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Comparison of Two Buyer-Vendor Coordination Models

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FOREWORDS

It is a great honor for Bandung Intitute of Technology (ITB) in collaboration with Universiti Malaya Pahang to host the second joint conference of The **The 4th Asia Pacific Conference on Manufacturing Systems** and **The 3rd International Manufacturing Engineering Conference** (APCOMS-iMEC 2017) at Yogyakarta. The special region that is very important to history of our country, Indonesia. It is also a great honor for ITB to work along with Sebelas Maret University in organizing APCOMS-iMEC 2017 locally in Yogyakarta.

We sincerely express our gratitude to Vice Chancellor of UMP; Dean of Sebelas Maret University; Professor Zahari Taha from the Fakulti Kejuruteraan Pembuatan Universiti Malaysia Pahang; The Head Secretary of The Creative Economy Agency of Indonesia (BEKRAF), Doctor Mesdin Simarmata; Professor Shih-Ming Wang, from Mechanical Engineering Department of Chung-Yuan Christian University, and; All parties, which have been very supportive to holding this conference in Indonesia and being part of our important milestone.

To date, we are witnessing another revolution of industrial development. The internet of things era has lead the change on consumer behavior, innovate production system technology, transform global manufacturing network. All of these may reshape our future. Our conference theme is about "**Taking The Factories to The Next Level**". All technologies which may bring the seamless integration (vertically-horizontally) within or between manufacturers are the hot topics to realize the concept of Industry 4.0. The current requirement analysis and future plan for a country within Asia Pacific will be needed accordingly.

On behalf of Bandung Institute of Technology, I encourage all participants of APCOMS-iMEC to work together and contribute to the future development of Manufacturing Technologies to strengthening and harmonizing as well the competitiveness of Asia Pacific countries and for our better society.

We wish all participants to have an excellent conference, expand our academic network, and enjoy the historical city of Yogyakarta.

Bandung, December 2017

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Peer review statement

All papers published in this volume of *IOP Conference Series: Materials Science and Engineering* have been peer reviewed through processes administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

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Comparison of Two Buyer-Vendor Coordination Models

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Abstract. This paper develops and compares two mathematical models for describing situation in coordination of buyer and vendor. In this case the vendor which is an Original Equipment Manufacturers (OEMS) of automotive parts, are supplying different type of buyers, i.e. automotive industry, repair shop and automotive dealers. It is well known that automotive industries are operated in Just in Time (JIT) Production Environment, so that the demand behaviour from this buyer has different characteristics than the demand behaviour from other buyers. Two mathematical models are developed in order to depict two different manufacturing strategies as the vendor response dealing with different type of buyers. These strategies are dividing production lot size for each type of buyer and consolidating all buyer's demand in to single production lot size.

1. Introduction and Literature Review

Nowadays, a company needs to perform activities in their business processes efficiently. This is done so that the company can produce products or services with better quality, cheaper price and faster delivery. A company that produce tangible product is called as manufacturing company. Manufacturing companies interacts with external entities such as suppliers. Suppliers have a role in providing raw materials. In addition, manufacturing companies also interact with other external entities i.e. distribution centre. Distribution centre helps company in distributing products to reach their targeted customers. External entities such as suppliers and distributions are usually separate from manufacturing companies. In addition, different parties usually own them. Therefore, each party might have different ways of managing their company.

At the past each company try to focus on how to improve the performance of their internal operations [1]. Because each company is independent, it may occur that the objective of a company is conflicting with the goals of the other company. For example, a manufacturing company has an economical quantity of orders, but this quantity might economical for the supplier side. In the era of Supply Chain Management (SCM), all activities in each supply chain member ranging from suppliers, manufacturers, to distribution centres must be integrated. Therefore, there exists a need to have a coordination mechanism to align objective of each supply chain member to improve the performance of the whole systems [1]. Buyer-vendor coordination is one of activity that can be done in order to improve the performance of the whole system. A buyer can be a manufacturer while the vendor is their suppliers. Or a buyer can be a distribution centre or retail while their vendor is a manufacturer. According to [2] replenishment decision at each member in supply chain can be coordinated in three ways: 1) using quantities discount so that it can attract the buyer to order with the quantity that is profitable from the supplier point of view [3, 4, 5, 6]; 2) synchronizing order from multiple buyers [7]; and 3) information sharing [8, 9]. The first two ways are related to the vendor's perspective coordination model or according to [10] it is called as decentralized model. As opposite of decentralized model is centralized model, where in the centralized model the decision regarding the lot size is determined by both vendor and buyer. However according to [10] this type of coordination model is difficult to apply due to incentive conflict.

In reality there exists a situation where the buyer operates in Just-in-Time (JIT) environment for example in several automotive manufacturers. When the buyer operates in JIT environment usually they prefer that the vendor delivers the item in the smaller quantity and more frequent delivery [11, 12]. To the best of author knowledge, the research on vendor perspective model for decentralized buyer-vendor coordination model where buyer operates in JIT environment was firstly conducted by [5, 6]. The motivation of their research is because when the buyer operates in JIT environment the vendor has to follows buyer's lot size or according to [13] it is said as buyer dominance. In addition, according to [14] sometimes it is un-economical. Therefore, the vendor need to find pricing strategy dealing with this situation to maintain the vendor's target profit. Other form of coordination mechanism in the decentralized model is what it is called as vendor-managed inventory (VMI) [15]. In VMI, vendor takes replenishment decision [15]. This can be happened because the buyer supports the vendor with real time data of inventory [16].

Research on a vendor and multiple buyers coordination models were conducted by several researchers in the past where the buyer can be categorized as homogeneous buyers and heterogeneous buyer. As in reality it is common that each buyer has different characteristics with others such as demand rate, holding cost and order cost, therefore we limit to review the coordination model to a vendor and multiple heterogeneous buyers. Research to determine optimal pricing policies for the case of one vendor multiple heterogeneous buyers was conducted by [17] who discussed about developing discount pricing structure. Other research such as [18] also conducted the research on coordination mechanism for one vendor multiple buyers when a vendor offers a single quantity discount schedule to many buyers.

The research in this paper is motivated by real case study of an automotive part manufacturer that supply a product to:1) automotive manufacturers; 2) repair shop and 3) automotive dealer. Demand rates for automotive manufacturer is different with that of repair shop and automotive dealer. Therefore, according to [1] it is categorized as a manufacturers and multiple buyers coordination models. In addition, the automotive manufacturer operates in JIT environment.

The remainder of the paper is organised as follows: Section 2 presents about Problem Statement and Mathematical Model followed by numerical example in Section 3 to illustrate the applicability of the proposed model. Some concluding remarks is presented in Section 4.

2. Problem and Mathematical Formulation

In the research presented in this paper, a real case study is presented where we consider a manufacturer of spare part who produce the product and sell it to two different types of buyers as it is illustrated in Figure 1. The 1st type of buyer is automotive manufacturer who operates in JIT environment. The 2nd type of buyer is retail which are repair shop and dealer. Recently, the vendor's production lot size is following the production lot size of the automotive manufacturer. This happens because the bargaining power of first type of buyer which is automotive manufacturer is strong. This can happen because the automotive industry can guarantee the continuity of the order to the vendor. For the 2nd type of buyer which is repair shop and dealer, a make-to-order contract is implemented, where in this case there are two alternatives that a vendor can do in order to fulfil the order for the second type of buyer. First, the vendor can do demand consolidation. It means that when the demand from the repair shop or dealer come, the vendor will not process it directly however they will wait for another demand from other retailer or repair shop until it reaches its economic production quantity

(Model 1). Second, vendor will fulfil the order immediately after they receive the order (Model 2). The decision that has to be made by the vendor is that about the selling price that they have to offer for each type of buyer.

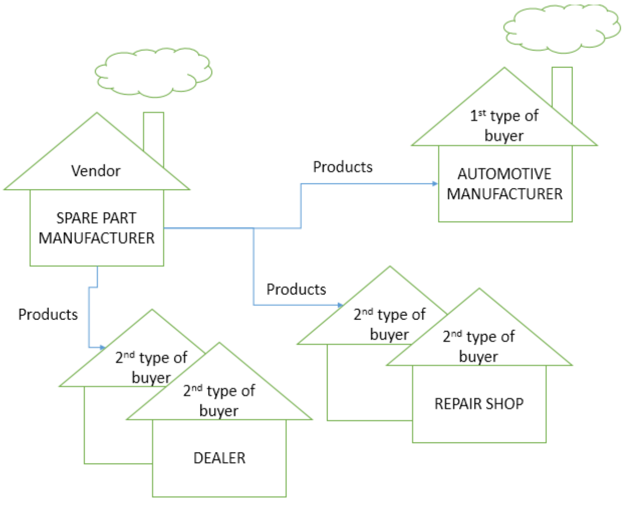

Figure 1. Problem Illustration

Notation:

D_1 : demand parts for the 1st buyer, units/time
D_2 : demand parts for the 2nd type buyers, units/time
Q_1 : production lot size for the 1st buyer, units
Q_2 : production lot size for the 2nd type buyers, units
P : vendor's production rate for fulfilling the demand, units/time
S_1 : 1st buyer's unit setup cost, $
S_v : vendor's unit setup cost, $
h_1 : 1st buyer's unit holding cost, $/unit/time
h_v : vendor's unit holding cost, $/unit/time
C_1 : vendor's unit selling price for 1st buyer, $/unit
C_v : vendor's unit production cost, $
τ_1 : production up time for fulfilling the demand from the 1st buyer
τ_2 : production up time for fulfilling the demand from the 2nd buyer and 3rd buyer

2.1. Model 1

This model presents a situation when a vendor which is an Original Equipment Manufacturer (OEM) supply the product to two type of buyers. They are: 1) automotive manufacture (1st type of buyer); 2) repair shop and dealer (2nd type of buyer). The 1st type of buyer is operated in JIT environment with these characteristics: 1) to meet the demand from the buyer then a vendor produces in a batch of Q_1 at a rate of P unit per time; 2) lot for lot shipment is applied. For 2nd type of buyer (repair shop and dealer), which are not operating in JIT environment, the vendor is free to decide the value of Q_2 (production lot size for the 2nd type of buyer in unit). Vendor produces with 2 separate production lots by assuming that:

$$T_2 = nT_1 \tag{1}$$

subject to:

$$\tau_1 + \tau_2 \le T_1 \tag{2}$$

where:

n : an integer multiplier

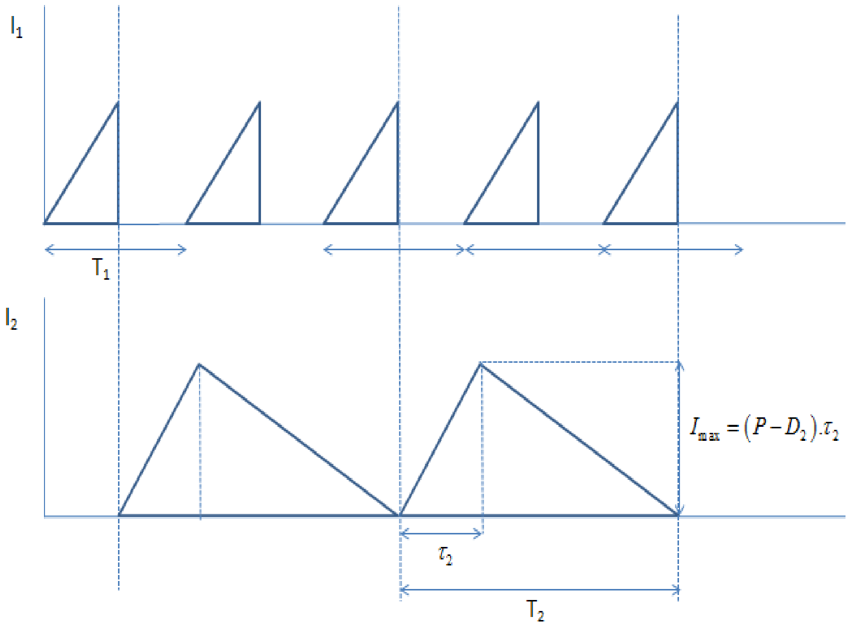

Figure 2. Inventory level of finished goods at vendor (Model 1)

Based on Figure 2 above it can be developed two expression of total cost. They are 1) total production cost for fulfilling demand of the 1st type of buyer (TC_1); 2) total production cost for fulfilling demand of the 2nd type of buyer (TC_2). The expression of TC_1 and TC_2 are derived through this following steps:

1. Finding the lot size in the buyer side for the 1st type of buyer
   To find the lot size in the buyer side, the expression of total cost described by [5] is used:

$$TC_{1B} = D.C_1 + DQ_1^{-1}.S_1 + \frac{1}{2}.Q_1.h_1.C_1 \tag{3}$$

   then the expression of lot size in the buyer side can be derived as follows:

$$Q_1^* = \left(\frac{2.D.S_1}{h_1.C_1}\right)^{1/2} \tag{4}$$

2. Find the expression of T_1 as follows:

$$T_1 = \frac{Q_1^*}{D_1} \tag{5}$$

   Then, subtituting equation (5) to equation (1) the expression of Q_2 can be expressed as:

$$Q_2 = n.\frac{Q_1^*}{D_1}.D_2 \tag{6}$$

3. Find the expression of TC_1

$$TC_1 = \frac{D_1}{Q_1^*}.S_v + \frac{1}{2}.\frac{(P - D_1)}{T_1}\tau_1^2.h_v.C_v \tag{7}$$

$$TC_1 = \frac{D_1}{\left(\frac{2.D.S_1}{h_1.C_1}\right)^{1/2}}.S_v + \frac{1}{2}.\frac{(P - D_1)}{T_1}\tau_1^2.h_v.C_v \tag{8}$$

4. Find TC_2

$$TC_2 = \frac{D_2}{Q_2}.S_v + \frac{1}{2}.I_{max}.h_v.C_v \tag{9}$$

$$TC_2 = \frac{D_1}{n.Q_1^*}.S_v + \frac{1}{2}.(P - D_2)\frac{n.\frac{Q_1^*}{D_1}.D_2}{P}.h_v.C_v \tag{10}$$

2.2. Model 2

In this model, the vendor produces product for the 1st type of buyer and 2nd type of buyer simultaneously. Inventory model of Model 2 is presented in Figure 3. Similar with Model 1, the cycle time T_1 is obtained from the perspective of 1st type of buyer.

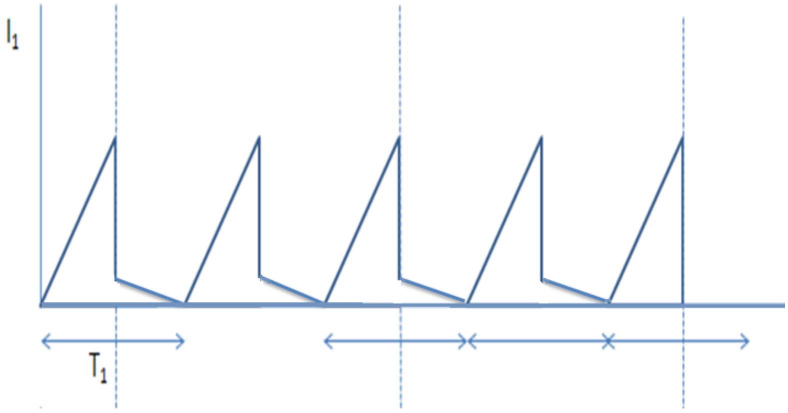

Figure 3. Inventory level of finished goods at vendor (Model 2)

Therefore, the production lot size of this model can be stated as

$$Q = (D_1 + D_2)T_1 \tag{11}$$

and the length of production time in each cycle can be calculated as

$$\tau = \frac{Q}{P} = \frac{D_1 + D_2}{P}T_1 \tag{12}$$

Hence, the total cost of this model can be written as

$$TC = \frac{S_v}{T_1} + \frac{1}{2}\left\{\left(\frac{D_1 + D_2}{P}\right)^2 (P - D_2)T_1 + \left((P - D_2)\frac{D_1 + D_2}{P} - D_1\right)\left(T_1 - \frac{D_1 + D_2}{P}T_1\right)\right\}h_v \tag{13}$$

3. Numerical Example

A numerical example represents the real situation when the vendor which is an OEM that produces the automotive part that has longer end-of-life with following parameters:

D_1 = 10,000 units/year
D_2 = 1,000 units/year
P = 20,000 units/year
S_1 = 50$
S_v = 500 $
h_1 = 10%$/$ inventory
h_v = 10% $/$ inventory
C_1 = 87 $
C_v = 70 $

For Model 1, following equation (4) one can obtain Q_1* = 339.03 units. Therefore, it is obtained T_1* = 0.033903 year from equation (5) and TC_1 = $15044.53/year from equation (8). Using iterative procedure, it is obtained that n* = 10. It is also calculated that TC_2 = $2602.07/year from equation (10). Therefore, total cost for Model 1 is $TC=TC_1+TC_2$. The value of TC= $17646.60.

For Model 2, following equation (13) total cost for Model 2 TC = \$15453.91. Therefore, TC Model 2 is less than that of Model 1.

4. Concluding Remarks

The research presented here are mainly about the buyer vendor coordination for an OEM manufacturer that support the component to 2 types of buyers which are: 1) automotive manufacturer and 2) repair shop and dealer. The automotive manufacturers operate in JIT environment. Two model that represents two manufacturing strategies are proposed. They are: 1) dividing production lot size for each type of buyer (Model 1); 2) consolidating all buyer's demand in to single production lot size. Based on the total cost (TC) obtained from those models, the OEM can decide which strategy provides lower operational cost.

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