and the type of logistics integration (three levels: third party, supplier, or both supplier and third party logistics). The number of employees involved was used as a proxy for the intensity of involvement.

Dependent variables included 20 statements (see Appendix A) on the effectiveness of VMI in terms of information quality enhancement (5 items), service quality improvement (10 items) and cost reduction (5 items). These statements were derived from the advantages of VMI reported in the literature. The survey instructed the participants to indicate the extent to which they agree or disagree (on a five-point Likert-type scale ranging from 1 = strongly disagree to 5 = strongly agree) with each statement before and after VMI implementation. The difference between the ratings assigned to each paired after and before statement was used to indicate the gap between the perceived and expected value of the VMI programs. A negative, zero, and positive value indicated that the expectation was not met, was satisfied, or was exceeded, respectively.

#### 3.2. Participants

Initial efforts were made to establish a list of electronic companies that had fully implemented VMI. Twenty-five companies were identified. The majority was large multinational companies and 100
individuals who had the requisite knowledge and experience of using VMI were contacted in them using email. After establishing the contact and sending the survey, a total of 94 useable questionnaires were received resulting in a response rate of 94%. Table 1 summarizes the characteristics of the respondents’ demographics and organizations.

4. Results

4.1. Instrument validity and reliability

The 20 items measuring the impact of VMI on information quality enhancement, service improvement, and cost reduction were subjected to a confirmatory factor analysis (CFA) to assess construct validity. LISREL 8 [19] with maximum likelihood estimation was used to conduct the CFA. Multiple fit indices are used: the traditional chi-square test ($\chi^2$), nonnormed fit index (NNFI), which is regarded as an appropriate test for small sample sizes [2], and the comparative fit index (CFI) [4]. The fit of the items to their respective factors (information quality enhancement, service improvement, and cost reduction) was highly satisfactory, based on ratings of the expected values, $\chi^2(165, N = 94) = 216, P = 0.046; \text{NNFI} = 0.91; \text{CFI} = 0.93$; based on the ratings of perceived values: $\chi^2(165, N = 94) = 209, P = 0.012; \text{NNFI} = 0.93, \text{CFI} = 0.94$. The loading for each item on its respective factor was also significant ($P < 0.01$). In terms of reliability, the Cronbach’s alphas for information quality, service improvement and cost reduction ranged from 0.83 to 0.89, which were within the recommended range between 0.7 and 0.9 [16].

4.2. Hypotheses testing

Table 2 displays the results of a series of analysis of variance (ANOVA) of the impacts of organizational size, employee involvement, and level of logistics integration on the expected and perceived values of the VMI. The results suggest that, apart from the perception of information quality, small rather than large organizations reported significantly higher expected and perceived value. This contradicts H1. In terms of employee involvement, high employee involvement indeed resulted in significantly higher expected and perceived values. This supports hypothesis H2a.

The findings also support H4a. Except for the perception of information quality, supply chain members who used both the supplier and third party logistics reported significantly higher expected and perceived value. The differences between the perceived and expected values of VMI are all negative. This suggests that the participants found VMI unsatisfactory, though only two significant gaps were found. First, the cost reduction gap was the smallest for members who used both the supplier and third party logistics, compared with other types of logistics integration, $F(2, 91) = 4.04, P < 0.05$. Second, in contrast to low employee involvement, members who worked for organizations having high employee involvement in the implementation of VMI reported the smallest gap in cost reduction, $F(1, 92) = 4.23, P < 0.05$. The findings partially support H2b, H3b, and H4.

4.3. Path analysis

Table 3 shows the intercorrelations of all the testing variables of the model. To test the model, the intercorrelations matrix was subjected to path analysis. In carrying out the path analysis, the model was sequentially modified using the modification index to improve the fit to the data and only significant relationships were retained. Overall, the final models (as shown in Fig. 2) produce a good fit to the data: Model 1a based on the ratings of the expected values of VMI: $\chi^2 = 2.86, P = 0.24; \text{NNFI} = 1.00; \text{CFI} = 1.00$; Model 1b based on the perceived values of VMI: $\chi^2 = 3.60, P = 0.46; \text{NNFI} = 1.00; \text{CFI} = 1.00$.

Model 1a accounts for 21% of the variance in information quality enhancement, 77% of service quality improvement, and 6.7% of the variance in cost reduction. The model yields four significant paths including those from employee involvement to information quality enhancement and service improvement, from information quality to service improvement, and cost reduction.

Model 1b accounts for 18% of the variance in information quality, 81% of service quality improvement, and 13% of the variance in cost reduction. Five paths were significant. These include paths from employee involvement to information quality and service improvement, from level of logistics integration to service,
Table 2
ANOVA of the benefits of VMI and their gaps in relation to organizational size, employee involvement and level of logistics integration

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Means with different superscripts are significantly different at P < 0.05 whereas those with the same do not.

* P < 0.05
** P < 0.01
*** P < 0.001
from information quality to service improvement, and finally from service improvement to cost reduction. In comparing Model 1a with 1b, similarities include the effect of employee involvement on information quality enhancement and the effect of information quality enhancement on service improvement. The differences include the additional effect of levels of logistics integration on service improvement and the

### Table 3

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<td>5 Information quality P</td>
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<td>6 Service improvement E</td>
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<td>7 Service improvement P</td>
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<td>8 Cost reduction E</td>
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<td>9 Cost reduction P</td>
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<td>0.32*** 0.16 ns -0.25† 0.33** 0.29*** 0.33*** 0.36*** 0.92*** (0.85)</td>
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**Note.** E: expectation; P: perception; ns: non-significant; coefficient alpha reported on the diagonal; N = 94.

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Fig. 2. Path coefficients for the VMI determinants and outcomes (standard errors in parenthesis).
mediator role of service improvement between information quality enhancement and cost reduction. These suggest subtle differences between the expected and perceived values of VMI.

5. Discussion

We used the limits-to-value model of Chircu and Kauffman to examine the effects of three key determinants on VMI in delivering service improvement and cost reduction. The findings suggest that members of small rather large organizations expected and perceived higher returns from VMI. A plausible reason is the type and amount of information that large organizations generate might have exceeded the capacity of VMI. Considering that in a multi-tier supply chain, the nature of information exchanged is likely to be highly complex and the volume of information that any IT systems have to handle is likely to be enormous. Most of the acclaimed benefits of VMI apply to repetitive production situations involving standard products rather than custom, continuous flow, or project situations. VMI will not work where setups take a long time and take place on a frequent basis to coincide with frequent shipments and receipts.

In the electronics industry, the production and setups are operated in a modular sourcing mode in which the manufacturers purchase preassembled modules of a product from several lower tier suppliers. The operations for large organizations are likely to involve multi-tier supply chains. This inevitably requires unprecedented collaboration between manufacturers and suppliers. Within the VMI arrangement, the prime responsibility of managing suppliers of lower tiers usually falls upon the first tier supplier. This arrangement will not only increase the level of details required for planning but also impose much strain on the first tier supplier. To avoid the creation of local information optima, one possible solution is to distribute information evenly along the supply chain to co-opt other key members that were previously excluded from VMI into a new arrangement commonly termed collaborative planning forecasting replenishment (CPFR).

The support for the second hypothesis generally concurs with the literature of the significance of employee involvement in reengineering initiatives [5]. In the case of VMI, high employee involvement ensures success. By co-opting internal employees in the process of information sharing and task execution, organizations are cultivating high-level involvement to provide opportunities for employees to make a significant contribution. Participation allows individual employees to see the value of the linked operations from supply to delivery. As the supply chain becomes transparent, employees are likely to understand their roles and, in turn, develop a high sense of task identification [15].

The rapid evolution of logistics and its effect on order fulfillment has implications for selecting supply chain partners. At a minimum, organizations should look for partners that can provide on-line supply chain visibility and connectivity in addition to performing traditional distribution and customer service functions. The findings indicate that the added values of VMI are more transparent to supply chain members in a strategic than in a less integrated logistics partnership. Then VMI technologies have a dual role: (1) to enable the coordination of information flow; and (2) to harness the collaborative aspects of a supply chain.

In assessing the effectiveness of VMI, we used a gap approach to measure the expected and perceived values. This has been well established in the marketing literature [28,29] and is increasingly prominent in the recent IT literature [12]. The general concern is to reduce the gap and increase customer satisfaction and loyalty. This approach is appropriate to our study, considering that the initial assessment of what VMI can offer may be unrealistic. As most, VMI programs require the manufacturers to invest in IT infrastructure to make the production level activity and inventory more visible to their suppliers; by giving the suppliers more control, manufacturers might expect higher returns. In our study, high levels of employee involvement and logistics integration were found to reduce the gap only in cost reduction. Because cost reduction is related to the optimization of production and planning capacity, high levels of employee involvement and logistics integration can mitigate situations of late and defective supplies. It is likely that both factors when coupled together will have the effects of raising the expected and perceived values of VMI.

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1 The increased responsibility on the first tier supplier has led to the emergence of a new supplier, referred to as the 0.5 tier supplier in the automotive industry.
6. Conclusions

The study empirically tested how some of the acclaimed benefits of VMI were subjected to some of the key barriers common in any IT implementation and reengineering initiatives. Establishing trust among supply chain members is another major barrier to the success of VMI. But even if information needed is available, supply chain members may be reluctant to reveal it due to a lack of trust and a fear that the information will be revealed to competitors.

The study was subject to the usual limitations associated with survey methods, however stringent statistical criteria and procedures were taken to ensure high reliability and good validity of the measures used to test the hypotheses. The 94% response rate made the findings representative of the companies that had actually implemented VMI.

In the conventional business model, suppliers will bill their customers once shipment is made, depending on the agreed payment terms. However, in some VMI, payment will only be made based on what the manufacturers have pulled from the hub. The effect of stretching and delaying the payment can have adverse effects on the suppliers’ cash flow. Finally, there is a danger of putting too much emphasis on inventory reduction to the point that it can cause more harm than good and place additional stress on shop workers [36]. Working towards VMI is not a solo effort but a company-wide effort to reinvent and streamline business processes with supporting technology. Unless everyone is involved and driven by the same objective to eliminate wasteful practices and improving service level, the initiative will not go far. Winning in supply chain performance is analogous to winning a decathlon. In the supply chain business, it is worth remembering the adage that a chain is only as strong as its weakest link. The optimal supply chain collaboration should by all means aim at minimizing the backend damage-control activity.

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Appendix A

A.1. Information quality

- Improved accuracy of information received/conveyed.
- Improved timeliness of information.
- Ability to capture real-time information.
- Achieve internal and external connectivity for IS support.
- Achieve daily download of information.

A.2. Service improvement

- Timely replenishment of parts only when required.
- Fewer incidences of production line disruption/stocks outs.
- Fewer incidences of reject shipments.
- Improved ability to react to upsides/downsides.
- Productivity improvement should be achieved with automation of manual tasks.
- Replenishments are made/received in friendly loads.
- Cycle times should be considerably shortened.
- Relationship with our VMI partners should be improved.
- Improved accuracy of forecasts resulting in better planning.
- Overall improvement in the level of customer service.

A.3. Cost reduction

- Inventory holdings/levels should be reduced.
- Lower transportation costs due to more efficient planning.
- Faster inventory turns.
- Less wastage as work in progress is affected when quality issue is encountered.
- Fewer product returns due to quality or obsolescence.

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