Development of delivery consolidation procedures at courier service companies using Monte Carlo simulation

Dody Hartanto* and Arsyad Bunyannudin

Industrial Engineering Department, Institut Teknologi Sepuluh Nopember, Surabaya

*dodyhartanto@ie.its.ac.id

Abstract. Courier service company offers several delivery time schemes. The longer the delivery time, the cheaper the tariff offered and vice versa. Longer delivery time scheme gives courier service company greater flexibility to consolidate delivery of product with different delivery time scheme so that utilization of vehicles and the number vehicle needed can be minimized. Therefore, it is very important for company to have good consolidation procedure to reduce cost of delivery. In this study, a procedure was developed to improve existing consolidation procedures. The main difficulty in developing procedures is due to uncertainty in the volume of goods and the scheme of the delivery time chosen by consumers both at origin and destination. Monte Carlo simulation is used to estimate improvements in utilization and the number of vehicle needed by using a new consolidation procedure. The simulation result shows that the proposed consolidation procedure able to increase utilization of the vehicle and reduce the number of vehicle needed. In the case of delivery goods on Jakarta-Bandung route, the proposed procedure able to reduce the number of vehicle needed by 13.4% and increase its utilization by 13%.

1. Introduction

The role of courier service companies is increasingly important in the logistics system[1]. This is due to the rapid development of e-commerce. Out of 262 million people, approximately 143.26 million people or 54.68 percent have accessed the internet. As many as 32.9 percent of them used the internet to buy products and 16.83 percent used it to sell products. This means that there are approximately four million Indonesians who conduct trade transactions through online or e-commerce. Online shopping need courier service companies. Many e-commerce companies such as lazada, shoppee, tokopedia, bukalapak and some other e-commerce companies do not carry out their own logistics activities. The role of logistics is carried out by 3PL, especially the courier service company. In addition, courier service companies also serve individual delivery[2] [3].

Courier service companies offer several schemes for the delivery time[4]. Some schemes of delivery time that are often offered by courier service companies include one-day delivery, three-days delivery and five days delivery. The longer the delivery time scheme, the company has more flexibility in consolidating the delivery of goods with different delivery time scheme. This allows companies to deliver goods at a lower unit cost because the costs are borne by more goods. Therefore, courier service companies must have a good consolidation procedure so that the capacity of vehicle can be utilized optimally. Therefore, in this study the consolidation procedure was developed to consolidate the delivery of goods with different delivery time schemes. The procedure is evaluated using montecarlo simulation.
There are two uncertainties which should be considered in developing consolidation procedure. The first uncertainty is the number of goods which have to be delivered, both in the origin and the destination. The second uncertainty is the scheme of the delivery time chosen by consumers. The longer the time chosen by consumers, the company has greater flexibility to consolidate delivery. It also needs to consider capacity of the vehicle to be used. These factors cause this problem to be a complex problem. Simulation is a suitable method to help in finding solutions to complex problems [5] [6] [7].

2. Methods

In this study, two Monte Carlo simulation models were developed. The first model is the simulation model for the existing consolidation procedure and the second simulation model is the Monte Carlo simulation model for the proposed consolidation procedure.

Existing consolidation procedures can be seen in the flowchart in Figure 1.

![Flowchart of Existing Consolidation Procedure](image)

**Figure 1.** Existing consolidation procedure

In the flowchart, we can see that the remaining capacity of one day delivery is not used to deliver goods with longer delivery time. Consolidation will only be considered for goods with two days delivery scheme and three-days delivery scheme. In addition, the process of determining the number of transport vehicles needed also does not consider the demand in the destination. This can cause inefficiencies in the delivery of goods in the opposite direction. The needed capacity may be greater than the total capacity of the departing transport vehicle. If this happens then the company needs to find additional transport vehicle which will usually be more expensive due to rush orders. The number of goods delivered from the two cities can be quite different.

The proposed consolidation procedures which developed to exploit the remaining capacity of vehicle used to deliver goods with shorter delivery time scheme can be seen in the figure 2. In the flowchart, it can be seen that the remaining capacity of the transport vehicle used to deliver goods with a certain delivery time scheme is used to deliver goods with a different delivery time scheme. For example, if there is still remaining capacity on the vehicle used to deliver goods with a one-day delivery time scheme, the remaining capacity will be used to deliver goods with a different delivery time scheme (two-days delivery scheme and three-days delivery scheme).
The two consolidation procedures will be simulated using the same data set, which is data in 2017. The use of the same data set is calculated to show the savings that can be obtained if in 2017 a new consolidation procedure has been used. Historical data on the number of goods and the scheme of the delivery time selected by consumers are used to make empirical distributions. The data used is only the last year data. Last year’s data is the data that is most similar to the data that will appear in the following year, 2018. The distribution will be used as a basis for generating the volume and the scheme of delivery time in the monte carlo simulation. The existing procedure and proposed procedure will be used in the case of delivering goods from Jakarta to Bandung and Bandung to Jakarta. Calculation of number truck needed in all delivery time scheme can be seen in the table 1. Truck capacity is 8 tons and there is only one type of truck.
Table 1. Monte Carlo Simulation of proposed consolidation delivery

| Day  | One-day Delivery | Two-day Delivery | Three-day Delivery | Number of Truck Needed | Remaining Capacity | Number of Truck Needed | Remaining Capacity | Number of Truck Needed | Remaining Capacity | Total |
|------|------------------|------------------|--------------------|------------------------|-------------------|------------------------|-------------------|------------------------|-------------------|-------|
| 1    | 3                | 7                | 2                  | 2                      | 0                 | 1                      | 5                 | 1                      | 6                 | 0     |
| 2    | 3                | 8                | 3                  | 1                      | 0                 | 1                      | 5                 | 1                      | 5                 | 0     |
| 3    | 3                | 9                | 4                  | 2                      | 0                 | 1                      | 5                 | 1                      | 4                 | 0     |
| 4    | 1                | 18               | 1                  | 1                      | 0                 | 1                      | 7                 | 2                      | 5                 | 0     |
| 5    | 1                | 14               | 7                  | 2                      | 1                 | 1                      | 7                 | 1                      | 1                 | 0     |
| 6    | 1                | 9                | 2                  | 1                      | 0                 | 1                      | 7                 | 1                      | 6                 | 1     |
| 7    | 3                | 6                | 1                  | 2                      | 0                 | 1                      | 5                 | 1                      | 7                 | 0     |
| 298  | 3                | 9                | 4                  | 1                      | 0                 | 1                      | 5                 | 1                      | 4                 | 0     |
| 299  | 1                | 9                | 2                  | 3                      | 0                 | 1                      | 7                 | 1                      | 6                 | 0     |
| 300  | 3                | 5                | 0                  | 2                      | 2                 | 1                      | 5                 | 0                      | 0                 | 1     |

The simulation model is validated in two ways: checking whether there is an unreasonable output and using some extreme parameters. If some parameters have extreme values, the simulation output can be predicted easily without having to do a simulation. So, if the output of the model is not in accordance with the prediction, it can be concluded if there are still errors in the model and the model must be corrected. Simulation is run five times as many as the minimum number of replications needed. The number of replication needed is calculated based on 95% confidence level.

3. Result and Discussion

The vehicle (truck) will depart on a daily basis to deliver goods with one-day delivery scheme. It is very possible that the number of goods with a one-day delivery scheme is less than the capacity of the vehicle. The remaining capacity can be used to deliver goods with a longer delivery time scheme. Goods with a longer delivery time scheme can arrive at the destination early. Courier service companies operate more efficient and consumers are also more pleased because the goods arrive earlier. Existing procedures have not utilized the remaining capacity of the vehicles used to deliver goods with a shorter delivery time scheme to send goods with a longer delivery time scheme. The remaining one-day delivery capacity should be used to deliver goods with a three-day delivery scheme and goods with a five-day delivery scheme. The remaining capacity of the transport vehicles to transport goods with a two-days delivery scheme can be used to send goods with a three-days delivery scheme. Even, the remaining capacity of vehicle for three-days delivery scheme that departs on certain days can also be used to deliver goods with a one-day and three-day delivery scheme.

Simulation result show that proposed procedure can reduce the number of vehicles needed by approximately 14%. In addition, there is also improvement in the utilization of vehicle. The utilization increase not less than 13%. The improvement in reduction in number of vehicle needed and increase in utilization can be seen in table 2.

Table 2. Reduction in number of vehicle needed and increase in utilization of vehicle.

| Improvement | Consolidation Procedure | Saving |
|-------------|--------------------------|--------|
| Number of Truck | Existing 97 | Proposed 84 | 13.40% |
| Utilization   | 75%          | 88%       | 13%    |

4. Conclusion and Future Research

In this study, a delivery consolidation procedure for courier service company has been developed. The procedure takes into account the utilization of the remaining capacity of vehicles used to deliver goods
with a different delivery time scheme. Monte Carlo simulation results show that the proposed consolidation procedures able to increase the utilization of vehicle and reduce the number of vehicles needed. In the case that is used as an example in this paper, the use of the proposed consolidation procedures can increase utilization and reduce the number of vehicle needed by 13%.

The consolidation procedure developed in this study does not consider several aspects that can also affect delivery efficiency. Further research that can be done to improve the consolidation procedure developed in this research include:

a. The consolidation procedure can be improved by considering the area that is located between origin and destination. In this study, the procedure only takes into account one origin and one goal.
b. The consolidation procedure can be developed for a combination of several different transport capacity.
c. Integer linear programming models can be developed to help develop simulation scenarios, especially in determining the combination of capacity of the transport vehicles used.

5. Reference

[1] Aidas V V & Gražvydas J. Principle and Benefits of Third Party Logistics Approach when Managing Logistics Supply Chain. Transport, 22:2, 68-72.
[2] Nijolė B, Aldona J, 2017, “3PL” Service Improvement Opportunities in Transport Companies, 10th International Scientific Conference, Procedia Engineering 187, P. 67 – 76.
[3] A. Gunasekaran and E.W.T. Ngai. 2014. The Successful Management of a Small Logistics Company. International Journal of Physical Distribution and Logistics Management, Vol. 33, Issue 9.
[4] Eleonora M, Saskia S, Corinne, Laetitia D and Barbara L. 2014. The Impact of E-commerce on Final Deliveries: Alternative Parcel Delivery Services in France and Germany. Transportation Research Procedia,Volume 4, P 178-190.
[5] Sheldon M. R. 2006. Simulation. Elsevier Academic Press. Amsterdam: 4th Ed.
[6] Reuven Y. R. 1991. Simulation and Monte-Carlo method. Wiley-Interscience, 3rd Ed.
[7] Michael P. 2002. Computer Simulation in Management Science. Wiley. Chichester, England, 5th ed.