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Performance Evaluation of Port Terminal Operators using Hybrid of TOPSIS and Balanced Scorecard

[1]Abbas Nasehi Jourshari, [2]Mohammad Doostar, [2]Mohammad Hassan Gholizadeh

[1]M.A Student of MBA, University Campus University of Guilan, Guilan, Rasht, Iran.
[2]Management Department, University of Guilan, Rasht, IRAN.

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ABSTRACT

Background: This study is conducted within two phase that aimed to manipulate Balanced Scorecard in evaluating the performance of port's operations terminals which referring the objectivity to Kaveh marine and port service company. In the first phase experts' view consisted the main purpose of the model on which it is localized. Then, the process of chronological model measured all of the factors and indexes that are embedded in the evaluation of terminals operations and performance monitoring based to their importance. In the second phase, TOPSIS Model is selected to prioritize five ranks of financial, customers, internal process, growth process and learning process in branches of Kaveh marine and port Service Company such as Shahid Rajaee, Port of Imam Khomeini, port of Anzali, Port of Khorramshahr, Port of Astara. the obtained results on which indicated on the base of four prospect of Balanced Scorecard shows that the branch of Imam Khomeini port identified as number one, the branch of Shahid Rejaee port identified as number two, the branch of Anzali port identified as number three, the branch of Khorramshahr port identified as number four and the branch of Astara port identified as number five.

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INTRODUCTION

One of the most important indicators for developing the countries' economy is said to be in the field of industrial development [1]. Nowadays the impact of transportation in the permanent development is undeniable [2]. This sector includes activities which are comprehensive in a way that implements as production, distribution and cargo consumption and also services and play a very noticeable role in the field of economic activities [3]. Marine transportation, as a very important factor in this industry and for enjoying advantages such as low prices and mass cargo transportation volume, is considered to have the major role in developing the countries' foreign commerce [4]. Iran, for its special geographical situation and accessibility to oceans (Free waters), enjoys a unique situation in the Marine transportation area. However, regarding our country's special situation in the region and being situated at the international paths of cargo transportation, Iran enjoys a significant potential for cargo transit [5].

The role of ports in Marine transportation is regarded as one of the main global supply chain's node and ring [6]. Service complexes that in economists, businessmen and producers' point of views are among world trade foundations play a significant role in the process of distributing and optimizing cost of shipment. Quality of products presented, is considered amidst the most important issues that are paid attention largely in the arena of world trade economic competiveness [2]. Those who run ports, by providing faster services to ships, try to encourage them to make more use of the port for loading and discharging purposes and by thriving their port to achieve more profits [1]. The constant investigations of port performance and its improvement, lead to enhancement of ports' competitive potentials, in addition, it shall have a great part in the country's development. The present study aims to expose a compound approach on which blends chronological process analysis and TOPSIS Model and Balanced Scorecard in order to shot the performance of ports operations terminal in their evaluation toward prioritizing Kaveh marine and port Service Company such as Shahid Rajaee, Port of Imam Khomeini, port of Anzali, Port of Khorramshahr, Port of Astara.

Corresponding Author: M.A Student of MBA, University Campus University of Guilan, Rasht, Iran.
E-mail: abbas.nas.ehi@yahoo.com

Balance Scorecard:

The Balanced Scorecard is one of the performance measurements and it is also as a performance management system to achieve organization goals. The Balanced Scorecard was first introduced in the early 1990s by Robert Kaplan and David Norton of the Harvard Business School. The concept has become popular and well known and then widely adopted by institution across the world. Before Balanced Scorecard developed by Kaplan and Norton, most companies measure their performance measurement that focuses on financial performance only [7,8]. Meanwhile, the financial performance itself only has influence to the short term measurement; it is also insufficient because it is not focuses on other perspective of performance such as customer, internal business process and learning, and growth perspective. On the other hand, the attention in these perspectives actually can influence financial perspective, such as investing and managing the intangibles assets the same ass in learning and growth perspective can provide foundation for future financial success itself. Kaplan and Norton attempted to do this with the Balanced Scorecard. The Balance Scorecard is a comprehensive and holistic performance measurement. It measures not only financial perspective, but also measures customer, internal process, and learning and growth perspective [9]. Kaplan and Norton argue that their scorecard is not a replacement for financial measurement; it is a complement for financial measurement. If the Balanced Scorecard is understood thoroughly and implemented appropriately in an organization/institution operation, it will have a potential contribution to the success of the organization/institution; however, the measurement of performance is fundamental in organization success [10].

Balance Scorecard perspectives:

Finance perspective:

The BSC retains the financial perspectives, as financial data are valuable in calculating the readily measurable economic consequences of the previous actions. Measures of financial performance indicate whether a company's strategy, implementation and execution contribute to bottom line improvement. Financial objectives typically relate to measures of profitability, including operating income, return on capital and economic value added [11, 12].

Customer perspective:

As customers are the source of business profits, satisfying customer needs is the ultimate objective of enterprises. With this perspective, management determines the expected target customers and market segments for operational units and monitors the performance of operational units in these target segments [13, 14].

Internal business process perspective:

The objective of this perspective is to satisfy shareholders and customers by excelling in some business processes with the greatest impact. In determining the objectives and measures, the first step should be to incorporate value chain analysis. An outmoded operating process should be adjusted to factor-in financial and customer dimension objectives [15]. A complete internal business process value chain that can meet the current and future needs should then be constructed [16].

Learning and growth perspective:

The BSC's learning and growth element is intended to identify the criteria for establishing the infrastructure of an organization's growth. This indicator is arguably the most critical of the BSC perspectives for addressing the future needs of an organization [17]. It may also be the most difficult parameter to measure. As Kaplan & Norton pointed out: "Managers in several organizations have noted that when they were evaluated solely on short term financial performance, they often found it difficult to sustain investments to enhance the capability of their people, systems, and organizational processes" [18].

Research Goals:

1) Localizing Balanced Scorecard for the evaluation of ports' operations terminal performance.
2) Prioritizing and measuring the indexes of Balanced Scorecard according to their importance in evaluation of performance on ports operations terminal using chronological process of analysis.
3) Evaluating ports operations terminal performance (branches of Kaveh Company) according to financial, customers, internal process, growth process and learning process.
4) TOPSIS Model manipulation and prioritizing ports operations terminal performance (branches of Kaveh company) according to financial, customers, internal process, growth process and learning process.

Methods:

The present study is applied form and can suggest appropriate hints enhancing the performance of Kaveh marine and port Service Company and branches as Shahid Rajaee, Port of Imam Khomeini, port of Anzali, Port of Khorramshahr, Port of Astara. Comparative and analysis approach are the main methods of the study and data

collections prepared by questionnaire on which scaled 1-10 according to Balanced Scorecard indexes that conducted face to face within interview of the participants. The reliability of the questionnaire is dependent on the chronological process analysis and delves to the even main and subcategories factors compare. The reliability of the questionnaire will be obtained by the variance rank of even comparing table, that if the rank is below 0. 10, the designed questionnaire is reliable [19].

Participants consist of managers in charge of ports operations terminals of Kaveh Company and its branches that are selected by Kokaran Model and determined 50. Individuals are considered experts, guiders and advisers that cover the participants and they are directing the questionnaire by their opinions. SANNA software is presented to calculate the TOPSIS model.

AHP:

AHP decomposes the complexity in the form of a simple hierarchy, descending from overall goal to criteria, sub-criteria (if exist) and alternatives; allocates relative weights of criteria and sub-criteria to compare the alternatives [20].

The basic principles of AHP can be summarized as defining and determining the problem; decomposing the problem in a hierarchy from top through the intermediate levels; constructing a set of pair-wise comparison matrices; testing the consistency index; synthesizing the hierarchy to find out the ranks of the alternatives [20]. AHP makes use of pair-wise comparisons to simplify the judgment process with 1-9 ratio scaling (see Table 1).

Table 1: The pairwise comparison scale [20].

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8		Intermediate values

When it is assumed (A_1, A_2,…A_n) is any set of n elements than a sample of square matrix can be produced as below by pair wise comparisons of each element. Here, each (A_i, A_j) judgment represented as "a_{ij}". Because a_{ii}=1 for all *i* diagonal of the matrix contains entries of 1.

$$\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nm} \end{pmatrix} \quad (1)$$

When (w_1, w_2,…,w_n) are the elements corresponding weights; the dominance of an element in the row over the element in the column represented as w_i/w_j. AHP method compares the related weights of each element in a set with respect to the goal. The general form of comparison matrix of AHP is given as follows [19];

$$A = \begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_n} & \cdots & \frac{w_n}{w_n} \end{pmatrix} \quad (2)$$

Than the problem turns in to general process to calculating the largest eigenvalue corresponding to eigenvector to assess the Consistency Index (C.I.) where *A* is the matrix, *x* is the eigenvector and λ is the eigenvalue. When we divide C.I. by the random consistency number the final value must be less than 0.10 [20].

$$C.I. = \frac{\lambda_{\max} - n}{n-1} \qquad Ax = \lambda x \quad (3)$$

TOPSIS Method:

TOPSIS method was introduced for the first time by Yoon and Hwang and was appraised by surveyors and different operators. TOPSIS is a decision making technique [21]. It is a goal based approach for finding the alternative that is closest to the ideal solution. In this method, options are graded based on ideal solution similarity. If an option is more similar to an ideal solution, it has a higher grade [22]. Ideal solution is a solution that is the best from any aspect that does not exist practically and we try to approximate it. Basically, for measuring similarity of alternative (or option) to ideal level and non-ideal, we consider distance of that alternative from ideal and non-ideal solution [23].

The steps of TOPSIS method are as follow [24]:

First step:

Construct the normalized decision matrix. This step converts the various attribute dimensions into non dimensional attributes. An element r_{ij} of the normalized decision matrix R is calculated as follows: (x_{ij} is the value of ith alternative in jth criteria) [25],

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}^2} \tag{4}$$

Second step:

Obtain a weighted normalized decision matrix, where w_j is the weight of jth criteria. $\Sigma wj = 1, \quad W = \{w_1, w_2, \dots w_n\}$

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \cdots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix}$$

Third step:

Determine the positive ideal solution (V^+) and negative ideal solution (V^-) [26].

$$V^+ = \{(\max_i v_{ij} | j \in j_1), (\min_i v_{ij} | j \in j_2) | \ i = 1,2, \dots, m\} \tag{5}$$

$$V^- = \{(\min_i v_{ij} | j \in j_1), (\max_i v_{ij} | j \in j_2) | \ i = 1,2, \dots, m\} \tag{6}$$

V^+ and V^- are the best and the worst weighted normalized values for all alternatives according to jth criterion, respectively. j_1 is the set of benefit attributes while j_2 is the set of cost attributes [27].

Fourth step:

In this step the Euclidean distance of each alternative from the overall ideal and negative ideal solution is determined, respectively, as follows:

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} \ v_{ij}^+)^2}, \qquad i = 1,2, \dots, m \tag{7}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} \ v_{ij}^+)^2}, \qquad i = 1,2, \dots, m \tag{8}$$

Fifth step:

Calculate the relative closeness to the ideal solution [28].

$$c_i^* = \frac{s_i}{(s_i^+ + s_i)}, 0 < c_i^+ < 1, \qquad i = 1,2, \dots, m \tag{9}$$

$$C_i^* = 1 \text{ if } A_i = A^+ C_i^* = 0 \text{ if } A_i = A \tag{10}$$

Sixth step:

Rank the alternatives in descending order of C_i^* or select alternatives with maximum value of C_i^*.

The Procedure of the Study:

This study is conducted within two phase that aimed to manipulate Balanced Scorecard in evaluating the performance of port's operations terminals.

1) In the first phase experts' view consisted the main purpose of the model on which it is localized. Then, the process of chronological model measured all of the factors and indexes that are embedded in the evaluation of terminals operations and performance monitoring based to their importance.

2) In the second phase, TOPSIS Model is selected to prioritize five ranks of financial, customers, internal process, growth process and learning process in branches of Kaveh marine and port Service Company such as Shahid Rajaee, Port of Imam Khomeini, port of Anzali, Port of Khorramshahr, Port of Astara.

Results:

In this step, in addition to Table 2, findings of localized, indexes and factors are measured by their importance value and prioritized by chronological process model. Results of these steps are pictured in Table 2.

Table 2: weight of Balanced Scorecard Perspective and criteria

Perspective	W	Criteria	W
Finance perspective	0.245	total income increase	0.289
		Cost reduction	0.242
		Reduction of trade debtors	0.164
		Profit increase	0.306
Customer	0.238	retain existing customers	0.241
		Attract a new customers	0.214
		Increase customer satisfaction	0.262
		Increase the quality of services	0.283
Internal business process	0.187	Reduction of ship waiting time	0.212
		Reduction of ship service time	0.234
		Reduction of trucks service time	0.181
		Being standby, port and marine equipment.	0.203
		increasing loading and unloading tonnage	0.170
Learning and growth	0.195	Information exchange with port stack holders	0.214
		Mechanization of port and marine processes	0.234
		Productivity Increase	0.181
		Establishment of the partnerships system	0.161
		development of human resource training	0.210
Sovereignty	0.245	Control and monitor the implementation of the Convention and national law	0.289
		Control and prevention of safety and environmental incident	0.242
		Management of the Coastal and Inland Waterway	0.164

According to the obtained results of the Balanced Scorecard indexes, the financial mode is measured 0.245 and considered the highest, internal mode measured 0. 187 and considered the poorest. Also process such growth and learning considered in the second and third rate by 0. 238 and 0. 195. in financial mode, the criteria of profit increase is measured 0. 306 and leveled as number one. The criteria of total income is measured 0. 289 and leveled as number two, cost decrease is measured 0. 242 and leveed as number three and trade doubt decrease is measure 0. 164 and leveled as number four. Among customer modes, the criteria of service quality enhancement is measured 0. 283 and ranked 1, the criteria of customer satisfaction is measured 0. 262 and ranked 2, the criteria of customer values is measured 0. 241 and ranked 3, the criteria of marketing a new customers is measured 0. 214 and ranked 4. Among internal processes modes, the criteria of ship's time servicing decrease is measured 0. 234 and labeled the first, ship's awaiting time decrease is measured 0. 212 and labeled the second, the readiness of the port and marine instruments is measured 0. 203 and labeled the third, tracks service time decrease is measured 0.181 and labeled the forth, increase of charge and discharge tonnage is measured 0. 170 and labeled the fifth. Among growth and learning modes, the criteria of marine and port process mechanization is measured 0.234 as the highest, electronic information exchanges is measured 0. 214 as the second, developing and optimization of human resource is measured 0. 210 as the third, optimization increase is measured 0. 181 as the forth and cooperation systems establishment is measured 0. 261 as the fifth. Then, after the evaluation of these branches according to the suggested indexes of Balanced Scorecard scale, the mean of the calculation estimated and based to the scores, the decision matrix is developed as Table 3. Next, the mentioned matrix was normalized and by multiple the calculations, the measures of parallel normalized matrix modes were obtained.

Table 3: Decision Making Matrix

	F	C	I	L
W	0.245	0.238	0.187	0.195
Shahid Rajaee	7.756	7.13	8.295	5.75
Port of Imam Khomeini	8.316	7.21	8.055	7.5
Port of Khorramshahr	6.42	6.008	5.25	3.25
port of Anzali	6.386	7.4	7.0075	4.5
Port of Astara	4.18	6.8	6.25	1.8

Thereafter, each branch of Kaveh marine and port service Company is prioritized according to its' ideal positive and negative solutions. Table 4 shows the final results of TOPSIS model and also the branches ranks according to the Balanced Scorecard modes.

Table 4: Final result of TOPSIS method

Branches	di+	di-	CI	Rank
Shahid Rajaee	0.03732	0.11394	0.75326	2
Port of Imam Khomeini	0.00471	0.14570	0.96869	1
Port of Khorramshahr	0.10504	0.05100	0.32684	4
port of Anzali	0.07065	0.07926	0.52871	3
Port of Astara	0.14211	0.01963	0.12136	5

Conclusion:

The localized financial mode of Balanced Scorecard consists of modes such as total income increase, trade doubt decrease and profit increase. The localized customer mode of Balanced Scorecard consists of modes such as customer values, marketing customer, customer satisfaction, service quality enhancement. The localized internal mode of Balanced Scorecard consist of modes such as ship's decrease of time awaiting, ship's time servicing decrease, tracks time servicing decrease, the readiness of the marine and port instruments, charge and discharge tonnage increase. The localized growth and learning modes of Balanced Scorecard consist of modes such as electronic information exchanges, port processes mechanization, optimization increase, cooperation system establishment, developing and optimizing human resource. the obtained results on which indicated on the base of four prospect of Balanced Scorecard shows that the branch of Imam Khomeini port obtained the score of $C_i = 0.96869$ and identified as number one, the branch of Shahid Rejaee port obtained the score of $C_i = 0.75326$ and identified as number two, the branch of Anzali port obtained the score of $C_i = 0.52871$ and identified as number three, the branch of Khorramshahr port obtained the score of $C_i = 0.32684$ and identified as number four and the branch of Astara port obtained the score of $C_i = 0.12136$ and identified as number five.

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