

The Integration of Production-Distribution on Newspapers Supply Chain for Cost Minimization using Analytic Models: Case Study

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Abstract. Newspapers are products with special characteristics which are perishable, have a shorter range of time between the production and distribution, zero inventory, and decreasing sales value along with increasing in time. Generally, the problem of production and distribution in the paper supply chain is the integration of production planning and distribution to minimize the total cost. The approach used in this article to solve the problem is using an analytical model. In this article, several parameters and constraints have been considered in the calculation of the total cost of the integration of production and distribution of newspapers during the determined time horizon. This model can be used by production and marketing managers as decision support in determining the optimal quantity of production and distribution in order to obtain minimum cost so that company's competitiveness level can be increased.

Keywords: Analytical Model, Integration of Production and Distribution, Newspaper Supply Chain.

1. Introduction

Due to rapid development in industries, the dependency among the supply chain members has been increasing and brings some extent of risk and uncertainty along with benefits [1]. To meet these challenges, a coordinated mechanism among the members is needed in decision making in order to mitigate the current challenges and to increase the system performance and individual profitability of the supply chain [2]. By developing this coordination, manufacturer can minimize total cost while maintaining benefits such as favorable solution considering economical, environmental, and social aspect among the supply chain members [3,4,5].

Production and distribution planning are the main activities in the supply chain [6]. Therefore, an efficient integration of production and distribution plans is critical to achieving competitive advantage [7].

Newspapers are commodities with special characteristics which are perishable, have a shorter range of time between the production and distribution, zero inventory, and decreasing sales value along with increasing in time. Due to the perishable nature of the product, the time from the start of production to the delivery of the finished product to the end-customer is shorter than for most other industries [8].



Thus, as a commodity that has been declining and in a crisis, newspapers need a coordinated production and distribution planning in their framework that can be used to meet the competitive potentials in the newspaper industry [9,10].

Several researchers have attempted to improve the coordination of production and distribution in the supply chain. These researches attempted in developing models and simulations. Different parameters and considerations were used in the models, such as production capacity constraint [11]. The later research proposed a model that considers the problem with one facility, multiple destinations and an infinite vehicle fleet [12]. Another research even considered many uncertainties along supply chain line such as delays, queues, machine breakdown, vehicle malfunction, and environmental factor [13]. The researchers also attempted to solve the problems in production-distribution planning by different objectives, such as minimizing consideration of many uncertainties along supply chain line such as minimizing total tardiness [14], maximizing total revenue [15] and minimizing total global cost [16].

The purpose of this article is to apply development of previous research method to solve newspapers production and distribution integration problems, taking a case study in a newspaper printing company in Surakarta. The company receives orders to print newspapers from three companies and there are four types of printed newspapers. The main raw materials required in the printing process is paper and ink. The company has 2 plate maker machine units and 3 units of printing machines. There are 7 units of distribution vehicles used to deliver newspapers to 11 cities. This article aims to solve the minimization of the cost of production and distribution so that the company has a higher competitiveness.

This article consists of 4 parts, namely introduction, method, result and discussion, and conclusion. The introduction shows the reasons and importances to integrate production and distribution of newspapers. The method section discusses the steps and model formulation to solve the problem. The results of data processing using related methods are discussed and analyzed in results and discussion section. Furthermore the essence of the entire article is explained in the conclusion section.

2. Method

Garside developed a production-distribution integration model. In this model, it is assumed that the relationships between the variables in the objective and limiting functions are linear. In addition, some parameters in this model considered stochastic due to its accommodation of ongoing uncertainty in the supply chain. Uncertainty in the form of delay, variation of vehicle speed, machine and vehicle break down will affect the value of the parameter of production time, travel time, production time capacity and time capacity when the vehicle becomes random or certain distributed probability [13].

This article uses development from existing model. The difference with existing model is that in the developed model, it is assumed that there is no delay in the production floor, the speed is same for all vehicle, the printing machines speed in producing each newspaper is identified, production time capacity and time capacity is restricted to certain time window. This model based on deterministic data which aims to determine the types of products that must be produced, the amount of production, the quantity and the number of shipments of each plant to each distribution center (DC), as well as inventory at the plant and DC. Since the modeled products are newspapers where no inventory stored in warehouses and DC, variables related to stock up in the decision variables, parameters, the objective function, and the constraints are removed from the model and some new relevant constraints are added.

Index

I = factory sets

J = set of distribution destinations

T = time period sets

K = product sets

V = sets of vehicles owned by the factory i

Parameter

- $Cp_{ik}(t)$ = Production cost of product k in the factory i in period t
 $Cs_{ikt}(t)$ = Set up cost of product k in the factory i in period t
 $B_i(t)$ = Production capacity in the factory i during t period (minute)
 Qp_{ik}^{max} = Maximum production capacity to make product k in factory i
 tp_{ik} = Required time to make one unit of product k in factory i
 C_v = Delivery cost for vehicle v (per minute)
 Q_v = Maximum transport capacity of the vehicle v (exemplar newspaper)
 $T_v(t)$ = Time capacity vehicle v during the time period t
 td_{ij}^v = Delivery time from factory i to distribution center j and back again to the factory i by using the vehicle v (minutes)
 $D_{jk}(t)$ = Demand for product k in distribution center j in period t

Decision Variable

- $P_{ik}(t)$ = Quantity of product k produced in factory i in period t (exemplar)
 $x_{ik}(t)$ = Decision whether factory i produce product k in period t
 $y_{ij}^v(t)$ = The number of direct delivery from factory i to distribution center j by vehicle v in period t
 $q_{ijk}^v(t)$ = Quantity of product k delivered from factory i to distribution center j by vehicle v in period t (unit)

Mathematical Model**Objective function**

$$\text{Minimize : } \sum_{t \in T} \sum_{i \in I} \sum_{k \in K} Cs_{ikt}(t) \cdot x_{ik}(t) + \sum_{t \in T} \sum_{i \in I} \sum_{k \in K} Cp_{ikt}(t) \cdot P_{ik}(t) + \sum_{t \in T} \sum_{i \in I} \sum_{k \in K} C_v \cdot td_{ij}^v \cdot y_{ij}^v(t) \quad (1)$$

Constraints

$$\sum_{k \in K} tp_{ik} \cdot P_{ik}(t) \leq B_i(t), \forall i \in I, t \in T \quad (2)$$

$$P_{ik}(t) \leq Qp_{ik}^{max} \cdot x_{ik}(t), \forall i \in I, k \in K, t \in T \quad (3)$$

$$P_{ik}(t) - \sum_{j \in J} \sum_{v \in V} q_{ijk}^v(t) = 0, \forall i \in I, k \in K, t \in T \quad (4)$$

$$\sum_{k \in K} q_{ijk}^v(t) \leq Q_v \cdot y_{ij}^v(t), \forall i \in I, v \in V, j \in J, t \in T \quad (5)$$

$$\sum_{j \in J} td_{ij}^v \cdot y_{ij}^v(t) \leq T_v(t), \forall i \in I, v \in V, t \in T \quad (6)$$

$$\sum_{i \in I} \sum_{t \in T} q_{ijk}^v(t) - D_{jk}(t) \geq 0, \forall j \in J, v \in V, k \in K, t \in T \quad (7)$$

$$Q_v - D_{jk}(t) \geq 0, \forall j \in J, v \in V, k \in K, t \in T \quad (8)$$

$$P_{ik}(t) \cdot x_{ik}(t) \geq 0, \forall i \in I, k \in K, t \in T \quad (9)$$

$$x_{ik}(t) = 1, \forall i \in I, k \in K, t \in T \quad (10)$$

$$y_{ij}^v(t) \geq 0 \text{ and integer number} \quad (11)$$

$$x_{ik}(t) \in \{0,1\} \quad (12)$$

$$P_{ik}(t) \geq 0, Cs_{ikt}(t) \geq 0, q_{ijk}^v(t) \geq 0 \quad (13)$$

This model will minimize the total cost of production set up cost, variable production cost and regular shipping cost. Constraints 2 and 3 guarantee that the production amount of each product does not exceed the capacity of production time and production capacity in each plant. Constraint 4 is the equilibrium equation of the number of each product in each plant and DC. Constraint 5 guarantees the quantity of shipments of all products not to exceed the vehicle carrying capacity of each plant. While the constraint 6 guarantees the number of direct shipments from the factory to the DC does not exceed the regular delivery time capacity of each vehicle. Constraint 11 imposes a non-negative and integer number for the decision variable $y_{ij}^v(t)$. Constraint 12 implies a binary number for the decision variable $x_{ik}(t)$. Constraint 13 implies a non-negative number of decision variables $P_{ik}(t)$, $Cs_{ikt}(t)$, and $q_{ijk}^v(t)$. Next, we conduct data collecting to provide input for parameters in the model. Then this model is calculated by using IBM ILOG CPLEX 12.7.1 software to get optimal result.

3. Result and Discussion

The proposed model was applied to a company that produces 4 types of newspaper and distributes to 11 cities using 7 vehicles during the planning horizon of 3 days. Here, we consider parameters such as production costs, set up cost, delivery time and demand for products for each distribution center. Data related to those parameters are presented in Table 1-4. It is important to note that the production time capacity for each period is 300 minutes, maximum transport capacity for each vehicle is 3550 exemplar and duration provided to deliver the newspapers from the factory is 240 minutes for each vehicle. Furthermore, the production capacities in the factory by coordinating 3 provided printing machines for newspaper 1, 2, 3, 4 are 24000, 28200, 12600 and 6600 exemplar respectively. Meanwhile, required time to produce each newspaper type is 217, 49, 38 and 130 minute respectively. Whereas the delivery cost of each vehicle in IDR/minute is 59, 78, 76,137, 237, 440 and 154 respectively.

Table 1. Production cost per unit (IDR)

Newspaper	Period 1	Period 2	Period 3
1	719	587	719
2	864	864	864
3	1390	1653	1653
4	1954	1954	2100

Table 2. Set up cost per unit (IDR)

Newspaper	Period 1	Period 2	Period 3
1	1491455	1267571	1542081
2	561356	559628	561615
3	471905	334402	337047
4	660182	695741	692931

Table 3. Delivery time from factory to distribution center by each vehicle

Distribution center	Vehicle						
	1	2	3	4	5	6	7
Solo	19						
Sukoharjo	43						
Sragen		57					
Wonogiri			113				
Karanganyar			57				
Klaten				57			
Boyolali					50		
Yogyakarta					120		
Salatiga						91	
Semarang						152	
Purwodadi							125

Table 4. Demand in each distribution center.

Distribution center	Newspaper	Demand (exemplar)		
		Per. 1	Per. 2	Per. 3
Solo	1	3244	3500	3447
	2	4000	4215	4112
	3	0	0	0
	4	0	0	0
Sukoharjo	1	2000	2674	3082
	2	600	642	517
	3	0	0	0
	4	0	0	0
Sragen	1	1500	1632	1530
	2	0	0	0
	3	0	0	0
	4	0	0	0
Wonogiri	1	1500	1555	1208
	2	0	0	0
	3	0	0	0
	4	0	0	0
Karanganyar	1	1500	1269	1443
	2	0	0	0
	3	0	0	0
	4	0	0	0
Klaten	1	1500	1468	1520
	2	0	0	0
	3	0	0	0
	4	0	0	0
Boyolali	1	1500	1324	1506
	2	0	0	0
	3	0	0	0
	4	0	0	0
Yogyakarta	1	1500	1123	1168
	2	0	0	0
	3	0	0	0
	4	2850	2675	2811
Salatiga	1	1000	978	1121
	2	0	0	0
	3	0	0	0
	4	0	0	0

Table 4. (cont'd.)

Semarang	1	1000	1002	879
	2	0	0	0
	3	1585	1453	1501
	4	0	0	0
Purwodadi	1	1000	992	1023
	2	0	0	0
	3	0	0	0
	4	0	0	0

Table 5. Production plan for each newspaper (exemplar)

Newspaper	Period 1	Period 2	Period 3
1	24000	23870	23965
2	28200	27650	26510
3	12600	12543	12430
4	6600	6543	6578

Table 6. Comparison between previous and proposed system

Aspect	Previous System	Proposed System
Total cost (production cost + set up cost + delivery cost)	Total cost during one period reaches IDR 15-20 million.	Total cost can be minimized during the planning horizon within 3 periods with optimal result of Rp. 10,181,000
Production quantity plan	Production quantity plans for each product are based on the forecast and has not considered the integration of production-distribution optimization.	Production quantity plans during the planning horizon, consider the constraints and parameters in the production-distribution integration model with the aim of minimizing costs.
Quantity of products delivered	Not all vehicles distribute products based on demand to specific destinations. Only one to two vehicles per destination are available.	Each vehicle has its own portion that has been plotted according to the distribution objectives for a certain period.

4. Conclusion

Analytic model of integration of production and distribution in the supply chain has been developed as a reference for newspaper production and distribution planning with the decision to minimize total cost during the planning horizon. Production and distribution planning can be applied optimally in the newspaper supply chain by integrating the production and distribution planning of four newspaper products, which are distributed to 11 cities in a daily period. Several parameters and constraints have been considered in the calculation of total cost of the integration of newspaper production and distribution during the determined planning horizon. The proposed model results IDR 10,181,000 in total cost, which is lower than the previous total cost before model is applied. The proposed model has the ability-applied to be used by the production and marketing managers as decision support in determining the optimal quantity of production and distribution in order to minimize production and distribution cost so that the level of competitiveness can be improved.

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