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Joint delivery planning with time windows: a case study on supply chain in newspaper industry

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Abstract. The newspaper industry has some special characteristics such as short delivery time that will affect the price of the product. Some the newspaper firms, mostly have the same agency area. Due to the distribution is considered one of the variables that have a relatively high cost, it is necessary to save the cost. Joint delivery is a way to reduce distribution costs. By joint delivery planning, the value of synergies is defined as the (percent) difference between the distribution costs in the original situation in which all firms perform individual distribution, and the distribution costs of all firms are piled up and the route scheme is prepared simultaneously. The calculation of distribution costs using Vehicle Routing Problem with Time Windows (VRPTW) approach and obtained a distribution cost savings of 7.61%.

1. Introduction

Supply chain (SC) in newspapers, the printing company is the main entity that has several processes, i.e. procure raw materials, print plate and newspapers, and also distribute it to consumers. There are several distribution activities such as transportation system route, volume distribution, number of vehicles, drivers, schedules, delivery times, etc. One of the important issues in the newspaper industry is the relatively high distribution costs, where similar firms have relatively similar distribution points and delivery time. The newspaper has a special character i.e. daily production and there is no stock because the information cannot be sold in delay. If the information is delayed then the product is not sold commercially [1].

The companies have time target to do their distribution. In this case, transportation is an important part of the supply chain. Even though there are often several manufacturers shipping in the same market region, coordination between two or more manufacturers is rare [2].

There is research has been able to build a model that can be used to optimize the supply chain profit by including uncertainties in the negotiation of the supply chain, transportation problems, and allocation of products from supplier to buyer in the planning, taking into account the time value of money [3].

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 [4].

Newspaper distribution activities have a criteria, time windows (has a time constraint (has several stages of working hours from 3:00 a.m to 6:00 a.m). Newspaper companies in Surakarta, namely PT. Aksara Solopos, Suara Merdeka and Jawa Pos operate their own distribution which mean they have a several same distribution point. Network design can improve the supply chain so as to increase profits and minimize expenditure costs [5].

This paper aims to determine the percentage of distribution cost savings when done joint route on the newspaper company specially in PT. Aksara Solopos and the calculation is based on the cost of fuel use and mileage.

2. Literature Review

Therefore, an approach is needed to optimize the preparation of route pbolem. Optimal route could be determined using Differential Evolution Algorithm to calculate the shortest route for every agents and maximized the usage of the vehicle using coordinates and demands of the agents. The result showed that there was an optimal route which has shorter route and travel time than the existing route on the distribution process [6].

Increased competition among firms, as well as increased expectations in quality and service from customers, require not only a more operation schedule and accurate planning process but also cost reduction in logistics functions [7]. To survive under the ever increasing competitive and global pressures to operate more efficiently, transportation companies were obliged to adopt a collaborative focus [8]. Empirical research suggests that the problem of calculating operational savings ahead was a major obstacle to horizontal cooperation [9]. Cost savings could be done by consolidating or merging distributions [10].

The incorporation of separate distribution networks associated with two consumer goods producers (Henkel and Schwarzkopf) into a single distribution network (joint distribution). In this case, distribution costs decreased about 15.3 percent as a result of joint route planning [11].

Vornhusen et al. also explained a case study of joint route planning where the grocery chain works together by planning a joint route to distribute the goods to the local supermarket [9]. Cost saving reached about 20.3 percent. There were three companies in Belgium reached a 25.83% reduction in transportation costs. Allocate this collaborative advantage to Shapley's value, an individual profit of 19.01% increased to 37.56%. By shipping orders and sending large orders into multiple shipments, partners in the alliance could increased their collaborative profits and individual benefits [12].

Wang mentioned a case study of major transport (product from center to retailer) [13]. There were many practical production systems with distribution operations where finished jobs were transferred from supplier to the customer by transporters. In these systems, the coordination of production and logistics operations could help to improve overall system performance and reduce the total operation cost [14].

3. Method

This section presents a framework of the total distribution cost comparison between each company to the distribution cost of joint route planning with VRPTW (Vehicle Routing Problem with Time Windows) method approach. The steps of the framework are explained below.

1. Data collection
   The data collection method used is observation to collect data and interview to the newspaper industry that before performing the model simulation, conceptual model is needed from the whole system in the form of agent identification and order of relations between agents [15]. It also uses hypothetical data to refine research on the distribution points of related newspapers. For this case study, the agents are located in the area of Surakarta city, and determine the path using Global Positioning System (GPS) tool and then get some data such as the number of agents, the number of vehicle, the amount of demand, and the route.

   It is assumed that the loading time of three companies is same, so the delivery can run on time with the vehicle capacity used is 6000 copies.

2. Pinning Agents using the Google Maps App
   The entire agency that exists in the newspaper industry on the object of research, mark on google maps to be calculated coordinates.

3. Completion of VRPTW model with Differential Evolution (DE) Software algorithm
   Vehicle Routing Problem with Time Windows (VRPTW) is a matter of determining the route with limited vehicle capacity. Fleet is expected to visit the place of request and fill it from the depot.

   Characteristics of VRPTW problems as follows:

   - The vehicle route begins and ends from and to the original depot
   - There is a place that must all be visited & fulfilled once
   - If the capacity of the vehicle is used and can not serve the next place, the vehicle can return to the depot to meet the capacity of the vehicle and serve the next place.
   - The goal is to minimize the total distance traveled by arranging the sequence of places to visit along with when the vehicle returns to fill its capacity again.

   Here is a basic mathematical model of VRP that has constraints on the vehicle's carrying capacity. If there are other constraints, then this model can be developed as needed.

   N   = Reseller and customer point, N = (0, 1, 2, ... , n)

   N   = 0 warehouse point

   N $\neq$ 0 customer point

   K   = Number of vehicle, K = (0, 1, 2, . . ., k)

   Vk   = Maximum vehicle capacity k

   dj   = Total customer demand j

   cijk = Cost / distance to take the location of the customer i to the customer j using the vehicle k.

Differential Evolution Algorithm Model

Total distribution cost minimizing function is :

$$Z = \sum_i \sum_j \sum_k c_{ijk} x_{ijk}$$

Every point is only visited by one vehicle :

$$\sum_i \sum_k x_{ijk} = 1$$

Only one vehicle out of one point :

$$\sum_j \sum_k x_{ijk} = 1$$

There is K vehicle out of warehouse :

$$\sum_j \sum_k x_{0jk} = K$$

There is K vehicle goes into warehouse :

$$\sum_i \sum_k x_{i0k} = 1$$

Total goods transported by one vehicle does not exceed capacity haul:

$$\sum_i \sum_j \sum_k d_j x_{ijk} \leq V_k$$

As :

$$x_{ijk} \begin{cases} 1 \; road \; trajectory \; i,j \; passed \; by \; vehicle \; k \\ 0 \; road \; trajectory \; i,j \; doesn't passed \; by \; vehicle \; k \end{cases}$$

The data needed to fulfill this algorithm include:
1. The maximum iteration, the maximum number of iterations in the DE algorithm
2. Iteration fails maximum, maximum number of iterations that do not provide the best solution
3. Maximum time, Maximum amount of distribution time
4. Population, Number of vector population
5. Number of points, Number of destinations (including depot / initial node)
6. Maximum Capacity, Maximum capacity of vehicles
7. Maximum distance, longest distance traveled by vehicle in one trip

Time Windows

Windows time is the time limit contained in the newspaper delivery system. The time limit given is the total delivery time is 3 hours from 03.00 - 06.00 WIB with the following mathematical models:

$T^k \leq 3$ hours = 180 minutes
L   = the total number of shipping routes
T^k = total vehicle time L to go through 1 route in 1 trip

Aplication of DE Algorithm

The next step of entering the data that has been obtained to calculated by using iteration 1,000 times and the maximum time of 1 hour.

Step 1.   Calculating Distance and Time
          Perform mileage calculations using the help of the Google Maps app.
Step 2.   Calculate the distribution costs and compare it with the company's distribution costs.

4. Result And Discussion

The company can optimize distribution costs by joint delivery by several similar companies. because with joint delivery, the distribution costs for transportation can be reduced. In this case, the company that will be compared in terms of transportation costs is PT. Aksara Solopos. Below is data collection and analysis of the calculation of joint delivery costs of the company.

The data used in this research use the list of agents inSurakarta city with daily demand in May 2018. There are 2 points as depot (A4 & A9) and 9 distribution points in the form of agent (A3-C3) spread with different demand for every agent. Fleet that overcome the demand in the city of Surakarta there is one car with a capacity of 6000 copies of newspapers.

In this research using Differential Evolution (DE) algorithm the distribution points raised in the map are then drawn with the x and y axes so that the position and coordinates of the points of distribution are known. Figure 1 shows the distribution points of PT Aksara Solopos and Table 1 explaining the number of demand and the list of company's distributors in Surakarta.

The amount of daily demand of each agent varies from 70 to 587 in May 2018 according to the Table 1. The coordinates of the agent can be determined using the google maps as shown in Table II. After the calculation by entering the data according to the Table II obtained the results of the most optimal new route that can be generated by the algorithm Differential Evolution (DE) (Figure II) with the order of newspaper distribution routes described in Table III. And then the order is proposed route using Google Maps as shown in figure 3.
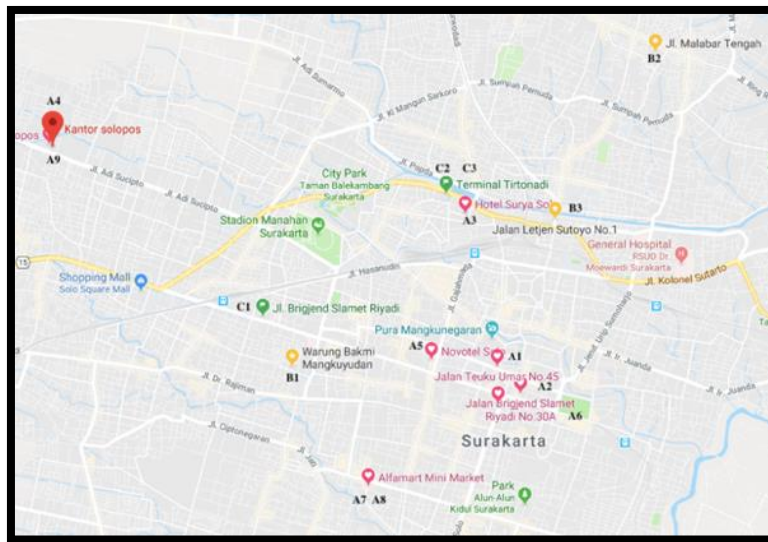

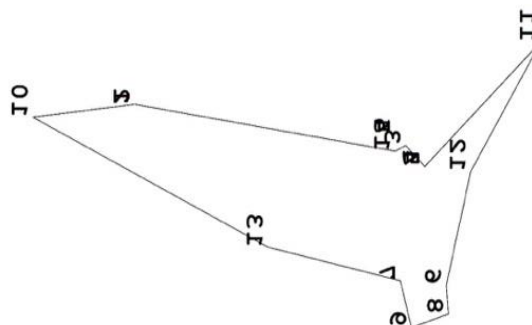**Figure 1.** Distribution Point PT Aksara Solopos

Figure 2. Iteration Layout

Table 1. Agent List and Number of Demand

| CODE | NAME OF AGENT | DEMAND | | | |
		SOLOPOS	SUARA MERDEKA	JAWA POS	TOTAL
A1	Surya 1	190	-	100	290
A2	ABC	294	-	-	294
A3	Wahyu	350	-	200	550
A4	Mandira/Kencana	280	165	178	623
A5	ABA	122	-	70	192
A6	Sheva	587	300	380	1267
A7	Momok 1	115	98'	-	115
A8	Asih	115	-	-	115
A9	Margono 2	315	265	-	580
B1	Fatwa	-	110	-	110
B2	Ismail	-	92	-	92
B3	NA	-	105	-	105
C1	Agus Prawoto	-	-	143	143
C2	Wiwid	-	-	90	90
C3	Risky	-	-	105	105
TOTAL					4671

Table 2. Coordinate Distribution Points

| CODE | Coordinate by Google | | DEMAND |
	X	y	
A1	-7.545586	110.779160	290
A2	-7.545586	110.779160	294
A3	-7.550793	110.817880	550
A4	-7.553314	110.820476	623
A5	-7.553469	110.820597	192
A6	-7.568512	110.823682	1267
A7	-7.567927	110.817130	115
A8	-7.572134	110.823997	115
A9	-7.573876	110.818691	580
B1	-7.547211	110.764590	110
B2	-7.5376275	110.837241	92
B3	-7.5540565	110.827214	105
C1	-7.5636606	110.798225	143
C2	-7.5515164	110.81642	90
C3	-7.5515164	110.81642	105

Table 3. Distribution Route Recommendation

ORDER	DURATION	DISTANCE
A4-C2-C3-A3-B3-B2-A6-A2-A1-A5-A7-A8-B1-C1-A9	73 Menit	24,4 Km

Table IV describes the calculation of distribution costs carried out by PT Aksara Solopos with 2 conditions. The first condition is the calculation of joint delivery costs where distributors in Surakarta use 1 car to joint delivery, and 5 other vehicles use car rental. The second condition is the calculation of the cost of the real condition distribution where no joint delivery is carried out but using car rental for the entire distribution area. The percentage difference is equal to 7.61% which is closest to figure 5.
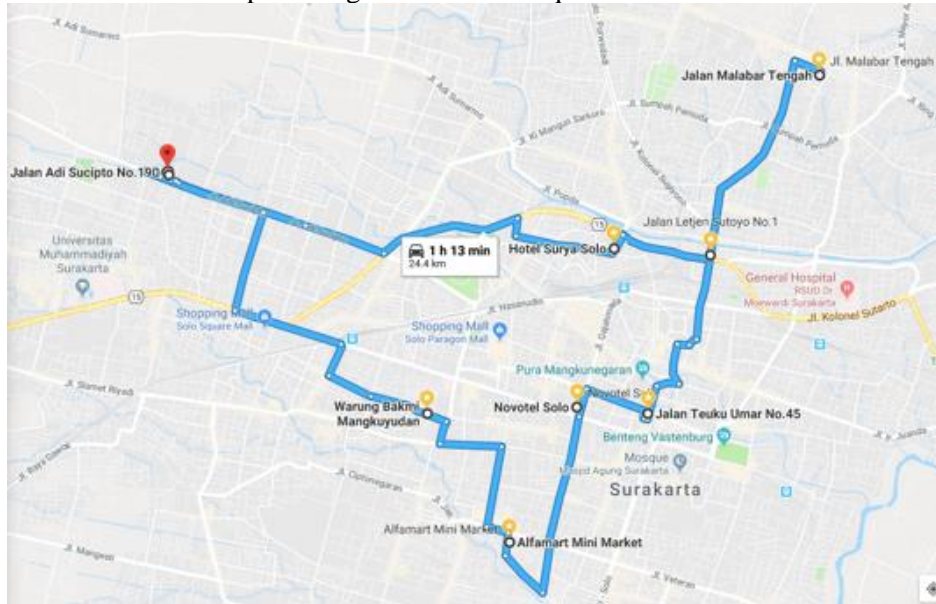

Figure 3. Joint Route Recommendation

Implementation of the route can be carried out provided there is no change of agent or change of current traffic sign. Figure 4 is a joint delivery scheme that illustrates that the Suara Merdeka, Jawa Pos, and PT. Aksara Solopos collects newspaper products in one place, that is at PT. Aksara Solopos, then will be distributed to all agents in Surakarta.
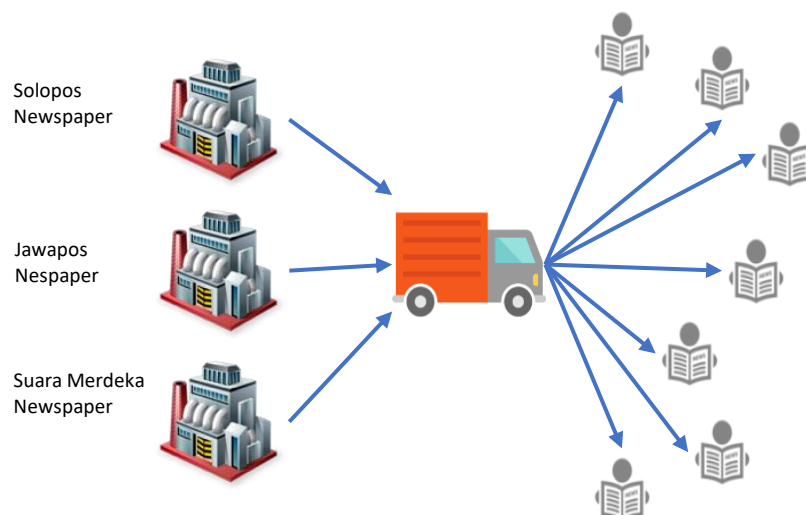

Figure 4. Joint Delivery Scheme
Table 4. Distribution Cost Comparison

No	Variable	Cost/year	Delta	Percentage
1	Joint Delivery	IDR33.483.840	IDR5.516.160	7,61
2	Real Condition	IDR39.000.000		
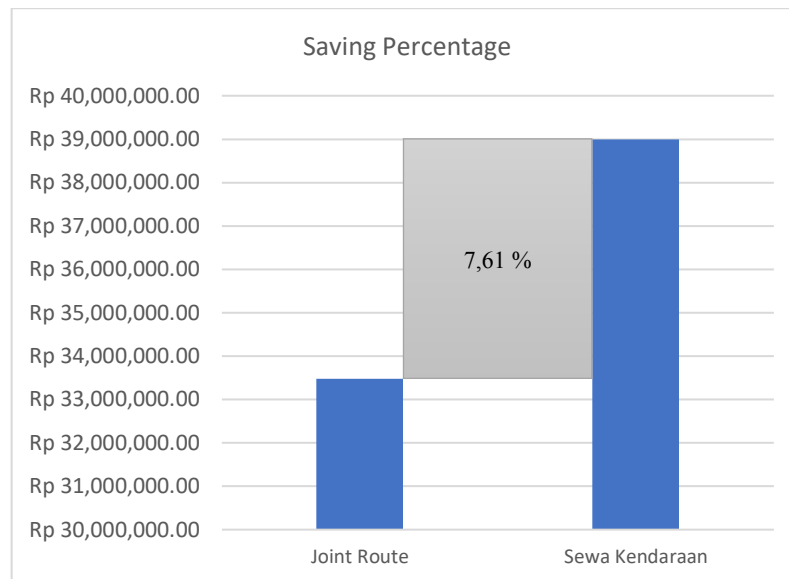
Figure 5. Cost Comparison Chart

Table 5. Joint Delivery Recommendation

No	Variable	Cost/month b = a/3	Quantity Kendaraan (c)	Total Cost d = b * c	Cost/year e = d * 12
			Joint Route		
1	Joint Delivery	IDR190.320	1	IDR190.320	IDR 2.283.840
2	Real Condition	IDR650.000	4	IDR2.600.000	IDR 31.200.000
	TOTAL COST				IDR 33.483.840

Table V explained about the calculation of distribution costs from the proposed joint delivery. Due to the distribution process in this area takes place every day, then in a month can be calculated that company experiencing distribution with distance of 24.4 km or 1 hour 13 minutes and if calculated fuel cost savings vehicle with assumption 1 liter BBM can go 10 km and 1 liter Pertalite worth IDR 7,800.00 then in one month can be savings of IDR 459,680.00 and in one year can save IDR 5,516,160,00, considerable savings considering no investment made the company to distribute the newspaper by hiring services expedition. The cost incurred in this case is IDR 650.000,00.

Joint delivery recommendation can be applied by the company's distribution manager by conducting further discussions in advance by similar companies so as to reduce distribution costs which have an impact on reducing expenditure costs and increasing profits.

5. Conslusion

From the data processing that has been done, it is proven that the joint route can minimize the cost of distribution of PT Aksara Solopos with the help of route determination of Vehicle Routing Problem with Time Window (VRPTW) using Differential Evolution (DE) algorithm. The proposed joint delivery provides cost savings of up to 72.22% for one year. Distribution manager of PT Aksara Solopos can applied this joint delivery by conducting further discussions between similar industry (Suara Merdeka Newspaper and Jawa Pos Newspaper) to reduce the expenditures cost and increase profit.

The development of this article can be done by increasing the company / newspaper industry involved in data processing, combining using qualitative methods of completion. It can also be done in the form of expanding the range of distribution and calculation of costs influenced by other variables.

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