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Consignment Review: Investigation into Its Potential as a Supply Chain Collaboration Program*

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Abstract

Purpose - This study aims to show that consignments can enable supply chain collaboration, based on the review of selected studies, and aims to investigate its potential to be a better collaboration program, through an analytical comparison with other collaboration initiatives.

Research design, data, and methodology - This study uses a literature review on selected studies that researched consignments. In addition, based on the proposed framework, the current consignment process and other well-known collaboration programs are analyzed in terms of three key collaboration aspects.

Results - Most studies employ simple research in terms of their purpose and methodology. An analysis with the proposed framework indicates the potential of consignments to foster supply chain collaboration.

Conclusions - Based on the literature review, this study suggests that future research needs to aim for diverse research goals and conduct sophisticated research on consignments. An analysis with the proposed framework shows that consignments would be more effective for supply chain collaboration if active information sharing and joint decision-making are implemented.

Keywords: Supply Chain Collaboration, Consignment, Contract, Inventory Management, Literature Review.

JEL Classifications: M11, M19, M20.

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1. Introduction

Supply chain collaboration has recently received much attention from practitioners and researchers because of its potential to overcome the inherent limitations of the supply chain system and optimize its overall performance (Simchi-Levi et al., 2000). In fact, many programs, including Quick Response (QR), Efficient Consumer Response (ECR), Vendor-Managed Inventory (VMI), and Collaborative Planning, Forecasting, and Replenishment (CPFR), were developed for supply chain collaboration and have been already applied to various businesses.

Unlike these new programs, consignment has a long history of being used in many businesses. The objective of this study is to examine the potential of consignment to be one of the supply chain collaboration program. Through the literature review on a selected group of studies about consignment, this study identifies the true nature of consignment as a collaboration program and offers some suggestions to future studies.

Based on the proposed framework with three key features of collaboration - information sharing, cost payment, and decision authority, this study also analyzes consignment and finds out the exact function that enables consignment to achieve supply chain collaboration. The analysis on consignment along with the other collaboration programs points out the weaknesses that the current form of consignment should overcome to be a more advanced collaboration program.

The contributions of this study are twofold. First, this study provides the general concept about potential benefits from consignment, specially related to supply chain collaboration. Due to the long history of being used in various industries, consignment may be still questioned about its ability to realize supply chain collaboration. Meanwhile, according to the literature review in this study, there have been many studies supporting that consignment can be an effective tool to bring supply chain collaboration, and many researchers would still keep looking into this program in diverse perspectives.

Second, this study analyzes consignment by applying a new framework with key common features of any collaboration programs. While many significant studies have shown the practical benefits of collaboration programs and have addressed col-

laboration-related topics such as information sharing and contracts, few of them conducted direct comparison between different programs based on their common collaborative features. Through comparison with other collaboration programs based on the proposed framework, this study recognizes not only the special function of consignment leading to supply chain collaboration, but also its potential to be a more advanced collaboration program.

2. Theoretical Background

For the theoretical background of consignment, this study describes its definition, requirements, and benefits as the supply chain collaboration program.

2.1. Definition

Consignment is probably more than 4,000 years old and has been used in daily commerce for centuries (Fenton & Sanborn, 1987). The modern form of consignment was employed in retail during the Great Depression and became popular due to the economic difficulties faced by both retailers and manufacturers during that financially difficult time. The industry lost interest in consignment during the postwar (1940s and 1950s) era in the United States because retailers were sure that a sufficient volume of products could be sold. Nevertheless, consignment is still used in the retail industry in various forms, such as straight purchasing agreements, product offerings, and in combination with VMI. Consignment has been widely applied to business areas such as paper, steel, commodity distribution, and healthcare (Ballard, 1987; Gerber, 1987).

In general, consignment is an agreement or contract made between a supplier and a buyer by which the supplier maintains his inventories on the buyer's premises until the buyer withdraws them for use (Harding, 1999). Since the ownership of the inventories is still held by the supplier, the buyer does not pay for them until they are consumed (Gerber, 1991). In general, the consignment agreement specifies the exact level of inventory, ownership transfer point, inventory invoice, and liability for loss or damage (Harding, 1999).

2.2. Requirements

Consignment requires several conditions to be an effective tool that realizes the supply chain collaboration. The following list of requirements for a successful consignment includes contract terms, system enhancement, and technical support.

First, in the consignment contract, the buyer and supplier should determine the proper level of inventory maintained at the buyer's warehouse. While the buyer prefers to hold a large amount of consignment inventory to prevent the incidents of stockout, the supplier should determine the inventory level at which it can provide the reasonable level of customer service at the reasonable cost (Williams, 2000). Proper adjustment of consigned stock level is crucial in operating consignment effectively and resulting in mutual benefits to the supplier and buyer. The inventory level in consignment should be carefully determined based on the consideration of sales forecast and cash flow projection.

Second, another requirement for a successful consignment is confirming the party who is responsible for checking the inventory movement. During the negotiation for the consignment contract, the supplier and buyer should carefully determine who is responsible for monitoring inventory movement and managing inventory turnover. In particularly, the contract should specify how slow moving goods are handled and to where those items are destined (Williams, 2000).

Third, the disposition of damaged or lost inventory is also another key issue that should be addressed in the consignment contract (Williams, 2000). Normally, the buyer has a full responsibility for those items in most consignment cases, but the specified rule included in the contract can reduce the chance of conflict possibly occurring between the buyer and supplier.

Fourth, the supplier's commitment to work on consignment stock is essential for a successful consignment (Gerber, 1991). Consignment requires a trustful supplier who has sufficient financial resources to keep providing the consignment stock to the buyer.

Fifth, the effective system for monitoring inventory is required for consignment. One of the key elements for the successful consignment is to ensure the effective inventory control by accounting for supplies in highly reliable manner (North, 1987). In order to maintain such a high level of inventory control, both suppler and buyer ought to prepare the efficient and consistent monitoring of inventory movement in the buyer's operations and obtain full knowledge of consumption rate, product application, delivery times, and stockout occurrence.

Finally, the advanced technology can significantly improve the operations of consignment. The computerized system can create near optimal schedules of the operations in both buyer's and supplier's sides with the consideration of available staff, space, equipment, cost, and revenue. Under the computerized system, the communication between the buyer and supplier can be very rapid and the information becomes more credential than under the traditional communication system (DiGiacomo, 1991). Every performance made by the computerized system can substantially support the functions of consignment practices.

2.3. Benefits

Consignment would provide both buyer and supplier with significant benefits, which are caused by its unique features. The following features of consignment enable its participants to receive specific benefits.

First, under the consignment agreement, partial or full stock at the buyer's warehouse is assigned for special treatment and this consignment stock is handled in a different way from the non-consignment stock. Due to the reduced burden of cost pay-

ment for inventory holding cost, the buyer is willing to decrease the number of purchase by increasing the batch size of orders (Sjoerdsma, 1991). Consequently, infrequent orders result in stabilized material price that may permits the benefit of economy of scale for the buyer. Normally, the consignment stock that is not sold by the buyer is returned to the supplier. In particular, for the buyer who is involved in the retail industry, the buyback option provides great advantage in that the waste of stock due to the product obsolescence can be significantly reduced (Gerber, 1987). For the buyer, the consignment stock means virtually stockless in terms of its value (Sjoerdsma, 1991), and it can reduce the inventory cost associated with financial investment.

Since the buyer is likely to maintain large inventories without increasing inventory dollars and fewer stockout and emergency delivery occur, he can save costs of shortage and backorder and maintain the customer service (Ballard, 1991). Consignment also allows the effective batching of deliveries that is scheduled by coordination of buyer and supplier so as to remove a large portion of intermediate warehousing expenses (Gerber, 1987). In conclusion, both buyer and supplier can save costs of inventory and transportation.

Second, the main feature of consignment, which is significantly different from the traditional system, is that the buyer does not pay for the products until they are actually consumed. Consequently, consignment results in the reduction of buyer's inventory cost, and in particular, the buyer can save the financial cost (or opportunity cost) for inventory holding (Sjoerdsma, 1991; Valentini & Zavanella, 2003; Williams, 2000). The delayed payment in consignment can improve the cash flow in the business (Ballard, 1991; DiGiacomo, 1991; North, 1987).

Third, consignment can enhance or improve the collaboration of operations between the supplier and buyer. A key requirement for the successful consignment is a mutual supports based on the high level of collaboration among participants. Through consignment, the supplier and buyer establish a close and long term relationship to achieve the mutual supports, and the benefits from supply chain collaboration can be obtained with consignment (Battini et al., 2010a).

A high level of coordination between the supplier and buyer also enables them improve the forecast (Gerber, 1987). Precise information about the demand allows the supplier to make better production schedule and it permits the buyer to make effective replenishment decisions. As a result, collaboration enhanced by consignment benefits both the supplier and buyer such as cost saving in production and capacity and the reduced number of stockout.

Finally, consignment is considered to be a flexible system in its initial application compared with JIT (Juts-In-Time) and stockless programs (Gerber, 1987, 1991). Consignment has been frequently compared with JIT and stockless programs in that one of their key goals is to remove the intermediate warehousing. While JIT and stockless require that the supplier and buyer's locations are close, geographical proximity is not required for the application of consignment. As a result, consignment is more flexible in its application and requires less initial investment to establish distribution channels than JIT and stockless programs.

3. Related Studies on Consignment

This study reviews selected studies that have researched consignment as a supply chain collaboration program. This study identifies the current trend of studies on consignment by analyzing the relevant studies in terms of their research focus, supply chain condition, inventory system, decision variables, performance measurement, and research methodology. Appendix describes the outcome of this analysis. The literature review also reveals that many studies focus two major issues-contract and inventory management. The followings show how these issues are addressed in the studies.

3.1. Contract

Since consignment normally begins with a formal contract between business partners, many studies perceive consignment as being essentially a business contract and focus on the special nature of this contract. The revenue sharing aspect of consignment has been frequently researched, and the related studies have evaluated its performance under various conditions (Adida & Ratisoontorn, 2011; Chen et al., 2011; Gerchak & Khmelnitsky, 2003; Hackett, 1993; Kim et al., 2014; Wang et al., 2004).

Hackett's study about consignment (1993) is to find the particular economic market conditions that entice a seller use the consignment contract. He considers consignment as the contract that pre-specifies the quantities of goods to be intermediated, the status of the goods as trust property, the middleman's commission, and the seller's reservation price. Under the consignment contract, the middleman takes possession of a good owned by a seller, promotes its sales to buyers, and is paid with a share of revenue. If no sales happen, possession reverts back to the seller. The middleman has authority to sell at any price greater than or equal to the sellers' predetermined reservation price. The seller can intermediate the sale of a good through consignment or through a dealer. Since the dealers own the goods they promote, they have incentive to choose the expected joint surplus maximizing level of promotional activity. Meanwhile, revenue sharing scheme used in consignment lowers the level of promotional activity and consequently decreases the expected joint surplus level. The model analyses indicate some situation that the seller may choose consignment as the intermediary contract form. When valuations are subjective and sellers have highly optimistic value estimates, consignment may be used. The result of the analyses also implies that consignment gives sellers with high opportunity costs with a chance of making profitable sales and limits the middleman's commitment, if sellers have relatively high reservation value in the resale market.

Wang et al. (2004) define consignment as a contract for revenue sharing between the retailer and supplier. Under consignment arrangement, the supplier retains the ownership of goods and determines the retail price. Only when the item is sold, the retailer deducts an agreed percentage from the selling price and

remits the balance to the supplier. They formulate the decision making of the retailer and supplier under consignment with revenue sharing as a Stackelberg game, and examine the impact of such a contract on the channel performance. The model analyses show that the channel performance significantly depends on demand price elasticity and the retailer's share of channel cost. In details, the expected channel profit loss, compared with the centralized system, increases with demand price elasticity and decreases with retailer's cost share. Under iso-price-elastic and multiplicative demand model, the decentralized channel profit cannot be less than 73.6% of the centralized channel profit, and profit shared extracted by the retailer cannot be below 50%. The result of analyses indicates that the retailer can extract nearly all the channel profit like the centralized decision maker, when the retailer's cost share reaches 100% or price elasticity is low.

Gerchak and Khmelnitsky (2003) consider the consignment arrangement with a revenue sharing scheme in atypical situation wherein retailers may not physically return unsold items to the manufacturer when the product is perishable like newspapers. In this case, the retailer may have allegedly under-report sales. The under-report sales may hurt the manufacturer and interfere with his rational stocking decisions, which are based on previous sales reports. Under-reporting may also result in damage to retailers in the long run. They develop a discounted dynamic model for the reporting system. The model analyses indicate that future deliveries depend on the report but actual sales have no impact on deliveries. The result of analyses implies that the retailer's untruthful reporting does not ruin the optimal system performance as long as the manufacturer anticipates and responds that optimally.

Adida and Ratisoontorn (2011) conduct an investigation on different types of consignment contracts under retail competition. They consider two different consignment contracts - price contract and revenue-share contract and examine their impacts on the consignment performance. They also mark the retailer's difference in terms of retailer's price sensitivity to competitor's price. Their model analyses reveal that the retailer get greater benefit from the consignment price contract than the others but supplier's benefit can be very different depending on the level of retailer differentiation.

Identifying the special consignment contract run by E-bay, the popular Internet auction website, Chen et al. (2011) examine whether the consignment contract with a price dependent sharing function. In the supply chain models, they evaluate performances of four channel strategies - centralized and three different revenue sharing contracts. The numerical examples of their models indicates that the price-decreasing revenue sharing contract has significant problems in that it fails to achieve a high level of channel performances in terms of demand, profit, and efficiency.

3.2. Inventory Management

Since the uniqueness of consignment resides in supplier's responsibility for paying the costs of holding the buyer's inventory, inventory management is another issue frequently studied. Studies on inventory management in consignment focus on either optimal inventory policy (Hill, 1997; Hill, 1999; Lee & Whang, 1999) or benefits of consignment stock policy (Battini et al., 2010a; Braglia et al., 2013; Braglia & Zavanella, 2003; Chen & Liu, 2007; Corbett, 2001; Valentini & Zavanella, 2003).

Aggarwal and Jaggi (1995) consider consignment wherein the supplier allows a certain fixed period to settle the account with the buyer for the deteriorating items. During this period, no interest is charged to delayed payment. With this consignment arrangement, they formulate the inventory management problem as the deterministic model. They also develop the solution algorithm to obtain the optimal order quantity under this special condition. Meanwhile, no further analyses had been conducted to compare consignment with other systems.

Hung et al.'s model for consignment (1995)represents the real case of the industry wherein the payment to suppliers is not made until stocks are actually moved to the customer's production line. Under this consignment arrangement, the warehouse space is provided by the customer for suppliers to use for stocking. Since they assume that the stock in the customer's warehouse is managed by the supplier, this system is considered to be the combination of VMI and consignment. They formulate the mode for consignment as an inventory control model based on MRP runs and provide the non-linear programming to obtain optimal solutions of delivery period and safety stock level with a time-period base. Their study does not conduct any in-depth analyses to examine the performance of the consignment system.

Normally, the decentralized supply chain is not efficient as the centralized one, and the alternative performance measurement scheme is required to align the incentives and interests of multiple managers in the decentralized supply chain system. Lee and Whang (1999) propose the performance measurement scheme having properties of cost conservation, incentive compatibility, and informationally decentralizability. One feature of their measurement scheme is the consignment arrangement wherein the transfer price is paid to the lower site only when the product is sold in the multi-echelon supply chain system. Meanwhile, no further analyses on the consignment practice are conducted in their study.

Based on Hill's joint economic lot size model (1999), Braglia and Zavanella (2003) develop the model for consignment stock strategy and compare its performance with one of non-consignment case. Under the consignment arrangement, the vendor keeps a certain amount of inventory at buyer's warehouse, in particular, between a maximum level (S) and a minimum level (s) and pays additional costs incurred in stock-out cases. The buyer does not pay for capital-linked holding costs for inventories at his warehouse, and the vendor can use the buyer's warehouse space like his own one. In their model assumption,

the major difference between Hill's model and the consignment system is that stocks are located at the vendor's warehouse in Hill's model but it is at the buyer's in consignment. Analyses of the proposed models imply that, in general, the consignment policy outperforms the traditional non-consignment policy when the variances of demand and lead times are high. The explicit form of optimal solutions for their consignment stock policy model is proposed by Zanoni and Grubbstrom (2004) and it provides a convenient method for obtaining the optimal solutions of the amount of delivery, the number of deliveries, and the number of deliveries to be delayed.

Valentini and Zavanella (2003) also formulate the model for the consignment stock management based on Hill's joint economic lot size model (1997), and examine the impact of consignment on the supply chain performance. According to their model of consignment arrangement policy, the buyer pays only the stocking cost and the supplier pays the financial opportunity cost for inventory holding at the buyer's warehouse, while the buyer has a full responsibility to pay both costs for inventories at his warehouse. The analyses of their proposed model show that the consignment policy results in 6% reduction in the total cost compared with the traditional system. The consignment stock policy also benefit both the supplier and buyer in that it leads to a high level of minimum inventory at buyer's warehouse and then it improves the service level at reasonable costs.

Corbett (2001) considers the consignment stock to be a remedy for typical problems of the traditional supply chain system, such as incentive conflicts and information asymmetries. The consignment scheme may reduce system inefficiency due to information asymmetries by changing the incentive system. He formulates the order quantity and reorder point (Q,r) problem as a principal-agent model in two player context and examine the impact of the consignment stock on the supply chain performance under information asymmetries about setup cost and backorder cost. According to his consignment scheme, the supplier own the inventory held at the buyer's warehouse until it is consumed and the supplier guarantees the base level of inventory enough to fulfill expected future demand. The analyses of his proposed model imply that, when the setup cost is known to only the supplier, the consignment stock can decrease the impact of information asymmetry. In a case that the supplier does not know buyer's backorder cost, the supplier should overcompensate for buyer's stockout in order to obtain the minimum system cost.

Battini et al. (2010a) examine superiority of the consignment policy over the traditional one. In the simple supply chain system with single buyer and single vendor, they evaluate the performance of the inventory system when the buyer switches it stock policy from EOQ to consignment. The numerical examples of their proposed models show that the consignment policy consistently outperforms the traditional one regardless of demand variance and space limitation.

Braglia et al. 's study (2013) considers the special situation where consignment is applied and evaluate its benefit. They intend to optimize the consignment stock policy when the vendor manufactures products in batch. Their proposed algorithm determines the key decisions on consignment stock policy in a way to minimize the total operating cost and is applied to the numerical examples to show the superiority of consignment over the non-integrated system.

3.3. Implications from Literature Review

While there has been many studies that conducted research on consignment as a collaboration program, several issues still need to be addressed. First, most studies on consignment pursue one of two research goals - proposing a better contract scheme or evaluating consignment's performance. By contrast, this study analyzes consignment by using a framework composed of three key collaborative elements and shows that the current consignment form can become a more advanced collaboration program through increased information sharing and decision authority. Several recent studies have investigated hybrid programs that combine consignment and VMI and have examined VMI's addition of collaboration to the decision authority of the typical consignment form (Bernstein et al., 2006; Chen et al., 2010; Gumus et al., 2008; Nagarajan & Rajagopalan, 2008; Ru & Wang, 2010; Savasaneril & Erkip, 2010). To fully understand consignment's potential to become a better collaboration program, it is necessary to consider the new consignment types with active information sharing activities and joint decision-making processes and to test their performances.

Second, most studies that model consignment assume a simple supply chain structure, which is a two-stage supply chain system with a single supplier and one buyer. Some studies consider cases involving multiple buyers to examine the effect of their interactions, but none of them considers multiple suppliers or supply chain systems with more than two echelons. Future studies must consider more complex supply chain structures to examine the effect of relationships among different parties at the same stage or at different stages.

Third, the literature review indicates that most studies assume that the supplier and buyer apply only limited types of inventory control systems. Future studies can obtain generalizable results by testing consignment with the inventory control policy other than EOQ or (s, S).

Fourth, many studies have used only those decision variables related to inventory control and production, and evaluate only monetary performances. A more sophisticated investigation on consignment from diverse perspectives would employ various decision variables such as price and production capacity, and a non-monetary criterion such as the bullwhip effect (Chen et al., 2000).

Finally, many studies evaluate the performance of consignment by using numerical examples and are usually based on simple, deterministic, and static models. Simulation under stochastic and dynamic conditions is a better way to test consignment in complex and realistic supply chain systems.

4. Framework for Analyzing Supply Chain Collaboration Programs

To establish the detailed nature of collaboration, this study develops a framework to analyze the unique elements of consignment as a collaboration program (Ryu, 2007). The literature on supply chain collaboration programs indicates that most collaboration programs share at least one special feature that leads to collaboration among different supply chain members. This study finds that many collaboration programs has one or more than one of three elements-information sharing, cost payment, and decision authority.

Information sharing is a typical form of collaboration that appears in most collaboration programs. Information sharing is the process by which supply chain members at the same or different echelons actively share information to ensure efficient management of the supply chain operations (Kim & Song, 2013). Most studies that address information sharing focus on its value by examining various types of information, such as customer demand (Cachon & Fisher, 2000; Cachon & Zipkin, 1999; Gavirneni et al., 1999), customer orders (Aviv, 2001; Cachon & Lariviere, 2001; Lee et al., 2000), inventory policy (Chopra & Meindl, 2004), and demand forecast (Gerber, 1991).

Supply chain collaboration can also be realized by changing the cost payment scheme of the supply chain operations. Any such system can realize collaboration among its members and improve overall system performance by either modifying its cost payment methods (e.g., through price discounts) or changing the member responsible for paying the costs (e.g., VMI). The quantity discount is a good example of how a simple modification to a typical cost payment method can lead to supply chain collaboration by increasing throughputs in the supply chain while decreasing supply chain costs (Sjoerdsma, 1991; Valentini & Zavanella, 2003; Williams, 2000).

The authority to make specific operational decisions is a key element of supply chain collaboration programs. The authority to make operational decisions is generally tied to ownership. During preliminary collaboration, limited decision-making authority is given to a single member of the supply chain system. For example, the supplier has full authority to decide on issues concerning ordering and inventory holding at the buyer's warehouse under VMI. In more advanced collaboration programs, system members make operational decisions jointly instead of allowing a decision authority monopoly. Collaborative planning, forecasting, and replenishment is an example of collaboration programs that apply a joint decision-making process. In general, joint decision-making benefits the overall supply chain system (Aviv, 2001; Raghunathan, 1999). Many studies show the benefits of VMI (Webster, 1995) and CPFR (Webster, 1995) and identify joint decision making as the key element of supply chain collaboration.

Using a framework comprising three collaboration elements allows researchers to analyze any supply chain collaboration program such as consignment in terms of those key elements and to identify the special features that lead to supply chain collaboration. The framework can also be used to evaluate a collaboration program's potential to become an advanced program that achieves optimal supply chain performance.

5. Analyses on Consignment and Other Collaboration Programs

Using the framework established above, this study analyzes several collaboration programs including consignment. Specifically, the study compares consignment with other collaboration programs in order to identify the features of consignment that are unique and that lead to supply chain collaboration.

After surveying the history of supply chain collaboration, this study finds five types of collaboration program: QR, ECR, VMI, and CPFR. Supply chain collaboration began with a very simple form and then evolved into a sophisticated type of system-wide collaboration. In the earliest collaboration programs, operational decisions were made through information sharing among supply chain partners. For example, retailers would provide information about market demands to suppliers in advance so that the suppliers could use resources efficiently and provide improved service to the retailers. Recent advances in information technologies like Electronic Data Interchange (EDI) and the Internet have improved the practicality and productivity of such information sharing activities (Iyer & Bergen, 1997).

Quick Response (QR) was introduced in 1984 by a group of leaders in the U.S. apparel and textile industries as a remedy for unreasonably long lead-times, which caused serious problems in inventory management (Webster, 1995). It improves the visibility of customer demand information and gives the supplier accurate demand forecasts (Cetinkaya & Lee, 2000).

Efficient Consumer Response (ECR) was first used in 1992by grocery industry leaders, and it contains components supplementary to information sharing that lead to efficient supply channel operations (Simchi-Levi et al., 2000). By focusing on efficient store management, replenishment, promotion, and product introduction, ECR improves the entire supply chain process in a way that provides better service to customers.

Vendor-Managed Inventory (VMI), initiated by Wal-Mart, is another well-known supply chain collaboration program (Cetinkaya & Lee, 2000). The key concept of VMI is letting the vendor take charge of managing retailer's inventories, and it lessens retailer's inventory management burden and builds flexibility into vendor's order replenishment and delivery.

Collaborative Planning, Forecasting, and Replenishment (CPFR) is the latest supply chain collaboration program, began as a 1996 pilot study on new software systems developed by Warner-Lambert, a consumer goods manufacturer, and Wal-Mart. The early form of CPFR aimed to foster forecasting collaboration between manufacturers and retailers in order to improve the accuracy of demand forecasting. This collaboration initiative is different from any previous collaboration programs because it enabled active collaboration activities. Under CPFR, every supply chain member involved in business processes makes opera-

tional plans and decisions together based on the pre-determined agreements.

In order to identify the unique nature of consignment, this study analyzes five supply chain collaboration programs using the framework composed of three collaboration elements. The results reveal consignment's special collaboration features and identify ways of improving the program and turning it into a more advanced one. Table 1 shows the outcomes of the analyses employing three coordination elements. The traditional system reflects the basic non-collaborative supply chain type, in which no information is shared among supply chain members, except when suppliers receive orders from buyers. In the traditional system, each supply chain member pays the costs and makes the decisions strictly associated with his ownership.

<Table 1> Analyses on collaboration programs

Collaboration system	Information sharing	Cost payment	Decision authority
Traditional system	No information is shared.	Associated with ownership.	Associated with ownership.
QR	Limited information about demand is shared.	Associated with ownership.	Associated with ownership.
ECR	Limited information about demand is shared.	Associated with ownership.	Associated with ownership.
Consignment	No information is shared.	Supplier pays financial cost for buyer's inventory holding.	Associated with ownership.
VMI	Information about buyer's inventory and demand is shared.	Supplier pays full cost for inventory holding and ordering.	Supplier decides ordering and inventory holding at buyer's warehouse.
CPFR	Information about demand, planning, and forecasting is shared.	Associated with ownership.	Associated with ownership but make decisions based on pre-set agreement

In QR, the buyer and supplier share only one type of information, market demand, but QR is not different from the traditional system in terms of cost payment and decision authority the same is true of ECR.

In consignment, no information other than buyer's orders is shared among supply chain members. However, consignment's cost payment scheme differs from that of the traditional system, as the supplier is responsible for paying the cost of buyer's inventory because the supplier owns it until it is consumed. Regarding decision authority, consignment and the traditional system are alike.

Under VMI, the supplier receives information about market demands directly from the buyer and then makes decisions about replenishment and inventory holding for the buyer. In most VMI cases, the supplier is responsible for paying the costs of ordering and inventory holding at the buyer's warehouse. Thus, the supplier makes the ordering and inventory decisions that are determined by the buyer in the traditional system. The VMI system seems to be a quasi-centralized decision-making system in which the supplier makes the decisions and pays the costs related to wider operational areas that require considerable information. Although VMI employs all three key supply chain collaboration elements, its collaboration form is too limited to serve as a fully advanced collaboration program. In VMI, decisions are still made by a single member (the supplier) instead of jointly, and only market demand is shared between the supplier and buyer.

In CPFR, various information-including market demand, forecasts, and plans-is shared among different supply chain members. While each individual member makes the decisions about the operations that he owns just like the traditional system, the most decisions are made based on the pre-set agreement among the members. On the other hand, the cost payment scheme is identical to that of the traditional system. Thus, to be a fully advanced collaboration program, CPFR needs to adjust its assignment of cost items to supply chain members.

In thus analyzing current supply chain collaboration programs with a framework comprising three key collaboration elements, this study finds that each program is underutilizing at least one key element necessary for optimal supply chain collaboration. The principle that allows consignment to realize supply chain collaboration lies on its special cost payment scheme. Since consignment reduces buyer's burden to pay for purchasing items, it can improve the supply chain performance by increasing overall throughput. In particular, consignment normally raises the entire volume of orders made by buyers but suppresses sudden swelling of inventories in the supply chain system just like the volume-based quantity discount (Chopra & Meindl, 2004).

The analysis with the proposed framework also reveals the weak points of the current consignment type and provides the direction to be a better collaboration program. Consignment has no collaboration function related to information sharing or decision authority, and this point indicates that consignment could become a more advanced supply chain collaboration program if it features active information sharing and joint decision-making.

6. Conclusions

The objective of this study is to examine the potential of consignment to be a fully advanced collaboration program. Based on the literature review, this study identifies some critical issues and elements of consignment that have been ignored by the past studies and provides the specific guideline for future studies.

While many researchers have already observed that consignment is one of collaboration programs, this review recognizes that future studies need to focus on some issues to understand the true nature of consignment. Most early studies focus on the simple two-stage supply chain system, with a single supplier and one buyer. Future studies can examine the complex interaction among supply chain members at different stages by including either multiple suppliers or supply chain systems with more than two echelons in their models (Wang et al., 2005).

Regarding inventory control systems, existing studies on consignment choose relatively simple inventory control systems for their model analysis; most use either EOQ or (s,S) policy. Moreover, studies focus of the decision variables related to inventory management and production, such as lot size and production rate. A few studies consider price, but other decision variables rarely appear. Studies measure consignment performance in terms of total cost, and some of them use total profit when they consider the price to bea decision variable. Future studies can evaluate non-economic performance such as inventory level (Caridi et al., 2005), customer service (Chen et al., 2007), and bullwhip effect (Disney et al., 2004) to identify the benefits of consignment.

Many studies rely on model analysis or numerical examples in their analyses. Numerical examples is useful to analyze complex supply chain models. However, most studies apply simple, deterministic, static models for their numerical examples. In order to figure out the true nature of consignment, future studies can use sophisticated simulation models with stochastic and dynamic conditions (Sari, 2008).

This study also analyzes consignment by applying an analytical framework comprising three key collaboration elements-information sharing, cost payment, and decision authority. The analysis indicates that the special cost scheme of consignment results in increased throughput and consequently leads to supply chain collaboration. This result implies that supply chain members can improve the overall supply chain performance by applying consignment instead of quantity discount without being worried about increased inventory level in the supply chain system.

The comparison with the other collaboration programs such as VMI and CPFR reveals that the current form of consignment needs to have additional collaboration features including active information sharing and joint decision-making processes to be a more advanced collaboration program. Future study can examine the new form of consignment with reinforced information sharing and joint decision making processes such as the combination of VMI and consignment (Savasaneril & Erkip, 2010).

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Appendix. Summary of studies about consignment

Author(s) (Year)	Research focus	Supply chain system	Inventory system	Decision variables	Performance measurement	Analysis method
Hackett (1993)	Incentives to use consignment contracts in particular market environments	One seller and one middleman	-	Promotional activity level	Dealer's and seller's profits	Model analysis
Aggarwal and Jaggi (1995)	Ordering policy of deteriorating items under permissible delay in payments	One supplier and one customer	Economic ordering policy	Order quantity	Total variable cost per cycle	Model analysis and numerical examples
Hung et al. (1995)	Developing a simple decision procedure for a consignment system	One supplier and one buyer	Periodic review system (s, S) policy	Delivery period and safety stock	Fluctuation index	Model analysis and numerical examples
Lee and Whang (1999)	Performance mechanisms for efficient decentralized supply chains	Two-echelons (stocking sites)	Order-up-to level (S) policy	Order-up-to level	Inventory holding cost and shortage cost	Model analysis
Corbett (2001)	Effects of information asymmetry about setup cost and backorder cost under the consignment contract	One supplier and one buyer	(Q, r) model	Lot size and reorder point	Setup cost, backorder cost, and inventory holding cost	Model analysis
Boyaci and Gallego (2002)	Coordinated decisions of pricing and inventory replenishment policies	One wholesaler and one retailer, One wholesaler and multiple retailers	EOQ	Retail price, wholesale price, and order quantity	Retailer's, wholesaler's, and channel profits	Model analysis
Braglia and Zavanella (2003)	Potentiality of the consignment stock policy	One vender and one buyer	EOQ and (s,S)	Number of shipment and production batch size	Setup cost, inventory holding cost, and order emission cost.	Model analysis and numerical examples
Gerchak and Khmelnitsky (2003)	Impact of under-report sales on the supply chain coordination	One supplier and one retailer	-	Sales report	Retailer's and supplier's profit	Model analysis
Valentini and Zavanella (2003)	Benefits and drawbacks of consignment stock	One supplier and one manufacturer	(s, S) policy	Order quantity	Setup cost, ordering cost, and inventory holding cost	Simulation and case study (automotive industry)
Wang et al. (2004)	Impact of various demand models on performance under consignment contract with revenue sharing	One manufacturer and one retailer	-	Retail price and production quantity	Sales and production cost	Model analysis and numerical examples
Zanoni and Grubbstrom (2004)	Provide the algorithm to obtain all the optimal solutions of the consignment stock mode proposed by Braglia and Zavanella (2003)	One vender and one buyer	EOQ	Number of shipment and production batch size	Setup cost, inventory holding cost and order emission cost	-
Persona et al. (2005)	Optimal (s, S) policy for consignment stock with obsolescent product	One vendor and one buyer	(s, S) policy	Number of shipment and production batch size	Ordering, setup, inventory holding, and obsolescence costs	Numerical examples
Chen and Liu (2007)	Optimal consignment policy with a fixed fee and a per-unit commission	One manufacturer and one retailer	-	Order quantity, fixed fee, and per-unit commission	Sales revenue, manufacturing cost, inventory carrying cost, and stockout cost	Numerical examples
Fang et al. (2008)	Optimal component procurement strategy for assembly-to-order customized product	Multiple supplier and one assembler	-	Production quantity and price	Sales revenue and production cost	Model analysis

Gumus et al. (2008)	Benefits of consignment inventory over Inventory sourcing	One vendor and one customer	EOQ	Production quantity and order quantity	Ordering cost, setup cost, inventory holding cost, and shipment release cost	Model analysis and numerical examples
Li et al. (2009)	Supply chain coordination problem for decentralized system with consignment contract with revenue sharing	One manufacturer and one retailer	-	Retail price, production quantity, and revenue share	Sales revenue, production cost, and purchasing cost	Model analysis and numerical examples
Zavanella and Zanoni (2009)	Benefits of CS stock for a vendor and buyers	One vendor and multiple buyers	EOQ	Ordering cycle time and number of transport operations	Setup, ordering, and inventory holding costs	Numerical examples
Battini et al. (2010a)	Benefits of consignment stock policy	One vendor and one buyer	EOQ w/ reorder point, (s, S) policy	Production rate, order quantity, and maximum/minimum inventory levels (s, S)	Costs of production, inventory holding and stockout	Numerical examples
Battini et al. (2010b)	Economic and logistic benefits of consignment stock policy	One vendor and multiple buyers	EOQ w/ reorder point, (s, S) policy	Production rate, order quantity, and maximum/minimum inventory levels (s, S)	Costs of production, inventory holding and stockout	Numerical examples
Chen et al. (2010)	Impact of VMI joint with consignment on performance of supply chain	One wholesaler and multiple retailers	EOQ	Wholesale price, retailer price, order quantity, and replenishment cycle	Sales revenue, inventory carrying cost, ordering cost, and setup cost	Model analysis and numerical examples
Guo et al. (2010)	Impact of cost information asymmetry on performance of different outsourcing structures	One OEM, one contract manufacturer, one supplier	-	Market price, production quantity, and wholesale price	Sales revenue and production cost	Model analysis and numerical examples
Ru and Wang (2010)	Impact of inventory manager on supply chain performance	One supplier and one retailer	-	Consignment price, production quantity, and retail price	Sales revenue, production cost, and sales cost	Model analysis
Sui et al. (2010)	Reinforcement learning approach for optimal replenishment policy in VMI with consignment inventory	One vendor and multiple retailers	(Q, R) policy	Replenishment quantity, ordering cycle time, and number of trucks	Sales revenue, inventory holding cost, stockout cost, and transportation cost	Numerical examples
Wadhwa et al. (2010)	Impacts of information transparency and demand pooling on supply chain performance	Two retailers, two distributors, two warehouses, one assembler, three manufacturers	(s, S) policy	-	Retailer's and distributor's service time, fill rate, shortage time	Simulation
Zhang et al. (2010)	Incentive schemes in consignment for channel coordination	One supplier and one retailer	-	Price, stocking factor (lot size), and revenue share	S revenue, manufacturing cost, and sales cost	Model analysis and numerical examples
Adida and Ratisoontorn (2011)	Effect of retail competition on channel performance under consignment contracts	One supplier and two retailers	-	Price, order quantity, and inventory	Sales revenue and inventory holding cost	Model analysis and numerical examples
Chen et al. (2011)	Impact of price trading forms on the channel coordination	One vendor and one retailer	-	Retail price and revenue sharing terms	Sales revenue, side payment, commission fee, and handling/merchandising cost	Model analysis and numerical examples

Zhao and Shi (2011)	Impact of different contracting strategies for complementary products on supply chain performance	Multiple suppliers and one buyer in competing supply chains		Retail price and production/inventory quantity,	Sales revenue, production, and handling/assembling costs	Model analysis
Jiang (2012)	Impacts of postponement of pricing and sales decisions on firm's performance	One manufacturer and one retailer	-	Production quantity, price, sales quantity, and revenue share	Sales revenue, production cost, and sales cost	Model analysis and numerical examples
Wang et al. (2012)	Optimal inventory control model to determine production batch and replenishment lot size for deteriorating product	One manufacturer and one buyer	EOQ	Replenishment size and number of replenishments	Replenishment cost, setup cost, inventory holding cost, and deterioration cost	Model analysis and numerical examples
Zanoni et al. (2012)	Effect of learning in production on replenishment problem	One vendor and one buyer	EOQ	Batch size of shipment and number of shipment,	Ordering cost, inventory holding cost, and labor cost	Numerical examples
Ben-Daya et al. (2013)	Benefits of VMI&CS partnership	One vendor and multiple buyers	Joint EOQ	Shipment size, replenishment cycle length, and inventory level	Ordering cost, setup cost, and inventory holding cost	Model analysis and numerical examples
Braglia et al. (2013)	Optimal consignment stock policy for fixed batch production process	One vendor and one buyer	EOQ	Order quantity, production rate, number of batch, and number of shipment	Setup cost, ordering cost, and inventory holding cost	Numerical examples
Hariga and Al-Ahmari (2013)	Integrated retail shelf space allocation and replenishment problem for VMI-CS partnership	One supplier and one retailer	Lot-for-lot through cross-docking	Ordering quantity, replenishment cycle, and shelf space allocated to retail product	Sales revenue, ordering cost, inventory holding cost, and cross-docking operation cost	Numerical examples