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Study on the Impact of Urban Consolidation Center (UCC) Usage in Yogyakarta City's Main Grocery Retailers in Terms of Transportation Cost

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Abstract. *The increase in urbanization has led to a rise in of the number of vehicles in the city and the frequency of goods delivery in urban environments. The concepts of city logistics have been developed and implemented to cope with those problems in the urban freight transport system. One cooperative freight transport scheme is the urban consolidation scheme. Urban consolidation centers (UCC) have been used by some cities over the last two decades to minimize unnecessary vehicle movement, congestion, and pollution. For a company that sells fast-moving consumer goods (FMCG), business prospects in supermarkets or groceries are currently still quite promising. Yogyakarta City ranks as the 6th most populous city in Indonesia, making it one of the largest cities in the country. Since there are many citizens and students from other towns across Indonesia, many modern retail businesses operate in Yogyakarta. If each of these businesses distribute their goods from their distribution centers (DCs) to their respective retailers, the number of freight transports will be substantial, and the congestion level will increase. This study examines the benefit of a collaboration strategy in which the top four retailers in Yogyakarta use a UCC. The advantage is expressed in total transportation cost. We developed three different scenarios that will be compared. In this research, the gravity location model is used to determine the location of the UCC, and the demand allocation model is used to determine the optimum of demand allocation from the UCC. This study reveals that using a collaborative strategy using a UCC can decrease the total transportation cost of the retailers.*

Keywords: *City logistics, urban consolidation center, location problem, gravity location model, demand allocation model*

Abstrak. *Peningkatan urbanisasi telah menyebabkan peningkatan jumlah kendaraan di kota dan frekuensi pengiriman barang di lingkungan perkotaan. Konsep logistik kota telah dikembangkan dan diimplementasikan untuk mengatasi masalah-masalah dalam sistem transportasi barang perkotaan. Salah satu skema angkutan barang koperasi adalah skema konsolidasi perkotaan. Urban consolidation centers (UCC) telah digunakan oleh beberapa kota selama dua dekade terakhir untuk meminimalkan pergerakan kendaraan, kemacetan, dan polusi yang tidak perlu. Bagi perusahaan yang menjual fast moving consumer goods (FMCG), prospek bisnis di supermarket atau bahan makanan saat ini masih cukup menjanjikan. Kota Yogyakarta menempati urutan ke-6 kota terpadat di Indonesia, menjadikannya salah satu kota terbesar di negara ini. Karena ada banyak warga dan mahasiswa dari kota-kota lain di seluruh Indonesia, banyak bisnis ritel modern beroperasi di Yogyakarta. Jika masing-masing bisnis ini mendistribusikan barang-barang mereka dari distribution centers (DC) ke pengecer masing-masing, jumlah transportasi barang akan sangat besar, dan tingkat kemacetan akan meningkat. Studi ini meneliti manfaat dari strategi kolaborasi dimana empat pengecer teratas di Yogyakarta menggunakan UCC. Keuntungan tersebut dinyatakan dalam total biaya transportasi. Kami mengembangkan tiga skenario berbeda yang akan dibandingkan. Dalam penelitian ini, model lokasi gravitasi digunakan untuk menentukan lokasi UCC, dan model alokasi permintaan digunakan untuk menentukan alokasi permintaan yang optimal dari UCC. Studi ini mengungkapkan bahwa strategi kolaboratif menggunakan UCC dapat mengurangi total biaya transportasi pengecer.*

Kata kunci: *Logistik kota, urban consolidation center, masalah lokasi, model lokasi gravitasi, model alokasi permintaan*

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Introduction

Nowadays, more and more people are migrating from rural to urban centers. The United Nations (UN) predicts that 68% of the world population will live in urban areas by 2050 (United Nations, 2018). According to the World Bank, 70% of the Indonesian population is predicted to live in the city by 2045 (Olivia and Laoli, 2019). The urbanization level in four provinces in Indonesia is estimated to be above 80% in 2035 (Statistics Indonesia, 2013). The increase in urbanization leads to the rise in the number of vehicles in the city and the frequency of goods delivery in urban environments (urban freight transport). Urban freight transport can lead to many problems in the city, such as the rise of congestion levels because of the increase of traffic demand, the environmental cost caused by traffic emissions, energy conservation, and truck accidents (Taniguchi et al. 2001). The concepts of city logistics have been developed and implemented to cope with those problems in the urban freight transport system. City logistics aim to achieve an efficient and environmentally friendly urban freight transport system (Taniguchi and Thompson, 2014).

According to Taniguchi and Thompson (2014), city logistics is the process of totally optimizing the logistics and transport activities by private companies with the support of advanced information systems in urban areas considering traffic congestion, traffic safety, and energy savings within the framework of a market economy (Taniguchi et al. 2001). There are some city logistics schemes currently in use according to Taniguchi et al. (2001) such as advanced information systems, cooperative freight transport systems, public logistics terminals, load factor controls, and underground freight transport systems. It is not unusual to combine these initiatives to be compatible with local transport planning policies. One of the cooperative freight transport schemes is the urban consolidation scheme (Taniguchi and Thompson, 2014).

An urban consolidation center (UCC), sometimes called an urban distribution center, has the fundamental principle of freight consolidation, or freight bundling. It was evident that to increase the efficiency of the urban freight transportation system, further deliveries must be bundled (Duin and Munuzuri in Taniguchi and Thompson, 2014). A UCC is a logistics facility that is located relatively near to the city center in an urban area. Freight destined for destinations in the city are dropped off at the UCC. The UCC operator sorts and consolidates these goods and delivers them to the final destinations (Browne et al. 2005).

There are some concepts of bundling that are suggested by Binsbergen and Visser (2001), namely bundling in time, bundling in activities, bundling in routing, and bundling in depots. Bundling in depots works best in practice to improve overall urban distribution. Bundling in depots enables the different companies to combine their cargo (Duin and Munuzuri in Taniguchi and Thompson, 2014).

The Urban Consolidation Center concept has been tested by some cities over the last two decades to minimize unnecessary vehicle movement, congestion, and pollution (Duin and Munuzuri in Taniguchi and Thompson, 2014). Roijen and Quak (2010) examined the influence of the urban consolidation center in Nijmegen, Netherlands. This UCC is called Binnenstadservice.nl. In this paper, 98 stores have been joined together in this UCC, and this number continues to grow. From this research, the UCC reduced the number of trucks used in the city center and their mileage, and the air quality in the city is not getting worse.

Additional research also studied the influence of UCCs and was performed by Browne et al. (2011). In this paper, a UCC was evaluated, and the results concluded that it can reduce thecongestion and environmental effects of freight transportation. A UCC could reduce the total distance traveled and emission of CO_2 by 20% and 54%, respectively.

Chwesiuk et al. (2010) examined UCC in a tourist destination city in the Westpomeranian Region of Poland to increase the efficiency of freight transport, especially in the holiday season, and reduce harmful effects such as congestion and environmental costs. Consolidation in freight transportation using a UCC can reduce the mileage of freight transport vehicles. This research has been done by Nevelling (2007). A UCC can reduce the mileage of freight transport vehicles in Stockholm by 30%. Heeswijk et al. (2019) studied the UCC in the city of Copenhagen using an agent-based simulation. The simulation tested 1458 schemes that combined some administrative measures and cost settings. Most of them gave significant environmental benefits; many of these schemes can reduce the truck mileage by about 65% and emissions by about 70%.

Olsson and Woxenius (2014) studied the importance of UCC location selection to improve the efficiency and the utilization in freight transportation in Gothenburg, Sweden. UCC location planning enabled the freight transport to be done in a shorter time and maximized the utilization of the trucks while reducing the number of trucks and overall congestion level in the urban area. UCC location selection problems have been studied by several researchers over the past decades (Agrebi et al, 2015). The location of a UCC is one of the most crucial decisions for logistics managers (Agrebi et al., 2015). The UCC selection problem is generally known as the location problem in logistics (Sopha et al., 2016).

Business prospects in supermarkets and groceries are currently still quite promising since those companies sells FMCG (fast-moving consumer goods). The Director-General of Domestic Trade, Suhanto, said that the potential of modern retail business was still showing a positive trend. According to Suhanto, based on the data from Nielsen, the growth of FMCG consumption in contemporary retail is 6.5% (Media Corner Indonesian's Ministry of Trade, 2019).

Based on the data from the Indonesian Retailer's Association (Aprindo), the value of modern retail sales in 2016, 2017, and 2018 are IDR 205 trillion, IDR 212 trillion, and IDR 233 trillion, respectively.

Yogyakarta City ranks 6th as the most populous city in Indonesia, making it one of the largest cities in the country (Wikipedia, 2019). Yogyakarta is also well known as student city destination. Since there are many citizens and students from other towns across the Indonesia who come to Yogyakarta City, there are many modern retail business players operating there. Currently, all the grocery retailers have their own distribution centers and fleets to distribute their products to their store branches. This means that currently there is no UCC in Yogyakarta City. If these business players continue to distribute their goods from their own distribution centers (DCs) to their respective stores, the number of freight vehicles will be significant in Yogyakarta City, and as the result the congestion level will increase.

It is better for every grocer or retailer in Yogyakarta City to undergo consolidation and collaborative distribution through the usage of UCCs to get the benefits shown in the previous research. These benefits include the reduction of freight fleets in the city, the drop in congestion levels, the improvement of air quality in the city, the reduction of environmental costs, etc. However, the previous research only studied the impact of UCCs on the city. There is no research to study the effects of consolidation and collaborative distribution on the shipping and carrier companies. Usually, the companies tend to avoid the consolidation and collaborative scheme of business because it will increase the complexity of coordination and information sharing between entities. This research looks at the impact of consolidation and collaborative distribution on the shipping and carrier companies of grocery retailers in Yogyakarta City. We study the impact of UCC usage in terms of transportation cost to find out the benefit the companies can get by utilizing consolidation and collaborative distribution.

Asih et al. (2016) studied the collaborative distribution in Yogyakarta city. In this study, they chose the optimum routing selection to show the benefit of the collaborative distribution model. The collaboration showed more savings in total cost compared to no collaboration. They calculated optimum mileage from route selection based on the capacitated vehicle routing problem and used an ant colony system algorithm to find the route and obtain the transportation cost. They performed research in Yogyakarta and its surrounding suburbs. The collaborative strategy applied in this study is sharing vehicles and distribution centers. They compared three scenarios: no collaborative strategy (existing condition), a collaborative strategy using a consolidation center with constrained capacity, and a collaborative strategy using a consolidation center with unconstrained capacity.

This research is similar to what was done by Asih et al. in 2016, but with notable differences. These differences are as follows:

- This research uses the network optimization model rather than the routing optimization model to see the benefit of the collaborative model in terms of transportation cost, since the problem is more strategic than operational.
- We use four retailers, which are the top four retailers in Yogyakarta City, as the pilot study of the benefits of a collaborative strategy and focus on cooking oil as the distribution object.
- We determine the optimum location of the UCC using the gravity location model in scenario two and the demand allocation model to allocate the demand from the UCC rather than using the clustering method to cluster the branch nodes to the UCC.

Research Methodology

This research begins with a literature study about city logistics and the use of urban consolidation centers. Since this study aims tobe a pilot study of the usage of UCCs in grocery retailers in Yogyakarta, we chose the top four most popular grocery retailers in the city. These four chosen retailers have several branches. We only examined cooking oil commodities for these retailers using collaborative distribution through the usage of a UCC. In this research, Retailer 1 has six branches, Retailer 2 has eight branches, Retailer 3 has five branches, and Retailer 4 has five branches. We collected data about the demand for cooking oil in each retail unit (the results of which can be seen in Table 1), distance from the distribution center (DC)/UCC to each retail unit, the location coordinate of each of retail branch (which can be seen in Table 2), truck capacity, distribution center capacity, and fuel price. We used Google Earth to find the location coordinates of each retail branch. After the data had been collected, we developed three scenarios that would be compared in terms of transportation cost by demand allocation. The scenarios that we developed can be described as follows:

Scenario 1: Existing condition
In this scenario, we use the existing condition, in which there is no UCC usage. Each retailer has their own DC that serves their retail branches. Retailer 1 will distribute to its Retail 1 branches, Retailer 2 will distribute to its Retail 2 branches, etc.

Scenario 2: Using one UCC
In this scenario, the location of one UCC is determined (we call it a centralized UCC) using the gravity location model. After the location of the UCC is known, we calculate the transportation costs.

Scenario 3: Using two UCCs
In this scenario, we choose two existing DCs, which play the role of UCC. We refer to them as decentralized UCCs. After we pick two DCs to use as UCCs, the network optimization model is used to allocate demand to production facilities, since each UCC has its capacity.

Table 1.
The Demand for Cooking Oil

Branches	Annual demand (kg)
1A	3974.4
1B	1987.2
1C	4968
1D	2980.8
1E	9936
1F	1987.2
2A	993.6
2B	1987.2
2C	4968
2D	993.6
2E	993.6
2F	6955.2
2G	3974.4
2H	1987.2
3A	11923.2
3B	5961.6
3C	14904
3D	8928
3E	29808
4A	3974.4
4B	7948.8
4C	19872
4D	3974.4
4E	27820.8

Table 2.
Location Coordinate of Branches and DC

Branches/DC	x_n	y_n
1A	-7.772129	110.389697
1B	-7.810622	110.387183
1C	-7.81267	110.402254
1D	-7.769363	110.409834
1E	-7.773292	110.36802
1F	-7.777949	110.379903
2A	-7.786826	110.394999
2B	-7.783122	110.391567
2C	-7.77481	110.361098
2D	-7.796243	110.352722
2E	-7.790565	110.366035
2F	-7.781842	110.41426
2G	-7.810046	110.377098
2H	-7.825325	110.390209
3A	-7.801885	110.389761
3B	-7.813486	110.3863
3C	-7.801496	110.411313
3D	-7.824462	110.390044
3E	-7.824504	110.37794

Table 2. *(Continued)*
Location Coordinate of Branches and DC

Branches/DC	x_n	y_n
4A	-7.776406	110.374442
4B	-7.78116	110.349936
4C	-7.742436	110.374671
4D	-7.783053	110.41437
4E	-7.816355	110.379255
DC 1	-7.78244	110.401372
DC 2	-7.752463	110.339830
DC 3	-7.801901	110.389811
DC 4	-7.776429	110.374535

After the three scenarios were developed, the transportation cost of each was compared and analyzed. Next, we describe the optimization models that we used in this study, which are the gravity location model and demand allocation network optimization model.

Gravity location model
According to Chopra and Meindl (2016), gravity location models can be used to determine the suitable geographical location within a region. The model aims to find the location for the UCC that minimizes the cost of transporting material from supplied points to market points. Gravity location models assume that both supply sources and markets are located as grid points on a plane. The distances are calculated as the geometric distance between two points on the plane. The transportation cost is also assumed to grow linearly with the quantity of shipping. The parameters of the gravity location models are as follows (Chopra and Meindl, 2016):

x_n, y_n = coordinate location of either a market or supply source n
F_n = cost of shipping one unit (or piece, pallet, truckload, or ton) one mile between the facility and either market or supply source n
D_n = quantity to be shipped between facility and market or supply source n

The model aims to minimize the total transportation cost (TC), which can be expressed as follows:

$$TC = \sum_{n=1}^{k} d_n D_n F_n \quad (1)$$

If (x,y) is the location selected for the facility, then the distance d_n between the facility at location (x,y) and the supply source or market n is given by

$$d_n = \sqrt{(x - x_n)^2 + (y - y_n)^2} \quad (2)$$

Demand allocation problem
According to Chopra and Meindl (2016), the goal of the demand allocation problem is to allocate the demand from different markets among the various plants to minimize the total cost of facilities, transportation, and inventory.

The parameters of this model are as follows:

n = number of factory locations
m = number of markets or demand points
Dj = annual demand from market j
Ki = capacity of factory i
c_{ij} = cost of producing and shipping one unit from factory i to market j (cost includes production, inventory, and transportation).

The decision variable of this model is x_{ij} = quantity shipped from factory i to market j.

The problem is formulated as follows:

$$Min \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij} \quad (3)$$

subject to

$$\sum_{i=1}^{n} x_{ij} = D_j \ \ \forall j = 1, .., m \quad (4)$$

$$\sum_{j=1}^{m} x_{ij} \leq K_i \ \ \forall i = 1, .., n \quad (5)$$

$$x_{ij} \geq 0 \quad (6)$$

The objective function (3) minimizes the total variable cost of transporting from factory *i* to market *j*. Constraint (4) ensures that the demand at each market is satisfied. Constraint (5) ensures that no plant can supply more than its capacity. Constraint (6) ensures non-negativity in decision variables.

Results and Discussion

In this section, the total transportation cost of each scenario is presented.

Scenario 1

In this scenario, we use the existing conditions of the four retailers. Demand from each branch is shipped by each DC retailer. Branches of Retail 1 are supplied by the DC of Retailer 1, branches of Retail 2 are supplied by the DC of Retailer 2, and so on. The transportation cost for each retailer is calculated by multiplying the distance from the DC to each branch, the demand of each branch, and fuel cost. The total transportation cost of the existing condition (Scenario 1) is the sum of the annual transportation cost of all retailers. The transportation cost of each retailer can be seen in Table 3.

Table 3.
Annual Transportation Cost for Each Retailer In The Existing Condition

Retailer	Annual transportation cost (Rp)
1	65641.4
2	139941
3	113632.99
4	196,94.34
Total	515709.53 ≈ 515710

Scenario 2

In this scenario, the location of the UCC is determined using the gravity location model. We used Excel Solver to solve this problem by inputting the coordinates of each branch of the four retailers, the projected annual demand of cooking oil, and fuel cost per kilogram per kilometer between the candidate UCC location and the location of all retail branches in rupiah. The calculation of fuel cost per kilogram per kilometer is as follows:

For one kilometer of travel, the truck needs 0.263 liters of fuel. Fuel cost price per liter is Rp 9,400 (Pertamina, 2020). The fuel cost per kilometer is Rp 2,472.2.

Truck capacity is 4,000 kg, so the transportation cost per kg per km is Rp 2,472.2 / 4000 kg = 0.618/km/kg.

Based on the Excel Solver, the optimal coordinate location for the UCC is -7.807 for *x* and 110.384 for *y*. After the location for UCC is obtained, we plotted the UCC location using Google Earth to get the actual distance between the UCC location and all retail branches. The total yearly transportation cost of scenario 2 is Rp 479,691.7978 ≈ Rp 479,692. The calculation of annual total transportation cost can be seen in Table 4.

Table 4.
The Comparison of The Total Annual Transportation Cost of Three Scenarios

Scenario	Total Annual Transportation Cost (Rp)
1	515,710
2	479,692
3	489,504

Scenario 3
In this scenario, two existing DCs are chosen to act as UCCs. We create a decentralization scenario by utilizing two UCCs. The DCs of Retailers 1 and 4 are chosen as the UCCs because the location is in the center of the spread of all the branches, which minimizes the distance. Because each DC has its own capacity, we used the demand allocation model to solve this demand allocation problem. The daily capacity allocation of Retailer 1 (DC/UCC 1) and Retailer 4 (DC/UCC 2) for cooking oil is 170.2 kg and 340.4 kg, respectively. We use the Excel Solver again to determine the daily demand allocation since we have the daily capacity allocation of the DCs. From the Excel Solver, the optimal allocation is UCC 1 supplies to branches 1A, 1E, 1F, 2C, 2D, 2E, 2G, 2H, 3B, 3E, 4A, 4B, 4C, 4E; and UCC 2 supplies to branches 1B, 1C, 1D, 2A, 2B, 2F, 3A, 3B, 3C, 3D, 4D. Branch 3B is supplied by both UCCs. The annual cost is obtained by multiplying the number of days in a year and the daily transportation cost. The total annual cost is 489,503.779 ≈ 489,504 The demand allocation can be seen in Table 5.

After the total annual transportation cost of all scenarios are obtained, then we compare the total yearly transportation cost of all scenarios, which can be seen in Table 4. Based on Table 4, we know that scenario 2 results in the lowest total annual transportation cost (we used one centralized UCC, where the location of the UCC is determined using gravity location models); in contrast, the existing condition has the highest total annual transportation cost. This is because we used the optimal location of UCC based on the gravity location model, which determines the best facility location for reducing the total transportation cost.

The total cost of scenario 3 (using two existing grocery retailers' DCs) is higher than scenario 2 because we do not optimize the location of the UCC and only optimize the demand allocation (through the demand allocation problem model).

This study revealed that retailers could reduce their transportation costs in terms of strategic network design by undergoing consolidation and employing collaborative distribution using a UCC. The total annual transportation cost of the two scenarios using UCCs is still lower than the existing conditions, though they use some of the current DCs to act as the UCCs in scenario 2. The grocery retailers can share their resources (distribution centers and freight fleets) to achieve the economies of scale and in result get the lower transportation cost by using the consolidation and collaborative distribution scheme.

Although this study just involves the city of Yogyakarta and four retailers, the results can be used in other cities that have many similar business entities (such as retailers) spread around the city. Using the UCC as the collaborative strategy will help the community reduce the adverse effects of urban freight in the city, such as congestion and pollution. The benefit is not only for the community, but also for the businesses to reduce their transportation costs. However, by collaborating with their facilities (using a UCC), the costs that arise in the UCC must be shared fairly among all parties who use the UCC.

The UCC can also be managed by the government to reduce the number of vehicles around the city. If it is managed by the government, all goods which will be delivered to a city must be collected in the UCC and then distributed to their destinations to fully realize the benefits of using a UCC in reducing the number of freight vehicles in the city.

Based on the results of this pilot study, it is hoped that the Yogyakarta City Government will implement the concept of consolidation and collaborative distribution using UCCs. It can reduce the impact of freight transport and distribution in the city by first determining which business sectors will be included in this scheme. Furthermore, this research can be used as the driving force for the implementation of urban logistics schemes in Indonesia, especially in the larger cities.

Table 5.
The Calculation of Total Annual Transportation Of Scenario 2

Retail Branch	DistanceFromUCC (Km)	Annual Demand (Kg)	Transportation Cost (Rp)
1A	4.4	3974.4	10807.18848
1B	0.8	1987.2	982.47168
1C	3.5	4968	10745.784
1D	6.9	2980.8	12710.72736
1E	6	9936	36842.688
1F	3.8	1987.2	4666.74048
2A	3.1	993.6	1903.53888
2B	3.5	1987.2	4298.3136
2C	6.5	4968	19956.456
2D	4.6	993.6	2824.60608
2E	3.5	993.6	2149.1568
2F	6	6955.2	25789.8816
2G	1.4	3974.4	3438.65088
2H	2.9	1987.2	3561.45984
3A	1	11923.2	7368.5376
3B	1.1	5961.6	4052.69568
3C	4.3	14904	39605.8896
3D	2.8	8942.4	15473.92896
3E	2.9	29808	53421.8976
4A	5.3	3974.4	13017.74976
4B	6.4	7948.8	31439.09376
4C	10.1	19872	124037.0496
4D	5.9	3974.4	14491.45728
4E	2.1	27820.8	36105.83424
Total annual transportation cost (Rp)			479691.7978

Table 6.
The Optimal Daily Demand Allocation of Scenario 3

From UCC 1 to (kg)				From UCC 2 to (kg)			
1A	0	2G	0	1A	11.04	2G	11.04
1B	5.52	2H	0	1B	0	2H	5.52
1C	13.8	3A	33.12	1C	0	3A	0
1D	8.28	3B	4.6	1D	0	3B	11.96
1E	0	3C	41.4	1E	27.6	3C	0
1F	0	3D	24.84	1F	5.52	3D	0
2A	2.76	3E	0	2A	0	3E	82.8
2B	5.52	4A	0	2B	0	4A	11.04
2C	0	4B	0	2C	13.8	4B	22.08
2D	0	4C	0	2D	2.76	4C	55.2
2E	0	4D	11.04	2E	2.76	4D	0
2F	19.32	4E	0	2F	0	4E	77.28

Conclusion

The usage of Urban Consolidation Centers (UCCs) can help cope with urban freight transportation problems in the city of Yogyakarta as determined through this pilot study examining four leading grocery retailers and cooking oil. The collaboration strategy of retailers using the UCC can decrease the total transportation cost in terms of the network design problem. The lowest total transportation cost is obtained through scenario 2 (using centralized UCC), in which the location of the UCC is determined using the gravity location model. The demand allocation model is used to determine the optimal demand allocation from the two UCCs when using the decentralized UCCs (scenario 3).

The total cost of the decentralized UCC scenario is still lower than the existing condition where every retailer distributes their goods from their own distribution center (DC) to their respective retailer branches. For further research, one can add other commodities or apply the methodology to another business sector other than retail groceries. Parameter benefits other than transportation cost or the risks arising from using the collaborative strategy would be beneficial aspects to examine as well.

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