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Consignment stocking policy models for supply chain systems: A critical review and comparative perspectives

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ABSTRACT

This paper studies the consignment stocking policy models for supply chain systems and categorizes different models from the view point of structural configuration of the systems, operational policies, component analyses, cost and profit measurements, and several other standard measures used in inventory management. A comprehensive survey of the models and their critical analyses are pursued here to understand the operational mechanics of different consignment policies that vary from product to product and system to system. The isolation mechanisms used for modeling are different types of supply systems, consignment types, operational mechanism, physical and/or geographical locations, and operational constraints, to name a few. The exercise performed here systematically identifies the appropriateness, and different advantages and disadvantages of the models. This study also examines different consignment models for determining manufacturing batch sizes, order quantity deliverable to the retailers, advertisement and price of the products, profits, independent and centralized operational policies for vendor and buyers, and optimizes many other system parameters and controllable operational variables. The review of the literature sheds different comparative perspectives of the models from practical point of applications and revelation of their theoretical underpinnings. The models have been examined from the managerial insights and several hints on applications of them have been indicated as appropriate in different locations. Several avenues for future research have also been pinpointed to enrich this area of research on consignment policy.

1. Introduction

Industrial engineering management principles for operating a system have been perceived for a long time from different aspects of optimization so that enterprise can benefit from these novel ideas to essentially improve the system performance and eventually reap benefit accordingly. From the time when Harris (1913) developed the first economic order quantity (EOQ) model, followed by Taft's (1918) economic production quantity (EPQ) model for a shop floor operation, numerous developments have been made in the field of industrial engineering and operations research (also see Erlenkotter, 1989). This year marks the century of birth of modeling an inventory system and questions are raised as to what has been accomplished in this field. It is impossible to give a full account of all these developments in a short treatise but a specific topical area can be explored with some objectives and a concise account of important developments. This paper will thus concentrate on studying the models of supply chain and logistics systems, especially the consignment stocking policy as to how it operates and what has been done toward modernization of the industrial operational policy. To understand the problems, a few terminologies are now explained to avoid confusion and misinterpretation in the context of supply chain and consignment stock.

Supply Chain Management (SCM) deals with *planning*, *design and control* of an integrated system of organizations, people, activities, information, and resources involved in movement and transformation of raw materials through a series/network of suppliers and buyers in order to create products and services for customers. Basically supply chain (SC) activities transform natural resources, raw materials and components into a finished product that is delivered to the end customer(s). On the same context, *logistics* is the process of planning, implementing, and controlling the efficient, cost effective *flow and storage* of raw materials, in-process inventory, finished goods, services, and related information (including inbound, outbound, internal, and external movements) from the point of origin to a point of consumption for the purpose of conforming to customer requirements. Its mission is to get the right materials to right place at right time under an optimized performance measure (e.g., operating cost, throughput rate) satisfying a set of constraints (budget, space, time, technological limitations, etc.). In any industrial environment or business organization, there is input and output of different

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transformation or service activities, so supply chain and logistics systems play an important role in running these integrated systems.

There are numerous policies for efficiently operating a supply chain system—consignment stocking policy is one of them. A *consignment stock* (CS) is (an inventory of) merchandise that is stored at its customer's (downstream companies, say, retailers) location but is owned by an upstream supplying company (vendor). A consignment stock is inventory that is not paid for until sold or used. Since consignment stock forms a part of the downstream stock, the customer must manage this stock in its system. The customer is not obliged to pay for the merchandise until it removes the product from the consignment stock. The customer can usually return the unused consignment stock to the supplier at any point in time. However, a consignment stock must be managed separately from the rest of its stock for each customer so that both parties are aware of the stocks which are stored at the customer location(s).

In a consignment transaction, there are typically two parties, the consignor and the consignee: the consignor (e.g., individual, distributor, vendor or manufacturer) is the party providing the goods to be sold or used, and the consignee (retailer) is the party receiving and selling or using the goods. While the consignor retains ownership of the inventory and the consignee maintains physical possession of the goods until sold or returned to the consignor. If the goods are sold, the consignee retains an agreed upon portion of the profits. Popular categories for consignment shops include clothing, antiques, furniture, sports equipment, musical instruments and books. Some common places of consignment operations in the USA are 7–11, Circle-K, different gas-stations and many other neighborhood corner-shops, The consignment process is more complicated on a large scale, often involving *vendor managed inventory* (VMI) and *scan based trading* (SBT). Obviously it requires precise bookkeeping and inventory management to ensure correct billing and proper payment. In terms of retail, this can be as simple as an apparel item brought in to be sold at a consignment shop or as complicated as SBT at a huge department store.

The primary benefit of the CS operational arrangement is in the consignee's saving money on inventory costs and investing no money for purchasing the goods that it sells—the consignor is paid only after the merchandise is sold; this could mean improved cash flow on the part of the consignee. Next, the consignee can actually save ordering and shipment time by not waiting for new inventory every time—the consignor arranges to replenish the inventory right after some or all of the consigned goods are sold—it is in the best interest of the consignor to keep the agent well-supplied.

On the risks associated with this system, the consignor will not receive any money until part or all of the consigned stock has been sold. In effect, the consignor's cash flow may suffer as more money is spent on manufacturing the goods, while cash coming in may be too slow to cover subsequent production runs. Also, higher product returns from the consignees after a long time allow the goods to rot or become damaged in warehouses. Unless a good profit sharing agreement, the consignee may not be responsive in pushing the products in the market.

A significant body of knowledge exists in literature on the consignment policy. The research is currently pursued from different perspectives or points of investigation of CS as well as applications in different situations of supply chain systems. The purpose of this study is to critically examine the existing literature on consignment policy and categorically investigate different models, their scopes and impact on the decision making processes to make a comparative study. Given this primary goal of this study, first an overview of the literature is given to highlight different categories of this subject matter and then detailed models are critically examined and compared from different perspective of research applications. Since many models are studied here to get a good grasp of different dimensions of consignment problems, expressing all models with the same assumptions and notations is practically difficult. Thus the notations for the models are defined locally than globally to avoid mistakes and confusion in casting the problems.

2. An overview of existing literature

In last one decade there has been some significant research on different issues relating consignment stock to improve the inventory performance of two or more participation organizations. Some of these organizations are considered in series and some are in diverging and converging systems with channel flow of materials. Most of these works have some common goal to improve the mutual benefits of the participating parties (consignors and consignees), embellished with different facets of the problem.

2.1. Consignment stock

The contract issues relating to consignment issues were studied by several researchers. Alp et al. (2003) investigated the outsourcing logistics for designing transportation contracts between a manufacturer and a transporter. Zhang et al. (2010) did channel coordination in a consignment contract and Ru and Wang (2010) determined who should controlled inventory in a supply chain under consignment contract. Guan and Zhao (2010) shed light on contracts for VMI program with continuous review policy. Adida and Ratisoontorn (2011) studied the situation with consignment contracts with retail competition and Chen (2011) looked at the behavioral pattern of returns with wholesale-price-discount contract in a newsvendor problem.

While Lee and Whang (1999) highlighted incentives and information of the decentralized multi-echelon supply chains, Corbett (2001) determined the cyclic stock, safety stock, and consignment stock for stochastic inventory systems in a supply chain with asymmetric information. Dong and Xu (2002) developed a supply chain model of vendor managed inventory followed by Gerchak and Khmelnitsky (2003) who studied a consignment system where suppliers cannot verify retailer's sales reports. From a practical perspective, Braglia and Zavanella (2003) modeled an industrial strategy for inventory management in supply chains that work under a consignment stock policy, and Chen and Liu (2008) developed an optimal consignment policy for the manufacturer under supply chain co-ordination.

2.2. Converging (assembly type) and distributive supply systems

Wang and Sarker (2004, 2005, 2006) studied the general serial, converging and diverging mechanisms of supply chain operations with fixed-interval lumpy demand of the retailers. Gümüş et al. (2008) studied the impact of consignment inventory and vendor-managed inventory for a two-party supply chain. Zavanella and Zanoni (2009) modeled a one-vendor multi-buyer integrated production-inventory model under the consignment stock case. Guo et al. (2010) studied the outsourcing structures and information flow in a three-tier supply chain and Kiesmuller and Broekmeulen (2010) enumerated some benefits of VMI strategies in a stochastic multi-product serial two echelon system. Battini et al. (2010a, 2010b) developed a framework and model for an integrated consignment stock inventory where they indicated that, in most cases, consignment stocking is shared by the both vendor and retailers. Srinivas and Rao (2010) optimized a supply chain for single-vendor multi-buyer consignment stock policy with genetic

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