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IFAC-PapersOnLine 48-3 (2015) 1343–1344

Contractual Delivery Time Finding with Accumulation of Goods in Consolidation Warehouse

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Abstract: The report addresses the problem of finding the estimation for optimal contractual time of delivery from the manufacturer's warehouse via an overseas consolidation warehouse to buyer's warehouse in the buyer's country in case of automotive delivery. Supply chain management, consolidation warehouse management and logistics management are carried out by supplier who is the party to the contract with the buyer. Optimality is considered in sense of minimization the supplier's relative costs including payments of penalties for delay in delivery. Truck's load capacity is also taken into account. The case of air delivery is also considered.

Keywords: delivery systems, automotive, transportation, decision making, average values, minimization, nonlinear programming.

1. INTRODUCTION

Supply chain management includes such important functions and business processes as supply chain coordination, transportation and logistics management, supplier management, and warehousing management. Supply chain coordination involves, among other things, a solution to the problem of finding a contractual time of delivery for different combinations of suppliers, customers, and goods. In our case the supplier management implies the evaluation of transportation management. That assumes multi-criteria decision making between time and cost price to solve the problems of determining the mode of transportation and finding the optimal contractual time of delivery. Warehouses also are critical component of production systems. There are a number of interesting new publications on this subject, e.g. Dolgui et al. (2010). In this report we consider such important components of the warehousing system as consolidation warehouses. The report is based on the results obtained in Arkhipova et al. (2005). A detailed description of the delivery systems with consolidation warehouses are given in Chistov et al. (2009).

2. MODEL DESCRIPTION AND STUDY

First consider the problem of finding the optimal goods accumulation time in overseas cargo consolidating warehouse. Minimum of ratio of transshipment, delivery and customs clearance total costs to the purchase cost of the goods included in the consolidated party is used as a criterion. Two cases of cargo delivery are considered: air and automotive delivery.

We suppose that the function (1) can be used as an objective function in case of air delivery

$$F_1(t) = hs\int_{t_n}^{t+t_{b1}}(\tau - t_n)d\tau \Big/ st + G/st + (lt + bmt + rst)/st. \quad (1)$$

The function (2) can be used as an objective function in case of auto delivery

$$F_2(t) = hs\int_{t_n}^{t+t_{b2}}(\tau - t_n)d\tau \Big/ st + (D+G)/st + l/s + r. \quad (2)$$

Variable t means time has passed since the last good's shipment from the warehouse, variable s means the average good's flow to the warehouse expressed in currency units for per day, m means the average weight (kg) of cargo having a price s for the supplier, t_n means normative time interval between the two moments: the moment of goods receipt to the consolidation warehouse and the moment when the buyer begins to impose penalty on the supplier for delayed delivery, h means penalty rate for per day of delay in delivery after t_n, rate does not depend on the length of delay in goods delivery, l means the warehouse services fee for processing each (s, m) consignment, b means air cargo shipping rate per kg (dispatched from consolidation warehouse and delivered to a customs warehouse in the buyer's country), D means a truckload price for transportation from consolidation warehouse to a customs warehouse in the buyer's country, r means the average import duty rates and taxes for per unit value of goods, G means customs brokerage service fee, it is assumed that this fee does not depend on the value of

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10.1016/j.ifacol.2015.06.272

consolidated party, t_{b1} is the average time of air cargo delivery from consolidation warehouse to the buyers warehouse including time for customs clearance, t_{b2} is the average time of truck cargo delivery from the consolidation warehouse to the buyers warehouse including time for customs clearance.

The values of s, m, h, l, r, in general, depend on t but here we have assumed that these are constants or average values. We also assumed that all goods are fully removed from the warehouse at the time of shipment and then time (t) is equal to 0 and accumulation process starts all over again.

Since the cases $t < t_n$ and $t = t_n$ are not practically interesting, then consider only the case $t > t_n$. We want to find the optimal goods accumulation time in cargo consolidating warehouse for two types of cargo transportation, correspondingly, air and truck transportation. Estimation for optimal goods accumulation time in consolidation warehouse in the case of air delivery is determined by the expression (3)

$$t_1^* = \sqrt{t_n^2 + 2\times G/(h\times s^2)} - t_{b1} \quad (3)$$

in case of automotive delivery is determined by (4)

$$t_2^* = \sqrt{t_n^2 + 2\times (D+G)/(h\times s^2)} - t_{b2}. \quad (4)$$

If carrier has a variety of different size trucks (k sizes) of different carrying capacity P_j with the cost of delivery D_j then formula (4) can be converted into formula (5)

$$t_{2j}^* = \sqrt{t_n^2 + 2\times (D_j+G)/(h\times s^2)} - t_{b2}. \quad (5)$$

From the formulas (3)-(5) it should be clear that

$$t_1^* < t_{21}^* < t_{22}^* < ... < t_{2j}^* ... < t_{2k}^*. \quad (6)$$

Relations (6) mean that the optimal accumulation time is minimal in the case of air delivery and increases with truck carrying capacity increasing in the case of automotive delivery.

As the j-size truck has a carrying capacity of P_j then the weight of the supplier's goods located in warehouse at the moment of vehicle departure cannot exceed truck load capacity since it is assumed that a warehouse is fully released at the moment of shipment. Obviously there is a constraint (7)

$$mt \le P_j. \quad (7)$$

The nonlinear programming problems can be formulated for the case when the penalty rate does not depend on the length of delay in goods delivery. Rejecting the summands that do not depend on t, it can be written as (8)-(9)

$$F_{2j}(t) = 1/2\times hs\times (t + t_{b2} - t_n)^2/st + (D_j+G)/st \to \min \quad (8)$$

$$mt - P_j \le 0. \quad (9)$$

This problem can be solved on the basis of the Kuhn-Tucker theorem (Karush-Kuhn-Tucker conditions), e.g. Intriligator (2002), constructing a Lagrangian function (10)

$$L(t,\lambda) = F_{2j}(t) + \lambda(mt - P_j). \quad (10)$$

The solution for this problem with respect to the variable t has the form (11)

$$t_{2j}^{1*} = P_j/m. \quad (11)$$

This solution means that the truck carrying capacity of P_j and cost of delivery D_j should be dispatched fully loaded from the consolidation warehouse. To avoid any contradictions and dilemmas in decision making about moment of shipment it is necessary to satisfy the equation (12) or equation (13)

$$t_{2j}^* = t_{2j}^{1*} \quad (12)$$

$$\sqrt{t_n^2 + 2\times (D_j+G)/(h\times s^2)} - t_{b2} = P_j/m. \quad (13)$$

From equation (13) we can find the value of normative time interval t_n (14) such that the optimal moment of shipment (in the sense of costs) coincides with the moment when the j-size track is fully loaded

$$t_n = \sqrt{P_j^2/m^2 + t_{b2} - 2\times (D_j+G)/(h\times s^2)}. \quad (14)$$

In this case the value of t_n depends on the capacity P_j and cost of delivery D_j of j-size truck.

Since the weight and dimensions of each goods item are usually known in advance then the size of truck which can carry the good item or the possibility of air delivery for it can also be determined in advance. That is why the possible values of P_j and D_j for each commodity are usually known in advance. Depending on these values, value of $t_n(P_j, D_j)$ can be determined.

The contractual delivery time t_c can be calculated as follows:

$$t_c = t_n + t_g. \quad (15)$$

The variable t_g means average time of cargo delivery from manufacturer's warehouse to consolidation warehouse. This time is different for various manufacturers since warehouses of manufacturers are located at different distances from the consolidation warehouse. The type transportation, in each case, is selected by the manufacturer's freight forwarder.

CONCLUSIONS

We consider that the results obtained can be used by suppliers, when a contract for the sale of goods is being negotiated, to make an offer for contractual time of delivery.

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