Critical aspects of Information and Communication Technology in Vendor Managed Inventory

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Abstract. The use of Information and communication technology (ICT) in supply chain collaboration has received substantial attention among researchers and practitioners. The multiple aspects of ICT offer a wide selection of research and application arenas. This paper discusses information sharing and takes a particular focus on the level of data integration when ICT is applied to support the replenishment process based on a Vendor Managed Inventory (VMI) principle, i.e. when the supplier is responsible for the replenishment process on the customer's behalf [1]. The findings conclude that it is not the capabilities of the computer technology and applications available that limit the level of data integration in the collaboration program. The most important limitation is the decision makers' competence and confidence in information sharing and computer systems, and the potential benefits these represent. The research methodology applied is a comparative case study where level of data integration and level of data utilization was studied in five cases of VMI collaboration.

1 Introduction

The aim of collaborative supply chains is to coordinate the supply, production and delivery processes, while balancing production and supply with customers' requirements and demand. Collaborative initiatives in the supply chain seek to gain real time information and to create a transparent, visible demand pattern that paces the entire supply chain [2]. Supply chain visibility offers higher predictability and insight into the demand situation which will dampen the "bullwhip" and artificial demand amplification [3, 4]. Information and communication technology (ICT) is considered an essential tool for obtaining demand visibility in the supply chain [5].

Automated replenishment concepts such as vendor managed inventory (VMI) and collaborative planning, forecasting and replenishment (CPFR) are based on automation of administrative processes supporting the materials flows through transparent information flows in the supply chain [6, 7, 8]. By implementing such ICT supported concepts, companies can achieve benefits in terms of reduced inventory levels, increased flexibility and reduced lead-times.

VMI is a concept for supply chain collaboration where the supplier is responsible for the replenishment process [9, 10] and in order to undertake this responsibility the supplier will require some information about the customer's demand pattern. Different types of demand data are suggested, e.g. forecasts, inventory levels, production schedules, incoming orders, Point-of-sales data etc.

The purpose of this paper is to identify critical aspects regarding how this information is shared, integrated and utilized when information is used to create visibility and support the VMI replenishment process. The focus is on the automation of the information exchanging processes, and whether the choice of ICT system and level of data integration[3] is dependent on how much data should be transferred. More specifically is it important to reveal whether it is considered more important to increase level of data integration when the level of data interchange is high. Based on these objectives two research questions (RQ) is discussed.

RQ 1: *Is the selection of ICT solution dependent on how much data is exchanged?*

RQ 2: *Is it more important to increase level of data integration when level of data exchange is high?*

2 Research approach

A multiple case study strategy where chosen to support the presented research questions. The case study approach is preferred due to the need for a thorough and extensive study of how ICT is applied in a VMI relation [11, 12]. In this study the problem is related to critical aspects of ICT and information sharing. Gaining a rich picture has been essential in order to understand what variables could have affected the outcome, therefore a case study is found more valuable than a survey that would not embrace the context of the data. Furthermore, a survey would require far more respondents than a case study. Also this research strategy is valuable in our study due to both the lack of and unavailability of sufficient amounts of data and, thus a too comprehensive and expensive data collection process [13].

Five cases are studied in order to compare the gathered information. Comparison is a powerful mechanism, but when used in a case study strategy the comparison should be focused on a limited number of attributes. This is due to the information richness in case studies, where a single case study per se constitutes a sufficient information source [14]. Five cases of successful and unsuccessful VMI collaboration were studied; a manufacturer of damped boring bars and a distributor

[3] To what extent transferred data is automatically incorporated into the recipient's computer system. Low level of data integration implies high degree of manual data entry.

that assembles parts into a complete machining package for their customers; a manufacturer of cardboard packaging and a manufacturer that uses the cardboard boxes for packaging pipes and accessories for water, gas and electrical installations; a car manufacturer and its relations to a supplier of aluminum wheel extensions; the same car manufacturer and a supplier of aluminum bumpers; a supplier of fasteners and tools for general assembly and a manufacturer of agricultural and farming equipment.

The unit of analysis was the application of ICT systems for data exchange with focus on level of data integration, degree of data utilization[4] and frequency and volume of data exchange[5]. The data collection process was based on semi-structured interviews with representatives from the companies holding logistic manager positions or similar, and after every interview minutes were written by the researcher and signed by the interviewees. Only cases where the customer is a manufacturer were included in this study. For the analysis it is essential to be aware that case 3 and 5 are considered unsuccessful. Case 3 is terminated due to high costs at the VMI warehouse and in case 5 where the collaboration has been in place for four years the supplier has yet to benefit financially from the program.

3 Literature review

It is indicated that the most important benefits of VMI rest on transparency and demand visibility in the supply chain. Fundamental for obtaining transparency and demand visibility is the customer's willingness to supply demand data. Similarly the supplier must be able to apply this data for planning purpose, and these two elements are said to be essential for VMI success [10, 15, 16]. The following is a brief literature review on the three main elements encompassed by this study, level of data integration, level of data utilization and computer system properties and compatibility. It is observed that there are different opinions both on what solutions are required and what benefits will derive from adopting different levels of integration.

3.1 Data integration

The use of ICT for information sharing in VMI is discussed by several authors and perceptions of its vitality differ. Advanced information systems, electronic data transmission and collection, highly integrated with online inventory levels, production planning and control are claimed vital by [9, 17]. Others, e.g. [18, 19, 20, 21] recognize their opportunities but do not state their vitality. The use of advanced

[4] To what extent received data is utilized for planning purposes. In this study high level of data utilization implies that much of the data received is used to improve supplier's replenishment performance.

[5] To what extent data is a construct of many different types of information. High complexity implies there are multiple variables that must be interpreted separately.

information systems will increase level of data integration and as the perceptions on this subject differ this will be an essential element studied here.

3.2 Data utilization

In general, demand information sharing is considered a means to obtain transparency in the supply chain and thereby a means to dampen the bullwhip effect [22]. It has been claimed by some authors [22, 15, 16] that the success of VMI does not only rest on exchange technology but also to what extent the supplier is able to utilize the advance demand information received for planning purposes. Theoretically, the supplier could be able to utilize information about future demand both to smooth manufacturing capacity in his own production system, negotiate better purchasing agreements with his sub suppliers and plan for economic full truck load distribution [20]. Data must be reliable to benefit from data utilization [15]. If for instance forecasts are unreliable and inventory level status is old the supplier should not apply this data for planning purposes and [15] suggests that under these circumstances VMI would offer no more benefits than traditional replenishment.

3.3 Computer system properties

A computer system is a facilitator of data exchange as long as the sending and receiving systems are compatible and interpret the exchanged data similarly [23]. A survey performed by KPMG among Norwegian industry [24] revealed that many companies retained from sharing demand information to suppliers because the computer system applied did not facilitate such interaction. However, it has been argued that technological barriers are falling [25]. Basic technology for data scanning and exchange is readily available, technical aspects are routine and implementation costs are low. It has even been argued that we are closer to the end than the beginning of ICT buildout [23].

From this brief review it is observed a divergence between what practitioners believe restrict them from exploiting data exchange benefits and what ICT specialists find limiting. ICT properties are included in this work in order to study whether there are any technological aspects of ICT that are critical to information sharing in VMI.

4 Findings and discussion

In all the cases studied, the customers provide the information periodically to the suppliers who plan the replenishment in their internal computer systems. No online communication or direct planning in customers' computer systems is applied. **Table** shows frequency of data exchange from customer to supplier in every case and how large share of the supplier's total product range is affected by the particular VMI program. Share of total range is included to visualize how much of the total demand information is encompassed by the VMI program. This will indicate how important the information appears for the supplier.

Table 1. Case data on frequency of data update and share of supplier's total product range

Element	Case 1	Case 2	Case 3	Case 4	Case 5
Frequency	24 h	24 h	weekly	weekly	weekly
Share of total range	80 %	0,4 %	33 %	1 %	5 %

4.1 RQ 1: Selection of ICT solution and the volume of data exchange

From the cases studies it is found that it is rarely the capabilities of the ICT systems applied that limit the utilization of such systems in VMI relationships. The level of utilization rests on the extent to which the actors think they can benefit from applying ICT. This perception is based on two elements, namely the confidence in the transferred data, and the ability to understand the opportunities. Firstly it is based on the actors' experience in application of ICT for information sharing and to what extent they have previously been able to trust the data transferred. Secondly it is based on the actors' comprehension of opportunities inherent in information sharing. The consequence of this perception is that only when the actors truly understand the concepts and the opportunities they will know what data should be transferred, and only when the right type of data is transferred the recipient can apply it for further planning feeling confident that he is making good decisions. Additionally, when the sender is aware how important the input is for the recipient he will focus on maintaining high quality information.

The level of data utilization and level of data integration is considered interdependent. When the desire for data exploitation is pronounced, the need for data transfer is realized, and the more integrated means are applied the better they facilitate utilization and achieve experience and competence. In the cases studied an iterative evolving process was observed, where the initial need for data exchange initiated investments in ICT. The better the chosen technology facilitated integration the higher the level of data utilization. This process was however highly dependent on the actors' comprehension of the concept and the opportunities. This finding is in line with [2] who indicate that the slow progress of implementation of automated replenishment programs may be due to lack of common understanding of the concepts. **Fig. 1** illustrates how level of integration and utilization interacts while resting on a fundamental level of comprehension.

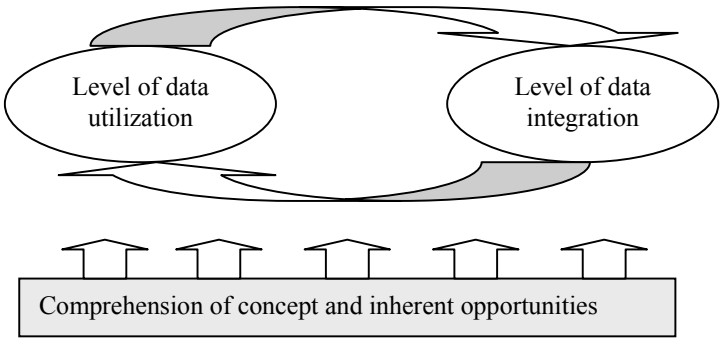

Fig. 1. Interdependency of level of integration and utilization, founded on comprehension

The conclusion of RQ 1 is that the selection and application of ICT solution does initially rest on how much data is expected to be transferred. However, as the relationship evolves and comprehension increases new opportunities are disclosed and there will be an interdependent increase in level of data integration and level of data utilization.

4.2 RQ 2: Data integration and data exchange

In all cases EDI or internet is used for information transfer but level of integration differs. Statements from all five cases indicate that the use of integrated communication systems have played a major part in the successfulness of their VMI programs. Even in the programs turning out not so favorable, the effect of the integrated automatic data transmission solutions are said to offer positive contributions. This supports [9] who state the vitality of advanced information systems but the evidence are not strong enough to contradict those who indicate that VMI can work with less integrated means [18, 20, 21].

For answering RQ 2 four specific variables were studied. Frequency of data transfer would indicate how often data is updated, level of product variants and level of shipped volumes would indicate the complexity of the data transferred and importance of ICT integration is a reflection on the interviewees perception of how beneficial integration has been to the supplier.

Table 2. Case data on variables for importance of data integration on a high-medium-low scale

Variables	Case 1	Case 2	Case 3	Case 4	Case 5
Information transfer Frequency	High	High	Low	Low	Low
Level of product variants	High	Low	Low	High	Low
Level of shipped volumes	Medium	Low	Medium	High	Medium
Importance of data integration	High	Low	Medium	High	Medium

From the empirical findings it can be concluded that it is the complexity of data that is the most important element. This is indicated by the fact that those cases where there were lots of product variants and lots of product specific data to handle the supplier benefited most from data integration. The fact that frequency and shipped volumes were high did not necessarily imply that the data was complex and difficult to handle.

Answering RQ 2 it could be argued that it is not the level of data exchange per se that is the critical aspect but the level of complexity in the set of data exchanged.

The findings of this study indicate that selection of ICT solution is a multifaceted decision. It is difficult to identify one specific critical variable because there are multiple elements influencing the selection process, both with respect to whether to apply ICT or not and the properties of the selected system.

5 Concluding remarks

The research reported in this paper has shown that the use of ICT for information sharing in VMI collaboration is not restricted by capabilities of the existing technology but by the level of competence among the applicants. It has also been shown that once a certain level of comprehension is obtained one will enter a loop of continuous enhancements to exploit the benefits inherent in the collaboration program. This loop will include a further utilization of ICT resources. From these findings one can argue that quality of exchanged data is critical because it builds confidence. Furthermore, understanding information needs of the partner and how exchanged data will be further utilised ensures emphasis on data quality. Even though the use of ICT for data exchange could be considered limited in the studied cases, positive effects were identified in terms of increased information quality, correct information and cost reductions from elimination of manual data entry.

These findings cannot be considered breaking news but they illustrate a gap between available and applied capabilities of existing ICT. It is necessary to educate practitioners to push them into the loop of continuous enhancements, simultaneously; further research on cutting edge capabilities to identify new technological potentials is required in order to stay ahead of application.

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