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Review of Vendor Managed Inventory: Investigation on How It Improves Supply Chain Performance

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Abstract

Purpose - This study reviews the past studies that have researched Vendor Managed Inventory (VMI) as a well-known supply chain collaboration program. The main goals of this study are to figure out how VMI brings significant benefits to the supply chain system and suggest additional areas that future studies would address to discover the true nature of VMI.
Research design, data, methodology - This study conducts literature reviews on numerous studies that have researched VMI. The past studies are classified in terms of several main issues that have been commonly addressed by many researchers. This study also identifies three key collaborative features of VMI, which possibly explain why VMI improves the supply chain performance.
Results - This study finds out that most past studies focused on a limited research issues about VMI. Many researchers have considered integrated decision making and information sharing to be key features that enables VMI to improve the supply chain performance.
Conclusions – Based on the findings from the literature review, this study suggests that future studies on VMI take account of new research issues and pay attention to cost payment that researchers have rarely addressed.

Keywords: Supply Chain Management, Supply Chain Collaboration, Vendor Managed Inventory, Information Sharing.

JEL Classifications: M11, M19, M21.

1. Introduction

The supply chain collaboration has received heavy attentions from both business practitioners and academic researchers, since its practical effectiveness is frequently observed in real businesses. Accordingly, a number of leading companies have developed supply chain collaboration programs and achieved remarkable accomplishment by applying them to their operations (Bookbinder et al., 2010; Niranjan et al., 2012). Among various collaboration programs such as Quick Response, Efficient Consumer Response, and Collaborative Planning, Forecasting, and Replenishment, Vendor Managed Inventory is the best known one that has been used in diverse industry sectors (Park & Shim, 2008).

Due to its practical advantage shown in the broad areas of businesses, there have been many studies that focus on VMI, and even some researchers already review them in their studies (Govindan, 2013; Marques et al., 2010). Meanwhile, few researchers address the important issue of how VMI improves the supply chain performance, because they apply their own forms of VMI to their studies and it is quite hard to identify the causative elements of VMI with lack of consensus on the composition of VMI.

This study reviews the past studies that have researched VMI as a supply chain collaboration program. By focusing on the main components and structures of VMI appeared in the past literature, this study intends to identify the key collaborative features of VMI and build the basis for developing new collaborative programs that are more advanced than VMI. In addition, this study observes the main issues that many researchers have addressed in their

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studies on VMI and introduces other important subjects that would provide full knowledge about VMI. This study has the following two main objectives. First, by observing every collaborative features of VMI that the past studies have focused, this study intends to figure out additional collaborative features that improve the current version of VMI and even become the basis for creating more advanced new supply chain collaboration programs. Second, by identifying some research areas that the most past studies have ignored, this study aims to suggest new research topics to the future researchers.

The literature review on more than hundred studies on VMI reveals that most of them consider decision authority and information sharing to be the main collaborative features of VMI. Meanwhile, cost payment has been ignored by most studies but it is the additional feature of VMI that possibly improves the supply chain performance. This study also finds that many studies have emphasized only limited areas of their studies on VMI, and future study would consider other important issues to understand the true nature of VMI.

This study is expected to make the academic and practical contributions. The future studies can conduct research on the research topics that this literature review recommends and obtain complete theoretical knowledge about VMI. In addition, the potential collaborative features of VMI that this study addresses provides the business practitioners with the ideas about how to develop new supply chain collaboration programs that can outperform the current version of VMI.

2. Background Information about VMI

In any business trades, the effective control of replenishment and inventory has been a long-lasting problem to be solved. The conventional supply chain system possesses an inevitable problem and there have been conflicting goals in the relationship between the supplier and buyer. The buyer seeks to place only the proper amount of orders according to the volatile demand and save the inventory holding cost. Meanwhile the supplier intends to minimize the cost of altering the production rate by maintaining stable orders placed by the buyer. Since the reliable supply is essential for the Just-In-Time (JIT) system, the decision on replenishment and inventory control becomes a serious problem for any companies that apply JIT to their operations. As a sequel to the original JIT, JIT II is developed to make the efficient balance between buyer's order and supplier's production. Under the JIT II partnership, the supplier sends a sales representative to the buyer and he works a full time job of participating buyer's purchasing scheduling (Pragman, 1996). Through the close working relationship between them under JIT II, the supplier and buyer can access the real time information of demands and production plan and make proper decisions on production and replenishment.

JIT and JIT II provide the certain circumstance that let both buyer and supplier realize that they should collaborate their operations to obtain the improved performance. Accordingly, the series of buyer-retailer partnerships such as Quick Response and Continuous Replenishment have been developed to collaborate buyer's and supplier's operations. The Quick Response (QR) system is designed to serve customer needs quickly through close cooperation between the supplier and retailer. Under this system, the retailer sends point-of-sales (POS) data to the supplier and the supplier uses this information to synchronize his production scheduling and inventory control with the actual sales of retailers (Choi & Sethi, 2010). Due to the QR system, the supplier can increase the accuracy of demand forecasting and prepare cost effective production schedule by using the point-of-sales data. The retailer is also able to respond to his customer needs properly on time. The key element of QR strategy is information sharing activity happening between the supplier and retailer, and they still independently perform any other operations including ordering, replenishment, production scheduling, and inventory control.

Just like QR, the Continuous Replenishment (CR) policy also let the supplier receive the POS data from retailers and maintain the specific inventory level or service level by scheduling shipments on the previously agreed intervals (Tyan & Wee, 2003). Due to the increased frequency of replenishments, CR leads to gradually decreased inventory level and improved customer service (Yao & Dresner, 2008).

Vendor Managed Inventory (VMI) is another type of buyer-supplier partnerships that are designed to bring the efficiency of supply chain operations (Simchi-Levi et al., 2000). VMI is observed to be more advanced form of supply chain collaboration than QR and CR, because it utilizes active collaborative activity beyond sharing information. VMI is defined to be a system where the upstream firm manages inventories on behalf of its downstream customer (Yao et al., 2012). In the VMI system, the supplier maintain buyer's inventory level by deciding the proper amount of orders and inventories based on POS data directly received from the buyer (Dong et al., 2007). Consequently, the VMI program provides the buyer with a significant benefit of reducing the burden of ordering and inventory management. Under VMI, the supplier can efficiently synchronize the inventory control, distribution, and manufacturing activities with buyer's sales, and systematically save the costs associated with those activities (Claassen et al., 2008).

VMI has two main objectives, which are to lower the inventory level and increase the service level (Levy & Grewel, 2000). Traditionally, it has been a common sense that these two goals cannot be achieved at the same time, but they are rather compromised. VMI is designed to overcome this limitation of traditional management. By

providing the supplier with the full authority of scheduling production, delivery, warehousing, and replenishment, VMI enables the supply chain system to minimize the required inventory level and maintain the proper service level.

VMI was first introduced as a partnership between Wal-Mart and Procter & Gamble in 1985. Since successful practices of VMI were noticed in retailing and electronics industries (Tyan & Wee, 2003), its application has been expanded to diverse areas including chemicals (Bookbinder et al., 2010), telecommunication (Haavik, 2000), healthcare systems (Smaros & Holmstrom, 2000), home delivery services (Cooke, 1998), and automotive industry (Smaros & Holmstrom, 2000). Despite the quite recent application of VMI to the industries, VMI has been recognized as an effective management tool that leads to significant success in improving the supply chain performance.

3. Overview of Past Studies on VMI

VMI has been analyzed by many past studies in diverse perspectives including research methodologies, structures of supply chain models, and detailed issues. Most studies that have researched VMI rely on the mathematical model analysis. A group of studies examine whether VMI brings real benefits to the supply chain system by comparing its performance with the others'. In their studies, they compare VMI with various programs or systems such as traditional non-VMI system (Disney & Towill, 2003a; Dong & Xu, 2002; Egri & Vancza, 2013; Govindan, 2015; Mateen & Chatterjee, 2015; Mishra & Raghunathan, 2004; Wong et al., 2009; Yu et al., 2009b), the supply chain system with information sharing (Fry et al., 2001; Kim, 2007; Salzarulo & Jacobs, 2014; Yao & Dresner, 2008), Collaborative Planning, Forecasting, and Replenishment (CPFR) (Sari, 2008a, b; Tyan & Wee, 2003), Continuous Replenishment Policy(CRP) (Tyan & Wee, 2003; Yao & Dresner, 2008), quantity discount program (Chakraborty et al., 2015), centralized decision making supply chain system (Bichescu & Fry, 2009; Bookbinder et al., 2010; Chen & Wei, 2012; Gerchak & Wang, 2004; Guan & Zhao, 2010; Nagarajan & Rajagopalan, 2008; Ru & Wang, 2010; Webster & Kevin Weng, 2008), decentralized system (Hariga et al., 2014), fully coordinated system (Dong & Xu, 2002), and consignment (Chen et al., 2010; Gumus et al., 2008; Ru & Wang, 2010; Savasaneril & Erkip, 2010).

Past studies evaluate VMI's performance in terms of many different measures. A large group of studies measure VMI's output by calculating the resultant cost (Bookbinder et al., 2010; Fry et al., 2001; Govindan, 2015; Guan & Zhao, 2010; Hariga et al., 2014; Kannan et al., 2013; Lee & Cho, 2014; Lee & Ren, 2011; Mateen & Chatterjee, 2015; Nagarajan & Rajagopalan, 2008; Ryu et al., 2013; Salzarulo & Jacobs, 2014; Tat et al., 2015; Zanoni et al., 2014; Zhao et al., 2010). Some studies include the sales related activity such as pricing in their models and evaluate the performance of VMI in terms of profit (Almehdawe & Mantin, 2010; Chakraborty et al., 2015; Chen et al., 2010; Chen, 2013; Dong & Xu, 2002; Kulp, 2002; Ma et al., 2013; Mishra & Raghunathan, 2004; Ru & Wang, 2010; Stalhane et al., 2014; Wang, 2009; Wong et al., 2009; Yu et al., 2009a; Yu et al., 2009b; Yugang et al., 2006). Other than the monetary values, some performance measures are counted to represent how VMI performs, for examples, inventory level (Angulo et al., 2004; Choudhary & Shankar, 2015; Kim, 2007; Savasaneril & Erkip, 2010; Yao & Dresner, 2008), leadtime (Park & Lee, 2006), customer service (Bichescu & Fry, 2009; Choi et al., 2004; Kuk, 2004; Sari, 2008a, b; Webster & Kevin Weng, 2008), efficiency (Chen & Wei, 2012), utility (Egri & Vancza, 2013), capacity utilization (Zanoni et al., 2012), and bullwhip effect (Disney et al., 2004; Disney & Towill, 2002a; Disney & Towill, 2002b; Disney & Towill, 2003a; Disney & Towill, 2003b; Kristianto et al., 2012).

Other than testing VMI's performance, a group of the studies focus on the algorithm development to obtain the optimal solutions of the VMI model, because the decision problems of VMI often become complicated with multiple operations including replenishment, shipment, and inventory allocation (Diabat, 2014; Shu et al., 2012; Yu et al., 2013; Yu & Huang, 2010).

The researchers use different structures of supply chain models in their studies on VMI. Most of them design a two-stage supply chain structure in their models. Many studies focus on the relatively simple relationship between a single supplier and one buyer. Meanwhile, other studies assumes more complicated structures such as one supplier with two buyers (Rad et al., 2014), one supplier with 3 buyers (Almehdawe & Mantin, 2010), and one supplier with multiple buyers (Cachon, 2001; Govindan, 2015; Hariga et al., 2014; Kannan et al., 2013; Mateen & Chatterjee, 2015; Yu et al., 2009b; Yugang et al., 2006) and they address the additional issues of inventory allocation, competition, or game.

Some researchers use the case study method to investigate the detailed nature of VMI that is fairly new to both academia and industries. Several studies investigate the real benefits of VMI and observe its implementation procedures in various types of companies such as manufacturers of consumer goods (Holmstrom, 1998b; Lee & Kim, 2007), grocery suppliers (Kaipia et al., 2002), construction company (Tanskanen et al., 2009), chemical goods producers, and paper manufacturers (Kauremaa et al., 2009). Some studies identify the significant changes made by VMI application to the information sharing process (Vigtil, 2007) and customer-vendor power relationship (Tyan & Wee, 2003). Meanwhile, some researchers notice that VMI has not been always successful and look for the key factors affecting its performance. Kwon et al.'s case study on a

consumer goods distributor (2007) reveals that VMI results in poor performances when the employees lack of skills and experiences or when they fail to fully understand a new operation process adopted to VMI. Dorling et al. (2006) identify seven key determinants for successful VMI from their case study on the food industry and suggest that companies should check all those determinants in the step-by-step procedure to successfully implement VMI to their operations. Niranjan et al. (2012) consider fifteen features related to product, company, and supplier to be prerequisites for successful VMI implementation and estimate their importance based on the cases of ten different companies. Danese (2004, 2006) conducts a case study on a pharmaceutical company and recognizes information flows, information system, and performance monitoring system as requisites to extend VMI to the entire supply chain system.

Relatively small group of researchers choose the empirical study for their studies on VMI. They commonly measure VMI's performances or examine the key factors that have significant impacts on VMI's achievement. Park and Lee (2006) examines how VMI implementation factors of operational process, inventory management, and information system affect the supply chain performances such as leadtime, stockout, and costs. Their analysis reveals that all three VMI factors significantly improve customer services and saves logistics costs. Another study on the extension of Park and Lee's model also shows that the supply chain performance is dependent on three VMI factors (Lee et al., 2006).

One study represents that employee involvement and logistics integration have significant impacts on how VMI improves customer service and saves costs (Kuk, 2004). Dong et al. (2007) consider market competition, product demand, buyer's operation, and buyer-supplier relationship to be the main determinants of VMI adoption. Their survey outcome shows that the firms are more likely to adopt VMI with more competitive supplier's market, greater levels of buyer-supplier relationship, and less uncertain buyer's operations. Claassen et al. (2008) examine information and vendor-customer relationship as key enablers for successful VMI implementation. Their analysis reveals that three factors including the quality of information system, information sharing, and relationship quality have significant impacts on the costs, customer service and supply chain control. Upadhyay et al.'s study (2013) examines total 35 different elements of VMI in terms of their importance to the customers. They also measure their difficulty to implement and suggest that a certain group of VMI elements should be implemented first. There are other special issues addressed by the researchers who conducted empirical studies, for example, the comparison of VMI factors between large and small industries (Borade & Bansod, 2010) and the learning curve effect on VMI's performance improvement (Yao et al., 2012). Appendix A summarizes the representative studies on VMI in terms of the research focus, supply chain structure, performance measurement, and methodology.

4. Major Issues and Collaborative Features of VMI

4.1. Main Issues Addressed in Past Studies

Since VMI as a new practice of supply chain integration becomes many academic researchers' interests, they have addressed diverse issues about VMI. In this chapter, this paper discusses key issues related to VMI based on a literature review of previous studies. VMI as a tool of supply chain management equips quite various operational features associated with information sharing, contract, stock allocation/transportation decision, inventory management, production/pricing, and game. Due to their importance in any studies on VMI, these issues have been main subjects considered by many researchers. This study provides detailed discussions about the issues that have been frequently covered by the past studies.

4.1.1. Information Sharing

One significant feature of VMI is information sharing that enables the supplier to forecast demand accurately and consequently smooth production. The past studies consider diverse types of information shared under VMI, and most of them assume that VMI allows the supplier to receive the sales data and inventory level directly from the buyer (Angulo et al., 2004; Kim, 2004; Kristianto et al., 2012; Kulp, 2002). Other than the information of demand and inventory, the operational information appears to be shared between the supplier and buyer, for example, the seasonal promotional plan (Achabal et al., 2000), customer needs (for new products or services) (Kulp et al., 2004), market-related information (price elasticity) (Yu et al., 2009b), customer queue length (Kim et al., 2004), and forecast distribution (Gerchak et al., 2007). Meanwhile, Vigitl's study (2007) on the past literature and multiple cases concludes that the current inventory position and forecasted demand are the most important information for the supplier under VMI.

The important role of information sharing in the VMI system is frequently emphasized by the past studies. In Yu et al.'s study (2009b), VMI is described as the system where the manufacturer receives the inventory and market-related information directly from retailers and he can increase his own profit by using this information. Kim et al. (2004) compare two VMI systems where the supplier share different amounts of information with the service facility. The numerical examples of their proposed model reveal that VMI saves more supply chain cost when both customer queue length and inventory information are shared than when only limited information of inventory position is known to the

supplier. Claassen et al. (2008) examines the specific factors that affect the performance of VMI. Their empirical study on Dutch companies reveals that information sharing is one of main enablers that have significant impacts on VMI's success.

Meanwhile, one might question whether VMI would still be beneficial even if information is imprecise or cannot be properly interpreted by the supplier. Cohen's study on informativeness and variability of demand (1999), Cohen's study on information precision and reliability (2002), Disney, Naim, and Potter's research on various e-business strategies (2004), Smaros et al.'s research on demand visibility (2003), and Angulo et al.'s study on information inaccuracy and delay (2004) commonly pursue evaluating the value of information sharing under VMI by considering diverse qualities of information. Kulp et al. (2004) conduct the empirical study on the food and consumer packaged goods industry and they conclude that information sharing on the inventory level and customer needs is required for the manufacture to be competitive but is not sufficient to obtain the above average profit margin.

Even there is an issue that information sharing may not bring the benefit to every supply chain members. Yu et al.(2009b) point out the information asymmetry situation where the vendor dominates most information under VMI and analyze the VMI program by applying the Stackelberg game where the vendor leads multiple retailers. According to their model analysis, VMI requires the cooperative contract to equally distribute the increased profit to all supply chain members, because the vendor can take advantage of the shared information to increase only his profit.

4.1.2. Contract

As a form of supply chain coordination schemes, VMI is based on a contract upon which all VMI participants agree regarding supply chain operations. Therefore, many researchers have noticed the importance of the contract, and they conduct research about the VMI contract from different perspectives. Some researchers focus on the contracts on inventory or service level, which determine supplier's roles in managing retailer's inventories under the VMI program. In particular, the contract can be used to prevent any problems caused by the VMI system where the supplier has a full authority to control buyer's inventories. Researchers propose some special contract such as (z, Z) contract under which the retailer sets a minimum inventory level at z and a maximum at Z and they are designed to secure the customer service level for the retailer under VMI (Fry et al., 2001).

As one of supply coordination techniques, VMI relies on its fundamental basis of contract, where all parties agree on certain requirements regarding each player's role in the supply chain system. These requirements are obviously relevant to the issue of performance measurement. Choi et al.'s study (2004) focuses on how the manufacturer can accurately measure the performance of his suppliers so that each supplier's performance correctly reflects the benefits for end customers. They propose a new method to measure supplier's service level based on his operational characteristics and it overcomes the weakness of the conventional measurement and enables the manufacturer to ensure maintaining his customer service at the desired level. Tatikonda et al.'s case study on a manufacturing company also show that the effective performance management system with the careful consideration of characteristics of customer, product, and partnership is a key to achieve the successful VMI program (2005).

In general, a certain form of contracts is established to make supply chain parties coordinate each other by providing economic incentives to them in the decentralized supply chain system. Revenue sharing commonly appear in several studies as the mechanism to uphold the coordination between the supplier and buyer under VMI. Under the usual revenue sharing contract, the buyer shares a portion of his profit with the supplier who supplies products at low price. Chen and Wei (2012) consider three different types of contracts including revenue sharing contract under VMI and examine how these contracts achieve the supply chain coordination. Guan and Zhao (2010) compare two cases – the vendor owns the inventories at retailer's place under the revenue sharing contract and the retailer has the ownership of the inventories under the franchising contract. In Xiao and Xu's study (2013), the revenue sharing contract is applied to VMI with the purpose of coordinating the price and service level decisions about a deteriorating product. Under the situation of the channel with the one manufacturer and multiple online retailers, Li et al. (2015) propose the contract that fairly distributes profits to all the members to support stability of the VMI partnership.

The revenue sharing contract as the channel coordination mechanism is occasionally examined in the VMI and consignment combined situation. Chen (2013) evaluates the performance of the consignment with revenue sharing contract in the highly perishable product industry. In the study on the cooperative setting with VMI and VMI plus consignment compared with the uncooperative setting of the wholesale price only contract, Chen et al. (2010) found that the proposed contract with revenue sharing and up-front lump-sum side payment brings the coordination among channel members. Gerchak and Wang's revenue sharing scheme is designed to achieve a coordinated system under VMI by applying the consignment and letting the retailer determine the parameters of revenue shares (2004).

Other than the revenue sharing, alternative forms of contracts have been applied to bring the channel coordination under VMI. Nagarajan and Rajagopalan (2008) propose a holding cost subsidy contract that make the manufacturer pay a certain amount of costs per retailer's inventory level so that the supplier has an incentive to make

proper decisions on replenishment for the entire supply chain performance in the VMI system. Once vendor's loss due to VMI implementation is noticed, Lim et al. (2007) introduce the contract that fairly distributes the benefit from VMI by adjusting the whole sale price with the consideration of vendor's burden of increased inventory holding costs and buyer's initial investment cost. Based on the continuous information exchange supported by VMI, the sales rebate contract is considered to be another mechanism that brings the channel coordination under VMI (Wong et al., 2009).

4.1.3. Inventory Control

Inventory management is the key operation that makes VMI different from any other collaboration programs. Since the responsibility to control buyer's inventory is given to the supplier, VMI results in dramatic changes in the ways to replenish inventories, allocate supplies, and use demand information. Most researchers addressing the inventory control issue in their studies on VMI examine whether the supply chain system can improve the performance by applying VMI to the inventory control operations. A series of studies evaluate the value of VMI in terms of the diverse performances such as costs, inventory level, and bullwhip effect by using various testing methods including mathematical model analysis, simulation, and case study (Achabal et al., 2000; Disney & Towill, 2002b; Disney & Towill, 2003a; Dong & Xu, 2002; Holmstrom, 1998a, b; 2007).

Several studies show that VMI as an effective inventory control system can be applied to some special industries. Paik and Kim (2000) design the heuristic algorithm that determines the order quantity and delivery frequency to minimize the cost under VMI and show that it can be applied as the effective inventory policy to the discount retailer. Choi et al. (2008) design the internet-based VMI system that support the complex inventory management process due to the interaction with multiple suppliers and sellers in the small online shopping mall. In Lee and Ren's study (2011), VMI is applied to the global trade and the exchange rate uncertainty is considered to be one of factors that affect the benefit of VMI. The RFID-based VMI system presented by Han et al. (2010) is designed to support a rapid integration and collaboration of ordering and replenishment processes occurring among multiple trading partners of the automobile part industry.

There are some studies that address special issues regarding inventory control under VMI. Mishra and Raghunathan (2004) focus on competition among multiple manufacturers caused by brand substitution and investigate its impact on the supply chain performance. The result of their model analysis indicates that the competition among different manufacturers due to the brand substitution results in higher inventory level under VMI than non-VMI. They explain that this high stocking level is another benefit that VMI provides for the retailer other than eliminating the burden of controlling inventories. Kraiselburd et al. (2004) view the issue of substitionary product under VMI in a different way. In the market where more than one suppliers offer substitionary products for one retailer, consumer's switching to other products leads to the substantial gap between supplier's and retailer's stockout costs. They consider this difference to be an agency cost in the supply chain system and it brings inefficiency in supplier's inventory control under VMI. Their model analyses on different channel systems show that the strength of VMI over non-VMI is bigger in the case that the consumers' loyalty is so high that they do not easily substitute to other brands even when the product is out of stock. Beside the conventional performance measures of VMI such as the profit and cost, Bernstein et al. (2006) focus on echelon operational autonomy that implies the perfect channel coordination condition. Their analysis reveals that VMI leads to the echelon operational autonomy and let the supplier determine the replenishment policy to minimize the entire channel cost.

4.1.4. Stock Allocation and Transportation Decision

In addition to inventory control, stock allocation and transportation management are quite relevant to VMI. Since the supplier takes a full responsibility for managing retailers' inventories, he is free to determine how to allocate and deliver available stocks to multiple retailers. Researchers who focus on this issue examine the optimal decision-making in stock allocation, which drives efficient stock distribution policy from the supplier's perspective under VMI. Regarding transportation management, researchers notice that VMI can be a useful method to resolve the conventional conflict between transportation efficiency and inventory holding cost saving. In the traditional supply chain, the supplier faces the problem of enjoying the economy of scale in transportation (full truck loads), because the increased size of truck loads naturally results in an increased inventory level. On the other hand, due to the full right of inventory management, the supplier can control both transportation batches and inventory levels more efficiently under VMI than in the traditional non-VMI system. A series of studies commonly focus on the coordinated plan of stock allocation and pursue the effective way to distribute stocks and deliver to the buyers (Almehdawe & Mantin, 2010; Cetinkaya & Lee, 2000; Chen et al., 2012; Disney et al., 2003; Fry et al., 2001; Mateen & Chatterjee, 2015; Nori, 1999; Shu et al., 2012; Zhao et al., 2010).

A group of studies also develop the complicated model that represents the integrated system of replenishment, stock allocation, and vehicle routing and they propose the solution algorithms to determine the optimal multiple operational decisions (Park & Shim, 2008). Stalhane et al. (2014) notice that VMI provides the supplier with transparency of distribution and flexibility in planning the shipment sizes and

timing, and they consider the vehicle routing problem that makes the routing schedules for the vehicles to visit multiple customers who are located at geographically different places in the tramp shipping industry. Disney et al. (2003) focus on the batching policy in the transportation and evaluate how VMI affect the performance of transportation operations. Their simulation outcomes indicate that VMI enables manufacturing to be free from batching and results in the transportation cost saving compared with the traditional and internal consolidated systems with a batching constraint.

When VMI is newly applied to the supply chain system, one key issue is the potential change in the relationship with third party logistics providers. Ricketts (1999) investigates the key motivations that cause a company to outsource its logistics functions in a situation involving VMI at the supplier and manufacturer levels. Through the empirical study, his study confirms that the VMI program has a significant impact on decision drivers, relationship among parties, and decision-making process. Kim (2004) also studies about a special case where VMI is applied to the outsourcing relationship between companies. A single company does outsourcing for production of the certain product items and the vendor managed replenishment is used when the company supplies the raw materials to its outsourcing partners. In his study, VMI is close to the centralized decision making system where a single company make all decisions of replenishment and shipment with full information of demand, production, and delivery processes.

4.1.5. Production and Pricing

A series of past studies examine the additional potential benefit of VMI in the production process. Some studies notice that VMI enables the supplier to make the integrated decisions on the production rate and order quantity in a way to optimize his own performance (Fry et al., 2001; Wang, 2009). In other studies, the integrated decisions of production rate and replenishment order are made by the supplier to obtain the optimal performance of the entire channel (Kim, 2012). Disney and Towill (2003a; 2003b) focus on manufacturer's production scheduling activities under VMI and compare it with the traditional system. Their simulation outcomes show that VMI is the effective production order system that properly responds to uncertain demands and controls the bullwhip effect.

In Kim and Park's study (2010), the vendor's decisions on production include not only the production quantity but also the capacity that is reserved for the retailer. Zanoni et al. (2012) pay attention to the learning effect in production and show that the vendor can exploit the advantage of VMI by properly revising production and shipment schedules based on his learning experience in production. In the situation that the multiple buyers have different replenishment cycles, Zhang et al. (2007) consider the a special case where the vendor can reduce the ordering cost by making the investment under VMI and propose the solution algorithm to determine the optimal production, replenishment, and investment decisions. Zanoni et al.'s study (2014) addresses the issue of environmental protection in the supply chain management and proposes the coordinated supply chain model that integrates the production, inventory replenishment, and shipment decisions in the VMI system with emission trading scheme. Their model analysis shows that the proposed VMI with consignment saves even the costs related to the greenhouse gas emission compared with the traditional system.

Some studies extend the application of VMI to the pricing decision. Diabat (2014) considers the vendor and buyer's problems of determining the sales quantity, sales price, and contract price to maximize total profit under VMI and proposes the heuristic to obtain the optimal solutions. In Shu et al.'s study (2012), the proposed VMI system with one vendor and multiple retailers indicates the integration of multiple decisions including inventory replenishment, pricing, and assigning the warehouse to each retailer. Similarly, Kim and Park's study (2010) shows that the vendor and retailer's decisions of replenishment, pricing, production, and capacity allocation are closely linked and they make their decisions to maximize their combined profit under VMI. On the other hand, Almehdawe and Mantin (2010) separates the entire VMI operations into manufacturer's problem of managing inventory and production and the retailer's problem of determining the sale price. Yu et al. (2009c) also consider two different problems under VMI, where the manufacturer controls the wholesale price, advertisement investment, and inventory replenishment, and the retailers decide the retail price and advertisement investment. Meanwhile, both the manufacturer and retailers seek to maximize their own profits individually.

4.1.6. Game

Since VMI is originated from the supplier-buyer partnership (Simchi-Levi et al., 2000), one research stream focuses on the game that represents the power competition between the upstream and downstream of the supply chain system. In general, the researchers use the game models to examine the performance of VMI under the situation that the supplier and buyer have different levels of power in their dyadic relationship.

A group of studies design the game-theoretical setting where the buyer leads the supplier under VMI according to the common examples of the early adopters of VMI such as Wal-Mart, Home Depot, and Kmart that are powerful retailers in their industries (Almehdawe & Mantin, 2010). Yu et al. (2009a) use the evolutionary game situation where the buyer is a leader under VMI to examine buyer's and supplier's profits after VMI adoption, and investigate the supply chain's evolutionary stability that indicates whether the buyer and supplier would accept the VMI strategy in both short term

and long term perspectives. In Chen et al.'s study (2010), VMI represents the Stackelberg game where the retailer makes decisions as a leader before the wholesaler does to maximize the whole channel profit. They evaluate VMI's performance by comparing with the uncooperative setting where the wholesaler pursues only his profit.

Another group of studies assume that the supplier is a leader rather than a follower in their game settings of VMI. In Yu et al.'s study (2009b), the manufacturer plays a role of leader against multiple retailers and dominates information in the VMI system. They develop the algorithm for the optimal solution under the Stackelberg game with information asymmetry and evaluate both manufacturer's and retailers' performances under VMI. Yugang et al. (2006) also regard the manufacturer as a leader who has a full power to control on the channel-wide inventory under the VMI situation with multiple retailers. They propose the solution algorithm for the equilibrium of the Stackelberg game and examine the impacts of environmental factors on manufacturer's and retailers' profits.

Some studies directly compare two different game situations – when the supplier is a leader and when the buyer is a leader. In the supply chain system with one supplier and one retailer, Bichescu and Fry (2009) compare VMI with three different power relationships – retailer lead, supplier lead, and equivalent relationships. The result shows that VMI outperforms non-VMI regardless of the power relationship, and the unequal power cases result in better channel performance than the equal power case no matter who the lead is. In the system with one manufacturer and multiple retailers, Almehdawe and Mantin (2010) consider two different VMI scenarios depending on who has channel power – either a manufacturer or one of retailers. Their analysis on the Stackelberg game model indicates that VMI achieves better supply chain performance when the retailer has a power than when the manufacturer does.

Meanwhile, Cachon's study (2001) uses the game theory to represent the inventory competition among multiple retailers rather than the dyadic power relationship between the upstream and downstream of the supply chain system. He proposes the Nash equilibrium solution of the game problem and compare the supply chain performances between VMI and the non-cooperative cases.

4.2. Key Collaborative Features of VMI

There have been some review papers on VMI, and they mainly discuss about how researchers define the concept of VMI and which research methodology they use in their studies (Govindan, 2013; Marques et al., 2010). Meanwhile, this study focuses on how the past studies recognize that VMI improves the supply chain performance. By identifying the key collaborative features of VMI from the literature review, this study intends to provide full knowledge about how VMI results in the improved performance and prepare the basis to develop more advanced supply chain collaboration programs that make better outcomes than VMI. This study identifies information sharing, integrated decision making, and cost payment as key collaborative features of VMI.

4.2.1. Information Sharing

Since the supplier is responsible for managing buyer's inventory under VMI, information sharing process that transfers the information of market demand and inventory level directly from the buyer to the supplier is essential to support the supplier to make proper replenishment decisions. In general, the effect of information sharing under VMI has been examined as the mixed impact of integrated decision making as well as information sharing (Chen, 2013; Kannan et al., 2013; Mishra & Raghunathan, 2004; Rad et al., 2014; Sari, 2008b; Webster & Kevin Weng, 2008).

Some researchers still take the issue of information sharing by examining how the quality of shared information affect the performance of VMI. In the VMI system where the vendor and retailer share information about sales, inventory level, and shipment, Angulo and Nachtman (2004) investigate how inaccuracy and delay of information affect the supply chain performance. Their model experiment shows that the information delay has a significant impact on every performance including customer service level and costs but the inaccurate information sharing does not affect any of them. In a comparison with the traditional retailer managed inventory, Kulp (2002) examines the impact of information properties when the manufacturer and retailer share sale and inventory information. His model analysis reveals that VMI outperforms the traditional system only when the precise and reliable information is shared between the supply chain members.

While most studies about the VMI program have emphasized the importance of information sharing as the requirement of successful VMI, others conclude that additional benefit from information sharing of VMI may be negligible. Based on the discrete event simulation model, Yang et al. (2003) investigate the impact of several factors on performances of the VMI program, and these factors include demand variability, review interval, number of retailers, and information availability. The simulation outcomes indicate that the impact of real time information on production decisions is minimal and the result implies that the benefit of VMI can be obtained without intensive information sharing. Their study still asserts that accurate information transfer is required for efficient operations of the VMI program.

4.2.2. Integrated Decision Making

The literature review shows that researchers have use diverse forms of VMI by adding special contract terms (Fry et al., 2001; Gerchak & Wang, 2004) or functions other than

replenishment (Cetinkaya & Lee, 2000). Meanwhile, most past studies share the unique feature of VMI, which is that the supplier control buyer's inventory. Compared with the traditional system where the buyer manages his own inventory, VMI let the supplier decide replenishment of buyer's inventory accordant with the control of his own inventory and production, and the supplier's integrated decision results in the improved supply chain performance just like the centralized decision making system.

In fact, the integrated decision making process has been considered to be a key feature that enables VMI to outperform the retailer managed inventory. In the supply chain system where multiple retailers compete one another, Cachon' study (2001) looks for the way to bring the optimal supply chain performance. He considers three cooperation strategies, which are changing retailers' incentives, choosing cheapest equilibrium, and letting the supplier make replenishment decisions. His model analysis reveals that the optimal decision is made by the last strategy, which is VMI.

One stream of studies that has focused on the integrated decision making as the key collaborative component of VMI evaluates the performance of VMI by comparing with the traditional system with only information sharing. In general, past studies indicated that VMI is not always better than the information sharing system. Fry et al. (2001) propose the special VMI contract that let the supplier sustain a proper inventory level to maintain the service level for the retailer. Their model analysis reveals that the proposed VMI contract brings the significant cost saving in many cases but it performs poorly compared with the retailer managed inventory with information sharing in a certain setting of contract terms. Kim's study (2007) also compares VMI with the simple demand information sharing system. According to the numerical examples of his model, VMI requires lower system-wide inventory level but the retailer needs to hold higher inventory level to maintain the service level. Choudhary and Shankar (2015) evaluate the value of VMI beyond information sharing by comparing VMI with the traditional system where the supplier knows about retailer's demand and inventory level. Their model experiment shows that the pure value of VMI beyond information sharing is quite sensitive to various system parameters related to ordering, demand, cost, and service requirement. Yao and Dresener (2008) compare three collaborative systems – information sharing system, continuous replenishment program(CRP), and VMI – with the traditional system. In their study, any of three collaborative systems leads to manufacturer's inventory reduction and in particular, VMI can outperform information sharing and CRP. Meanwhile, their model analysis shows that the retailer may not receive any benefit from three collaborative systems. Savasaneril and Erkip (2010) consider three types of supply chain systems, which are the traditional system with information sharing, VMI only system and VMI combined with consignment. Their study identifies a number of situations where VMI does not outperform the information sharing system and the manufacturer may not obtain cost savings from VMI when he has sufficient production capacity for serving the retailer. Salzarulo and Jacobs's study (2014) evaluates the incremental value of centralized decision making by comparing three systems including make-to-stock, make-to-order, and VMI. Their model experiment indicates that the cost savings due to the centralized decision making of VMI is about 2.2% and slightly larger than 1.8% of cost saving caused by only information sharing.

A group of studies examine the impact of decision authority on the supply chain performance by comparing three supply chain systems with different decision making schemes – traditional system where all members make their own decisions independently, VMI system where the supplier determines replenishment of buyer's inventory, and centralized system where one has a full authority to make every operational decisions to optimize the supply chain output (Bichescu & Fry, 2009; Bookbinder et al., 2010; Chen & Wei, 2012; Dong & Xu, 2002; Ru & Wang, 2010). Most of these studies commonly conclude that VMI outperforms the retailer managed system but it still has some room to be improved compared with the centralized system. By implication, the past studies show that the integrated decision making feature alone may not bring the significant value beyond information sharing. On the other hand, the results from some studies indicate that VMI has a potential to make the further improved performance once its integrated decisions are expanded to the extensive areas just like the centralized decision making system.

4.2.3. Cost Payment

A fairly large number of researchers have studied about VMI, and there is still no consensus on its format and characteristics of VMI, because most of them define VMI models in their own ways with unique features. In particular, the past studies describe different cost payment schemes that indicate who pays the cost for holding inventory at buyer's warehouse under VMI. A group of studies characterize their VMI models in the situation where the supplier is responsible for the cost for holding buyer's inventory (Almehdawe & Mantin, 2010; Lee & Ren, 2011; Mishra & Raghunathan, 2004; Rad et al., 2014; Salzarulo & Jacobs, 2014; Tat et al., 2015; Webster & Kevin Weng, 2008; Xiao & Xu, 2013). In other studies, the buyer still pays the cost to keep his inventory under VMI (Bichescu & Fry, 2009; Cachon, 2001; Chakraborty et al., 2015; Diabat, 2014; Kannan et al., 2013; Kulp, 2002; Mateen & Chatterjee, 2015; Szmerekovsky & Zhang, 2008; Zhang et al., 2007).

Another form of VMI can be found as the combination of VMI and consignment in many studies (Bookbinder et al., 2010; Gumus et al., 2008; Zanoni et al., 2014; Zavanella & Zanoni, 2009). In most of their models, the inventory holding

cost is divided into stocking cost and financing cost and the supplier is responsible for only the financing cost for the inventory stored at buyer's warehouse under VMI (Valentini & Zavanella, 2003).

Since the supplier makes decisions on ordering and replenishment of buyer's inventory under VMI, whether the supplier should pay the cost for holding buyer's inventory can affect the resultant inventory level and even the total cost. While there have been a relatively small number of studies that address this issue, overall, most of them conclude that VMI is better off when the supplier pays all inventory holding costs or when VMI is combined with consignment. Bernstein et al.(2006) compare two different types of VMI including the first VMI system where the whole inventory holding cost is paid by the supplier and the second VMI system where the supplier pays only his inventory holding cost. Their model analysis reveals that the first VMI system is preferred to the second VMI system because the first one leads to the echelon operational autonomy where the supplier makes his operational decisions to minimize the entire supply chain cost. Gumus et al. (2008) compare two programs, which are the consignment only program and the consignment program combined with VMI. Their numerical examples show that the combination of VMI and consignment outperforms the consignment only program. On the other hand, the individual member can be worse off in certain conditions under the VMI plus consignment system and by implication, this program requires the additional scheme to split the resultant cost saving fairly into the supplier and buyer. Nagarajan and Rajagopalan (2008) consider a special contract that let the manufacturer pay a certain portion of costs for holding retailer's inventory. Their analysis on the model indicates that the transfer payment between the manufacturer and buyer forces the manufacturer to make proper replenishment decisions and consequently makes VMI outperform the retailer managed inventory in most cases.

5. Conclusion

This study reviews more than a hundred of past studies that have researched VMI as a supply chain collaboration program. Through the observation on key components and structures of VMI appeared in the past literature, three main collaborative features of VMI are recognized and they are found to play critical roles in making the improved supply chain performance. In addition, this study discusses about several main issues that the researchers have frequently addressed in their studies on VMI.

This study finds out the following key points from the literature review and obtains practical and theoretical implications from them. First, most of past studies commonly consider decision authority and information sharing to be the main collaborative features of VMI, and only a few studies pay attention to cost payment. This result implies that more researchers need to conduct their research on cost payment and look for the basis to develop more advanced collaboration programs than the current VMI.

Second, this literature review shows that many researchers have learn about VMI by relying on only limited numbers of research issues such as the various inventory policies and the impact of information sharing. By implication, future studies can obtain full knowledge about VMI by addressing additional relevant issues such as how to provide the incentives to VMI participants and how to use shared information.

This study identifies several issues that most researchers have missed in their studies. Based on the findings for the literature reviews, the potential research topics and the direction of research are presented as follows.

First, the comparison with more than one kind of other programs can reveal the true value of VMI. While quite a lot of studies examine the benefits of VMI by comparing with various programs, most of them consider only a single program other than VMI (Disney & Towill, 2003a; Fry et al., 2001; Kim, 2007). In particular, the traditional retailer managed inventory is most frequently used as the benchmark in many past studies (Disney & Towill, 2003b; Lee & Cho, 2014; Mishra & Raghunathan, 2004). Meanwhile, their analyses are sufficient to figure out the advantages of VMI over non VMI, and the study can figure out the disadvantages only when VMI is compared with more advanced program or ideal system (Bookbinder et al., 2010; Sari, 2008b; Tyan & Wee, 2003). In future studies, more researchers are expected to evaluate the performance of VMI by comparing more than one programs including more advanced ones to obtain the basis for developing new collaborative programs that overcome the weaknesses of VMI.

Second, future studies can figure out the overall impact of VMI on the whole supply chain system by considering the supply chain structure with more than two echelons. Since VMI has been defined as the contract that is held between two supply chain members, most of the past studies rely on the simple two stage supply chain system with one supplier and one buyer (Achabal et al., 2000; Bichescu & Fry, 2009; Chen & Wei, 2012; Gumus et al., 2008; Wang, 2009) or one supplier and multiple buyers (Almehdawe & Mantin, 2010; Cachon, 2001; Rad et al., 2014). Meanwhile, some researchers point out that VMI should be applied to the entire supply chain system for its optimal achievement (Danese, 2004), and the supply chain structure is composed of more than two echelons in most real cases. By implication, the accurate and real influence of VMI on the whole supply chain system is possibly captured by future studies only when they examine VMI in the context of the realistic supply chain system with more than two stages.

Third, in future studies that test the value of VMI, diverse

performance measurements should be evaluated to explain why VMI achieves greater outputs than non-VMI. While some researchers measure more than one type of operational outcomes from VMI, most past studies reply on the profit and cost to evaluate the benefit of VMI (Chen & Wei, 2012; Choudhary & Shankar, 2015; Guan & Zhao, 2010). Although the monetary value is an important measurement that conclusively tells the value of VMI, it is limited to explain about how VMI improves the supply chain performance. By testing VMI in terms of various intermediate outputs such as bullwhip effect (Disney & Towill, 2003b; Kristianto et al., 2012) and customer service level (Bichescu & Fry, 2009; Sari, 2008b; Webster & Kevin Weng, 2008) as well as the profit or cost, future studies can identify the main collaborative features of VMI that enable it to outperform non-VMI.

Forth, more case and empirical studies are required to handle the various issues about VMI. The literature reviews reveal that many researchers have heavily relied on mathematical modeling and simulation analysis in their studies on VMI. Even though the model analysis is an effective way to get the answers to the specific questions such as testing the value of VMI, it is limited to expand the research idea to diverse issues. Instead, the case and empirical studies are recommended for the future studies to address the various research topics, for examples, the major requirements of VMI's success (Claassen et al., 2008; Dong et al., 2007; Dorling et al., 2006; Kuk, 2004; Niranjan et al., 2012; Upadhyay et al., 2013) and its application to the special industries (Ryu et al., 2013; Tanskanen et al., 2009; Tyan & Wee, 2003).

Fifth, future studies need to keep looking for the new collaborative feature of VMI other than the integrated decision making and information sharing. While there have been many researchers that depend on integrated decision making and information sharing to explain the reason that VMI brings the benefit to the supply chain system (Angulo et al., 2004; Bookbinder et al., 2010; Choudhary & Shankar, 2015; Kulp et al., 2004; Salzarulo & Jacobs, 2014; Yao & Dresner, 2008), other functions including cost payment have been rarely treated as key collaborative features of VMI (Bernstein et al., 2006; Gumus et al., 2008). In the future studies, researchers can develop the basis to introduce new collaborative programs that are more advanced than VMI by analyzing its various collaborative features.

Sixth, future studies should answer to the question of how to use the shared information. Under VMI, the supplier can access to diverse information such as daily demand data and inventory levels, and he has the opportunity to exploit this information for forecasting demands and making operational plans (Kristianto et al., 2012). While abundant studies have supported the importance of information sharing for successful implementation of VMI, what future researchers should really explore is how the supplier and buyer can use the shared information to fully retrieve benefits from it.

Finally, future studies are expected to focus on the new version of VMI that is superior to the conventional VMI. Some past studies have already considered different hybrid versions of VMI by combining with consignment (Chen et al., 2010; Gumus et al., 2008; Ru & Wang, 2010), revenue sharing (Chen & Wei, 2012; Gerchak & Wang, 2004), and others (Ryu et al., 2013; Szmerekovsky & Zhang, 2008). Much more studies should attempt to develop the innovative programs that overcome any weaknesses of the current VMI and achieve the ultimate supply chain collaboration.

This study has the following limitations. First, this literature review covers only a portion of past studies on VMI. In particular, most past studies appear in this study use the model analysis and simulation as their research methodologies. Future literature reviews can expand their research scope by examining more empirical or case studies on VMI and propose new research models that represent the certain relationships among key elements of VMI.

Second, this study focuses on only VMI in its literature review, even though it addresses the issue of the collaborative features. There have been various supply chain collaboration programs other than VMI, for example, QR, CR, and CPFR. Obviously, the only way to fully understand about the collaborative features of VMI is to review past studies on the other kinds of collaboration programs and directly compare VMI with them. This research issue is rendered to future studies.

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Appendix A. Taxonomy of Representative Studies on VMI

Authors (Year)	Research focus	Supply chain structure	Performance measurement	Methodology
Cachon (2001)	Comparison of three cooperative strategies in retailers' inventory competition	A supplier and multiple retailers	Costs	Model analysis and numerical examples
Fry et al. (2001)	A proposed replenishment contract (z, Z) under VMI	A supplier and a retailer	Supply chain cost	Model analysis and numerical examples
Disney and Towill (2003)	Impact of VMI on supply chain performance	A manufacturer and a distributor	Bullwhip effect	Simulation
Disney et al. (2003)	Comparison of three transportation operations – traditional, internal consolidation, and VMI	A manufacturer and a distributor	Total daily transport cost	Simulation
Angulo et al. (2004)	Effect of information accuracy and delay	Four echelons	Inventory level, fill rate, costs	Simulation

Authors (Year)	Research focus	Supply chain structure	Performance measurement	Methodology
Choi et al. (2004)	A new way to measure service level and proposed contract under VMI	A manufacturer and a supplier	Service level	Model analysis and numerical examples
Disney et al. (2004)	Comparison of five different supply chain systems	Four echelons	Inventory holding cost, bullwhip effect	Simulation (Beer game)
Gerchak and Wang (2004)	Revenue sharing vs. wholesale-price driven contracts under VMI	A retailer and multiple suppliers	Profits	Model analysis and numerical examples
Kim (2004)	Optimal replenishment policy integrated with shipment decision in outsourcing system	A supplier and a buyer	Total system cost	Model analysis and numerical examples
Kim et al. (2004)	Impact of information sharing on VMI's performances	A service facility and a supplier	Inventory holding and setup costs	Model analysis and numerical examples
Kulp et al. (2004)	Effect of Information Integration	-	Wholesale price, Stockout, profit margins	Empirical study
Mishra and Raghunathan (2004)	Impact of VMI on brand competition	Two manufacturers and a retailer	Profits	Model analysis and numerical examples
Tatikonda et al. (2004)	Implementation process and outcomes of VMI	-	Customer service, cost/time savings, business relationship	Case study
Bernstein and Federgruen (2006)	Sharing inventory holding cost under VMI	A supplier and multiple retailers	Costs	Model analysis
Dong et al. (2007)	Key environmental factors of VMI adoption	-	Degree of VMI Adoption	Empirical study
Claassen et al. (2008)	Success Factors of VMI	-	Cost reductions, customer service, supply chain control	Empirical study
Nagarajan and Rajagopalan (2008)	Contracts to share inventory holding costs under VMI	A manufacturer and a retailer	Supply chain cost	Model analysis and numerical examples
Bichescu and Fry (2009)	Impact of channel power on VMI's performance	A supplier and a retailer	System cost, customer service	Model analysis and numerical examples
Wong et al. (2009)	Sales rebate contracts under VMI	A supplier and multiple retailers	Profits	Model analysis and numerical examples
Yu et al (2009a)	Effect of VMI implementation in short-term and long-term periods	A supplier and a buyer	Supply chain profit	Model analysis and simulation
Yu et al (2009b)	Effect of information asymmetry in VMI	A manufacturer and multiple retailers	Profits	Model analysis and numerical examples
Almehdawe and Mantin (2010)	Impact of leadership on VMI's performance	A manufacturer and three retailers	Profits	Numerical examples
Chen et al. (2010)	Revenue sharing contract with side payment under VMI	A wholesaler and multiple retailers	Profits	Model analysis and numerical examples
Darwish and Odah (2010)	Algorithm development for optimal replenishment decision under VMI	A vendor and multiple retailers	System cost	Numerical examples
Guan and Zhao (2010)	Revenue sharing vs. franchising contracts under VMI	A vendor and a retailer	Cost, perfect contract	Model analysis and numerical examples
Kim and Park (2010)	Integrated decisions on price, capacity, production, and inventory	A vendor and a retailer	Profits	Numerical examples

Authors (Year)	Research focus	Supply chain structure	Performance measurement	Methodology
Lee and Ren (2011)	VMI implementation in global environment with uncertain exchange rate	A supplier and a retailer	Costs	Numerical examples
Chen and Wei (2012)	Three different price and revenue sharing contracts under VMI	A manufacturer and a retailer	Profit, efficiency	Numerical examples
Shu et al. (2012)	Integrated decisions on location, transportation, price, and replenishment	A vendor and multiple retailers	Vendor's profit	Model analysis and numerical examples
Xiao and Xu (2013)	Revenue sharing contract under VMI with deteriorating product	A supplier and a retailer	Profits	Model analysis and numerical examples
Diabat (2014)	Optimal sales decision under VMI	A vendor and multiple buyers	Supply chain profit	Numerical examples
Zanoni et al. (2014)	Effect of VMI with consignment contract under emission trading scheme	A vendor and a buyer	Costs	Numerical examples
Govindan (2015)	Effect of VMI implementation and algorithm development of optimal replenishment decision	A vendor and multiple retailers	System cost	Numerical examples
Li et al. (2015)	Profit sharing method under VMI	A manufacturer and multiple retailers	Profits	Model analysis and numerical examples