Model Evaluation and Ranking of How to Optimize the Transport of Container Shipping Companies Using TOPSIS Technique

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Abstract. Today, along with enhancement of social well-being and economic development, demand for transportation is growing increasingly. Many countries are seeking for providing transportation services at a reasonable price. Therefore, optimization of carrying goods on national or international roads is highly important in terms of costs and transportation indicator, so that the goods are shipped at minimum costs and maximum profit for the forwarding agencies. For this purpose, the limitations should be identified. In this paper, considering critical indicators and various modes of transportation, we attempt to choose and rank the best option with respect to pre-defined criteria imposing least costs. The indicators and criteria determined in this research for selecting the best mode of container loading are those introduced by transport experts (sima marine shipping company) based on the their importance for the company. These indicators include forwarding charges, volume of containers and quantity of portable containers (20ft and 40ft), which

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are not equally important and each has been given a weight by company's experts, the total of which equals one. To use the weights in a logical manner, shannon entropy technique was applied. Our aim in this research is selection of the best option for carrying the containers under conditions which the demand for the goods to be shipped overweighs the capacity of the ship, known as critical point in loading the containers. To achieve this aim, for ranking containerized shipping a multi-criteria decision analysis method called topsis is used to rank m options against n criteria.

Keywords: Shannon entropy; topsis; critical point; transportation pattern; multi-criteria decision analysis.

1. Introduction

Due to the trend of globalization, economic corporations are willing to expand the level of their activities. This expansion and great distances between origins and destinations, an increase in costs is inevitable. As a result, reduction of costs is an engagement for managers and organizations. One principal solution to reduce costs or maximize the profits arising from any container to be exported is an accurate model and a plan for optimal selection of shipments and containers (salimi, 2012). In some cases, high demand and low capacity of vessels is a major constraint. It is hard to select least costly and most profitable containers. Transportation is a dynamic, comprehensive and complicated phenomenon, different branches of which nurtures and invigorates roots of economic vitality. Promotion of present societies is measured by development criteria in transportation sector and the level of utilization of society members of these facilities. Using topsis technique as a remedial multi-criteria decision analysis method, this article tries to compare the obtained funds notwithstanding the constraints and define important indicators (adell and rajabzadeh, 2010). Since 1950, containerized traffic has been growing as safety increased and costs, duration of shipping and multi-modal transport decreased. In most forwarding companies, the cargoes are carried in a containerized form (20ft to 40ft, in iran) that is a great technological development in international transportation network.

This development has spread quickly throughout the world, particularly to persian gulf states and the middle east because of special advantages it provides. Unification is required due to goods differences in size, weight, chemical specifications, etc. And for efficient shipping. In fact, containerization is a general method for unification to carry the shipment more easily, more quickly and at a lower cost. A dominant policy of ports in recent decades was construction of specialized container terminals and addition of machines and relevant infrastructure. Rejecting this change and ignoring containerized shipping will certainly be followed negative impacts for the national economy as well as shipping industry. The negative impacts are: ports lacking container facilities certainly will not be referred by shipping lines, losing some of their trade partners. As containerized and integrated shipping is relatively viable, those ports and agencies, refusing to

join this system will lose a market share. Since the shipping agencies are impacted by the trading companies, ignoring the containerized system will cause negative effects in commercial transactions of developing countries (shakibinasab, 2012).

Figure 1. Shipping process in shipping companies

2. Theoretical Background

The use of topsis has been increasing in transportation industry since it was first introduced. In 2004, an article under the tile of 'selecting an optimal irrigation system for sugarcane plantations using the topsis method' was published, in which the author had used topsis technique

to select the best method for carrying sugarcane through identification of some effective qualitative factors (moameni and eghbal, 2004). In another research in 2012-'selection of a logistical shipping company using analytical hierarchical process (ahp) and topsis'-the goal was selection of a transportation mode among a number of available options against multiple criteria by using ahp for finding the relative weight of each criterion and topsis for ranking the options (farizanifarsangi, 2012). In 1996, a paper on strategies of transportation and site selection of leather industries and with regard to qualitative factors has solved the problem using fuzzy topsis (ftopsis) (ahmadi and hoori, 1996). In our research, we attempted to apply quantitative criteria to facilitate and scrutinize the ranking, and for determining the weights adjusted them using shannon entropy in addition to asking for expert opinions and converted them to a regular range. These are particularities of this research in transportation industry compared to previous studies.

3.   The Hypothesized Model

Here, according to conceptual model, efforts are made to

  1) describe how consignments are shipped
  2) mention how important the selection is,
  3) how shipping options are prioritized and
  4) how the process is selected and scheduled for shipping.
  The conceptual model is as follows

4.   Research Methodology

Methodologically, this work is a model designing of a descriptive or pilot type. It is an applied one based on the information from a shipping company (sima marine), the results of which van be used in order to improve shipping conditions under critical and sensitive circumstances in terms of limited loading capacity and diversity of containers. The prioritization process for various modes of transportation is based on technical

and economic information provided by sima marine company. This information includes:
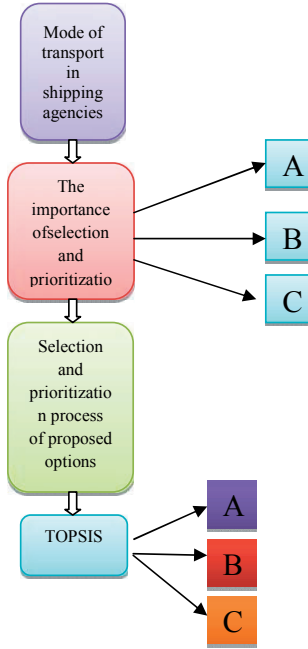

Figure 2. A conceptual model for representation and description of the process

1.shipper's capacity (tons)

2. number of portable containers

3.weight and dimensions of each container Shipping charges for each container (riahi, 2012).

Following technical and economic information was obtained and modes of transportation were determined by the company based on experts' opinions. The options should be ranked and prioritized regarding capacity of the shipper and the load carried in each mode according to the criteria, conducted by topsis. Of course, there are more techniques for prioritization the modes and the proposed options such as cost-benefit analysis, net profit value (NPV), equivalent uniform annualized cost (EUAC) and equivalent uniform annualized benefit(EUAB) used in a variety of conditions (oskoonegad, 2010).

Since the containerized transportation system is not operating in a desirable manner, its obvious examples are seen in internal transportation. Under current conditions, internal road and railway sector does not have devices needed for carrying containers. The existing traditional machineries work in containerized shipping using some apparatuses or in months when the demand for shipping is high, limiting the capacity of the vehicles (shakibinasab, 2012). Regarding this approach, prioritization and selection of an optimal option in order to reduce transport costs and increase profits is the main goal of this article. We are not looking for a solution to select a site considering costs and times of each one, but we are going to find a solution to select optimally and determine necessary priorities of shipping goods under conditions of limited capacity resulting in reduction of selection cost for all containers. To do this, one can use multi-criteria decision analysis method (madm), which we used topsis technique to rank and select an optimal option with respect to predetermined criteria (fadavi, 2011).

Topsis (technique for order preference by similarity to an ideal solution) model introduced by hwang and yoon (1981) which is an operational design approach that helps select the optimal levels of service quality attributes that would facilitate the delivery of customer satisfaction.

Topsis views a multi-attribute decision making problem with m alternatives as a geometric system with m points in the n-dimensional space(young, j.a. and varble, d.l, 1997).

The method is based on the concept that the chosen alternative should have the shortest distance from the positive-ideal solution and the longest distance from the negative-ideal solution (yoon and hwang, 1995). This technique can be extremely useful for service design. Similarly, loss function is better suited to highlight the future long-term damage caused by not delivering on customer-defined service standards (nejati et al., 2009). The topsis procedure consists of the following steps (yoon and hwang, 1995): (1) create decision matrix (n) and calculate the normalized decision matrix(nd). Relation 1:

$$N_{ij} = \frac{A_{ij}}{\sqrt{\sum_{I=1}^{n} a_{ij}^2}}, \quad j = 1, ..., n$$

Where i is the number of alternatives, j is the number of indicators and n_{ij} is the normalized of alternative i forindicatorj. (2) calculate the weighted normalized decision matrix (v). Relation 2:

$$V = nd * W_{n*n}$$

Where $w_{n \times n}$ is the importance (weight) of each indicators. (3) determine the ideal (A^+) and negative-ideal solution (A^-).

$$A^+ = \{(Max_i V_{ij}|J \in j), (Min_i V_{ij}|J \in \acute{j})|I = 1, 2, 3, ..., m\} = \{V_1^+, V_2^+, ..., V_n^+\}$$

$$A^- = \{(Min_i V_{ij}|J \in j), (Max_i V_{ij}|J \in \acute{j})|I = 1, 2, 3, ..., m\} = \{V_1^-, V_2^-, ..., V_n^-\}$$

(4) calculate the sum of distances from positive and negative ideal for each indicator. Relation 3:

$$D_i^+ = \sqrt{\sum_{J=1}^{n} (V_{ij} - V_j^+)^2}, \quad i = 1, 2, ..., m$$

Relation 4:

$$D_i^- = \sqrt{\sum_{J=1}^{n} (V_{ij} - V_j^-)^2}, \quad i = 1, 2, ..., m$$

(5) calculate the relative closeness to the ideal solution (CL^*)).
Relation 5:

$$Cl_i^* = \frac{D_i^-}{D_i^+ + D_i^-}$$

5. Findings

Technical and economical information of the company together with the quantity of containers to be carried on the critical point-a time, when demand for carrying overweighs capacity of the ship should be prepared. Table1 shows the state of a ship on the critical point, load carried by a ship over beyond its capacity (50000 tons) (i.e. there are 62000tons of containerized cargoes on the ship, 12000 tons more than ship's capacity) (riahi, 2012) so that various modes of loading and shipping will be determined and prioritized based on contents of table1, with minimal costs.

**Table 1:** Technical and economical information of portable containers

Number of containers by types of goods	2500	2500	4500	3000	5000	3000
Weight of containers (tons)	2	4	2	4	4	2
Cost for each container ($)	10	50	10	50	50	10
Total costs ($)	25000	125000	45000	150000	250000	30000

Table 2: Proposed options for container transportation in critical point

	Costs of proposed Options for containers ($)	Weight of all containers In each option (ton)	Arrangement of portable Containers in each option
A₁	555000	48000	3000 *2+2500*4+3000*4+5000*4
A₂	475000	47000	4500*2+3000*4+5000*4+3000*2
A₃	550000	47000	3000*4+5000*4+2500*4+2500*2

According to table1 and opinions of the company's experts as well as considering abilities and facilities of the company, option 3 was proposed for container transportation under critical conditions, which the capacity of ship in each option should be less than 50000 tons. As seen in table2, three proposals were introduced by the company's experts for container transportation. Container arrangement, weight and costs were determined for each mode.

In the following diagram, various modes of the proposed options are shown by the company's experts to compare various parameters to each other.
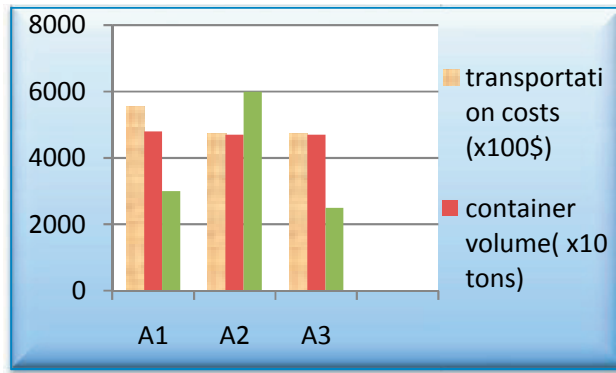
This matrix includes proposed options and concerned indices for assessing the options. Columns contain 4indices and rows contain 3 options proposed by experts of sima marine shipping company. In this matrix, cost index is negative for options and it is positive for other indices

Table 3: Decision matrix including options and indices

Indices\Options	Transportation costs (x100$)	Container volume (x10 tons)	Number of 20ft containers	Number of 40ft containers
A_1	-555000	48000	3000	10500
A_2	-475000	47000	6000	8000
A_3	550000-	47000	2500	10500

In a decision matrix, as the determined indices are not the same, weighted normalized matrix (v) should be calculated to be able to perform assessment and ranking procedure based on topsis, and to find acceptable and distinct results. Before the decision matrix is normalized, index weight matrix $(w_{n \times n}) - a$ diameter matrix- should be calculated-for which we used shannonentropy technique (mohammadpour, 2011). Based on shannon entropy, a diameter matrix $(w_{4 \times 4})$ should be calculated in the following process, where the entries on the main diameter are weights obtained by shannon entry technique.

This technique depends on entries of decision matrix so that we can calculate the information content of a decision matrix in the form of (p_{ij}) as follows.

$$P_{ij} = \frac{A_{ij}}{\sum_{I=1}^{m} a_{ij}}$$

Where a_{ij} = entries of decision matrix (asgharpour, 2011) other stages of this technique and the results are given in table 4.

Table 4: Relations and stages of shannon entropy for calculating adjusted weights

$E_j =- k\sum_{i=1}^{3}[p_{ij} . \text{Ln } p_{ij}]; \forall j$ $K= \frac{1}{\ln 3}$	$D_j = 1- e_j ; \forall j$	$W_j= \frac{D_j}{\sum_{j=1}^{4} d_j} ; \forall j$	$W_j^*= \frac{\Gamma_j . W_j}{\sum_{j=1}^{4} \gamma_j . w_j} ; \forall j$
$E_1 = 0.999$	$D_1 = 0.001$	$W_1 = 0.012$	$W_1^* = 0.024$
$E_2 = 0.999$	$D_2 = 0.001$	$W_2 = 0.012$	$W_2^* = 0.018$
$E_3 = 0.929$	$D_3 = 0.071$	$W_3 = 0.876$	$W_3^* = 0.905$
$E_4 = 0.992$	$D_4 = 0.008$	$W_4 = 0.098$	$W_4^* = 0.05$

According to table contents, (γ_j) oral weight values were determined for costs, container volumes, number of 20-feet containers, number of 40-feet containers to be 0.4 0.3 0.2 0.1, respectively by the transportation agency experts, and the weights obtained by shannon entropy including w_j^* values are seen in table 4. With regard to explanations presented in section 4.1, this research deals with ranking transportation options. Table 5 shows weightedand normalized decision matrix (v) together with positive state (a_j^+) and negative states (a_j^-). It also shows the remaining stages of topsistechnique for ranking including euclidean distance against positive (d_i^+) and negative (d_i^+) ideal solutions as well as relative closenessof options (a_i) to the ideal option (c_i).

Table 5: Weighted and normalized matrix and positive/negative ideal solutions

Indices / Options	Transportation costs	Container volume	Number of 20 ft containers	Number of 40 ft containers
A_1	-0.014	0.01	0.379	0.033
A_2	-0.012	0.01	0.758	0.023
A_3	-0.014	0.01	0.315	0.031
A_j^+	-0.012	0.01	0.758	0.033
A_j^-	-0.014	0.01	0.315	0.023

Following the calculations of weighted normalized matrices and positive/negative ideals states in table 5, as mentioned earlier, other topsis stages are conducted for final ranking: figure 3. The distance of options from positive and negative ideal states $(d_i^- - d_i^+)$ as well as relative closeness (cl_i^*)

$d_1^+ = 0.370$	$d_1^- = 0.064$	$d_1^+ = 0.01$	$d_1^- = 0.442$	$d_1^+ = 0.442$	$d_1^- = 0.008$
$CL_1^* = 0.144$		$CL_1^* = 0.977$		$CL_1^* = 0.008$	

6.   Conclusions

Considering the indices and options determined by experts of the transportation agency (marine shipping company) (see table), topsis technique was used in this research to select and prioritize the options in 5 stages. During running this algorithm, with regard to topsis and the indices in question, it was revealed that the second option is of higher priority and importance to the company compared to other proposed options, since it has highest relative closeness to the ideal states (cl_i^*). Table 6 shows a comparison between proposed options and the priorities of options.

Table 6: Sequencing and prioritization of options

Options	d_i^-	d_i^+	CL_i^*	Prioritization of options
A_1	0.064	0.370	0.144	2
A_2	0.442	0.01	0.977	1
A_3	0.008	0.442	0.017	3

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