Selection of city distribution locations in urbanized areas

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Abstract

This paper aims to apply a preference method for selecting optimal city distribution reloading locations in urbanized areas. The focus in the optimization is on trucks entering the urbanized area where the truck can choose between at least two locations with similar distances determined by a specified integer value generated randomly by a given interval. Results from a numerical example show that a sorting order of city distribution reloading locations with similar distance can be effectively obtained with this approach.

Keywords: Freight transportation; city distribution; reloading location; preference method

1. Introduction

With the continuing growth of urbanized areas, the demand for freight transport, not only between cities but also in cities, will continue to increase. Consequently, also the city distribution in urbanized areas will grow. More trucks used for city distribution will inevitably result in congestion and environmental pollution, such as emissions, noise, etc. City distribution consisting of satellites, vehicles and operations, as proposed by Crainic et al. can effectively resolve part of the congestion and sustainability problem [1]. This paper focuses on the problem of city distribution location selecting among alternatives associated with multiple evaluating indicators, and each candidate location has similar distance from the current position of the distribution truck. According to Al-Kloub et al. [2] and Ma et al. [3],

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Multiple attribute decision making (MADM) refers to the problem of selecting among alternatives associated with multiple attributes, so this problem belongs to the Multi-attribute decision making problems.

As shown in Fig.1, the selection of city distribution reloading locations during the process of organizing the city distribution in the urbanized area is, during city distribution process, when there have some reloading locations with similar travel distance (e.g., S1 and S3), trucks from external zones should select the most suitable location for freight transhipping into city-freighter by a certain mathematic method, the ordered preference technique with ideal solution.

In this paper, trucks, city-freighters, customer zone (the urbanized area e.g. shops and homes) and external zone (outside the urbanized area) are defined the same as Crainic et al. [1]. A customer corresponds to a cluster of stores or locations (e.g., homes) where freight actually originates or is delivered. Each customer zone is made up of several customers. It is of a rather small size and is assumed to be homogeneous with respect to its population density, land use, and commercial profile: what type of stores, their number, and so on. External zones represent locations outside the urbanized area, where the freight traffic to and from the cities originates. The intermodal hubs and terminals (e.g., ports, rail terminals, airports), as well as production and warehouses, located close to (but outside) the urbanized area, belong to that set.

Currently, trucks are used for freight distribution in the urbanized area, and in addition, city-freighters are used. This are vehicles with a relatively small freight loading capacity that can travel along the narrow and crowded streets of the city centres to perform the required distribution activities. These city-freighters should also be significantly more environment-friendly (e.g., electric or hydrogen-based traction), to contribute towards reaching the Kyoto emission targets and to reduce traffic-related noise and other perceived negative impacts of city distribution.

The similar distance is determined by a specified integer value $d$ generated randomly. $d_1$, $d_2$ are the positive real numbers that the policy maker determines. Then the distances from the locations to the current truck position belongs to range $[d_1, d]$ are regarded as the similar distance.

There are some preference indicators for each city distribution reloading location. At each location, it emphasizes the real-time co-ordination operation by using advanced communication, computing, and decision technologies based on Intelligent Transport Systems (ITS). For the problem of city distribution
locations selection in urbanized areas, the assumed condition is that there are city-freighters available at each location, with similar travel distance from the present travelling point to the location for the truck, at least more than two locations keep or so.

The research goals of this paper are: (1) to introduce a possible microscopic decision making technique for the integrated management of city distribution; (2) to introduce a random method selecting some locations with similar distances from current position; (3) to find out the solution which has the maximum closeness with the ideal solutions, namely, the most suitable location for freight reloading.

The paper is organized as follows. At the beginning of the paper, in Section 2, literature review of city distribution is introduced, and the related research literature is divided into three aspects: the inter-modal platforms for the city logistics organization, the planning and operation of distribution activities in urban regions, and the capacity utilization for urban vehicles. After that, the mathematic methods for selecting the city distribution location are described in Section 3, including reviewer of preference techniques and preference technique with ideal solution description, applying for resolving the problem put out in this paper. Then in Section 4, the numerical calculation and result analysis are carried out on the basis of the existing research data available in the literature with preference technique with ideal solution so as to prove the effectiveness and feasibility of this study. At the last of the paper, the different research work carried out in this paper is summarized, and the future research work is also put forward.

2. Literature review of city distribution

According to Demetsky, McDermott and Robeson, freight distribution has long been seen as an important component in urban congestion [4,5]. After that, the concept of ‘city distribution centres’ and ‘city logistics’ were promoted by Janssen and Oldenburger [6], Ruske [7], and Taniguchi et al. [8], emphasizing the sustainability of the distribution system. During the last two decades, researches focused on the transhipment platforms for the city logistics organization, the planning and operation of distribution activities in urban regions, and the capacity utilization for urban vehicles.

For the transshipment platforms for the city logistics organization, according to van Duin the centralized distribution, organized at a distribution centre at the edge of a city, was thought to provide a firm basis for improvement of the quality of the inner city [9]. Crainic et al. [1] introduced a possible organizational and technological framework for the integrated management of urban freight transportation and identified a number of important associated planning and operational issues and the corresponding Operations Research models. A formulation for one of these problems and the design of the proposed logistical structure were also described, and the model city and challenge is Rome.

According to Crainic et al. [1], distribution process using satellite platforms, based on Intelligent Transportation Systems (ITS), Commercial Vehicle Operation (CVO) systems and Advanced Fleet Management Systems (AFMS), can be described as Fig. 2. The platform consists of vehicles including trucks and city-freighters, satellites, and operations. Satellites are city distribution locations where freight is transhipped from normal trucks to city-freighters for distribution within the city centre. Satellites are locations where freight is transhipped from normal trucks to city-freighters for distribution within the city centre, such as existing installations including underground parking lots, municipal bus depots and other existing freight location for cargo operations, without any storage facilities, trans-dock transhipment being the operational model. And these are also the facilities are highlighted in this research.

The freight packaged in transport units, such as roll-container, pallet and box, coming from various external zones may be transhipped from trucks to city-freighters at satellites for city distribution within the core congested urban areas, to the customer zones. Each customer zone is of a rather small size and is assumed to be homogeneous with respect to its population density, land use, and commercial profile. A centroid is associated to each external zone and customer zone.
For the planning and operation of distribution activities in urban regions, Crainic and Laporte [10] classified the various decisions and management policies according to the three planning levels: 1) Strategic (long term) planning at the firm level typically involves the highest level of management and requires large capital investments over long time horizons; 2) tactical (medium term) planning aims to ensure, over a medium term horizon, an efficient and rational allocation of existing resources in order to improve the performance of the whole system; and, 3) operational (short term) planning is performed by local management (masters of city distribution location and dispatchers, for example) in a highly dynamic environment where the time factor plays an important role and detailed representations of vehicles, facilities and activities are essential. In strategic planning, location models studied include: covering models, centre models and median models, network design models, and regional multimodal planning. Tactical planning research includes: service network design for inter-modal transportation and vehicle routing problems. Dynamic model to support carrier operations and capacitated routing with uncertainties are studied for operational issues. Van Binsbergen and Visser [11] Analyse, develop possible solutions for the problems related to urban goods distribution, and establish an integrated concept for an efficient goods distribution process for urban areas. The authors also develop a comprehensive policy plan for implementing effective policy measures, which aims at improving the efficiency of the goods distribution process for urban areas. Toth and Vigo [12] studied the branch-and-bound algorithms for the capacitated (with the weight or volume limitation) vehicle routing problem. Ljungberg and Gebresenbet [13] mapped out city centre goods distribution in Uppsala, Sweden, in order to investigate the potential for coordinated goods distribution to reduce cost, congestion and environmental impact. Qualitative and quantitative data were collected using questionnaires, interviews and measurements at loading and unloading zones for retail shops.

For the capacity utilization for urban vehicles, Morris et al. [14] analyzed data from 74 “Freight Mobility Interviews”—surveys conducted with key transportation executives whose products and services are shipped into New York City’s central business district (CBD). Quantitative data collected included company profiles, defined by product category; kind of transportation service; type of distribution channel; characteristics of dispatched truck trip; and time and cost for last leg of the trip.

What we shall do in this paper is to carry out the research on the aspect of the transhipment platforms for the city logistics organization. Namely, how to select the most suitable location among the transhipment sites with the given similar distance, and the ordered preference method is used to get the suitable solution.
3. Mathematic method description

3.1. Preference techniques

For preference techniques, Timmermans et al. discussed some stated versus revealed preference models for housing preference and choosing processes. There are two kinds of models for the stated models: algebraic models and non-algebraic models [15]. Algebraic models include compositional models which housing preference structures are estimated by recording separately and explicitly how people evaluate housing attributes and by measuring the relative importance of each attribute [15,16]. The conjoint preference models studied by Joseph et al. are also belong to it and the models are based on the measurement of people’s evaluations of housing profiles, which being compiled according to the principles underlying the design of statistical experiments [17]. All of these models assume that simple algebraic rules can be used to represent people’s utility functions for housing, and the simple algebraic rules have specific behavioural implications. The algebraic models by definition cannot represent more complicated if-then structures, hence, as an alternative to the algebraic models, many different qualitative model approaches have been suggested, namely, non-algebraic models. The main advantage of this approach over the algebraic rules is its flexibility. Many different kinds of assumptions can be made, and the simulation can be as creative as one can imagine. But this may also be the main disadvantage of this approach, and it lacks the theoretical and analytical rigor of the conjoint choice models.

The revealed models established by Timmermans et al. [15], Adamowicz et al. [18] are based on observations of housing choices in real markets and such housing choice data is assumed to reflect people’s preferences. The modelers’ task is to examine whether some assumed preference structure will adequately describe observed housing patterns. This approach has been successfully applied in many different housing preference and housing choice studies. But it has a fundamental disadvantage: it is very difficult to disentangle preference from disequilibrium conditions in the marketplace.

In this paper, the problem studied belongs to the MADM problems, so we will make some reviewers for several common techniques, such as Technique for Ordered Preference by Similarity to Ideal Solution (TOPSIS)[19, 20, 21, 22, 23], the Analytic Hierarchy Process (AHP) [24, 25, 26, 27], Gray Relational Analysis (GRA)[28, 29, 30, 31, 32].

For the TOPSIS, the baseline of TOPSIS is rather straightforward, and it originates from the concept of a displaced ideal point from which the compromise solution has the shortest distance [19, 20]. Later on, Hwang and Yoon further concluded that the ranking of alternatives are based on the shortest distance from the Positive-ideal solution (PIS) and the farthest distance from the Negative-ideal solution (NIS) [33], as shown in Fig. 3.

TOPSIS simultaneously considers the distances to both PIS and NIS, and a preference order is ranked according to their relative closeness, and a combination of these two distance measures. The operations within the TOPSIS process include: decision matrix normalization, distance measurements, and aggregation operators. For MADM, a decision matrix is usually required prior to the beginning of the process and it contains competitive alternatives row-wise, with their attributes’ ratings or scores column-wise. Normalization is an operation to make these scores conform to or reduce to a norm or standard. According to Yoon and Hwang [34] and Milani et al. [22], a few common normalization methods are organized and they are classified as vector normalization, linear normalization, and non-monotonic normalization to fit real-world situations under different circumstances. Originally, TOPSIS utilized Euclidean distances to measure the alternatives with their PIS and NIS so that the chosen alternative should have the shortest distance from the PIS and the farthest distance from the NIS. In fact, there are a couple of common distance measurements, i.e., Minkowski’s $L_p$ metric in an n-dimensional space, where $p$ is the set of all positive integers and $p \geq 1$ [35]. Weighted $L_p$ metric and the measurements
can be considered as the judgment in making a choice. According to Shih et al. [23], a group TOPSIS model is proposed for decision making. It is rather simple to use and meaningful for aggregation, and will not cause more computational burden than the original TOPSIS. While after examining the necessity of incremental analysis for MADM, Shih applied it for group TOPSIS and developed the 11-step procedure for evaluation, which proved to be robust and effective [36].

For the gray relational analysis technique, proposed by Deng [37], is a method that can measure the correlation between series and belongs to the category of data analysis method or geometric method. The measured series can be time series, indicator series, etc. In recent years, this method is used constantly to resolve MADM. The method of gray related analysis to multiple attribute decision making problems with interval numbers is given by Zhang [29], which concerned interval fuzzy input parameters. An integrated methodology of performing an ordered pair of materials and end-of-life product strategies for the purpose of material selection, including the technical factor, economic factor and the environmental factor, are presented by Chan and Kumar [31] for a manufacturing enterprise. In their methodology, it was proposed to use gray relational analysis, the multi-criteria weighted average in decision-making process to rank the materials with respect to several criteria. Kuo et al. [30] used gray relational analysis for solving multiple attribute decision-making problem of picking the best from among multiple available alternatives. Lin et al. [32] proposed a practical expert diagnosis model which mainly adopted the gray relational analysis technique, a data analytic method based on the generalized distance function, to discriminate the normal objects and abnormal objects. Gray related analysis and Dempster–Shafer theory are used to deal with supplier selection in a fuzzy group setting, and gray related analysis is employed as a means to reflect uncertainty in multi-attribute models through interval numbers [38].

For the Analytic Hierarchy Process, according to Vaidya and Kumar [27], it is an Eigen value approach to the pair-wise comparisons. It also provides a methodology to calibrate the numeric scale for the measurement of quantitative as well as qualitative performances. The scale ranges from 1/9 for ‘least valued than’, to 1 for ‘equal’, and to 9 for ‘absolutely more important than’ covering the entire spectrum of the comparison.

In this paper, AHP is used to obtain subjective weight vector of all attributes for getting the decision matrix, and decision managers working in transhipment dispatch centre in Shanghai City and Chengdu City at present are the respondents to the survey for the AHP analysis, so as to decide the importance degree of each indicator. But the weight vector of all attributes is still subjective, so objective weight vector is gained by Entropy method [39, 40, 41], and combination weights is calculated by the multiplication synthesis. This will be described later.

The positive-ideal solution and negative-ideal solution could be got by TOPSIS technique, and the gray correlation between each solution and the positive-ideal solution or the negative-ideal solution could be
got by GRA separately. So here the ideal transhipment location is got on the basis of TOPSIS method and the gray correlations between each location and the positive-ideal location or the negative-ideal solution are got on the basis of gray correlation technique.

3.2. Preference technique with ideal solution

Preference Technique with Ideal Solution is constructed in this paper to make an ordered preference for the transhipment locations with similar distance. The method is described in the following:

First of all, the weighted standardized matrix $U$ of all indicators is calculated on the basis of the combination weights $Z_j$ of all indicators, which is decided by an integrated approach proposed by Ma et al. (1997), so that the resulting attribute weights and rankings of alternatives could reflect both the subjective considerations of a decision making and the objective information. Analytic Hierarchy Process is used here to determine the subjective weight vector and Entropy method is used to determine objective weight vector. The multiplication synthesis is used to make combination weights for the subjective weight and the objective weight. The weighted standardized matrix $U$ is calculated with the combination weight vector $Z$.

After that, the positive-ideal solution $U_0^+$ and negative-ideal solution $U_0^-$ of all indicators are calculated. Then the gray correlation grade $R^+$ between all the solutions and positive-ideal solution, the gray correlation grade $R^-$ between all the solutions and negative-ideal solution is determined respectively.

Then the closeness (Balakrishnan et al., 2010; Dangalchev, 2006; Pornsakulvanich et al., 2008; Bove and Johnson, 2001) between the current solution and positive-ideal solution $R^i_+$ or negative-ideal ideal solution $R^-i$ is determined respectively. So the closeness of each solution $C_i(i = 1,2,...,m)$, with $m$ being the number of solutions, is calculated. The descending order is got from all $C_i$ and the first one is our choice.

4. Example calculation and result analysis

4.1. Example description

The data of the example is from the research of Crainic et al. [1], shown as in Table 1. There are six reloading city distribution locations (CDL) $B_i(i = 1,2,...,6)$, including location $B_1$, $B_2$, $B_3$, $B_4$, $B_5$ and $B_6$. Each city distribution location (CDL) would not perform any other activity and there would be no significant physical installations and no warehousing. The distance from the city distribution location $B_i$ to the location of current truck is represented by the symbol of $d(i = 1,2,3,4,5,6)$. A specified integer value $d$ generated randomly [8,11] is 10, and the similar distance range is [8,10]. So the CDL with the familiar distance are $B_1$, $B_2$, $B_3$, $B_4$, $B_5$. There are five evaluating indicators $A_j(j = 1,2,3,4,5)$ for each location. Indicator $A_1$ is the average transhipment time of one city-freighter on location $i$. Indicator $A_2$ is the fixed cost on location $i$. It is composed of the acquisition cost of the fleet of city-freighters and its subsequent maintenance, including the construction or installation satellite location for the city-freighters, the operation of the satellites corresponding to the salaries of co-ordination (and, eventually, transfer) personnel, and driver costs. Indicator $A_3$ is the freight average transhipment cost on location $i$. Indicator $A_4$ is the maximum number of trucks on location $i$ and indicator $A_5$ is the maximum number of city-freighters on location $i$. Variable $x_{ij}$ is the $j$-indicator value with location solution $i$ and $j$. Capacities are in
vehicle/hour, the unit of time is the minute, the unit of freight average transhipment cost is the USD/ton, and unit of the fixed operational cost on location is in 1000 USD.

Table 1. Data of locations and indicators

<table>
<thead>
<tr>
<th>Location</th>
<th>Location</th>
<th>(A_1) (min)</th>
<th>(A_2) (thousand USD)</th>
<th>(A_3) (USD/ton)</th>
<th>(A_4) (T/h)</th>
<th>(A_5) (Veh/h)</th>
<th>(d_i) (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B_1</td>
<td>0.17</td>
<td>2000</td>
<td>100</td>
<td>60</td>
<td>120</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>B_2</td>
<td>0.17</td>
<td>3750</td>
<td>100</td>
<td>180</td>
<td>480</td>
<td>8.8</td>
<td></td>
</tr>
<tr>
<td>B_3</td>
<td>0.17</td>
<td>2000</td>
<td>100</td>
<td>60</td>
<td>120</td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td>B_4</td>
<td>0.17</td>
<td>3750</td>
<td>100</td>
<td>180</td>
<td>480</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>B_5</td>
<td>0.17</td>
<td>2500</td>
<td>100</td>
<td>120</td>
<td>240</td>
<td>9.3</td>
<td></td>
</tr>
<tr>
<td>B_6</td>
<td>0.17</td>
<td>3750</td>
<td>100</td>
<td>180</td>
<td>480</td>
<td>10.6</td>
<td></td>
</tr>
</tbody>
</table>

4.2. Weighted standardized decision matrix of all indicators

The subjective weight vector determined by the Analytic Hierarchy Process is \(\alpha_j = (0.5388, 0.0822, 0.1517, 0.0919, 0.1354)\), and the objective weight vector determined by the Entropy method is \(\beta_j = (0.0000, 0.1299, 0.0000, 0.3386, 0.5315)\). The multiplication synthesis calculated by equation (1) is used to make combination weights \(\omega_j\) for the subjective weight \(\alpha_j, (j = 1, 2, 3, 4, 5)\) and the objective weight \(\beta_j, (j = 1, 2, 3, 4, 5)\):

\[
\omega_j = \frac{\alpha_j \beta_j}{\sum_{j=1}^{n} \alpha_j \beta_j}, \quad j = 1, 2, ..., n \tag{1}
\]

Symbol \(n\) is the number of indicators. Then the combination weight vector is \(\omega = (\omega_1, \omega_2, \omega_3, \omega_4, \omega_5) = (0.0000, 0.0938, 0.0000, 0.2736, 0.6326)\).

The decision matrix is \(X = (x_{ij})_{mn} = \begin{bmatrix} 0.17 & 2000 & 100 & 60 & 120 \\ 0.17 & 3750 & 100 & 180 & 480 \\ 0.17 & 2000 & 100 & 60 & 120 \\ 0.17 & 3750 & 100 & 180 & 480 \\ 0.17 & 2500 & 100 & 120 & 240 \end{bmatrix}\), and the standardized matrix \(Y\) of the decision matrix \((x_{ij})_{mn}\) is \(Y = (y_{ij})_{mn}\) with \(y_{ij}\) being calculated by equation (2)

\[
y_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad (1 = 1, 2, ..., m, j = 1, 2, ..., n) \tag{2}
\]
The weighted standardized matrix is calculated by
\[ Y = (y_{ij})_{m \times n} = \begin{bmatrix} 0.4472 & 0.3072 & 0.4472 & 0.2041 & 0.1622 \\ 0.4472 & 0.5761 & 0.4472 & 0.6124 & 0.6489 \\ 0.4472 & 0.3072 & 0.4472 & 0.2041 & 0.1622 \\ 0.4472 & 0.5761 & 0.4472 & 0.6124 & 0.6489 \\ 0.4472 & 0.3840 & 0.4472 & 0.4082 & 0.3244 \end{bmatrix} \]

4.3. Gray correlation grade between all the solutions and the ideal solution

The positive-ideal solution \( U_0^+ \) of all indicators is
\[ U_0^+ = \left\{ \left( \max_{1 \leq i \leq n} u_{ij} \right), \left( \min_{1 \leq j \leq m} u_{ij} \right) \right\} = (u_0^+(1), u_0^+(2), \ldots, u_0^+(m)) = (0.0000, 0.0288, 0.0000, 0.1675, 0.4105), \]
and the negative-ideal solution \( U_0^- \) of all indicators is
\[ U_0^- = \left\{ \left( \min_{1 \leq i \leq n} u_{ij} \right), \left( \max_{1 \leq j \leq m} u_{ij} \right) \right\} = (u_0^-(1), u_0^-(2), \ldots, u_0^-(m)) = (0.0000, 0.0541, 0.0000, 0.1675, 0.4105). \]

Set \( J^+ \) is the bigger the better values and set \( J^- \) is the smaller the better values. Symbol \( u_0^+(j) \) is the best positive-ideal solution of indicator \( j \) and symbol \( u_0^-(j) \) is the best negative-ideal solution of indicator \( j \). For example, for the indicator \( A_i \) in the data calculation, the average time of reloading of city-freighter on location \( i \), the best positive-ideal solution of this indicator should be the smallest value of all the locations, and the best negative-ideal solution of this indicator should be the bigger value of all the locations.

Then the gray correlation grade \( R^{++} \) between all the solutions and positive-ideal solution is
\[ R^{++} = (R_1^{++}, R_2^{++}, \ldots, R_m^{++}), \]
the gray correlation grade \( R^{++}_i \) between the solution \( i \) and the positive-ideal solution is calculated by equation (3).

\[ R^{++}_i = \frac{1}{n} \sum_{j=1}^{n} r^{++}_{ij}, \quad (i = 1, 2, \ldots, m) \quad (3) \]

Gray correlation coefficient \( r^{++}_{ij} \) of both the solution \( i \) and the positive-ideal solution for the \( j \)-indicator is calculated by equation (4).

\[ r^{++}_{ij} = \frac{m + \xi M}{\Delta_i(k) + \xi M} \quad (4) \]
Here, $\Delta_i(k) = |u_i^*(k) - u_i(k)|$, $m = \min\Delta_i(k)$, $M = \max\Delta_i(k)$, and the symbol $\xi$ is the identification coefficient, the value is 0.5. As a result, $R^*$ is

$$
R^* = \begin{bmatrix}
1.0000 & 1.0000 & 1.0000 & 0.5795 & 0.3333 \\
1.0000 & 0.8589 & 1.0000 & 1.0000 & 1.0000 \\
1.0000 & 1.0000 & 1.0000 & 0.5795 & 0.3333 \\
1.0000 & 0.8589 & 1.0000 & 1.0000 & 1.0000 \\
1.0000 & 0.9553 & 1.0000 & 0.7340 & 0.4285
\end{bmatrix}, \quad \text{and } R^{**} = (0.7826, 0.9718, 0.7826, 0.9718, 0.8236).
$$

Similarly, the gray correlation grade $R^-_{ij}$ between all the solutions and negative-ideal solution is $R^- = (R^-_1, R^-_2, \ldots, R^-_{i}, \ldots, R^-_n)$, and the gray correlation grade $R^-_{i}$ between the solution $i$ and the negative-ideal solution is calculated by equation (5).

$$
R^-_{i} = \frac{1}{n} \sum_{j=1}^{n} r^-_{ij}, \quad (i = 1, 2, \ldots, m) \tag{5}
$$

Gray correlation coefficient $r^-_{ij}$ of the solution $i$ and the negative-ideal solution for the $j$-indicator is calculated by equation (6).

$$
r^-_{ij} = \frac{m + \xi M}{\Delta_j(k) + \xi M} \tag{6}
$$

Here $\Delta_j(k) = |u_j^*(k) - u_j(k)|$, $m = \min\Delta_j(k)$, $M = \max\Delta_j(k)$. As a result, $R^-$ is

$$
R^- = \begin{bmatrix}
1.0000 & 0.8589 & 1.0000 & 1.0000 & 0.5795 & 0.3333 \\
1.0000 & 1.0000 & 1.0000 & 0.5795 & 0.3333 \\
1.0000 & 0.8589 & 1.0000 & 1.0000 & 1.0000 \\
1.0000 & 1.0000 & 1.0000 & 0.7340 & 0.4285 \\
1.0000 & 0.8948 & 1.0000 & 0.7336 & 0.6001
\end{bmatrix}
$$

and $R^- = (0.9718, 0.7826, 0.9718, 0.7826, 0.8457)$.

4.4. Gray correlation closeness of all indicators and result analysis

After calculating the corresponding gray correlation grade $R^+_i$ between the solution $i$ and the positive-ideal solution, the gray correlation grade $R^-_i$ between the solution $i$ and the negative-ideal solution, the closeness of each solution is calculated by equation (7).

$$
C_i = \frac{R^+_i}{R^+_i + R^-_i}, \quad (i = 1, 2, \ldots, m) \tag{7}
$$
The gray correlation closeness for all indicators is \( C = (c_1, c_2, \ldots, c_n) \). The result is \( C = (0.4461, 0.5539, 0.4461, 0.5539, 0.4934) \) and the descending order is \( 0.5539 = 0.5539 > 0.4933 > 0.4461 = 0.4461 \), namely \( C_2 = C_4 > C_3 = C_1 \). So location \( B_2 \) or \( B_4 \) is our preference.

5. Conclusion

Based on the research of city distribution, especially the research of the transhipment platforms for the city logistics organization[1,9], and from the more microscopic point of view, the paper focus on the study of the optimal choice for the city distribution transhipment locations with similar distances, which determined by a specified integer value generated randomly by a given interval. Example shows applying the preference technique with ideal solution for choosing the optimal transhipment location will supply the effective decision solution for the Vehicle Scheduling Management Centre and the truck driver during the city distribution activities.

But this research is carried out on the basis of some ideal conditions, without considering the traffic real-time state from the truck present location point to the transhipment location point, traffic jam, road construction, incidents, etc. So the research work considering traffic jam delay time indicator \( A_6 \), traffic incident delay time indicator \( A_7 \), in additional to all the indicators considered in the example, need to be carried out in the future. In addition, the decision managers working in transhipment dispatch centre in two cities responded well to this analysis results in the paper, but the results might not be appropriate to city administrators or residents, so, the research work taking their coordination into consideration also need to be done.

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