EFFICIENT NETWORK DESIGN OF A PARCEL DELIVERY SERVICE

(max 20 pages)

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ABSTRACT

The network construction is an extremely important issue in the logistics business, such as parcel delivery business, concerning both the cost and the quality of their operations. For example, the transportation cost can be saved by concentrating the route of transportation applying hub-and-spoke system to raise the load factor of vehicles.

However, the choice of transportation modes and routes can be limited by the status of infrastructures and the demand of the operation quality. Also, the size and the density of network affect the construction of the network.

In this paper, the present status of the parcel delivery business and its network characteristics is reviewed at first. Then, a network reconstruction model is presented followed by the assessment of the cost saving policies.

Keywords: parcel delivery, Japanese parcel delivery market, network model, line haul

INTRODUCTION

The network construction is an extremely important issue in the logistics business, such as parcel delivery business, concerning both the cost and the quality of their operations. For example, the transportation cost can be saved by concentrating the route of transportation applying hub-and-spoke system to raise the load factor of vehicles.

However, the choice of transportation modes and routes can be limited by the status of infrastructures and the demand of the operation quality. Also, the size and the density of network affect the construction of the network.

The transportation network in this paper is defined as follows; the whole network is consisted of the nodes and links. In the parcel delivery business, the nodes are the terminals, which are the bases for the line haul transportation and the centers, which are the bases for the distributions. The links can be defined as the transportation routes that connect those nodes.

In Japan, for example, each of the major parcel delivery operators set at least one terminal in each prefecture and more than one in the densely-populated areas such as Tokyo or Osaka. However, the number of centers and how they are located depends on how densely each operator wishes to construct their network. For example, comparing Yamato Transport and Sagawa Express, the two major operators in Japan, Yamato possesses more than 4000 centers in Japan, while Sagawa possesses less than 1000 nodes, including terminals.

Most of the links in Japan are connected by trucks, while the use of trains and airs are rare. The load capacity of trucks commonly used is 10 tons, subject to the road condition in Japan.

The transportation network of Japanese parcel delivery business is consisted of the 1) transportation between terminals, 2) transportation between terminal and centers, and 3) delivery from center to customers. The line haul between terminals is the horizontal transportation and the network from terminal to customers is vertical structure. In this paper, the territory of each terminal is called “Region”, that of each center is called “Area”, and that of each truck used for pick-up and delivery is called “Zone” (Figure 1).

The next day delivery is the standard within 600km in Japan, thus the line haul transportations are connected directly. It can be said that the transportation network is constructed considering the delivery time as priority matter than the improvement of the load factor.

For this reason, hub-and-spoke network is being developed in the vertical network inside the Region, while the route concentration is not sufficient in the horizontal network between the Regions. However, taking the development of mail order market into account, the transportation network needs to be constructed sufficiently in order to keep the delivery cost at low level.

In this paper, the present status of the parcel delivery business and its network characteristics is reviewed at first. Then, a network reconstruction model is presented followed by the assessment of the cost saving policies.

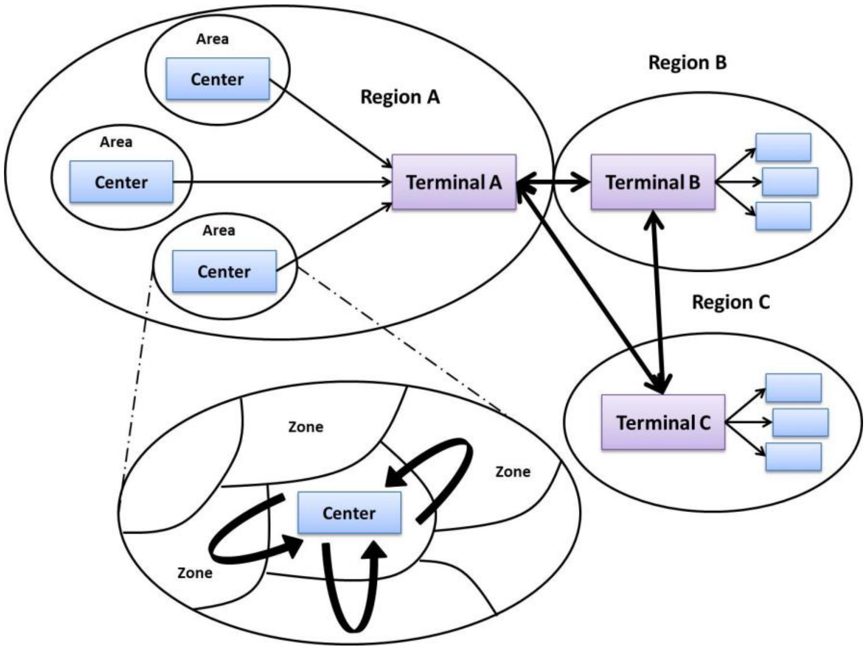

Figure 1－Basic Network of Parcel Delivery Service

Source：TOKUNAGA, OKADA, SUDA (1995)

The Position of This Paper

There is difference between analysis of inside-Area and –Region networks and that of inter-Region networks. The networks of inside-Area and –Region are considered as one-to-many network structures, while that of inter-Region is considered as many-to-many network. Thus, there also is a difference between the models used to analyze them.

Daganzo(1988) deals with delivery route in Area. Tokunaga et al. (1995), which adopts the basic concept of Daganzo(1988), suggests the cost minimization model which determines dispositions of center and transportation routes inside-Area and –Region.

Following are some of the researches which analyze line haul transportation network model. Campbell(1990) classifies transportation routes under three types and suggests network model to determine transportation routes and disposition of distributions considering economy of scale in transportation. Hall(1989) analyzes selecting terminal problem corresponding to load volume. Taniguchi and Nemoto(2001) discusses the two-stage optimization problem of transportation network which determines optimal disposition and size of terminal, and selection of terminals to consolidate and transportation routes.

The purposes of these models are construction of efficient network to minimize transportation or environmental cost. To focus on transportation cost, it is important to improve load factor by consolidation. However, it is conceivable that empty trucks run on the return trip between large and small cities due to the imbalance of load volume. In Japanese case, it was indicated that 11 % trucks of Japan Post run with no loads.

In this model, considering imbalance of actual load volume between terminals, we add backhaul trucks cost to network cost. In addition, transportation cost is calculated by truck-kilometer instead of ton-kilometer to describe the change in the load volume in network cost.

The Current Situation of the Japanese Parcel Delivery Business

The number of items delivered has been constantly and rapidly increasing in Japanese parcel delivery market from its beginning, due to the expansion of the service area and the introduction of new services, such as cold delivery services and golf equipment delivery services. Recently, the growth in the mail order market, including online shopping market, led to the increase in the number of the B to C item deliveries, thus the presence of parcel delivery operators is much more important in our daily life.

Although, the parcel delivery market itself is developing due to the online shopping items, parcel delivery operators are facing cost reduction by reorganizing their network. This is because of the profitability difference between the B to C and C to C items; B to C items are lower in profitability than C to C items. Even if the number of parcels increases continuously, the increase of B to C items may make Japanese parcel delivery operators reorganize their network.

According to “Research Report about Freight and Cost of Truck Transportation Business” (2011) presented by Ministry of Land, Infrastructure, Transport and Tourism, the total number of parcels in Japan is about 34 hundred million, with that of about 99% parcels are transported by trucks. In addition, the number of mail amounts to about 53.4 million.

In Japan, major two companies, Yamato Transport (about 42%) and Sagawa Express (about 39%), have large share of parcel delivery market. Japan Post which was main operator until the gain in power of private companies has only 11.4% share because of confusion about merge its brand “Yu-Pack” with “Pelican Express” which was provided by Nippon Express.

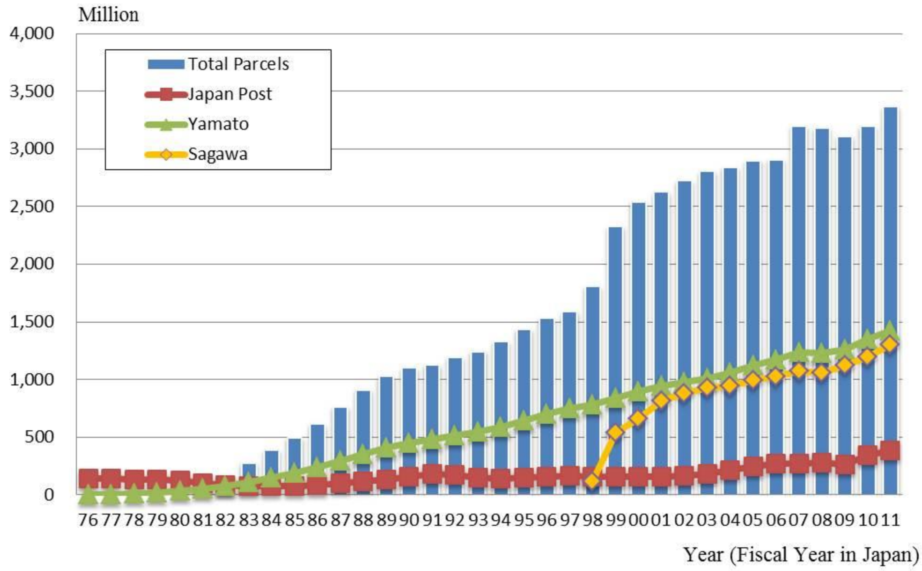

Figure 2 – The Total Number of Parcels and the Number of Major Brand in Japan
Source: Ministry of Land, Infrastructure, Transport and Tourism

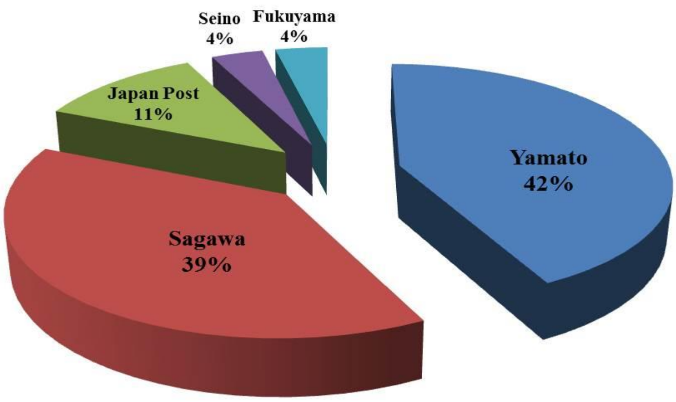

Figure 3 – The Market Share of Japanese Parcel Delivery's Operators in 2011
(Compared with the number of parcels)
Source: Ministry of Land, Infrastructure, Transport and Tourism

LINE HAUL TRANSIT MODEL

In this chapter, the line haul transit model which is applied raw data of Japanese parcel delivery operator (Yamato Transport Co., Ltd.) such as volume and terminal dispositions are suggested. After that, we analyze and evaluate the effect of policies, such as using larger trucks and setting hubs.

The model in this paper is short-term model on the presupposition that terminal dispositions are fixed. At first, all transportation routes between the terminals are connected point-to-point. The basic concept of the model is reorganization of transportation routes, by calculating the cost reduction before and after the transit takes place.

The Total Cost of the Network

In this paper, the transportation costs are defined as the number of trucks between terminals multiplied by the distance between them and the cost per truck-kilometer (Equation.1). As Equation (1) shown, we call the terminal of origin "i", and that of destination "j". The maintenance cost of existing terminals is excluded since this model is short-term model. For this reason, the initial network cost is transportation cost between the terminals.

$$\sum_{i}^{n}\sum_{j}^{n} N_{ij}\, D_{ij}\, c \qquad (1)$$

- N_{ij} : *Number of trucks operated between i and j*
- D_{ij} : *Distance between i and j*
- c : *Transportation cost per truck − kilometer (yen)*

Next, we define the transit cost. In addition to the terminal of origin and destination, we call that of transit "k", and define the transit cost for combination of i, j, k as A_{ijk}. In this paper, total cost of network "Z" is defined as the sum of Equation (1) and total A_{ijk} (Equation.2).

$$Z = \sum_{i}^{n}\sum_{j}^{n} N_{ij} D_{ij}\, c + \sum_{i}^{n}\sum_{j}^{n}\sum_{k}^{n} A_{ijk} \quad (2)$$

. A_{ijk} : *Transit cost for terminal combination of i, j, k*

Number of Trucks

Number of trucks (N_{ij}) is determined by number of parcels between terminals and load capacity of truck (L). To calculate the number of trucks, ROUNDUP Formulas in Excel is used in Equation (3).

$$N_{ij} = ROUNDUP(\frac{V_{ij}}{L}, 0) \quad (3)$$

. V_{ij} : *Number of parcels between i and j*

. L : *Load capacity of truck* (number of parcels)

Transit Cost

A_{ijk} is calculated by multiplying parcel volume between terminals by inefficiency index of transit operation and the transit cost per parcel.

$$A_{ijk} = V_{ij} \times E \times tc \quad (4)$$

. E: *inefficiency index of transit operation* $(0 \leqq E \leqq 1)$

. tc : *transit cost per parcel (yen)*

If parcels are transshipped one by one, E is great. However, if operators use transit implements which can carry a number of parcels at one time, E is low. In this paper, we use the Yamato's data of dispositions of terminal and number of parcels between terminals. The actual transit operation of Yamato is also applied for the transit operation of this model. Yamato uses roll box pallets (BOX) when parcels are loaded into trucks (Figure.4). According to Yamato, it is revealed that the time and labor of transit operations were hardly taken when using BOX, comparing with carrying parcels one by one. Therefore, transit cost in this model is assumed only transportation cost to terminal "k" for transiting, transit operational cost, however, is excluded.

Figure 4 – Roll BOX Pallet

Source：The author took at Kunitachi-Yaho Center of Yamato Transport

The Calculation of Cost Reduction (R_{ijk})

N_{ij} is affected by V_{ij}. Although the number of parcels is given, OD matrix changes when transit takes place. Figure.5 shows the example of change in V_{ij} and N_{ij} when transit takes place. In this example, V_{AB} and V_{AC} are loaded on the "A"→"C" route, and then V_{AB} is transited at terminal "C", finally V_{AB} and V_{CB} are loaded on the "C"→"B" route. Accordingly, N_{AB} becomes 0, and N_{AC} and N_{CB} increase. So it is possible that total cost of network also increase depending on the distance between three terminals. The transit should only take place when the total cost reduces.

Before transit

	A	B	C
A		8(1)	15(1)
B	7(1)		18(2)
C	12(1)	9(1)	

※1 The number of trucks appears in brackets
※2 *L = 16*

After transit

	A	B	C
A		0(0)	23(2)
B	7(1)		18(2)
C	12(1)	17(2)	

※1 The number of trucks appears in brackets
※2 *L = 16*

Figure 5 – An Example of Change in OD Matrix After Transit

In this model, at first, we determine combination of terminals which the transit should take place. After the transit takes place, the OD matrix may change and the transportation cost may need to be recalculated. This series of steps are repeated to reorganize transportation route.

The calculation of the cost reduction "R_{ijk}" which is the measure of determining combination of terminals is shown below. R_{ijk} is calculated by subtracting the cost after the transit (TC_{ijk}) from before the transit occurs (DC_{ijk}). R_{ijk} and DC_{ijk}, TC_{ijk} are shown as Equation (5), (6), (7).

$$R_{ijk} = DC_{ijk} - TC_{ijk} \tag{5}$$
$$DC_{ijk} = \left(N_{ij} \times D_{ij} + N_{ik} \times D_{ik} + N_{jk} \times D_{jk}\right) \times c \times M \tag{6}$$
$$TC_{ijk} = \left(N'_{ik} \times D_{ik} + N'_{kj} \times D_{kj}\right) \times c \times M + A_{ijk} \tag{7}$$

- R_{ijk} : *Reduction cost for the terminal combination of* i, j, k
- DC_{ijk} : *Total transportation cost for terminal combination of* i, j, k *when each route is transported directly*
- TC_{ijk} : *Total transportation cost for terminal combination of* i, j, k *when load for* $i \rightarrow j$ *is transited at* k
- N_{ij}: *Number of trucks operated between* i *and* j
- N'_{ik} : *Number of trucks between* i *and* k *when loads for* $i \rightarrow j$ *and* $i \rightarrow k$ *are loaded on the route*
- D_{ij} : *Distance between* i *and* j
- c : *Transportation cost per truck – kilometer (yen)*
- M : *Unit cost for modes*
- A_{ijk} : *Transit cost for terminal combination of* i, j, k

In addition, N'_{ij} is defined as Equation (3)'.

$$N'_{ik} = roundup\left(\frac{V_{ij} + V_{ik}}{L}, 0\right) \tag{3'}$$

Restricting Conditions

For applying line haul transit model to the actual operation, we assume 5 restricting conditions as follows, a) direct routes of full load trucks, b) backhaul trucks routes, c) time, d) driver's working hours, e) terminal capacity. In this paper, constraint conditions of a),b) and c) are considered. Conditions of d) and e) are future tasks and excluded in this model.

Restriction of Direct Routes of Full Load Trucks

When a truck routing between i and j is fully loaded, that truck must run directly j without transit at k. For example, as shown in Figure.6, if there are two trucks between terminal A and B, one truck is fully loaded and another one's load factor is 50%, we hypothesize that the full load truck runs directly and the other one routes to B via C.

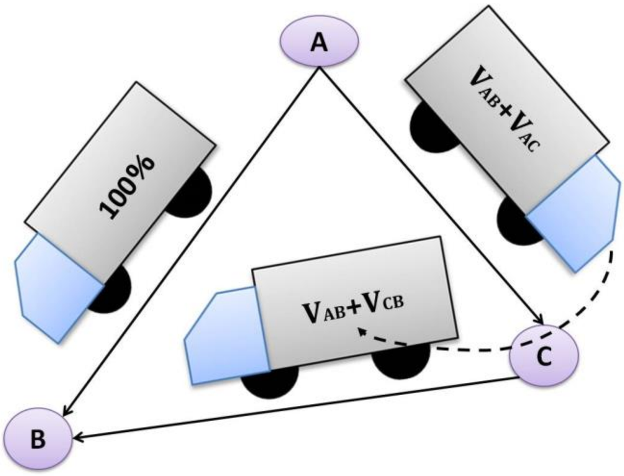

Figure 6 – Restricting Conditions

Restriction of Backhaul Trucks Routes

The trucks arriving at those destinations need to return to original terminals. The cost which incurs backhaul trucks is considered in this model. If operators do not comprehend parcel volume between their terminals, some empty trucks run on the routes. In Japan, it becomes problem that load factor of Japan Post trucks especially "down route trucks" are particularly low. So, we assume that when trucks arriving at destination return to their each origination, they must load the following day's parcel from terminal j to i. The number of parcels is calculated by dividing average monthly data by 30. Because of this, the backhaul trucks must load the same number of parcels from j to i. Thus N_{ij} and N_{ji} must be the same number such as Equation (8) and Figure.7.

$$\begin{gathered} if\,.N_{ij} > N_{ji} \\ N(sym)_{ji} = N_{ji} + (N_{ij} - N_{ji}) \end{gathered} \tag{8}$$

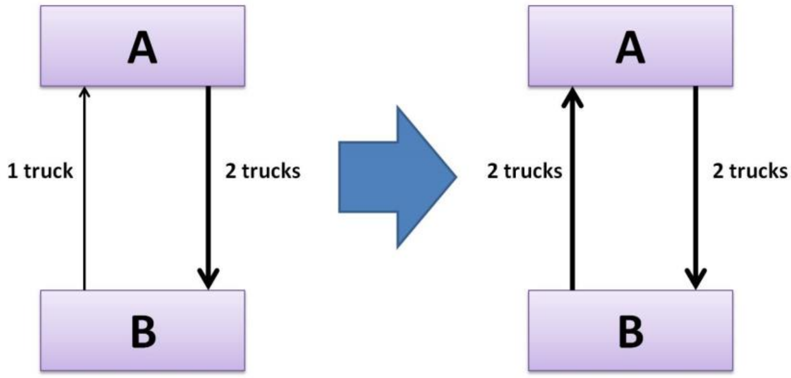

Figure 7 – Restriction of Backhaul Trucks Routes

Time Restriction

Time restriction is defined on the assumption of next-day delivery provided by the Japanese parcel operators. In fact, levels of domestic delivery services are segmented into next-day delivery and two-days-later delivery, according to the distance from departure.

However, for the simplification, we assume that all delivery services are in the range of next-day delivery in this model.

The total time of transportation and transit at the combination of terminals i, j, k is defined as t_{ijk}. If t_{ijk} is more than fixed value, the transit is not considered in the route. Let maximum time T be 12 hours in this model. t_{ijk} is determined by average speed of trucks (S) and D_{jk}, average time of transit per parcel W(supposing that it takes 1/60 hours to transit per parcel in this paper), V_{jk} and E (Equation .9).

$$\boldsymbol{t_{ijk} = \frac{D_{ij}}{S} + E \times V_{ij} \times W + \frac{D_{jk}}{S} + E \times V_{jk} \times W \leqq 12 = T} \quad (9)$$

- t_{ijk} *: total time of combination i,j and k*
- S *: the average speed of trucks*
- W *: the average time of transit per parcel*

Restriction of Driver's Working Hours

In this model, we set time restriction focusing on parcel. Although, in the actual operation, however, we need to consider driver's working hours. According to Ministry of Health, Labour, and Welfare[1], total working hours, and rest time and so on are regulated. If these restrictions are subjected to this model, it is necessary to consider rest time, and in some case to provide new additional drivers. Thus, the additional cost for providing new drivers also needs to be considered. In this model, driver's cost is included in c for simplification, and the actual calculation is kept as one of the future issues.

Restriction of Terminal Capacity

If we consider actual operation, because the terminal capacity is determined by the number of berth, terminal size and so on, the situation of individual terminals needs to be considered. In this model, however, it is assumed that every truck depart from each terminal at same time. So, if we consider terminal capacity, it is possible to concentrate more parcels than actual cases. Owe to this, in this paper, this restricting condition is also kept as one of the future issues.

The Flowchart of the Model

In this section, the outline and flowchart of the model is shown. First, we select the every combination of terminal i, j and k, and then every R_{ijk} is calculated. After considering restricting conditions, the combination of i, j, k which achieve the maximum reduction ($MAX\, R_{ijk}$) is selected and practiced. This calculation is repeated as long as $MAX\, R_{ijk}$ is above 0. Figure.8 shows these processes in a flowchart.

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[1] Ministry of Health, Labour and Welfare (2011) "The Improvement Standard Points of Truck Driver's Working Hours"

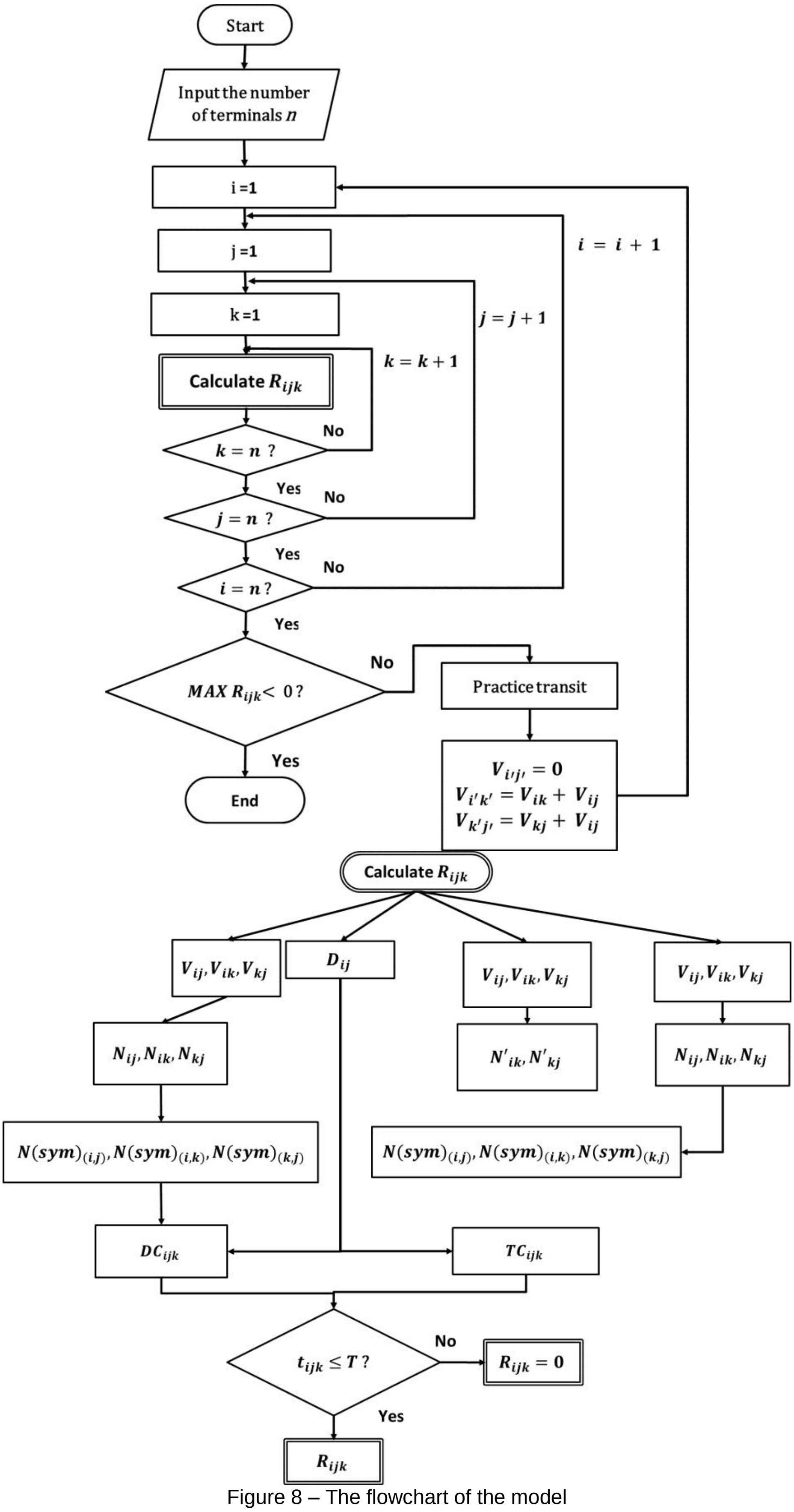

Figure 8 – The flowchart of the model

Unit Cost

In the case of 10tons-trucks, c is determined as 144.3 yen per truck-kilometer by "Research Report about Freight and Cost of Truck Transportation Business" presented by Ministry of Land, Infrastructure, Transport and Tourism and Japan Trucking Association.

In this model, one of the policies which we assume is using semi-trailers instead of 10tons-trucks. Semi-trailer's c in Japan was not able to obtain. We found out, however, semi-trailer's c was 1.3 times higher than 10tons-truck's according to Yamato. So, in this model, semi-trailer's c is calculated by multiplying 1.3 as unit cost for modes (M).

CONCLUSION AND ASSESSMENT OF THE POLICIES

This section discusses conclusions and assessments of 3 policies (Case.1 to 3). To compare with each case, we set a standard as Case.0. In each case, cost and the number of trucks reduction and percentages of transit parcels are shown in the each table compared with Case.0 and the condition before transit occurs. Table.1 shows kinds of trucks, transit restriction, L, an average speed of trucks (S) and M. In the Case.1, 10tons-trucks are used. In the Case.2, 10tons-trucks are changed into semi-trailers. In addition, we consider setting hubs and terminals which permit transit only at hubs in the Case.3.

Table I – Conditions of Each Case

	Kinds of Trucks	Transit Restriction	L	S	M
Case.0 【standard】	10tons-truck	—	45×16=720 ($L_{BOX} \times LB_T$)	60	1.0
Case.1	10tons-truck	Without	45×16=720 ($L_{BOX} \times LB_T$)	60	1.0
Case.2	Semi-trailer	Without	45×24=1,080 ($L_{BOX} \times LB_T$)	50	1.3
Case.3	10tons-truck	Transit only at hubs (2 Terminals)	720	60	1.0
	Semi-trailer		1080	50	1.3

In the Case.0, initial total cost is defined as Z^0 (Equation.10).

$$Z^0 = \textbf{594,391,902 (yen)} \qquad (10)$$

. Z^0 : *initial total cost of network*

Case.1 (10tons-truck)

Conclusion of Case.1 is shown in Table.2. In the Case.1, percentage of the total cost reduction is 7.2%, reduction in the number of trucks is 11.9%, and the number of transit parcels is 5.9%.

Figure.9 shows the number of parcels of each terminal. It results clearly that transits often take place at terminals located near the densely-populated area.

Table II – The Conclusion of Case.1

	Case.0	Before transit	After transit
Total cost (yen)	**594,391,859**	**594,391,859**	**551,704,383**
The number of trucks	**8,062**	**8,062**	**7,101**
	percentage		
Total cost reduction (compared with Case.0)	**7.2%**		
Total cost reduction (compared with before transit)	**7.2%**		
The number of trucks reduction (compared with Case.0)	**11.9%**		
The number of trucks reduction (compared with before transit)	**11.9%**		
The number of transit parcels (compared with total parcels)	**5.9%**		

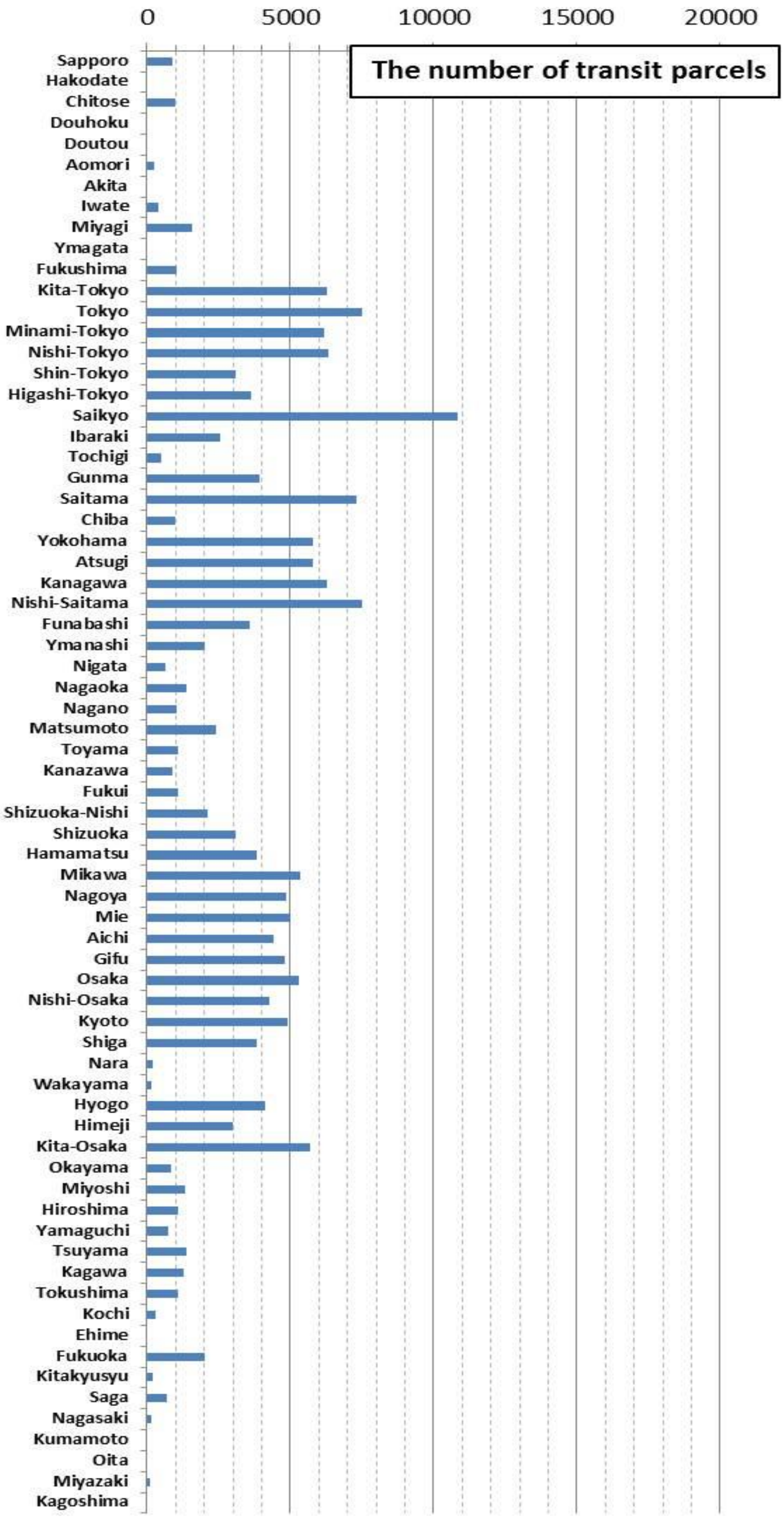

Figure 9 – The number of transit parcels in each terminal（Case.1）

Case.2（Semi-trailer）

In the Case.2, all 10tons-trucks are changed into semi-trailers. If semi-trailers are used, the costs for expansion of berth in terminals and reconsideration of transportation routes are needed to be considered to compare with other cases. However, it is difficult to estimate cost of each terminal for capital investment. So, we assume that it takes 2 billion yen to introduce semi-trailers per terminal based on data of new capital investment in Yamato's annual financial reports. These costs for using semi-trailers are divided by statutory useful life of distribution facility (in the case of Japan, it is 38 years), and then divided by 360 days. As a result, we add the total cost and 146,199 yen per terminal.

Table.3 shows the conclusion of Case.2. The total cost reduction is also compared with Case.0. This is because semi-trailers are used between terminals even if there are a few parcels. Moreover, the assumption that operators should deliver until next day prevents the transit of parcels between long-distance-terminal combinations, which in the actual operations the transit should be taken place.

On the other hand, the percentages of total cost reduction, the number of trucks and the number of trucks compared with before transit are increased more than Case.1. Hence, bigger trucks make the transits more frequently.

Table III – The Conclusion of Case.2

	Case.0	Before transit	After transit
Total cost (yen)	**594,391,859**	**692,951,309**	**604,759,697**
The number of trucks	**8,062**	**6,550**	**5,599**
	percentage		
Total cost reduction（compared with Case.0）	**-1.74%**		
Total cost reduction（compared with before transit）	**12.9%**		
The number of trucks reduction（compared with Case.0）	**30.6%**		
The number of trucks reduction（compared with before transit）	**14.5%**		
The number of transit parcels (compared with total parcels)	**10.3%**		

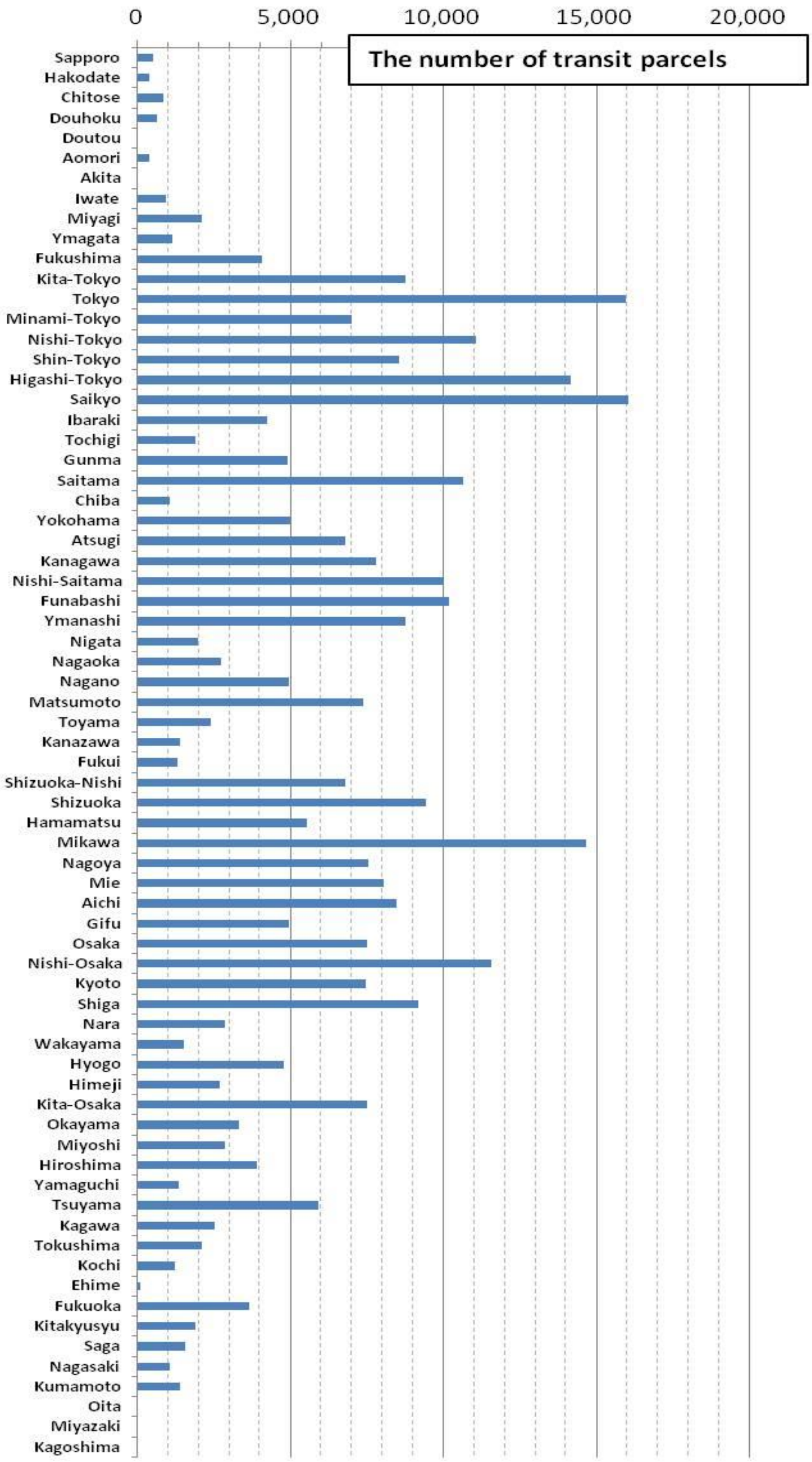

Figure 10 – The number of transit parcels in each terminal（Case.2）

Case.3（Selecting 2 hubs）

It is difficult to expand all terminals for considering costs for capital investment. In addition, the roads are limited for running semi-trailers in Japan. In the Case.3, every combination of hub terminals is selected in all 70 terminals.

Table.4 shows top 30 terminal combinations which achieve highest percentage of the total cost reduction in all 2,415 combinations. It is found out that at least one of the terminals in each of the top 30 combinations is located in Tokai region, the central region of Japan.

Table IV – Top 30 Terminals Combinations Achieving Highest Percentage of the Total Cost Reduction

hub 1	hub 2	percentage of total cost reduction	percentage of the number of trucks reduction	percentage of the transit parcels
Mikawa	Shiga	1.34%	1.14%	0.53%
Shizuoka-Nishi	Mie	1.33%	1.17%	0.70%
Mie	Aichi	1.33%	1.19%	0.62%
Mikawa	Mie	1.33%	1.17%	0.55%
Saikyo	Mie	1.32%	1.17%	0.82%
Nishi-Tokyo	Mie	1.32%	1.14%	0.73%
Nagoya	Shiga	1.32%	1.17%	0.62%
Mie	Shiga	1.32%	1.14%	0.55%
Nagoya	Mie	1.32%	1.12%	0.60%
Tokyo	Mikawa	1.32%	1.17%	0.87%
Saikyo	Nagoya	1.32%	0.99%	0.94%
Tokyo	Nagoya	1.32%	1.04%	0.91%
Shizuoka-Nishi	Nagoya	1.31%	1.07%	0.80%
Nishi-Tokyo	Nagoya	1.31%	1.12%	0.76%
Kita-Tokyo	Nagoya	1.31%	1.17%	0.94%
Aichi	Shiga	1.31%	1.17%	0.61%
Atsugi	Nagoya	1.31%	1.22%	0.74%
Kita-Tokyo	Mikawa	1.31%	1.07%	0.90%
Tokyo	Mie	1.31%	1.12%	0.82%
Shizuoka-Nishi	Mikawa	1.30%	1.12%	0.71%
Kanagawa	Nagoya	1.30%	1.12%	0.78%
Saikyo	Shiga	1.30%	1.02%	0.84%
Kita-Tokyo	Mie	1.30%	1.17%	0.68%
Shizuoka-Nishi	Aichi	1.30%	1.14%	0.74%
Shizuoka-Nishi	Shiga	1.30%	1.07%	0.65%
Shizuoka	Shiga	1.30%	1.17%	0.61%
Yamanashi	Mikawa	1.29%	1.12%	0.67%
Mikawa	Nishi-Osaka	1.29%	1.09%	0.59%
Mikawa	Aichi	1.29%	1.14%	0.69%
Kanagawa	Shiga	1.29%	1.14%	0.73%

The simulation result in terminals combination of Mikawa and Shiga which achieves maximum reduction is shown as Table.5. The effect of cost reduction tends to be smaller because the transits are restricted to certain terminals.Furthermore, the progress of the simulation shows transportation between Mikawa and Shiga is not utilized. This is because that the Mikawa and Shiga are too close to operate the semi-trailers.

Table V – The Conclusion of Case.3 (Mikawa and Shiga)

	Case.0	Before transit	After transit
Total cost (yen)	**594,391,859**	**594,695,755**	**586,719,406**
The number of trucks	**8,062**	**8,062**	**7,949**
	percentage		
Total cost reduction (compared with Case.0)	**1.29%**		
Total cost reduction (compared with before transit)	**1.34%**		
The number of trucks reduction (compared with Case.0)	**1.14%**		
The number of trucks reduction (compared with before transit)	**1.14%**		
The number of transit parcels (compared with total parcels)	**0.53%**		

DISCUSSION

The conclusions above give following four implications following.

1. Using larger trucks makes transit frequently.
2. Transits tend to take place at the terminal which locates near origin or destination.
3. Transits tend to occur at the terminals which are concentrated parcels.
4. In the Case.3, the percentage of total cost reduction between the near terminals tends to be higher than far terminals.

These implications and conclusions of each case also suggest subjects of the model in this paper.

First, we should distinguish next-day delivery from two-days-later or select kinds of trucks according to V_{ij} to increase total cost reduction.

Second, considering transportation schedules and increasing trucks between hub terminals is expected to express the actual operations better and transit more frequently than the present model. Transit terminals tend to select near terminals from origins or destinations and transport long distance loaded mixed parcels. In Case.3, however, total cost reduction tends to be high when the combination of near terminals is selected as hubs. It shows the number of trucks between hub terminals is not many. This is because that it is hardly permitted transiting twice for time restriction. Thus it is difficult to be constructed the hub-and-spoke network. Setting frequency of transportation is possible to solve some problems such as this.

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