Optimisation of Single-Vendor Multi-Products Multi-Buyers Supply Chain System under Stochastic Demand Condition

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ABSTRACT – Batik has relatively high annual sales in Indonesia. Therefore, enhancing the performance of the batik supply chain will substantially increase profits for all parties involved. This article describes the development of an optimisation model for a single-vendor, multiple-product, and multiple-buyer supply chain system of a batik products. The optimisation model was then solved using an evolutionary algorithm and capable of enhancing total cost performance by up to 31.73%.

1. INTRODUCTION

When a business begins to expand, the supply chain system will expand its sales channels, shifting from single vendor single buyer to single vendor multiple buyers. Study about single vendor multiple buyers supply chain system has been initiated by Joglekar and Tharthare [1]. In that study, the buyers were assumed identical with the decision variable is economic lot size. Next study that considered heterogenous buyers has been investigated by Banerjee and Burton [2]. Managing the ordering period and production cycle of buyers and vendors has also been identified as an important factor to manage [3].

Agrawal and Yadav [4] conducted a study a single vendor and multiple buyers supply chain system in a price-dependent demand environment. In that study, the objective function is to maximise profits for all of the supply chain parties. Chan, et al. [5] also conducted another study that resulted in a model for supply chain optimisation with a single vendor and multiple buyers. According to that study, integrated optimisation for all supply chain parties is superior to individual optimisation between supply chain parties. Due to the significance of vendor-buyer cooperation, Liu et al. [6] have also investigated vendor-buyer cooperation in providing CSR to support business success.

In this paper, an optimisation model for a supply chain of products with high annual sales in Indonesia, specifically batik, is developed. The supply chain manages the shipment of multiple products from one vendor to multiple buyers. The problem to be solved is determining the optimal production size and inventory control strategy for each buyer so as to minimise the entire supply chain costs.

2. METHODOLOGY

The supply chain system under consideration is for batik product that consists of single-vendor, 5 product types and 6 unidentical buyers; Every product type has 5 different sizes, which are S, M, L, XL and XXL. Buyer 5 has only ordered Product Type 4, whereas Buyer 6 has only ordered Product Type 5. The notations used to develop the optimization model are provided below.

TCB	: total cost of the buyer (Indonesia Rupiah/ IDR)
TCV	: total cost of the vendor (IDR)
GTC	: grand total cost (IDR)
B; b	: number of buyers; index of buyer
V; v	: number of vendors; index of vendor
S; s	: number of product size; index of product size
P; p	: number of product types; index of product type
IHB	: total inv. holding cost of the buyers (IDR)
LSB	: total lost sales of the buyers (IDR)
IHV	: total inv. holding cost of the vendor (IDR)
LSV	: total lost sales of the vendor (IDR)
hb	: holding cost/unit/month in the buyer (IDR)
hv	: holding cost/unit/month in the vendor (IDR)
A	: ordering cost per order (IDR)
πb	: net profit per unit product in the buyer (IDR)
πv	: net profit per unit product in the vendor (IDR)
x	: number of stocks out (units)
U	: production quantity of a product type (units)
u	: production qty of item of a product type (units)
m	: disaggregation factor of every product type
D	: demand of buyer (units)
Q	: delivery quantity to buyer (units)
R	: production quantity in the vendor (units)
Dl	: demand during lead time of the buyer (units)
$\bar{I}$	: average inventory per month (units)
r	: reorder level of the buyer (units)
l	: lead time
z	: inventory level when receiving an order
I_{max}	: maximum inventory

2.1 Total Cost of the Buyer

The *TCB* is shown in Equation 1.

$$TCB = IHB + LSB = \sum_{p=1}^{P}\sum_{b=1}^{B} hb_{bp} \times \left(\frac{1}{2}\left(I_{max_{bp}} - z_{bp}\right)\right) + \sum_{p=1}^{P}\sum_{b=1}^{B} \pi b_{bp} \times x_{bp} \quad (1)$$

2.2 Total Cost of the Vendor

The *TCV* is shown in Equation 2.

$$TCV = IHV + LSV = \sum_{p=1}^{P}\sum_{s=1}^{S}\frac{1}{2}\left(Max\left(0;\, R_{sp} - Q_{sp}\right)\right)\times hv_p + \sum_{p=1}^{P}\sum_{s=1}^{S}\pi v_{sp} \times x_p \qquad (2)$$

3. RESULT AND DISCUSSION

Below are the parameters of the batik supply chain system under consideration.

$D_{11} = Normal(250,25); D_{12} = Uniform(50,150);\ D_{13} = Uniform(20,200);\ D_{14} = Normal(170,30)$
$D_{21} = Normal(150,15); D_{12} = Uniform(30,100);\ D_{13} = Uniform(5,170);\ D_{14} = Normal(120,17)$
$D_{31} = Normal(70,10); D_{12} = Uniform(20,60);\ D_{13} = Uniform(10,90);\ D_{14} = Normal(80,20)$
$D_{41} = Normal(200,30); D_{12} = Uniform(15,160);\ D_{13} = Uniform(15,110);\ D_{14} = Normal(90,15);\ D_{45} = Normal(120;25)$
$D_{51} = Normal(115,30); D_{12} = Uniform(25,120);\ D_{13} = Uniform(35,210);\ D_{14} = Normal(90,25);\ D_{56} = Normal(75;35)$

Holding cost for every product type in the buyer (hb_{pb}):
$hb_{11} = 2100;\ hb_{12} = 2250;\ hb_{13} = 2500;\ hb_{14} = 2500$
$hb_{21} = 2100;\ hb_{22} = 2250;\ hb_{23} = 2500;\ hb_{24} = 2500$
$hb_{31} = 2100;\ hb_{32} = 2250;\ hb_{33} = 2500;\ hb_{34} = 2500$
$hb_{41} = 2100;\ hb_{42} = 2250;\ hb_{43} = 2500;\ hb_{44} = 2500;\ hb_{45} = 2500$
$hb_{51} = 2100;\ hb_{52} = 2250;\ hb_{53} = 2500;\ hb_{54} = 2500;\ hb_{56} = 2500$

Holding cost for every product type in the vendor (hv_p):
$hv_1 = 2000;\ hv_2 = 2000;\ hv_3 = 2000;\ hv_4 = 2000;\ hv_5 = 2000$

Ordering cost of every buyer (A_b):
$A_1 = 100000;\ A_2 = 130000;\ A_3 = 200000;\ A_4 = 170000;\ A_5 = 170000;\ A_6 = 170000$

Profit loss of every product type in every buyer (πb_{bp}):
$\pi b_{11} = 25000;\ \pi b_{12} = 40000;\ \pi b_{13} = 65000;\ \pi b_{14} = 75000$
$\pi b_{21} = 30000;\ \pi b_{22} = 40000;\ \pi b_{23} = 75000;\ \pi b_{24} = 75000$
$\pi b_{31} = 25000;\ \pi b_{32} = 40000;\ \pi b_{33} = 75000;\ \pi b_{34} = 80000$
$\pi b_{41} = 25000;\ \pi b_{42} = 40000;\ \pi b_{43} = 85000;\ \pi b_{44} = 85000;\ \pi b_{45} = 85000$
$\pi b_{51} = 40000;\ \pi b_{52} = 50000;\ \pi b_{53} = 85000;\ \pi b_{54} = 85000;\ \pi b_{56} = 95000$

There are as many as 25 variables for determining the amount of production of each product type, and 42 variables for determining the inventory control strategy of all buyers. All the 67 variables were optimised using the evolutionary algorithm, and the results are shown in Table 1 and Table 2.

Table 1. Optimum decision variables for the buyers

Buyer	Replenishment Strategy	t	I_{max} of Product				
			1	2	3	4	5
1	Periodic Review	4	26	44	46	34	50
2	Periodic Review	13	28	30	30	35	21
3	Periodic Review	3	22	22	22	20	52
4	Periodic Review	3	23	39	29	35	13
Buyer	Replenishment Strategy	r	*Q* of Product				
			1	2	3	4	5
5	Continuous Review	14	-	-	-	72	-
6	Continuous Review	16	-	-	-	-	76

Table 2. Optimum production quantity of the products

Product	Size				
	S	M	L	XL	XXL
1	1	1	2	1	1
2	1	2	1	3	2
3	2	2	2	3	2
4	3	2	3	2	2
5	1	2	1	1	2

The *GTC*; which is the sum of *TCB* and *TCV*; of the solution is IDR 1.024.107.250,- while the existing *GTC* for the entire supply chain is IDR 1.500.207.000,-. It shows that the proposed solution is able to improve the cost performance up to 31.73%.

4. CONCLUSION

The proposed optimisation model is able to improve the cost performance of the supply chain system.

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