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Integration of three echelon supply chain (supplier-manufacturer-distributor-drop shipper) with permissible delay in payment and penalty contract

M F Ibrahim[1*] and Suparno[1]
[1] Department of Industrial Engineering, Institut Teknologi Sepuluh Nopember, Kampus ITS Sukolilo-Surabaya 60111, Indonesia

*faisalibrahim.ie@gmail.com

Abstract. Supply Chain Management (SCM) has to be considered in the company in order to improve the sustainability and competitiveness. SCM executed to integrating any companies on the supply chain in a way of coordinating the flow of goods, information, and financial. Permissible delay in payment is one of the coordination ways with allowing the costumers delay the payments to a vendor in some certain periods without any interest charges. In the supply chain system, drop-shipping player already familiar in this era. In drop-shipping internet retailing, the supplier will hold supplies and also carry out physical distribution service on behalf of drop-shipper. Drop-shipper will just focus on selling, on the other hand, their supplier will be responsible for the physical process. Generally, drop-shipper have information of the customer demands better than the distributor. But, it is also unrare when the drop-shipper send the estimation of demands which bigger than their own estimation in order to maximize their own interest, so they hope supplies of the distributor will always enough to accommodate their demands. Contributions in this research will be focused on integration of three echelons supply chain, which are the supplier, manufacturer, distributor, and drop-shipper. With considering delay in payment on first and second echelons, and also the contract penalty on third echelon. The problem on this research will be modeled in some kind of cases which can represent the problem of real supply chain system. Sensitivity analysis will be done on certain significant variables toward the changes of total supply chain cost. Coordination with delay in payment success to integrate supply chain. Contract penalty plan success to maintain the profit of distributor and drop-shipper.

1. Introduction

Supply Chain Management (SCM) has to be considered in the company in order to improve the sustainable and competitiveness. According to Seuring [1], cooperation is the only way for a company to increase supply competitiveness. SCM's ran to integrate the companies in a supply chain by meansof coordinating the flow of goods, information, and financial with the aim of fulfilling consumer demands and competitive supply chain [2]. With focusing to the sustainable supply chain management, a company will realize if the inventory in every supply chains will be more efficient if it is maintained with a better cooperation and coordination [3]. It is difficult for share complete information in decentralization supply chain, due to the majority of members are independent company which focus on maximizing their own benefits [4]. Different with centralization which allows every player in supply chain to cooperate

together in the decision making. As an example according to Glock [5], coordination decisions in term of filling the supplies in a chain supply system can improve the channel efficiency and the position of the company which involves there. Centralization scenario and joint decision making will run in line to increase the total benefits of supply chain [6].

Delay in payment is one way to coordinate with allowing the costumers to delay their payment to the vendor in some certain period without any interest expenses [7]. Delay in payment will be given by the seller to buyers for anticipating the decreasing amount of inventory in the downstream. With providing them that policy also will attract buyers to buy in a bigger lot from their economic order quantity. With the improvement of buyer order quantity, then the inventory will move to the buyers [8]. For buyers, a benefit exists because buyers get time before they have to pay. According to Goyal **Error! Reference source not found.** when the supplier gives certain period for delaying the payment, indirectly supplier provide their customer loan without any interest expenses until the period ended. In result, generally, costumers will hold that until the end of period.

The online retail sale is estimated will always grow, we know 7% of general retail sales in 2011 will be becoming 9% in 2016 [10]. In drop-shipping internet retailing, the supplier will hold supplies and also carry out physical distribution service on behalf of drop-shipper [11]. Thus, drop-shipper will only focus on sales, and in the other hand physical process will always be handled by their supplier. Drop-shipping channel becomes more efficient rather than traditional channel because generally traditional channel usually lacked coordination [12]. In the previous research Gan et al. [13] stated if generally drop-shipper have the information of customer demands which is better that distributor. It is very common when the drop-shipper send the estimation of demands which bigger than their own estimation in order to maximize their own interest, so they hope supplies of the distributor will always enough to accommodate their demands. For prevent that kind of cases, they have to establish a commitment penalty contract.

In some decades ago, research which did by Goyal **Error! Reference source not found.** success to develop the model of economic order quantity with consideration of delay in payment. The research focused on the decision variables of the optimal quantity. Research on delay in payment developed frequently, the researcher tries to analyze some different situation of supplies and assumption. In some research about delay in payment which focused on the purpose function of deciding optimal lot size already discussed by Chung et al. [14], Nurshanti [15], Glock [5], and Jaber and Osman [7]. Some years ago, Aljazzar et al. [8] tried to develop delay in payment model of one echelon with a long term purpose. Then, Aljazzar et al. [3] tried to develop that delay in payment model into two echelons. Recently, Marchi et al. [6] developed investment sharing model which beneficial to both vendor and buyer. The development of strategic model for determination of price and size order on chain supply with drop-shipping has been done by Chiang and Feng [12]. On the research which did by Gan et al. [13], developed a penalty contract model which has a purpose for the supplier to get demand retailed information that more valid and expected profit supplier can be optimized. In another research, Khouja and Stylianou [16] developed inventory model with drop-shipping option. In the research which did by Edirisinghe and Atkins [17], echelon meant as a relation among two players. For example, supplier and distributor called as one echelon. Different with the research which did by Heydari et al. [18], echelon meant as a number of players which exist inside chain supply system. In this research, the echelon is defined as a relation between two players.

This research based on two different topics which have gap between each other. The first topic is the research on delay in payment and the second topic is the research about drop – shipping. Previous research discussed lots of delay in payment in some cases, explicitly can be seen on Table 1. The concept of one level delay in payment with one-way payment method already developed in some previous research, such as Aljazzar et al. [8]; Chung et al. [14]; Glock [5]; [7]. In the other hand, second concept of delay in payment level with one way of payment also already developed in some previous research, such as Aljazzar et al. [3]; Nurshanti [15]; Moussawi-Haidar et al. [19]. Most of the inventory system which used in previous research is EOQ or EPQ inventory system. Delay in payment model on EOQ inventory system also already developed in some previous research, such as Aljazzar et al. [8]; Aljazzar

et al. [3]; Chung et al. [14]; Glock [5]; Jaber and Osman [7]; Jaber et al. [20]; and Nurshanti [15] on EPQ.

Table 1. Input parameters.

No.	Researcher	Delay in Payment		Inventory System		Payment Method
		1 Level	2 Level	EOQ	EPQ	1 Method
1	Aljazzar et al. [8]	√		√		√
2	Chung et al. [14]	√		√		√
3	Glock [5]	√		√		√
4	Jaber and Osman [7]	√		√		√
5	Aljazzar et al. [3]		√	√		√
6	Nurshanti [15]		√		√	√
7	Moussawi-Haidar et al. [19]		√	√		√

This research will refer to research by Aljazzar et al. [3] in model development because having the second system of delay in payment level which are supplier – manufacturer, manufacturer – retailer. That condition can represent chain supply system of first and second echelon on this research. Previous researches on delay in payment like something above generally between traditional channel, for example, the one which given by manufacturer to distributor or distributor to retailer. By looking at the conditions of the channel in the current era which is busy on the entering of new player, drop-shipper, so that things also important to be researched. How the way of coordination on supply chain which also membered by the drop – shipper.

Drops–shipper has some superiority on marketing because they just focus on product disposal without any needed to think about the physical distribution of goods. The supplier that supplies the drop–shipper will become the holder which control the stock. It often happens when the information of demand which given by drop–shipper to supplier create some disadvantages because the information is not valid. In the other hand, it also often when the supplier cannot fulfill the demand of drop – shipper, so it is creating shortage cost and some disadvantages to drop – shipper. From some previous research about drop – shipping, research successfully discussed that topic in some cases, such as:

1. Model concept of stock with drop – shipper as a member Chiang and Feng [12]; Khouja and Stylianou [16].
2. Concept of penalty contract for coordinating supplier and drop–shipper Gan et al. [13].

Some penalty policies Gan et al. [13] can be used to coordinating the third echelon on developing the model in this research. The current research tries to develop penalty contract which can accommodate win–win interactions between supplier and drop – shipper, so two sides can feel benefited. Because drop–shipper does not have any inventory, so the invemtory system of the player one level above drop–shipper will be different compare with any other traditional player. Inventory model Khouja and Stylianou [16] will be used by the player one level above drop–shipper in developing the model in this research.

Focus on some research above as the primary reference, such as Aljazzar et al. [3]; Gan et al. [13]; Jaber et al. [20]; Khouja and Stylianou [16]. The current research will combine some relevant model in that researchers. Thus, will develop the model which can be applied in supply chain system on this research. Focus of this research is on coordination between players in supply chain of three echelons with one of the player is drop–shipper. One first and second echelon will create coordination model with delay in payment as a consideration and on the third echelon will create coordination model with penalty contract as a consideration.

Contribution in this research will be focused on integration of three echelons supply chain, which are the supplier, manufacturer, distributor, and drop-shipper. The consideration which will be used is coordination by delay in payment on first and second echelons, and also coordination by penalty contract

on third echelons. The problem on this research will be modeled and resolved by assuming general cycle time. With using simulation of some kind of cases which can represent the problem of supply chain system that already explained previously, will be counted the total cost of supply chain in all cases. Then, the influence of every each independent variables in total cost of supply chain under some scenario cases will be analyzed. At the end, the sensitivity analysis will be applied on certain significant variables toward the changes of total supply chain cost. Thus, the best scenario can identify from each player in supply chain.

2. Notations and assumptions

Based on performance criteria and decision variables which have been formulated, current research define the parameters that will be used to build mathematical models in this research as mentioned below:

i : Supply Chain Player (s: supplier, m: manufacturer, d: distributor, and ds: drop-shipper).
j : Type of supplies level (w: raw material, f: finished goods).
$A_{i,j}$: Setup / order cost which issued by player i toward the item j.
$C_{i,j}$: Production / purchasing cost per item which issued by player i toward the item j.
$h_{i,j}$: Financial holding cost per item which issued by player i toward the item j.
$S_{i,j}$: Physical (storage) holding cost per item which issued by player i toward the item j.
Q : Distributor order quantity.
Q_{ds} : Drop-shipper order quantity.
n_1 : Total of shipments by supplier to manufacture per manufacturing raw material cycle.
n_2 : Total of shipments by manufacture to distributor per distributor cycle.
α : Total of raw materials needed to producing one finished product.
t_i : Period of delay in payments offered by player i.
τ_i : Time of payments which done by player i.
k_i : Return of investment for player i.
P : The annual production rate of manufacturing.
D : The annual distributor demand $D<P$.
T : General cycle length $= \frac{n_2 Q}{D}$.
T_s : Supplier cycle length $= \frac{n_2 Q}{P}$.
T_w : Manufacturing raw materials cycle length $= \frac{n_2 Q}{n_1 P}$.
T_m : Finished product manufacturing cycle length $= \frac{n_2 Q}{D}$.
T_d : Distributor cycle length $= \frac{Q}{D}$.
m : Minimum drop-shipper purchase commitment.
v : Shortage penalty.
w : Less than contract penalty.

In order to simplify the formation of model, several assumptions are defined which will be used for this model development, such as:

- One supplier, one manufacture, one distributor, and one drop-shipper.
- Demands on manufacture and distributor is deterministic and constant over time.
- Supplier production level higher than manufacture demand for raw material, and manufacture production level higher than distributor demand.
- Only consider one product.
- All of the shipment in supply chain have the same size.
- There are two components of holding cost: financial and physical holding costs.

- The period of delay in payment is offered by supplier to manufacture and manufacture to distributor.
- Period of delay in payment become the decision variables.
- Manufacture and distributor invest what their vendor debt (supplier or manufacture) $C_{i,j}Q$ in free risk investment during the permitted period.
- Distributor and manufacture pay the debt with one single payment τ.
- Manufacture has two warehouse: for raw materials and finished goods.
- Drop-shipper demand level is deterministic.
- Demand on manufacture and distributor is deterministic and constant over time.
- Not consider the product shipment cost.
- Penalty based on time on echelon 1, 2, and based on quantity on echelon 3.

3. Mathematical model

In this part, the mathematical model is formulated which has a purpose to get the optimal decision variables with some certain consideration that has been described in the performance criteria. Other considerations which also be a concern are cost and income component of each player in the supply chain. In this research will be considered the general length of cycle in formulating a mathematical model, where the length of cycle is $T=\frac{n_2Q}{D}$. Manufacture will ship the same amount of interval adjusted for production of items for the distributor through ongoing cycle including during production. Manufacture begins production when the supplies empty. It is also assumed that manufacturer can do the shipment to buyers along with ongoing production processes. The proposed mathematical model will be divided into some cases. Each case is a combination of sub-case of echelon 1 (supplier and manufacturer), echelon 2 (manufacturer and distributor), and echelon 3 (distributor and drop–shipper).

3.1. Scenario 1: $0\leq t_s=\tau_m\leq\frac{n_2Q}{Pn_1}$ and $0\leq t_m=\tau_d\leq\frac{Q}{D}$ and $m=Q>Q_{ds}$

In this case, echelon 1 assumed if supplier provide the manufacture certain period of time t_s for finishing the payment without any interest expenses. Manufacture do the payment τ_m at the last time of the period t_s. On echelon 2, assumed if manufacture provides the distributor certain period t_m to finish the payment without any interest expenses. Distributor do the payment τ_d at the last time of the period t_m. On echelon 3, assumed if in one general cycle $T=\frac{n_2Q}{D}$ distributor demand equal with the commitment quantity which already been agreed by the drop-shipper before. But, the amount of demand from the drop-shipper less than commitment which has been agreed before. The annual total cost of supplier which include setup cost, production, physical holding cost, financial holding cost, and opportunity cost can be formulated as:

$$\psi^1_{s,f}=\frac{A_{s,f}D}{n_2Q}+C_{s,f}\alpha D+\frac{n_1(n_1-1)}{2}\left(h_{s,f}+S_{s,f}\right)\frac{\alpha n_2QD}{Pn_1{}^2}+h_{s,f}\tau_m\alpha D+\left(C_{m,w}-C_{s,f}\right)e^{k_st_s}\alpha D \quad (1)$$

Manufacture invest $C_{m,w}Q$ which haven't paid to supplier in free risk investation. Cost component which related with the annual manufacture raw materials cost include ordering, purchasing, physical holding cost, financial holding cost, and the income of investation interest expenses can be formulated as :

$$\psi^1_{m,w}=\frac{n_1A_{m,w}D}{n_2Q}+\frac{C_{m,w}\alpha n_2QD}{n_2Q}+\frac{h_{m,w}\alpha^2n_2{}^2Q^2D}{2\alpha Pn_1n_2Q}-\frac{h_{m,w}\alpha n_2Qt_sD}{n_2Q}+\frac{h_{m,w}n_1\alpha Pt_s{}^2D}{2n_2Q}+\frac{S_{m,w}\alpha n_2{}^2Q^2D}{2Pn_1n_2Q}-\frac{C_{m,w}\alpha n_2Qe^{k_m\tau_m}D}{n_2Q} \quad (2)$$

Manufacture providing distributor certain period t_m for finishing the payment $C_{d,f}Q$ without any interest expenses. However, it will cause the opportunity cost in manufacture with comparison if distributor total debt invested. Cost component which related with the annual cost finish manufacture product include setup, production, physical holding cost, financial holding cost, and opportunity cost can be formulated as:

$$\psi^1_{m,f}=\frac{A_{m,f}D}{n_2Q}+C_{m,f}D+\left(h_{m,f}+S_{m,f}\right)\left(\frac{Q(2D+(P-D)n_2-P)}{2P}\right)+h_{m,f}\tau_dD+\left(C_{d,f}-C_{m,f}\right)e^{k_mt_m}D \quad (3)$$

Distributor invest $C_{d,f}Q$ which haven't paid to manufacture in free risk investation. Distributor also get compensation from the drop-shipper because of the demands which less than the commitment which has been agreed before. Cost component which relate with the annual cost distributor product include ordering, purchasing, physical holding cost, financial holding cost, investation interest expenses income, and contract penalty compensation income can be formulated as:

$$\psi_{d,f}^{1}=\frac{A_{d,f}D}{Q}+C_{d,f}D+\frac{h_{d,f}(Q-Dt_m)^2}{2Q}+\frac{S_{d,f}Q}{2}-C_{d,f}D\left(1-e^{k_d t_m}\right)-\frac{w(m-Q_{ds})D}{n_2Q} \quad (4)$$

With the existance of contract penalty which agreed by distributor and drop-shipper, so drop-shipper will charged because in one general cycle $T=\frac{n_2Q}{D}$ demands from the drop-shipper less than commitment which has been agreed before. Drop-shipper doesn't has inventory cost component because the product which sold will directly sent by distributor. Cost component which related with the annual drop-shipper cost product include ordering, purchasing, and penalty charge can be formulated as:

$$\psi_{ds,f}^{1}=\frac{Q_{ds}A_{ds,f}D}{n_2Q}+\frac{C_{ds,f}Q_{ds}D}{n_2Q}+\frac{w(m-Q_{ds})\,D}{n_2Q} \quad (5)$$

The total annual cost of the system can be searched by summing up the total annual fees of each player:

$$\psi_{SC}^{1}=\frac{A_{s,f}D}{n_2Q}+C_{s,f}\alpha D+\frac{n_1(n_1-1)}{2}\left(h_{s,f}+S_{s,f}\right)\frac{\alpha n_2QD}{Pn_1^{\,2}}+h_{s,f}\tau_m\alpha D+\left(C_{m,w}-C_{s,f}\right)e^{k_s t_s}\alpha D+\frac{n_1A_{m,w}D}{n_2Q}+$$
$$\frac{C_{m,w}\alpha n_2QD}{n_2Q}+\frac{h_{m,w}\alpha^2n_2^{\,2}Q^2D}{2\alpha Pn_1n_2Q}-\frac{h_{m,w}\alpha n_2Qt_sD}{n_2Q}+\frac{h_{m,w}n_1\alpha Pt_s^{\,2}D}{2n_2Q}+\frac{S_{m,w}\alpha n_2^{\,2}Q^2D}{2Pn_1n_2Q}-\frac{C_{m,w}\alpha n_2Qe^{k_m\tau_m}D}{n_2Q}+$$
$$\frac{A_{m,f}D}{n_2Q}+C_{m,f}D+\left(h_{m,f}+S_{m,f}\right)\left(\frac{Q(2D+(P-D)n_2-P)}{2P}\right)+h_{m,f}\tau_dD+\left(C_{d,f}-C_{m,f}\right)e^{k_m t_m}D+\frac{A_{d,f}D}{Q}+C_{d,f}D+$$
$$\frac{h_{d,f}(Q-Dt_m)^2}{2Q}+\frac{S_{d,f}Q}{2}-C_{d,f}D\left(1-e^{k_d t_m}\right)-\frac{w(m-Q_{ds})D}{n_2Q}+\frac{Q_{ds}A_{ds,f}D}{n_2Q}+\frac{C_{ds,f}Q_{ds}D}{n_2Q}+\frac{w(m-Q_{ds})\,D}{n_2Q} \quad (6)$$

3.2. Scenario 2 : $0\le t_s=\tau_m\le\frac{n_2Q}{Pn_1}$ and $0\le t_m<\tau_d\le\frac{Q}{D}$ and $Q<Q_{ds}\le m$

In this case, echelon 1 assumed if supplier provide manufacture relief in certain period of time t_s for finishing the payment which out any interest expenses. Manufacture do the payment at the end of period t_s. On echelon 2, assumed if manufacture provide distributor relief in certain period t_m for finishing the payment without interest expenses. Distributor do the payment τ_d after the end of the period t_m and before receiving the next shipping. On the echelon 3, assumed if in one general cycle $T=\frac{n_2Q}{D}$ distributor demands less than the commitment quantity which has been agreed by drop-shipper before. It turns out that the drop-shipper demand is in line with the commitment and more than the distributor demand. Thus, the total annual cost of the system is :

$$\psi_{SC}^{2}=\frac{A_{s,f}D}{n_2Q}+C_{s,f}\alpha D+\frac{n_1(n_1-1)}{2}\left(h_{s,f}+S_{s,f}\right)\frac{\alpha n_2QD}{Pn_1^{\,2}}+h_{s,f}\tau_m\alpha D+\left(C_{m,w}-C_{s,f}\right)e^{k_s t_s}\alpha D+\frac{n_1A_{m,w}D}{n_2Q}+$$
$$\frac{C_{m,w}\alpha n_2QD}{n_2Q}+\frac{h_{m,w}\alpha^2n_2^{\,2}Q^2D}{2\alpha Pn_1n_2Q}-\frac{h_{m,w}\alpha n_2Qt_sD}{n_2Q}+\frac{h_{m,w}n_1\alpha Pt_s^{\,2}D}{2n_2Q}+\frac{S_{m,w}\alpha n_2^{\,2}Q^2D}{2Pn_1n_2Q}-\frac{C_{m,w}\alpha n_2Qe^{k_m\tau_m}D}{n_2Q}+$$
$$\frac{A_{m,f}D}{n_2Q}+C_{m,f}D+\left(h_{m,f}+S_{m,f}\right)\left(\frac{Q(2D+(P-D)n_2-P)}{2P}\right)+h_{m,f}\tau_dD+\left(C_{d,f}-C_{m,f}\right)e^{k_m t_m}D-C_{d,f}e^{k_m(\tau_d-t_m)}D+$$
$$\frac{A_{d,f}D}{Q}+C_{d,f}D+\frac{h_{d,f}(Q-D_dt_m)^2}{2Q}+\frac{S_{d,f}Q}{2}+C_{d,f}e^{k_m(\tau_d-t_m)}D+\frac{v(Q_{ds}-Qn_2)D}{n_2Q}-C_{d,f}D\left(1-e^{k_d t_m}\right)+\frac{Q_{ds}A_{ds,f}D}{n_2Q}+$$
$$\frac{C_{ds,f}Q_{ds}D}{n_2Q}-\frac{v(Q_{ds}-Qn_2)D}{n_2Q} \quad (7)$$

3.3. Scenario 3: $0 \le t_s < \tau_m \le \frac{n_2 Q}{P n_1}$ and $0 \le t_m = \tau_d \le \frac{Q}{D}$ and $m = Q > Q_{ds}$

In this case, echelon 1 assumed if supplier provide manufacture relief in certain period of time t_s for finishing the payment without any interest expenses. Manufacture do the payment τ_m after the end of period t_s and before receiving the next shipping. On the echelon 2, assumed if manufacture provide distributor relief in certain period t_m for finishing the payment without any interest expenses. Distributor do the payment τ_d at the end of period t_m. On echelon 3, assumed if in one general cycle $T=\frac{n_2 Q}{D}$ distributor demands equal with the commitment quantity which has been agreed by drop-shipper before. But demand from the drop-shipper less than the commitment which has been agreed before. Thus, the total annual cost of the system is :

$$\psi_{SC}^{3}=\frac{A_{s,f}D}{n_2 Q}+C_{s,f}\alpha D+\frac{n_1(n_1\text{-}1)}{2}\left(h_{s,f}+S_{s,f}\right)\frac{\alpha n_2 QD}{P{n_1}^2}+h_{s,f}\tau_m\alpha D+\left(C_{m,w}\text{-}C_{s,f}\right)e^{k_s t_s}\alpha D\text{-}$$

$$C_{m,w}e^{k_s(\tau_m-t_s)}\alpha D+\frac{n_1 A_{m,w}D}{n_2 Q}+\frac{C_{m,w}\alpha n_2 QD}{n_2 Q}+\frac{h_{m,w}\alpha^2 {n_2}^2 Q^2 D}{2\alpha P n_1 n_2 Q}\text{-}\frac{h_{m,w}\alpha n_2 Q t_s D}{n_2 Q}+\frac{h_{m,w}n_1\alpha P{t_s}^2 D}{2n_2 Q}+$$

$$\frac{S_{m,w}\alpha {n_2}^2 Q^2 D}{2P n_1 n_2 Q}+\frac{C_{m,w}\alpha n_2 Q e^{k_s(\tau_m-t_s)}D}{n_2 Q}\text{-}\frac{C_{m,w}\alpha n_2 Q e^{k_m\tau_m}D}{n_2 Q}+\frac{A_{m,f}D}{n_2 Q}+C_{m,f}D+$$

$$\left(h_{m,f}+S_{m,f}\right)\left(\frac{Q(2D+(P\text{-}D)n_2\text{-}P)}{2P}\right)+h_{m,f}\tau_d D+\left(C_{d,f}\text{-}C_{m,f}\right)e^{k_m t_m}D+\frac{A_{d,f}D}{Q}+C_{d,f}D+\frac{h_{d,f}(Q-Dt_m)^2}{2Q}+$$

$$\frac{S_{d,f}Q}{2}\text{-}C_{d,f}D\left(1\text{-}e^{k_d t_m}\right)\text{-}\frac{w(m-Q_{ds})D}{n_2 Q}+\frac{Q_{ds}A_{ds,f}D}{n_2 Q}+\frac{C_{ds,f}Q_{ds}D}{n_2 Q}+\frac{w(m-Q_{ds})D}{n_2 Q} \quad (8)$$

3.4. Scenario 4: $0 \le t_s < \tau_m \le \frac{n_2 Q}{P n_1}$ and $0 \le t_m < \tau_d \le \frac{Q}{D}$ and $Q < Q_{ds} \le m$

In this case, echelon 1 assumed if supplier provide manufacture relief in certain period of time t_s for finishing the payment without any interest expenses. Manufacture do the payment τ_m after the end of period t_s and before receiving the next shipping. On echelon 2, assumed if manufacture provide distributor relief in certain period t_m for finishing the payment without any interest expenses. Distributor do the payment τ_d after the end of period $t_m$and before receiving the next shipping. On echelon 3, assumed if in one general cycle $T=\frac{n_2 Q}{D}$ distributor demands less than the commitment quantity which has been agreed by drop-shipper before. It turns out that drop-shipper demands in line with commitment and more than distributor demands. Thus, the total annual cost of the system is :

$$\psi_{SC}^{4}=\frac{A_{s,f}D}{n_2 Q}+C_{s,f}\alpha D+\frac{n_1(n_1\text{-}1)}{2}\left(h_{s,f}+S_{s,f}\right)\frac{\alpha n_2 QD}{P{n_1}^2}+h_{s,f}\tau_m\alpha D+\left(C_{m,w}\text{-}C_{s,f}\right)e^{k_s t_s}\alpha D\text{-}$$

$$C_{m,w}e^{k_s(\tau_m-t_s)}\alpha D+\frac{n_1 A_{m,w}D}{n_2 Q}+\frac{C_{m,w}\alpha n_2 QD}{n_2 Q}+\frac{h_{m,w}\alpha^2 {n_2}^2 Q^2 D}{2\alpha P n_1 n_2 Q}\text{-}\frac{h_{m,w}\alpha n_2 Q t_s D}{n_2 Q}+\frac{h_{m,w}n_1\alpha P{t_s}^2 D}{2n_2 Q}+$$

$$\frac{S_{m,w}\alpha {n_2}^2 Q^2 D}{2P n_1 n_2 Q}+\frac{C_{m,w}\alpha n_2 Q e^{k_s(\tau_m-t_s)}D}{n_2 Q}\text{-}\frac{C_{m,w}\alpha n_2 Q e^{k_m\tau_m}D}{n_2 Q}+\frac{A_{m,f}D}{n_2 Q}+C_{m,f}D+$$

$$\left(h_{m,f}+S_{m,f}\right)\left(\frac{Q(2D+(P\text{-}D)n_2\text{-}P)}{2P}\right)+h_{m,f}\tau_d D+\left(C_{d,f}\text{-}C_{m,f}\right)e^{k_m t_m}D\text{-}C_{d,f}e^{k_m(\tau_d-t_m)}D+\frac{A_{d,f}D}{Q}+$$

$$C_{d,f}D+\frac{h_{d,f}(Q-D_d t_m)^2}{2Q}+\frac{S_{d,f}Q}{2}+C_{d,f}e^{k_m(\tau_d-t_m)}D+\frac{v(Q_{ds}-Qn_2)D}{n_2 Q}\text{-}C_{d,f}D\left(1\text{-}e^{k_d t_m}\right)+\frac{Q_{ds}A_{ds,f}D}{n_2 Q}+\frac{C_{ds,f}Q_{ds}D}{n_2 Q}\text{-}\frac{v(Q_{ds}-Qn_2)D}{n_2 Q} \quad (9)$$

4. Numerical results and discussion

In this part will be carried out the numerical experiment on model which has been developed previously. The experiment will be made for each case scenario which has been explained previously. From all of

the case scenarios, will be decided the optimum condition in supply chain system which could produce the most minimum total cost. Before doing the numerical experiment, first, need to set the value of known variables. Variable values which used in this research adopted data from the previous research. Most of the data refer to the research which conducted by Aljazzar et al. [3]. The input parameter which will be used in this research is shown in table 2.

Table 2. Input parameters.

D	P	α	$A_{s,f}$	$A_{m,w}$	$A_{m,f}$	$A_{d,f}$	$A_{ds,f}$	$C_{s,f}$	$C_{m,w}$	$C_{m,f}$	$C_{d,f}$	$C_{ds,f}$
3069	4720	1	441	206	175	384	2.5	20	30	50	70	80
$h_{s,f}$	$h_{m,w}$	$h_{m,f}$	$h_{d,f}$	$S_{s,f}$	$S_{m,w}$	$S_{m,f}$	$S_{d,f}$	n_1	n_2	k_s	k_m	k_d
3	3	12	13,3	3	7,5	9	7,7	1	2	1%	8%	4%
v	e	w										
30	10%	50										

The basic parameter which already explained will be used for the search of the optimal solution from decision variable. In this research, the search of solution did by Solver on Excel software. The use of Solver in Excel chosen because computing with Excel Solver is simpler and produces relatively short computation period. To validate the result of calculations with Excel Solver, then it will also be done manual calculations. From several experiments conducted can show that calculations using Excel Solver or manual have relatively similar results. After doing the counting for all of the cases scenario, a decision is made for each case scenario. The calculation result of all case scenarios can be seen in table 3.

Table 3 shows the result of the numerical experiment showed that supplier identical provide a short period of time of delay the payment. The total of the minimum cost which issued by supplier also occurs when the short delay period is given. Supplier provides time to delay the payment which relatively short because of a small percentage of supplier return on investment (ROI), which is 1%. Minimum total cost of manufacture occurs when an actor who is one level below delay the payment out of time which provided before. And also seen if total cost which issued by manufacturer will become lower when manufacturer delays the payment out of time which provided by supplier than does the payment on time. That kind of thing happened because the percentage of manufacture ROI is very high if it's compared with the percentage of supplier ROI. The total cost of distributor has seen lower when distributor does the payment in accordance with the time which provided by the manufacturer. This kind of thing happened because the percentage of distributor ROI which lower if it's compared with the percentage of manufacture ROI. In the other hand, total cost on drop-shipper become lowest when the distributor can fulfill all of their demands. With the integration of supply chain, best scenario that comes from case scenario which has the least total cost of supply chain system is scenario 1.

Table 3. Result of the numerical example.

Skenario	**0**	**1***	**2**	**3**	**4**
Q	296	326	311	326	311
t_s	0.00	0.01	0.01	0.01	0.01
τ_m	0.00	0.01	0.01	0.02	0.02
t_m	0.00	0.09	0.06	0.09	0.06
τ_d	0.00	0.09	0.07	0.09	0.07
m	592	651	745	651	745
SC	94,355	94,233	94,334	2,276	2,378
MC	221,935	224,662	14,804	316,880	107,021
DC	237,264	233,316	440,702	233,316	440,702
DsC	243,218	243,218	266,082	243,218	266,082
TSC	796,773	795,429	815,922	795,691	816,183

Table 4 shows the test of varying k_d, it can conclude if higher percentage of distributor ROI will also cause higher total benefits. That is happen because the improvement percentage of distributor ROI. Higher percentage of distributor ROI will generate higher Q values. Higher Q values will generate longer t_m value or period of payment delay which provided by manufacture to distributor. When percentage of distributor investment return increase 50% will decreasing the total cost on supply chain as big as 0,13%. The decreasing of total cost in that supply chain always increase in line with the increase of distributor investment return percentage. Order quantity will be increased in line with the improvement of distributor investment return percentage. After further calculation, it can be seen that there is an increase of order quantity by 7% when the percentage of distributor investment is increasing 50%.

Table 4. Sensitivity when varying k_d.

k_d	Q	t_s	τ_m	t_m	τ_d	m	SC	MC	DC	DsC	TSC
0.04	326	0.01	0.01	0.09	0.09	651	94233	224662	233316	243218	795429
0.06	349	0.01	0.01	0.11	0.11	698	94094	225547	231548	243218	794407
0.08	379	0.01	0.01	0.12	0.12	758	93939	226193	229908	243218	793258
0.1	418	0.01	0.01	0.14	0.14	836	93774	227049	227969	243218	792010
0.12	470	0.01	0.01	0.15	0.15	940	93595	228228	225593	243218	790634
0.14	542	0.01	0.01	0.18	0.18	1085	93403	229929	222538	243218	789088
0.16	650	0.01	0.01	0.21	0.21	1300	93196	232519	218369	243218	787302

The increase of return of investment distributor causes an increase in delay in payment period provided by the manufacturer to distributor. That thing can be connected with the increasements on Q quantity of orders, the higher the Q value will result the value or the delay in payment period gived by the manufacturer to the distributor will be longer. If it is seen more detail, when the increasements of order quantity exist as big as 7%, will cause the delay in payment period increased which given by the manufacturer to the distributor by 22%. That increasement will increase in line with order quantity increasements and return of investment distributor percentage.

According to the test of varying, it can be concluded if the higher percentage of distributor ROI will generate lower cost on distributor itself. But, if we see the change of cost issued by the manufacturer, it's actually increased. This kind of thing happened because of the longer period of delay in payment. Thus, that will lead to increase the opportunity cost of manufacture. But, the manufacturer also gets more benefits because of distributor order quantity which increased. Thus, from table 4 we can conclude if the percentage of distributor ROI is one of the parameter which significantly influential in supply chain system which investigated.

From that calculation results can be seen that the total cost of minimum supply chain occurs when the distributor has a greater percentage of return on investment than manufacturer and manufacturer has a greater percentage of return on investment than the supplier. When the percentage of distributor return on investment is between the two other players, which is manufacturer has the highest percentage of return on investment and the lowest is supplier. Then there is an increase in supply chain cost by 0.17%. When the distributors has the lowest percentage of return on investment compared to the other two players, the highest supplier and manufacturing is under the supplier. There is an increasement of total supply chain cost by 0.38% compared to the initial condition when the distributor has the highest percentage of return on investment. Different things happen when the percentage of return on investment distributor is between the two other players, but the highest is supplier and the lowest is manufacturing. There is an increase in total cost of supply chain by 0.26%, lower than the smallest return on investment of distributors. However, in that scenario the increase in total cost of supply chain is higher than the distributor return of investment which is between the other two players, the highest is manufacturer and the lowest is supplier with an increase of 0.17%. When return of investment percentage of that three

players is same, also raise the total cost of supply chain by 0.22%. A larger Q value occurs when the return of investment percentage distributor is greater as well. The value of Q is also influenced by the return of investment percentage of all players. Thus, we can conclude if the percentage of return on distributor investment is very important on the improvement of order quantity.

Table 5. Sensitivity when varying (k_d, k_m, k_s).

Scenario	Q	ts	τm	tm	τd	m	SC	MC	DC	DsC	TSC
kd > km > ks 0.09 > 0.06 > 0.03	387	0.01	0.01	0.13	0.13	773	93,891	226,660	229,176	243,218	792,945*
km > kd > ks 0.09 > 0.06 > 0.03	353	0.01	0.01	0.11	0.11	706	94,059	225,490	231,489	243,218	794,256
ks > km > kd 0.09 > 0.06 > 0.03	313	0.01	0.01	0.07	0.07	773	94,259	224,090	234,371	243,218	795,939
ks > kr > km 0.09 > 0.06 > 0.03	331	0.01	0.01	0.10	0.10	663	94,140	225,544	232,099	243,218	795,002
ks = km = kd 0.06 = 0.06 = 0.06	331	0.01	0.01	0.10	0.10	663	94,161	225,192	232,099	243,218	794,670

The analysis of financial holding cost manufacturer - raw material is also done by increasing the cost of existing as much as 50% stage by stage. The result of variation financial holding cost manufacturer – raw material detail can be seen in table 6. When there is an increase of financial holding costs manufacturer – raw material as big as 50% will cause a decrease in order quantity by 2% from the previous. This decrease of order quantity is due to the cost of the manufacturer which constantly increases. When there is an increase in financial holding cost manufacturer – raw material as big as 50% will result in the increase of manufacturer cost itself by 0.06% from the previous condition. The increased cost to be borne by the manufacturer led to a decline period of delay in payment provided by the manufacturer to the distributor. As can be seen in table 6, manufacturer reduces the period of delay in payment provided to distributors from the previous 0.09 years to 0.08 years. Period of delay in payment was declined when the costs incurred by the manufacturer continue to increase.

Table 6. Sensitivity when varying financial holding cost manufacturer - raw material $(h_{m,w})$.

$h_{m,w}$	*Q*	*ts*	*τm*	*tm*	*τd*	*m*	*SC*	*MC*	*DC*	*DsC*	*TSC*
3	326	0.01	0.01	0.09	0.09	652	94,233	224,662	233,316	243,218	795,429
5	319	0.01	0.01	0.09	0.09	638	94,276	224,804	233,401	243,218	795,699
7	310	0.01	0.01	0.09	0.09	620	94,339	225,012	233,524	243,218	796,093
10	298	0.02	0.02	0.08	0.08	597	94,535	225,199	233,686	243,218	796,638
15	291	0.06	0.06	0.08	0.08	582	94,877	225,174	233,799	243,218	797,068
23	286	0.08	0.08	0.08	0.08	572	95,094	225,162	233,872	243,218	797,347
34	283	0.09	0.09	0.08	0.08	566	95,235	225,157	233,919	243,218	797,529

As can be seen in table 6, the costs were borne by the supplier also increase in proportion to the increase of costs borne by the manufacturer. If the manufacturer decreases the period of delay in payments which given to the distributor when the cost increase. In term of suppliers actually, happen different things, suppliers actually increase the period of delay in payments given to manufacturer. From the results of the experiment can be concluded that suppliers have been trying to stabilize the order quantity by providing a longer delay in the payment period. However, the quantity of order continues to decrease due to the costs that borne by manufacturer continuously increased. The increase of cost causes the shortening of payment delay period given by the manufacturer to the distributor so that the order quantity of distributor decreases. The total cost of supply chain increased in line with the increase of

financial holding cost manufacturer–raw material warehouse. Costs issued by suppliers also continue to increase in line with increased financial holding costs manufacturer-raw material warehouse is increasing. The cost which issued by manufacturer initially increased but thereafter declined. That thing happens because the supplier continues to provide additional time limits for payment settlement for the manufacturer, while on the other hand at the same time manufacturer reduces the delay in payment period given to the distributor.

Table 7. Sensitivity when varying drop-shipper demand.

Demand Probabilities	Q	m	Qds	SC	MC	DC	DsC	TSC
0.90	326	651	586	94,233	224,662	233,316	243,218	795,429
0.8	326	651	521	94,233	224,662	248,661	233,244	800,800
0.70	326	651	456	94,233	224,662	264,006	223,270	806,171
0.6	326	651	391	94,233	224,662	279,351	213,296	811,542
0.50	326	651	326	94,233	224,662	294,696	203,321	816,912
0.4	326	651	261	94,233	224,662	310,041	193,347	822,283
0.30	326	651	195	94,233	224,662	325,386	183,373	827,654

Table 7 shows distributor will stand on the contract which already agreed before. Overall total cost of supply chain system will increase. Total cost which issued by drop-shipper seen decreased, this kind of thing caused by the product price which is higher than penalty cost which must be paid by the drop-shipper to the distributor. Even if the distributor doesn't change the minimum quantity in contract penalty and will get the compensation from the drop-shipper but total cost which issued by distributor has seen increased. This is caused by penalty charge which given by drop-shipper lower than purchasing cost of one distributor product. But if we look the overall of total system cost that will be increased because there are some actors who must pay more charge.

5. Conclusions

The model which created on this research can accommodate supply chain system of three integrated echelons. Where on the first and second echelons, coordination between actors did with the consideration of permissible delay in payment. Then, on the third echelon which one of the actors is drop-shipper, coordination between actors did by the consideration of contract penalty. Coordination with consideration of delay payment period success to integrate supply chain. This kind of thing can be seen from overall total cost of supply chain system which lower if we considering the payment delay period than not considering it. With providing the certain period of time for delay the payment by supplier and manufacture, so the actor one level below will have more benefits with investing their income until the payment done. Distributor order quantity influential to order quantity and even production of a player who is in upstream. That optimal quantity of order influenced significantly by the delay in payment period which provided by the seller. The longer period of payment delay which provided by the seller will force the buyer to do ordering above optimal quantity of them. Because buyer will get more benefits with getting the longer payment delay period. Ordering quantity which based on information of drop-shipper demand level becoming a reference for the distributor in order to decide the quantity in contract penalty plan. The distributor will stand on quantity corresponding on contract even if the demand of the drop-shipper decreased. That kind of thing must be done by the distributor to maintain their benefits. Where drop-shipper must guarantee the cost which increases time to time because of excess supplies. Other considerations can be used to develop a model in further research. For example, compensation if the buyer makes a payment faster than the end of the period of time delayed

payments provided. Probabilistic demand type and discount when a buyer makes a certain quantity purchase.

6. References

[1] Seuring S 2004 Integrated chain management and supply chain management comparative analysis and illustrative cases *Journal of Cleaner Production* **12** pp 1059-1071
[2] Stadtler H 2005 Supply chain management and advanced planning—basics, overview and challenges *European Journal of Operational Research* **163** pp 575-588
[3] Aljazzar S M, Jaber M Y and Moussawi-Haidar L 2016 Coordination of a three-level supply chain (supplier–manufacturer–retailer) with permissible delay in payments *Applied Mathematical Modelling* **40** pp 9594-9614
[4] Iyer G, Narasimhan C and Niraj R 2007 Information and Inventory in Distribution Channels *Management Science* **53** pp 1551-1561
[5] Glock C H 2012 The joint economic lot size problem: A review *Int. Journal of Production Economics* **135** pp 671-686
[6] Marchi B, Ries J M, Zanoni S and Glock C H 2016 A joint economic lot size model with financial collaboration and uncertain investment opportunity *Int. Journal of Production Economics* **176** pp 170-182
[7] Jaber M Y and Osman I H 2006 Coordinating a two-level supply chain with delay in payments and profit sharing *Computers & Industrial Engineering* **50** pp 385-400
[8] Aljazzar S M, Jaber M Y and Goyal S K 2015 Coordination of a two-level supply chain (manufacturer–retailer) with permissible delay in payments *Int. Journal of Systems Science: Operations & Logistics* **3** pp 176-188
[9] Goyal S K 1985 Economic Order Quantity under Conditions of Permissible Delay in Payments *The Journal of the Operational Research Society* **36** pp 335-338
[10] Yu D Z, Cheong T and Sun D 2017 Impact of supply chain power and drop-shipping on a manufacturer's optimal distribution channel strategy *European Journal of Operational Research* **259** pp 554-563
[11] Rabinovich E, Rungtusanatham M and Laseter T M 2008 Physical distribution service performance and Internet retailer margins: The drop-shipping context *Journal of Operations Management* **26** pp 767-780
[12] Chiang W K and Feng Y 2010 Retailer or e-tailer? Strategic pricing and economic-lot-size decisions in a competitive supply chain with drop-shipping *Journal of the Operational Research Society* **61** pp 1645-1653
[13] Gan X, Sethi S P and Zhou J Commitment-penalty contracts in drop-shipping supply chains with asymmetric demand information *European Journal of Operational Research* **204** pp 449-462
[14] Chung K -J, Goyal S K and Huang Y -F 2005 The optimal inventory policies under permissible delay in payments depending on the ordering quantity *Int. Journal of Production Economics* **95** pp 203-213
[15] Nurshanti I 2011 Kebijakan Persediaan Terintegrasi Pada Sistem Dual Sales Channel Mempertimbangkan Penundaan Pembayaran *Industrial Engineering Master Thesis* (Surabaya: Institut Teknologi Sepuluh Nopember)
[16] Khouja M and Stylianou A C 2009 A inventory model with a drop-shipping option for e-business *Omega* **37** pp 896-908
[17] Edirisinghe C and Atkins D 2017 Lower bounding inventory allocations for risk pooling in two-echelon supply chains *Int. Journal of Production Economics* **187** pp 159-167
[18] Heydari J, Mahmoodi M and Taleizadeh A A 2016 Lead time aggregation: A three-echelon supply chain model *Transportation Research Part E: Logistics and Transportation Review* **89** pp 215-233

[19] Moussawi-Haidar L, Dbouk W, Jaber M Y and Osman I H 2014 Coordinating a three-level supply chain with delay in payments and a discounted interest rate *Computers & Industrial Engineering* **69** pp 29-42
[20] Jaber M Y, Bonney M and Guiffrida A L 2010 Coordinating a three-level supply chain with learning-based continuous improvement *Int. Journal of Production Economics* **127** pp. 27-38