International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 4 No. 1 Sep. 2013, pp. 189-194

http://www.issr-journals.org/ijias/

Application of ELECTRE III and Shannon Entropy for Strategy Selection

Hassan Jafari

Marine Transportation Department,
Faculty of Maritime Economics & Management,
Khoramshahr marine science & Technology University,
Khoramshahr, Iran

ABSTRACT: One of the potential problems in ports, which are expected to be compounded with the growth of the volumes of trade, is the dwelling of goods and its consequent costs. Container dwell time equals the duration containers are discharged and transported from ships to depots in order to be stored until the time the goods owner has released containers and dismissed it from terminals. The dwelling of goods results in taking up storage yards and port lots through congestion as well as decreasing Executive efficiency in loading and discharging which may cause an increase in lay time and demurrage costs. The purpose of the current study is an Application of ELECTRE III and Shannon Entropy for Strategy Selection for decreasing the Containers Dwell Time in Iranian Seaports. Firstly, factors involving in the Containers dwell time were dealt with in a review of the literature. Secondly, Executive strategies to decrease the Containers dwell time were formalized employing Delphi method. Thirdly, the strategies, formalized at the second stage, were prioritized by use of Shannon Entropy and ELECTRE III. According to The final results of the ELECTRE III method following strategies gained highest priority, using electronic systems, reducing the paperwork and parallel processes in cargo clearance, employing road and rail intermodal transport, round-the-clock customs operation, enhancing coordination and collaboration among organizations involved in the issuance of cargo clearance, respectively.

KEYWORDS: Container, dwelling, Shannon Entropy, ELECTRE III, Strategies, Iran's ports.

1 INTRODUCTION

Ports traffic is steadily increasing; ships are getting larger and types of goods being transported are varying. As larger ships are built and more means of transportation join terminals, more and more their times of arrival coincide [1]. From international perspective, the ports whose capacities do not meet these changes in demand in terms of infrastructure and services will lose their competitiveness in goods transport [2]. Temporary storage of containers in trade ports is one of the essential steps in maritime transport, which is comprised of two major parts including carriage of goods from the vessel to depots, and vice versa, termed as "container admission and departure operation" [3].

However, the admission and departure operations are not always maintained in balance that subsequently could create problems in ports regarding the storage of massive volumes of goods which is termed as "the dwelling of goods" [4]. In other words, the dwelling of goods is defined as the difference between the amounts of goods entering depots for a definite period of time with the amount of goods exiting depots in this period for any reason [5]. These goods could be used for many reasons such as export or delivery to the end users. Moreover, the inventory of goods remained needs to be added to this amount [6]. One of the potential problems in ports, which are expected to be compounded with the growth of the volumes of trade, is the dwelling of goods and its consequent costs [7]. The dwelling of goods results in taking up storage yards and port lots through congestion as well as decreasing Executive efficiency in loading and discharging which may cause an increase in lay time and demurrage costs.

By definition, this could be said that the dwelling of goods is a major issue in Iran's ports and Shahid Rajaie's port is just a

Corresponding Author: Hassan Jafari (hassanport53@yahoo.com)

case in point and the effects of this phenomenon is all encompassing [8]. As an instance, Anzali's port had 806,000 tons of dwelled goods in 2009 with an increase of 40% compared to the previous year [9]. The total quantity of discharged goods in the port amounted 3/4 million tons [10]. The statistics show ports of Amirabad and Noushahr contained 300,000 and 500,000 tons of dwelled goods respectively [11]-[12]. Concerning the abovementioned issues, the aim of present study is to identify and prioritize the Executive strategies to decrease the Containers dwell time in Iranian seaports.

2 MATERIAL AND METHOD

The present study is considered as an applied research because its results could be used to reduce the Containers dwell time in ports. A descriptive method is used based on the type and nature of the research, its objectives and questions. On the other hand, to collect data a survey is conducted. To obtain its objectives, this research has been performed at three stages: Firstly, factors involving in the dwelling of goods and container in country will be dealt with in a review of the literature. Secondly, Executive strategies to decrease dwelling of goods and container will be collected employing Delphi method. Thirdly, the strategies, collected at the second stage, will be prioritized using Shannon Entropy and ELECTRE III in terms of the practicability and efficacy, implementation costs, time needed, on the dwelling of goods.

The population in this research is the whole experts in Port and Maritime Organization. Since no data was available as to their exact number, a preliminary questionnaire was sent out to 18 experts in Port and Maritime Organization. An estimation of the first variance analysis with a 95% confidence level resulted in 120 subjects.

2.1 ELECTRE III

The acronym ELECTRE stands for: *ELimination Et Choix Traduisant la Realité* (Elimination and Choice Translating Reality). It is a well-known outranking decision aid methodology which helps a decision maker in either choosing a subset of best alternatives from a given set of alternatives, or in ranking the alternatives from the best to the worst, or in sorting the alternatives to some pre-defined and preference-ordered classes, based on evaluation of the alternatives on a consistent family of criteria. A characteristic feature of ELECTRE is the use of an outranking relation for the representation of decision maker's preferences. The underlying idea is that, if strong mathematical hypothesis which demands complex answers from decision makers, can be avoided, a better but less rich result (outranking relation) can be obtained by systematically comparing the alternatives on each criterion [13].

Since the development of the ELECTRE method by Bernard Roy in the mid 60"s, several versions of the method have been proposed, starting from ELECTRE I and Is, for the selection of alternatives in a multiple criteria choice problems, ELECTRE II, for constructing a ranking of alternatives using true criteria (without thresholds), ELECTRE III and IV, also used for constructing ranking of alternatives but differs from ELECTRE by its application of pseudo criteria (indifference and preference threshold), and ELECTRE TRI, is designed to solve sorting problems [14].

These thresholds are shown with $p_j(p_j\ (*)), q_j\ (g_j\ (*))$ and $v_j(g_j(*))$, respectively. Actually, they are used to estimate outranking relations as well as inclusion of uncertainty in the gathered data about alternatives. The values of these thresholds and weights (or importance) $w_j$for each of the criteria must be defined for all criteria. If we consider two arbitrary options a and b, the concordance index (C (a, b)), is calculated using following equation [15]:

$$c(a,b) = \frac{a}{w}\sum_{j=1}^{n} w_j\, c_j\, c(a,b) \ \text{ and } W = \sum_{j=1}^{n} w_j \qquad (1)$$

If option a is better than or equivalent to b minus the indifference threshold for criterion j then, C (a, b) =1. However, if the performance of option a plus the preference threshold is less than that of option b then option a is treated as not better than b for this criterion and C (a, b) = 0. Otherwise, the value of concordance index is between these two extremes and is determined as a linear variation between them these concepts are defined as bellow [16]:

$$\begin{cases} c(a,b) = 1 \ \text{ if} \rightarrow w_j(a) + q_j(g_j(a)) \geq g_j(b) \\ c(a,b) = 0 \ \text{ if} \rightarrow g_j(a) + p_j(g_j(a)) \leq g_j(b) \\ \text{otherwise} \rightarrow \frac{g_j(b) - g_j(a) + p_j(g_j(a))}{p_j(g_j(a)) - q_j(g_j(a))} \end{cases} \qquad (2)$$

Where q_j (*) and p_j (*) denote the indifference and preference thresholds, respectively, on criterion j and $g_j(a)$ and $g_j(b)$ are the assessments for the j the criterion of the project options a and b, respectively.

Also the veto threshold for each criterion must be assigned to allow discordance to be introduced into the outranking relations. Existence of discordance indicates the overrule of concordance index at the presence of any criterion for which option b outperforms option a by at least the veto threshold [13]:

$$g_j(b) \geq g_j(a) + v_j(g_j(a)) \tag{3}$$

If option is better than option b in general, there may be some criteria for which option a is worse than option b that it moderates any overall preference for option a. In that case the discordance index for that criterion reflects this. It can have a value from 0 to 1. A value 0 indicates that option b is not better than option a by more than the preference threshold, and a value 1 indicates that option b is better than option a by a margin greater than the veto threshold. It is written as D_j (a, b) and is defined as follows [15]:

$$\begin{cases} D(a,b) = 1 \text{ if} \rightarrow G_j(a) + V_j(g_j(a)) \leq g_j(b) \\ D(a,b) = 0 \text{ if} \rightarrow g_j(a) + p_j(g_j(a)) \geq g_j(b) \\ \text{otherwise} \rightarrow \frac{g_j(b) - g_j(a) + p_j(g_j(a))}{V_j(g_j(a)) - P_j(g_j(a))} \end{cases} \tag{4}$$

Finally, the degree or credibility of outranking (S (a, b)) is defined by [15]:

$$\begin{aligned} S(a,b) &= S(a,b) \text{ if} \rightarrow D_j(a,b) \leq C_j(a,b), \forall j \\ S(a,b) &= s(a,b) \prod_{j \in \gamma(a,b)} \frac{1 - D(a,b)}{1 - C(a,b)} \end{aligned} \tag{5}$$

Where γ (a, b) is the set of criteria for which $D_j(a,b) > C_j(a,b)$.

2.2 SHANNON ENTROPY

Shannon and Weaver proposed the entropy concept, which is a measure of uncertainty in information formulated in terms of probability theory [17]. Since the entropy concept is well suited for measuring the relative contrast intensities of criteria to represent the average intrinsic information transmitted to the decision maker, conveniently it would be a proper option for our purpose [18]. Shannon developed measure H that satisfied the following properties for all pi within the estimated joint probability distribution:

It is proved that the only function that satisfied these properties is:

$$H_{shannon} = -\sum_i p_i \log(p_i) \tag{6}$$

Shannon's concept is capable of being deployed as a weighting calculation method, through the following steps [19]:

Step 1: Normalize the evaluation index as:

$$p_{ij} = \frac{x_{ij}}{\sum_j x_{ij}} \tag{7}$$

Step 2: Calculate entropy measure of every index using the following equation:

$$e_J = -K \sum_{i=1}^{m} P_{ij} \, 1n \, (P_{ij}) \tag{8}$$

$$\text{Where } K = (1n(m))^{-1} \tag{9}$$

Step 3: Define the divergence through:

$$div_j = 1 - e_j \tag{10}$$

The more the div_j is the more important the criterion jth.

Step 4: Obtain the normalized weights of indexes as:

$$p_{ij} = \frac{div_j}{\sum_j div_j} \tag{11}$$

3 RESULTS

Container dwell time equals the duration containers are discharged and transported from ships to depots in order to be stored until the time the goods owner has released containers and dismissed it from terminals. Where this period exceeds the prescribed time, it is said that the container or goods have been dwelled. The duration of this depends on several factors and at the same time indicates the efficiency and performance of the organizational and managerial structure of a port. That is to say, when goods dwelling time is shorter it may, to some extent, imply that the port is performing efficiently at all stages from discharging of cargos until clearing from the customs. At this stage, factors involving in the Containers dwell time in country are dealt with in the review of literature. Labor force means all those who work in different departments of ports and the customs. [1]. The technical infrastructure includes advanced and efficient cranes in dock and container yard, the latest methods of goods and container inspection, the latest and effective administrative automation for reducing human error [4]. The customs, the principal administrator of cargo release, can influence a country import and export procedures [5]. The inadequacy of transportation in a country increases production costs of various products and decreases the competitiveness of its industry in the global market [10]. Electronic systems could digitally transfer the requisite information including bill of lading, insurance policy, invoices, etc. without any hard copy and perform economic activities as fast as possible [5]. Undoubtedly, the majority of problems that result in the dwelling of containers in ports of Iran are related to goods owners. [12]. the entry of every goods into a country depends on obtaining permits from different organization which will vary for different goods [8]. Another issue that could affect the Containers dwell time in Iran could be political issues and the consequences. These problems may severely decrease a direct connection between the owners and vendors abroad or the ease of money transfer. The bureaucracy has always been posing problems in the issuance of permits and requisite documents for releasing goods. To some extent, the dwelling of goods may arise out of geographical and social issues. Although their roles in the dwelling of goods seem immaterial, their influence however should not be overlooked [9].

At the Second stage, Executive strategies to decrease the Containers dwell time were formalized employing Delphi method as presented in Table 3.

At the Third stage, the strategies, formalized at the second stage, were prioritized by help of Shannon Entropy and ELECTRE III in terms of the practicability and efficacy, implementation costs, time needed, and the dwelling of goods. Foremost, the indicators were determined by help of Shannon Entropy as shown in Table 1.

Table 1. Weight of indicators according to Shannon Entropy

Indicators	Practicability And Efficacy	Cost	Time
Initial	P	C	T
Weight	0.27000	0.32000	0.41000

Then the identified strategies were formed according to elites' comments on a 1-9 scale based on weighed indicators and decision-making ELECTRE III method as shown in table 2 below.

Table 2. ELECTRE III method decision making matrix

NO	MAX	MIN	MIN	NO	MAX	MIN	MIN
	P	C	T		P	C	T
1	5	1	2.5	12	7.8	6	5
2	4	7	5	13	7.9	4	5.1
3	3	7.5	8	14	6	5	5.2
4	5	6	4.9	15	7.5	2	3
5	6	5	6	16	6.9	8	7
6	4	4.90	5.33	17	8.3	3.56	4.1
7	8	3.99	4.11	18	6	5.36	4.90
8	7.11	5.9	3.8	19	6.9	9	7.5
9	7	4	5.2	20	8.5	3.2	2.6
10	7.11	3	6.5	21	8.6	2	2
11	6.12	4.5	6.44	22	8.7	2.3	1.9

Finally by use of ELECTRE method above mentioned strategies have been prioritized. The final result of ELECTRE method presented in table 3.

Table 3. Final Priority of the strategies

No.	Strategy	Priority
1	Levying heavy fine on dwelled goods in port warehouses to be paid by goods owners	6
2	Improving transportation tariff to encourage truck owners	13
3	Stabilizing the market and reducing great fluctuations which may stimulate high demands	18
4	Utilizing periodical training to boost efficiency of staff and operators in the customs	16
5	Improving banks and goods owners collaboration to facilitate opening credit	10
6	Omitting extra declarations	15
7	Expediting cargo clearance procedures	8
8	Issuing customs permit through computers	17
9	Using a single form in the issuance of permits	9
10	Developing appropriate relationships with other international companies	9
11	Providing better facilities for importers and exporters	15
12	Better training for staff and employees in order to master the customs law	7
13	Reducing complicated paperwork	16
14	Improving the costs of warehousing	4
15	Improving organizations` correlation and collaboration to issue clearance permits	3
16	Building specialized warehouses at different parts of country	14
17	Considering appropriate incentives for goods owners in case of early clearance	5
18	Employing specialized companies and workers to transfer goods	11
19	Increasing the numbers of trucks and locomotives in a country	12
20	The customs round-the-clock operation	3
21	Employing rail and road intermodal transport	1
22	Using electronic systems to reduce paper work and parallelism in goods clearance	2

4 CONCLUSION

The present study has been performed at three stages aiming at identifying and prioritizing Executive strategies to decrease the Containers dwell time in the Iranian seaports. Firstly, factors involving in the Containers dwell time were dealt with in a review of the literature. Secondly, Executive strategies to decrease the Containers dwell time were formalized employing Delphi method. Thirdly, the strategies, formalized at the second stage, were prioritized by help of Shannon Entropy and ELECTRE III in terms of the practicability, implementation costs, time needed, and the efficacy of goods dwelling. The eventual results of the ELECTRE III method indicate the priority of these strategies as following: Employing rail and road intermodal transport, using electronic systems to reduce paper work and parallelism in goods clearance, the customs round-the-clock operation, Improving organizations` correlation and collaboration to issue clearance permits, respectively.

REFERENCES

[1] Ken. C, "Automation Helps Clearing Customs," *Journal of Global Trade & Transportation*, Philadelphia, Vol. 114, pp. 14, 1994.

[2] Lalwani, C. & Beresford, A., "Container Control and Cargo Clearance Using Computer Packages," *Journal of Annual Review in Automatic Programming*, Vol. 12, (Part 2), pp. 338-343, 1985.

[3] Nicoll, J., "Innovative Approaches to Port Challenges -Dwell Time and Transit Tim Management*," International Convention of Norfolk Virginia,* USA, 4 October 2007.

[4] Rugaihuruza, J., "Infrastructure, Operational Efficiency and Port Productivity Management in Pmaesa Region," *the African Ports-Maritime Conference*, 10th-14th December 2007, Tanzania.

[5] Rasouli-Nia, A., & Bahrami, G, "Evaluation of Container Port martyr Rajai Sediment and solution to solve problems," *Eleventh Conference on Marine Industry*, November 88, Kish Island, pp. 5-1, 2009.

[6] sarai, kh., "Iran's accession to the WTO and its effects on the country's ports," *maritime agencies fourteenth national conference*, 19-21 May 2006, Mahmoud Abad, Iran.
[7] sarai, kh., "Statistical Analysis of goods in ports south of the country and predicted Sediment trends," *thesis, Amirkabir University*, Tehran, 1995.
[8] Shahshahani, M., "What effect on the slowly operational clearance merchandise is in the warehouse?," Thesis, *Tehran University, Tehran*, 2007.
[9] Jafari, H., Noshadi, E. and khosheghbal, B., "Ranking Ports Based on Competitive Indicators by Using ORESTE Method," *International Research Journal of Applied and Basic Sciences*, 4 (6): 1492-1498, 2013.
[10] Jafari, H., "Identification and Prioritization of Causes of Halt and Lag in Container Handling Operation," *International Journal of Basic Sciences & Applied Research*, 2 (3), 345-353, 2013.
[11] Jafari, H., "Empirical Study the Status of Necessary Infrastructure for Knowledge Management Implementation in Southern Ports of Iran," *International Journal of Basic Sciences & Applied Research*, Vol. 2 (4), 426-433, 2013.
[12] Jafari, H., and khosheghbal, B., "Studying Seaport's Hinterland-Foreland Concepts and the Effective Factors on Their Development," *International Research Journal of Applied and Basic Sciences*, 4 (5): 1039-1046, 2013.
[13] Rogers, M., Bruen, M., "Using ELECTRE to rank options within an environmental appraisal – two case studies," *Civil Engineering Systems* 13, 203–221, 1996.
[14] Rogers, M., Bruen, M., "Choosing realistic values of indifference, preference and veto thresholds for use with environmental criteria within ELECTRE," *European Journal of Operational Research* 107, 542–551, 1998.
[15] Rogers, M., Bruen, M., "New system for weighting environmental criteria for use with ELECTRE III," *European Journal of Operational Research* 107, 552–563, 1998.
[16] Rogers, M., Bruen, M., Maystre, L., "ELECTRE and decision support methods and applications in engineering and infrastructure investment," *Kluwer Academic Publishers*, London, 2000.
[17] Bruhn, J., Lehmann, L. E., Röpcke, H., Bouillon, T. W., & Hoeft, A., "Shannon entropy applied to the measurement of the electroencephalographic effects of desflurane," *Anesthesiology*, 95(1), 30-35, 2001.
[18] Coifman, R. R., & Wickerhauser, M. V., "Entropy-based algorithms for best basis selection, Information Theory," *IEEE Transactions on*, 38(2), 713-718, 1992.
[19] Lin, J., "Divergence measures based on the Shannon entropy," *Information Theory, IEEE Transactions on*, 37(1), 145-151, 1991.