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Empirical Analysis of the Containers Dwell Time in Container Ports Using Multiple-Criteria Decision-Making Methods

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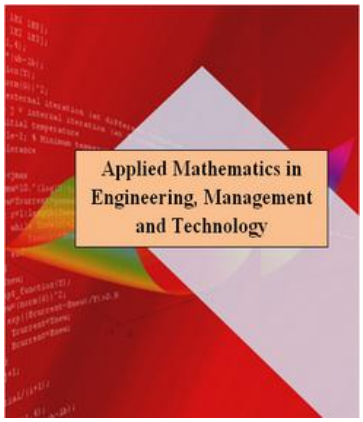

Abstract:
The present study has been performed at three stages aiming at identifying and prioritizing Executive strategies to decrease the Goods and Containers dwell time in the Iranian seaports. Firstly, factors involving in the Goods and Containers dwell time were dealt with in a review of the literature. Secondly, Executive strategies to decrease the Goods and Containers dwell time were formalized employing Delphi method. Thirdly, the strategies, formalized at the second stage, were prioritized by use of *Analytical Hierarchy Process (AHP)* and *MAPPAC* in terms of the practicability, implementation costs, time needed, and the efficacy in reducing Goods and Containers dwell time. The eventual results of the MAPPAC method indicate the priority of these strategies as following: 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**.**

Keywords: Container, the dwelling of goods, Analytical Hierarchy Process, MAPPAC, Executive Strategies, Iran`s ports.

1. Introduction

From national economic perspective, maritime transport plays the significant role of a major facilitator in international trade. 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. 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 (Saraai, 1995). 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”.
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”. 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. 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 (Saraai, 1995).
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. 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 ShahidRajaie’s port is just a case in point and the effects of this phenomenon is all encompassing. 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. The total quantity of discharged goods in the port amounted 3/4 million tons (najafi, 1389). The statistics show ports of Amirabaad and Noushahr contained 300,000 and 500,000 tons of dwelled goods respectively. Concerning the abovementioned issues, the aim of present study is to identify and prioritize the Executive strategies to decrease the Goods and Containers dwell time in Iranian seaports.

2. Research objectives

Accordingly, the primary questions that will have been answered by the end of the present study are as follows.

1. What are the most important contributing factors in the dwelling of containers in ports?
2. What are the strategies that lead to the reduction ofthe Goods and Containers dwell time?
3. What are the priorities of the strategies like the reduction of goods and container dwelling in terms of practicability, Executive costs and time needed, and the efficacy in reducing Goods and Containers dwell time.

3. Literature Review

Shahshahani (2007) conducted a pioneering research that dealt with examining problems of goods dwelling in Iran`s ports. However, the study made no reference in terms of the contributing factors in goods dwelling and its objectives were solely stated as an examination of the effects of goods density on the Executive procedure of ports. The author argues that the density of goods in ports affects the regular routine of Iran Customs and Ports and Maritime Organization which directly affects the national economic planning and import. Eventually, commercial ships begin to line up to enter ports. From Shahshahani's viewpoint, goods density is considered as the accumulated commercial goods, imported and waited in ports to be released and transported to warehouse or customs lots; Due to the constant discharge at the ports, goods density could hinder the regular routine.

Based on the connection between the dwelling of goods and land transportation capacity, Saraai (1995) firstly predicts the infrastructure and superstructure capacity of the transportation system in the upcoming years following the time of research, then drawing on these predictions, estimates the pattern of variation in goods dwelling in three scenarios as pessimistic, mediocre, and optimistic. To predict the dwelling of goods, that is the main objective of the present study, a mathematical model of time function is employed which presents the dwelling of goods as the following:

The dwelling of goods equals the differences of the sum of all imported goods in depots and all goods that leave depots (to be exported or conveyed for consumption). The result of this would be added up to the goods remained in the past that could be presented as following:

$$C(t) = \sum \big(I(t) - E(t)\big) + C(t-1)$$

- C(t) the goods dwelled in the depots in t duration
- I(t) the total of the goods imported to depots in t duration
- E(t) the total of the exported goods from ports in t duration
- C(t-1) the goods dwelled in depots in t-1 duration

In the research, the author tried to predict the amount of would-be-dwelled goods in the upcoming years by mean of data of the year 1995. Finally, suggestions were made to reduce goods dwelling in ports of Iran as following:

1) Revising the regulations and rules of the national customs.
2) Making economically unfeasible to store goods in warehouses and ports lots through creating an exponential rate of warehousing, adopting encouraging policies and levying fines on goods owners.

3) Reducing the time to proclaim goods abandoned.

One of the most recent researches on the dwelling of goods is that conducted by Rasouli et al. (2009) which points out some influential factors in the sediment of goods in ports. In that research, no statistical method has been used and the authors solely stated some contributory factors. Factors such as the customs formalities and lack of special transportation facilities are presented as contributory elements in the research.

The body of research concerning the dwelling of goods in ports has not been well examined. Lalwani et al. (1998) examined the effect of computerization on the reduction of cargo clearance time in ports and declared that the use of computers plays a significant role in the dwelling time in ports. It should be pointed out that the research was lunched at the time the role of computers in terminals operations were not prominent and most of cargo clearance operations were being carried out manually.

The authors as a case study focused on some ports in England, and explained the role of computers in enhancing cargo clearance time in ports by comparing automated ports with non-automated ports. Ken (1994) investigated the role of automation in reducing cargo clearance time in ports of Australia and New Zealand. The author described and presented a fully computerized system, namely CEDIFIT, which could be used for cargo clearance in Australia and New Zealand ports and airports.

Considering one of the ports of Australia as a case study, Ken (1994) concludes that this method has been effective in reducing the goods release time by 50%. Rugaihuruza (2007) has examined the potential factors influencing Executive efficiency and productivity in Darussalam port. The dwelling of goods, which is one of the contributing factors in efficiency and productivity of ports, is investigated in the mentioned study. The author examines the relationship between the dwelling of goods and the capacity of Darussalam port. At the conclusion of his article, Rugaihuruza (2007) suggests some factors to reduce the time of dwelling of goods in container yards. Utilizing high speed and efficient equipment, improving individual`s skills through training and specialization of those who work in container yard, enhancing infrastructure and ports linking routes.

The management of dwelling time and transit time in ports is subjects of a study conducted by Jim Nicoll (2007). Jim Nicoll chose Halifax port for the case study because of his holding the position of the head of information and services department at that time. Goods dwelling and transit time are presented in the article as two challenges which ports administrators encounter in the course of improving quality and consistency of customers and goods owners services. The author continues with presenting statistical data on the dwelling of goods indicating that more than 50% of the received containers leave the port in less than one day and only 2% of containers stay more than 10 days. Statistical data also demonstrate that the dwelling of goods in ports of developed countries is not serious a matter.

Jim Nicoll (2007) introduces the Container Tracking System (CTS) as the method for reducing the dwelling time in Halifax port in which four stages have to be followed to reduce goods dwelling:

1) The containers arrived are stored in the nearest place and in the shortest time according to the input data.
2) The data for each container is stored in a database.
3) Some software programs are used to analyze data concerning the dwelling and transit time at any point in time.
4) Constantly latest methods are employed to improve this system.

4. Material and method

The present study is considered as an applied research because its results could be used to reduce the Goods and 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 *Analytical*

Hierarchy Process (AHP) and MAPPAC in terms of the practicability, implementation costs, time needed, and efficacy on the dwelling of goods.

4.1. MAPPAC Method

The MAPPAC method is a multi-objective ranking method. The method constructs two complete preorders of variants, which common part constitutes the final ranking (Paruccini and Matarazzo, 1994). The MAPPAC method algorithm is composed of 3 phases: definition of input data (variants, criteria), pairwise comparison of variants for each pair of criteria resulting in the definition of indifference (I) and preference (P) relations and aggregation of preferences constructing the final Ranking(Martel and Matarazzo, 2005). MulticriterionAnalysis of Preferences by Means of Pairwise Actions and Criterion Comparisons method (MAPPAC), firsth introduced by Matarazzo, is based on the comparison of pairs of feasible actions taking into account all possible pairs of criteria(Matarazzo, 1986). The proposed method, known as MAPPAC, is based on a pairwise comparison of alternatives relative to each pair of criteria, defining the two relations P (preference) and I (indifference), which constitute a complete preorder. Moreover, by aggregating these preferences, it is possible to obtain a variety of relations on a set of feasible actions(Matarazzo, 1988).

The MAPPAC method has three assumptions(Matarazzo, 1990);

- For each K_i a quantitative, V_{ij} can be assigned to each alternative, a_j representing the performance of a_j with respect to K_i.
- A quantitative value, V_{ij} can be assigned to each alternative, a_j on the basis of each criterion, K_i.
- The value, $v(v_{ij})$ of each V_{ij} can be quantified on the interval [0,1].
- The criteria are mutually difference independent.

For each K_i a value, V_{ij} is assigned to each $a_j$representing the performance of a_j on the basis of K_i. A numerical weight, w_i is assigned to each K_i representing the importance of K_i with

$$\sum_{i=1}^{n} w_i = 1 \tag{1}$$

For each K_i representing the importance of $v(v_{ij})$ to each V_{ij} with$0 \le v(v_{ij}) \le 1$. Basic preference indices,$\pi_{gh(w_e,w_f),}$ are then calculated between each pair of alternatives, w_e,and $w_f$on the basis of each pair of criteria, K_g and $K_f$with(Matarazzo, 1991),

$$\pi_{gh(w_e,w_f)=1\ if\ v(v_{ge})>v(v_{gf})\wedge v(v_{he})>v(v_{hf})} \tag{2}$$

$$\pi_{gh(w_e,w_f)=0\ if\ v(v_{ge})<v(v_{gf})\wedge v(v_{he})<v(v_{hf})} \tag{3}$$

$$\pi_{gh(w_e,w_f)=\frac{1}{2}\ if\ v(v_{ge})=v(v_{gf})\wedge v(v_{he})=v(v_{hf})} \tag{4}$$

$$\pi_{gh}(a_e,a_f) = \frac{w_g\left(v(v_{ge})-(v_{gf})\right)}{w_g\left(v(v_{ge})-(v_{gf})\right)+w_h\left(v(v_{hf})-(v_{he})\right)}\ if \quad \begin{matrix}\left(v(v_{ge}) > v(v_{gf}) \wedge\ v(v_{he}) \le v(v_{hf})\right) \\ \vee \\ \left(v(v_{ge}) = v(v_{gf}) \wedge\ v(v_{he}) < v(v_{hf})\right)\end{matrix} \tag{5}$$

$$\pi_{gh}(a_{e,}a_f) = \frac{w_g\left(v(v_{he}) - (v_{hf})\right)}{w_g\left(v(v_{gf}) - (v_{ge})\right) + w_h\left(v(v_{he}) - (v_{hf})\right)} \; if \quad \begin{matrix} \left(v(v_{ge}) \le v(v_{gf}) \wedge\ v(v_{he}) > v(v_{hf})\right) \\ \vee \\ \left(v(v_{ge}) < v(v_{gf}) \wedge\ v(v_{he}) \ge v(v_{hf})\right) \\ \vee \end{matrix} \quad (6)$$

An overall value, $\pi_e$is assigned to each alternative, a_e with $\pi_e = \sum_{a_f \in A/a_e} \pi_{ef}$ Then the a_e with the greatest associated π_e is selected and set a side as the optimal alternative. The $\pi_e$arerecalculated, excluding the optimal alternative from A, and the remaining $a_e$with the greatest associated π_e is selected as the second best Alternative [35]. This Process is repeated until each of the alternatives have been ranked. A similar Process is then performed, beginning with the selection of the least optimal alternative from A. This alternative is then removed from A, the $\pi_e$are recalculated, and the remaining $a_e$with the lowest $\pi_e$is selected as the second worst alternative. This Process is continued until each of the alternatives has been ranked. These ascending and descending rankings are then combined to arrive at a weak linear ordering of A.

4.2. Analytical Hierarchy Process (AHP).

Analytical Hierarchy Process (AHP) is one of the most famous techniques in Multiple Criteria Decision Making (MCDM) invented by Thomas L. Saaty. The technique is useful when decision making faced with multiple criteria and decision making index. Indicators can be quantitative or qualitative. In AHP, a series of paired comparisons are made between the indicators and highlights the weight of each indicator compared to competing alternatives (Saaty, 1990). The logic of AHP combines matrices of paired comparisons together as the optimal decision forms and ultimately the rate of decision adaption is measured; then the good, the bad, accepted or rejected, will be judged. In this method, multiple quantitative and qualitative criteria are considered and various options to be involved in decision making(Saaty, 1977).

4.3. Population and Sampling

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 20 experts in Port and Maritime Organization. An estimation of the first variance analysis with a 95% confidence level resulted in 100 subjects. Wherever in this research the word “elite” is used refers to these 100 participants.

5. Results

5.1. First stage

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 Goods and Containers dwell time in country are dealt with in the review of literature.

The performance of labor force in ports and the customs: labor force means all those who work in different departments of ports and the customs. This factor includes managers at different levels, staff, cranes and carriers operators and those in charge of cargo clearance and inspection. Basically, these decisions and the roles of these individuals play a significant role in reducing the dwelling of goods.

Technical infrastructure: 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. Therefore, to develop ports infrastructure is one of the most important factors in reducing the Goods and Containers dwell time in ports.

The customs operation: the customs, the principal administrator of cargo release, can influence a country import and export procedures. The customs administrative departments in ports are comprised of four major divisions as cargo counting, appraisal, affairs and management work. Each of these divisions may influence the import and export procedure as well as the dwelling of goods in ports.

The national transportation system: the inadequacy of transportation in a country increases production costs of various products and decreases the competitiveness of its industry in the global market. However, what is of importance to goods owners and shippers is not the transport costs per se but the sum of production and distribution costs. Being appropriate, the transportation infrastructure could significantly affect the overall costs. Rail and road transportation are being the widely used means of transportation in Iran responsible for most of the transportation. The objective of these two factors is to define the effect of transportation infrastructure on the dwelling of goods in ports of Iran.

The integrated information system: 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. Utilizing electronic systems in Iran`s ports may considerably reduce the amount of paper documents transfer in ports and customs and may as well play a significant role in facilitating the import and export of country and reducing the Goods and Containers dwell time.

Goods owners: undoubtedly, the majority of problems that result in the dwelling of containers in ports of Iran are related to goods owners. Although goods owners are inclined to send out their goods from ports to be delivered to the market, but this is not always the case in practice. There are reasons indicating that because of fluctuations in the market owners are not inclined to release their goods promptly. Owners firstly open a credit in a bank in order to import goods, then, after purchasing goods and shipping them into country, they need to pay off their debts for the goods to be released. Sometimes, liquidity shortage and high fluctuations in the market do not allow the owners to remain solvent which results in the dwelling of goods.

The procedure of issuing requisite permits for releasing goods by respective organizations: The entry of every goods into a country depends on obtaining permits from different organization which will vary for different goods. The most important organizations involved in issuing permits are the health and standard organization which oversee the entry of goods into country. In addition to the issuance of permits by different organization, collaboration with banks in issuing credit to goods owners is important owing to the fact that this improves the export process. Any complex and onerous task in obtaining permits from different organizations may result in the dwelling of goods in ports and increasing the time of the dwelling.

Political issues: another issue that could affect the Goods and 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 complexities and bureaucracy: the bureaucracy has always been posing problems in the issuance of permits and requisite documents for releasing goods. The complex and time-consuming paperwork prolongs the cargo clearance and compounds the dwelling of goods.

Geographical and social issues: 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.

5.2. Second stage

At this stage, Executive strategies to decrease the Goods and Containers dwell time were formalized employing Delphi method.

Table 1- Executive strategies to decrease the Goods and Containers dwell time

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

5.3. Third stage

At this stage, the strategies, formalized at the second stage, were prioritized by help of *Analytical Hierarchy Process (AHP)* and *MAPPAC* in terms of the practicability, implementation costs, time needed, and the efficacy the dwelling of goods. Foremost, the indicators were determined by help of *Analytical Hierarchy Process (AHP)* as shown in table 2.

Table 2- the weight of indicators according to *Analytical Hierarchy Process (AHP)*

indicators	practicability	cost	time	efficacy
initial	P	C	T	E
weight	.25	.19	.16	.4

Then the identified strategies were formed according to elites' comments on a 1-9 scale based on weighed indicators and decision-making MAPPACmethod as shown in table 3 below.

Table 3- MAPPAC method decision making matric

NO	MAX	MIN	MIN	MAX	NO	MAX	MIN	MIN	MAX
	P	C	T	E		P	C	T	E
1	5	1	2.5	7	12	7.8	6	5	7.4
2	4	7	5	6.90	13	7.9	4	5.1	8
3	3	7.5	8	6.33	14	6	5	5.2	6.5
4	5	6	4.9	7	15	7.5	2	3	8.1
5	6	5	6	8	16	6.9	8	7	7.56
6	4	4.90	5.33	7.25	17	8.3	3.56	4.1	8.23
7	8	3.99	4.11	7.65	18	6	5.36	4.90	7.45
8	7.11	5.9	3.8	7	19	6.9	9	7.5	7.98
9	7	4	5.2	7.12	20	8.5	3.2	2.6	8.6
10	7.11	3	6.5	7.33	21	8.6	2	2	8.68
11	6.12	4.5	6.44	6.99	22	8.7	2.3	1.9	8.72

Table 6- Final Ranking of the alternatives

No.	Strategy	FROM BELOW	FROM ABOVE	TOTAL
1	Levying heavy fine on dwelled goods in port warehouses to be paid by goods owners	6	13	8
2	Improving transportation tariff to encourage truck owners	21	21	17
3	Stabilizing the market and reducing great fluctuations which may stimulate high demands	22	22	18
4	Utilizing periodical training to boost efficiency of staff and operators in the customs	20	19	16
5	Improving banks and goods owners collaboration to facilitate opening credit	9	11	9
6	Omitting extra declarations	17	18	15
7	Expediting cargo clearance procedures	8	7	6
8	Issuing customs permit through computers	15	14	13

9	Using a single form in the issuance of permits	14	10	10
10	Developing appropriate relationships with other international companies	11	9	9
11	Providing better facilities for importers and exporters	18	17	15
12	Better training for staff and employees in order to master the customs law	1	8	7
13	Reducing complicated paperwork	7	6	5
14	Improving the costs of warehousing	19	20	16
15	Improving organizations` correlation and collaboration to issue clearance permits	4	5	4
16	Building specialized warehouses at different parts of country	16	15	14
17	Considering appropriate incentives for goods owners in case of early clearance	5	4	4
18	Employing specialized companies and workers to transfer goods	13	12	11
19	Increasing the numbers of trucks and locomotives in a country	12	16	12
20	The customs round-the-clock operation	3	3	3
21	Employing rail and road intermodal transport	2	2	2
22	Using electronic systems to reduce paper work and parallelism in goods clearance	1	1	1

6. Conclusion

The present study has been performed at three stages aiming at identifying and prioritizing Executive strategies to decrease the Goods and Containers dwell time in the iranian seaports. Firstly, factors involving in the Goods and Containers dwell time were dealt with in a review of the literature. Secondly, Executive strategies to decrease the Goods and Containers dwell time were formalized employing Delphi method. Thirdly, the strategies, formalized at the second stage, were prioritized by help of *Analytical Hierarchy Process (AHP)* and *MAPPAC* in terms of the practicability, implementation costs, time needed, and the efficacy of goods dwelling. The eventual results of the MAPPAC method indicate the priority of these strategies as following: Using electronic systems to reduce paper work and parallelism in goods clearance, employing rail and road intermodal transport, the customs round-the-clock operation, improving organizations` correlation and collaboration to issue clearance permits, reducing complicated paperwork. On the other hand, the following strategies received lower priorities: Stabilizing the market and reducing great fluctuations which may stimulate high demands, improving transportation tariff to encourage truck owners, utilizing periodical training to boost efficiency of staff and operators in the customs, improving the costs of warehousing, omitting extra declarations, providing better facilities for importers and exporters, respectively.

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