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EFFICIENCY AND LOGISTIC CAPABILITIES OF COMMERCIAL SEAPORTS

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ABSTRACT

EFFICIENCY AND LOGISTIC CAPABILITIES OF COMMERCIAL SEAPORTS

The competition arose by deep-sea container transportation had also prepared an environment of intense competition for container terminals. The factors such as correct pricing, speed and quality of all the services and how strong the ports hinterland's are determinants of whether they are going to keep their customer within this intense competition, or not. However, the ports are now regarded not elements of only vessel operations, but as an integral part of the whole logistics and supply chain that provide directly and indirectly value added and positive social impact as well.

There are many studies found in literature regarding to measure port's efficiency and benchmarking with other ports. These studies are mostly focused on efficiency measurement with Data Envelopment Analysis (DEA) method and mostly public data (berth length, quantity of port cranes, total throughput etc.) had been used in these studies. In this study, ports are considered as complete logistics and supply chain entities that create added value and it is aimed at creating "a new balanced score card method" whereby environmental and social aspects of ports can be evaluated as well as their operational and financial performances. In this context, the aim of the study is to create a four-dimension port's balanced score card in order to benchmark container terminals or to monitor the changes in the performance of a single port over different periods. To reach this aim, the views and subjective judgments of the professionals working in the port industry were received and these judgments were evaluated by the Analytic Hierarchy Process (AHP) method.

ÖZET

LİMANLARIN VERİMLİLİK VE LOJİSTİK YETERLİLİKLERİ

Günümüzde özellikle açık deniz konteyner taşımacılığının ortaya çıkardığı rekabet konteyner limanları için de yoğun bir rekabet ortamını hazırlamıştır. Limanların bu ortamda müşterilerini ellerinde tutabilmeleri doğru fiyatlandırma, verilen tüm hizmetlerin hızı ve kalitesi, limanın hinterland bağlantısının ne kadar güçlü olduğu gibi faktörler belirlemektedir. Bununla birlikte artık limanlar sadece taşımacılığın deniz ayağına hizmet veren yapılar değil, büsbütün bir lojistik ve tedarik zinciri unsuru olarak bu sisteme ve limanın kurulmuş olduğu bölgeye vermiş oldukları nitelikli hizmetler ve yaratılan işgücü ile doğrudan ve dolaylı olarak katma değer ortaya çıkaran birimler olarak değerlendirilmektedir.

Literatürde limanların operasyonel verimliliklerinin ölçülmesi ve diğer limanlarla karşılaştırılması amacıyla yapılmış birçok çalışma bulunmaktadır. Bu çalışmalar çoğunlukla Veri Zarflama Analizi (VZA) yöntemi kullanılarak sınırlı sayıda kamuya açık veri ile yapılmıştır (rıhtım uzunluğu, ekipman sayısı ve yıllık elleçlenen TEU gibi). Bu çalışmada ise, limanların katma değer yaratan komplike bir lojistik ve tedarik zinciri birimi olarak kabul edilmesinden yola çıkılarak; limanların operasyonel ve finansal etkinlikleri ile birlikte liman faaliyetlerinin çevresel ve sosyal boyutlarının da değerlendirilebileceği yeni bir "dengelenmiş skor kart" metodunun ortaya çıkarılması amaçlanmıştır. Bu kapsamda, çalışmanın amacı, birden çok konteyner terminalinin kıyaslanabileceği veya tek bir terminale belirli periyodlarda uygulandığı taktirde o terminale ait performans değişimlerinin takip edilebileceği "limanlar için dengelenmiş skor kart" oluşturmaktır. Bu amaca ulaşabilmek için, liman endüstrisinde çalışan profesyonellerin görüşleri alınmış ve bu kişisel yargılar Analitik Hiyerarşi Süreci (AHS) yötemiyle değerlendirilmiştir.

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λ_{max} = The value in order to calculate Consistency Index (CI) and Consistency Ratio (CR).

LIST OF ACRONYMS/ABBREVIATIONS

AHP:	Analytic Hierarch Process
ANP:	Analytic Network Process
ATT:	Average Vessel Turnaround Time
AVR. :	Average
CI:	Consistency Index
CIY:	Containerisation International Yearbook
CR:	Consistency Ratio
DEA:	Data Envelopment Analysis
DMU:	Decision Making Unit
ELECTRE:	ELimination and Choice Expressing REality
ESI:	Environmental and Safety Performance Index
FBI:	Financial and Business Performance Index
GHG:	Greenhouse Gas
GIS:	Geographic Information System
GL:	Germanischer Lloyd
HR:	Human Resources
IP:	Integer Programming
KPI:	Key Performance Indicators
LCI:	Logistic Chain and Operational Performance Index
MACBETH: Technique	Measuring Attractiveness by a Categorical Based Evaluation
MCDM:	Multiple-Criteria Decision-Making
PPI:	Port Performance Index
PROMETHEE:	Preference Ranking Organization METHod for Enrichment of Evaluations
PV:	Priority Vector
QC:	Quay Crane
RTG:	Rubber Tire Gantry Crane

SEI:	Socio-Economic Performance Index
SEM:	Structural Equation Modeling
TEU:	Twenty-Foot Equivalent Unit
TOPSIS:	The Technique for Order of Preference by Similarity to Ideal Solution
VLCC:	Very Large Crude Carrier

1. INTRODUCTION

1.1. Scope of Research

With the globalization of world trade, maritime transportation and port industry have become more competitive over the years. Especially after the bankruptcy of the Hanjin company, the changes in the maritime industry has led to the merger of large line operators (The Alliance: NYK Line – Hapag Lloyd – YML) and scrapping significant amount of vessels. Accordingly, this situation has also led to a decrease in ship's supply and increase in freight rates: fewer vessels mean more competition for ports. It should be mentioned at this point, one of the strategic advantages that required to gain competitive advantage is the value-creating applications in order to be unique/irreplaceable for customers, while the others are the applications for efficiency and productivity that will provide cost advantages.

This leads ports to regularly allocate their resources for investment in the name of improving operational efficiency and effectiveness, as well as to improve port capacity through investing on port facilities, including equipment and infrastructure. However, allocation of resources must be done in accordance with a specific strategy, otherwise there is a strong possibility for the resources might unnecessarily be wasted without reaching the any of desired targets. According to Acar, this strategy can be defined as a set of "specific plans" which will help organizations to reach their goal on exceeding organizational performance (Acar, 2008). Line operators, who are the most important customers of the ports, also frequently evaluate performance of the container ports as a part of their internal business process. Factors such as port tariffs, averagely how much time are lost while waiting for berths and how fast their ships are being operated at piers, play an important role in terminal selection and are crucial in assessing ports with other factors such as port's geographic location, depth, proximity to international markets and size of hinterland.

In the literature, we can see that mostly DEA method is used in benchmarking the performances of Turkish ports. However, it is obvious that benchmarks prepared with limited public data (annual throughput, total berth length, total terminal area and number of equipment, etc.) and aiming to measure operational or operational and economic performance cannot respond to the complicated needs of today.

For this reason, with the idea of establishing a common performance evaluation and benchmark system that can be used for container terminals, it is aimed to establish a port's balanced score card which can evaluate The Logistic Chain and Operational Performance, Financial and Business performance, Socio-Economic Performance and Environmental and Safety Performance dimensions which have resulted from port activities. These four dimensions are believed to have the ability to represent all phases of port activities, as the ports are considered as a complex logistics and supply chain element. For this purpose, Port's Balanced Scorecard (PBSC) method that has specifically developed for this study and Analytic Hierarchy Process (AHP) method were used to select and rank the criteria.

1.2. Objectives of Research

Main objectives of research are listed below;

a. Identifying key performance indicators which are related with port's performance in below segments:

   - Logistic Chain and Operational Performance
   - Financial and Business Performance
   - Socio-Economic Performance
   - Environmental and Safety Performance

b. Developing a four-dimension Port's Balanced Scored Card (PBSC) to evaluate and benchmarking ports.

1.3. Methodological Approach

Various indicators used in the evaluation and benchmark of the ports after the literature research was identified and listed. The four main dimensions mentioned above have been uncovered which were considered to be used creating the Port's Balanced Score Card. Relevant indicators were selected to form each dimension. When selecting indicators, it is aimed to use the most useful ones and the least possible number of indicators. In the later stage, the research questionnaire prepared with Saaty's 1-9 scale was sent to the competent participants in the port sector in Turkey (Saaty, 2008). The data obtained by the questionnaire were evaluated by the Analytic Hierarchy Process (AHP) method in order to find the priorities (weights) of the four main dimensions relative to each other and the indicators forming each dimension were also pair wisely compared. Finally, a balanced score card was created considering the weights of the dimensions. The coverage of the research has been determined as Turkish ports.

1.4. Thesis Outline

The following sections of the thesis are planned as follows:

In chapter 2, performance measurement, notions of efficiency, productivity and some Multiple-Criteria Decision-Making (MCDM) methods were explained.

In chapter 3, literature review of port performance and efficiency analysis was made, there is also a detailed list of port performance indicators obtained during the literature search.

In chapter 4, methodology and proposal for a new ports' balanced score card were presented.

In chapter 5, there is a discusion and conclusion section in which whole study was summarized, the limitations of the study were explained and suggestions about future research was made.

In chapter 6, the references can be found this section.

In chapter 7, in this section, examples of the questionnaire forms regarding the conducted survey are available in both English and Turkish.

1. PERFORMANCE MEASUREMENT AND MCDM METHODS

2.1. Performance Measurement

Performance evaluation is of great importance to both investors and managers in order to understand the current situation of the companies, whether they successfully achieved the results they aimed for the activities they carry out, whether they are wasting their resources while achieving these targets and perform their services efficiently and effectively. Performance measurement is an analytical process. In this process, it includes the steps of "data collection", "analyzing" and "reporting" regularly and systematically in order to monitor the sources are used, the services are produced and the results are obtained (Lorcu, 2010).

Performance measurement methods can be applied to non-profit hospitals, government entities, banks and schools as well as private sector companies. On a larger scale, comparisons of production or service performances that are carried out in different geographical areas can also be made. The performance measurement methods used may vary according to the type of data is used, structure of production, and the priorities of decision makers (Coelli, Rao, O'Donnell, & Battese, 2005).

2.2.Performance, Productivity, Efficiency and Effectiveness

A simple example of production can be given in which a company uses materials, labour and capital (inputs) in order to produce planes as outputs. How can be defined productivity of the company? We can find performance by ratio of productivity in the most basic way, the ratio of outputs to inputs (Lovell, 1993). This means that it performs better as the ratio grows. However, we can examine the increase or decrease in performance by comparing the output/input ratios of the same company over years. This method can be

applied to a wide range of companies that serve in different categories. Likewise, the companies which are offering similar services can be compared to each other for a benchmark or by taking a single company, the performance of its different branches can be measured (Coelli, Rao, O'Donnell, & Battese, 2005).

According Lovell's classic definition of productivity, following equitation can be written:

"Productivity = Output(s)/Input(s)"

It's not very troublesome when we use single input and single output. In case we intend to use multiple inputs and outputs, an "index" must be created from inputs/outputs in order to get a ratio measure of productivity (Coelli, Rao, O'Donnell, & Battese, 2005).

According to Daraio and Simar, productivity and efficiency are interrelated but not the same concepts, they defined efficiency as a "distance" between the quantity of input/output, and the best possible frontier for a firm can be defined with quantity of these (Daraio & Simar, 2007).

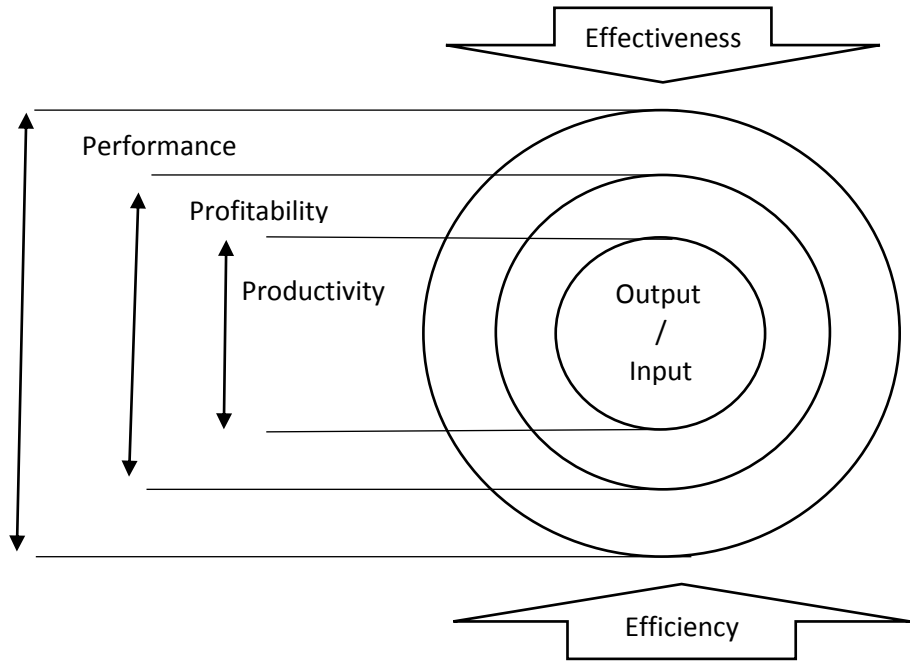

Figure 1.1 *The Triple-P model/Reprinted from Understanding the concept of productivity (Tangen, 2002).*

In his Triple-P model, Tangen considered the productivity in the center of diagram; it is most restricted (narrow-scoped) element and simply it is found by output/input ratio. Efficiency is about utilization of resources and Effectiveness is related with term of output. The Triple-P is well designed model to understand all performance related elements and their relationship with each other and it shows notion of performance comprises all of other elements (Tangen, 2002).

2.2.1. Total factor productivity and partial productivity

When we talk about "Total Factor Productivity", that should mean that we involve all production factors (Coelli, Rao, O'Donnell, & Battese, 2005). For example, only crane's productivity cannot represent a whole port's productivity, since it's just a partial measure of overall productivity. So, we must involve all related indicators such as crane productivity, vessel and berth productivities etc. in order to obtain total factor productivity of a container terminal. Otherwise, these indicators are monitors for partial productivity when considered independently of each other.

Tangen, questioned definition of the productivity and practically explained relationships between input and output how can positively affective the productivity in five differently conditions (Tangen, 2002).

1- If output and input increases, increase in output must be proportionally higher than the increase in input.
2- Output increases, input stays same.
3- Output increases, input decreases.
4- Output stays same, input decreases.
5- Output decreases, and decreasing in input is higher than output's.

According to Tangen, productivity is strongly connected to the creation of value, he also pointed out the relationship between productivity and profitability. It was assumed that productivity figured with physical units while profitability is about monetary units

(Tangen, 2002). For describing this relationship, Miller, built the equation of "Profitability = Productivity + Price Recovery" (Miller, 1984).

If productivity is a notion which is represented by only output/input ratio, performance is much wider concept that includes terms such as speed, quality and cost. The relations between concepts of performance, profitability and productivity were shown very clear in Tangen's The Triple-P model (Tangen, 2002). The difference between two concepts, when effectiveness is about accomplishing the expected/planed results, efficiency is performing any given task with best possible way; while using as less as possible time, effort and sources.

2.2.2. Efficiency

It is possible to define Efficiency as achieving targeted goals with the minimum use of the all usable resources (Martic, Novakovic, & Baggia, 2009).

Economic Efficiency: Economic efficiency is a condition when every resource is allocated in a best way while minimizing waste and inefficiency (Investopedia, n.d.)

Cost efficiency is combination of technical and allocative efficiency. It is required to be both technical and allocative efficiency in order to be cost efficient.

Allocative (price) Efficiency: When society get best return from its inadequate resources, then we can talk about presence of the allocative efficiency. It is possible to use resources with quite different ways, and allocative efficiency is about practicing the most efficient way for allocation. It should be noted that technical efficiency is also required in order to achieve to allocative efficiency (Productivity Commission 2013 On efficiency and effectiveness: some definitions, Staff Research Note, Canberra.).

Productive Efficiency: It is about producing maximum amount of goods while consuming minimum amount of resources (at minimum cost) and it is an economic indicator where an economy will no longer be able to create additional amounts of a good except reducing the production level of another merchandise if the economy operating in its production frontier (Investopedia, n.d.). Since it takes "prices" into account, it is exceeds and includes the notion of "technical efficiency" (Productivity Commission 2013 On efficiency and effectiveness: some definitions, Staff Research Note, Canberra.).

Technical efficiency: Measured as the ratio between the observed output and the maximum output with fixed input or as the ratio between the observed input and the minimum input with a fixed output (Porcelli, 2009). According to Porcelli, both technical and allocative efficiency can be found by input and output approaches (Porcelli, 2009) :

- Input approach: Producing maximum output as input usage allows. Minimizing usage on input targeted while output is fixed.

- Output approach: Using little input as output production allows. Maximizing output while input is fixed while avoiding "waste" of resources.

Dynamic efficiency: Dynamic efficiency is related to better allocation of resources across time periods. That can be possible with improvements on technology; a better production system will allow for more output with less amount of input (Productivity Commission 2013 On efficiency and effectiveness: some definitions, Staff Research Note, Canberra.)

Production (Possibility) Frontier: The Production Frontier may be used to define relationship between input and output (Coelli, Rao, O'Donnell, & Battese, 2005). The Production Frontier shows the maximum possible output available for each input level.

Technical efficiency is connected to production frontier so depending the technical efficiency of a firm is either about if it is being operated on the production frontier or not. Efficient production is achieved when a product is created at its lowest average total cost.

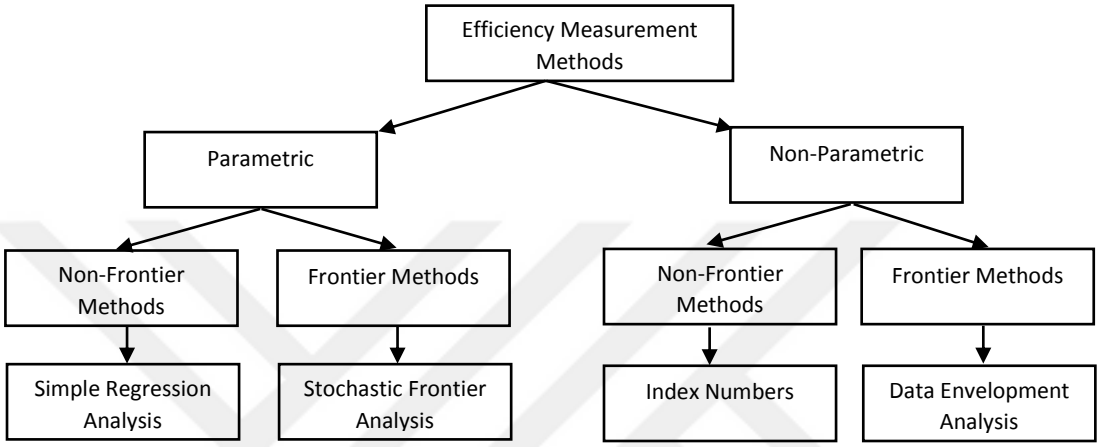

Figure 1.2 *Efficiency Measurement Methods/Reprinted from An Assessment of Comparative Efficiency Measurement Techniques (Sarafidis, 2002).*

2.2.3. Multiple Criteria Decision Making (MCDM or MCDA) Analysis

Multiple-criteria Decision Making (MCDM) is a sub-branch of operations research, it used when existence of multiple and conflicting criteria. The MCDM methods made progress very dependently to advancement on computer technology and that made possible to analysis of complicated problems. It is quite possible to encounter with MCDM problems in daily life and professional life (Xu & Yang, 2001). For example; tonnage, type, price and the built date can be considered when buying a vessel to operate as well as many criteria should be required to evaluate when buying a new car. Only in an extraordinary situation a VLCC or a luxury brand new car can be sold as cheapest one.

In simple MCDM problems, there may be one unit of measurement for the criteria, but the problems encountered in real life are much more complex and the criteria can be expressed in many different units (Triantaphyllou & Mann, 1995).

Main features of MCDM methods (Xu & Yang, 2001):

- There are hierarchy among criteria.
- There are usually contradiction(s) between criteria. For example, a bigger vessel can carry more amount of cargo but she will have lower maneuverability.
- There are diverse units to measure. For example; while evaluating a port's performance, different measuring units such as duration, ratio, tonnes per hour etc. can be used.
- Panelists participating in the study may not be exactly consistent.
- There may be missing/incomplete datasets.
- MCDM study may be in an extend scale. There may be many criteria with hundreds of sub-criteria.
- Finally, it may not possible to encounter with accurately results due to all negativeness which were mentioned above.

A general view of the MCDM models is given in Figure 2.3 below. The "decision" referred to here is the final result to be achieved. In order to achieve this result, it is necessary to select the best "alternative" among others by evaluating the "criteria" given.

For example, if it is required to make a choice in order to buy a car, the following criteria can be considered:

Criteria 1: Tax advantage

Criteria 2: Speed

Criteria 3: Horse power

Criteria 4: Price

Criteria 5: Interior volume

A "decision" will be made among the following alternatives according to the importance of the above given criteria. If the priorities respectively are price, tax advantage, interior volume, speed and horse power, Volkswagen will be the best alternative.

Alternative 1: Ferrari (speed/horse power)

Alternative 2: Renault (price/interior volume)

Alternative 3: Volkswagen (price/tax advantage/interior volume)

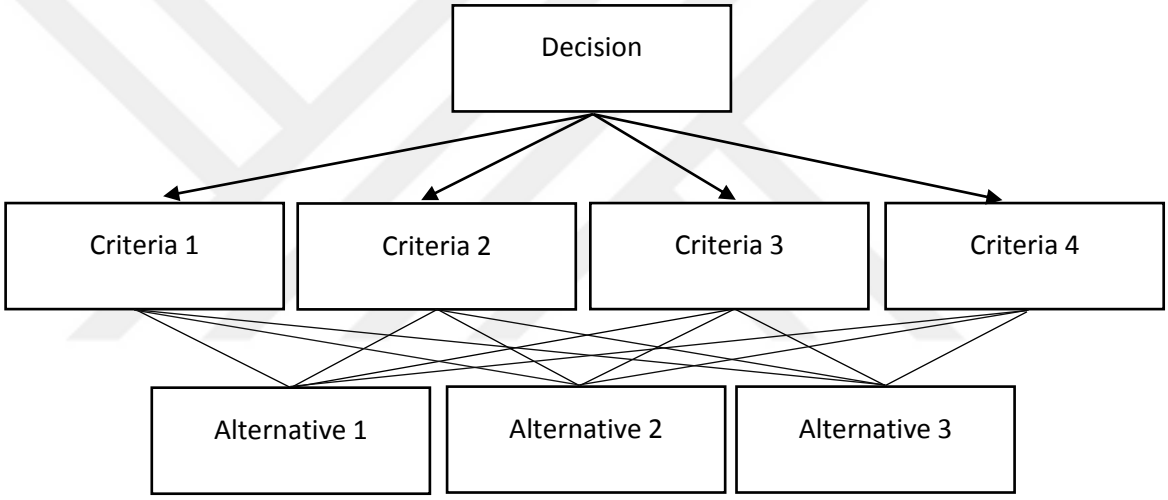

Figure 1.3 *Multi Criteria Decision Making (MCDM) Model.*

A typical MCDM problem is represented by a decision matrix in below. The goal is to find the best one among alternatives. The following matrix has M of alternatives and N of decision criteria. There are alternatives in the rows, and evaluation factors in the columns. Accordingly, each alternative is evaluated according to decision criteria, and each decision criterion can be weighted relative to each other (Triantaphyllou & Mann, 1995).

In MCDM methods, the weighting is done according to the cardinal scale and indicated by "w," the sum of the weights is required to be equal to 1.

$$
\begin{array}{cccccccc}
 & . & \boldsymbol{C_1} & \boldsymbol{C_2} & \boldsymbol{C_3} & \boldsymbol{C_4} & \ldots & \boldsymbol{C_N} \\
\boldsymbol{Alt.} & . & \boldsymbol{W_1} & \boldsymbol{W_2} & \boldsymbol{W_3} & \boldsymbol{W_4} & \ldots & \boldsymbol{W_N}
\end{array}
$$

$$
\begin{bmatrix}
A_1 & . & a_{11} & a_{12} & a_{13} & a_{14} & \ldots & a_{1N} \\
A_2 & . & a_{21} & a_{22} & a_{23} & a_{24} & \ldots & a_{2N} \\
A_3 & . & a_{31} & a_{32} & a_{33} & a_{34} & \ldots & a_{3N} \\
A_4 & . & a_{41} & a_{42} & a_{43} & a_{44} & \ldots & a_{4N} \\
. & . & . & . & . & . & \ldots & . \\
. & . & . & . & . & . & \ldots & . \\
. & . & . & . & . & . & \ldots & . \\
A_M & . & a_{M1} & a_{M2} & a_{M3} & a_{M4} & \ldots & a_{MN}
\end{bmatrix}
$$

Decision matrix for MCDM problems is shown above. C = Criteria, A= Alternatives, W= Weights (Triantaphyllou & Mann, 1995).

The below table summarizes some MDCM methods that are often used to solve problems in a wide range.

Table 1.1 *Comparison of MCDM methods.*

MCDM Method	**Description**	**Advantage**	**Disadvantage**	**Areas of Application**
Analytic Hierarchy Process (AHP)	A MCDM method using a hierarchical structure consisting of target, criteria and sub-criteria and alternatives.	-Fuzzy analysis can be applied. -Flexible and we can check inconsistencies. -A hierarchical structure can be establish, so weighting (importance) of each indicator can be seen.	-More numbers of pairwise comparisons are required. -It may be though for decision maker to use and clearly understand the 1-9-point Saaty scale.	Performance-type problems, develop estimate model, resource management
Analytic Network Process (ANP)	It is a network model that contains dependency and feedback. There are Interdependence within clusters and outer dependence	-Elements are allowed to be dependent.For this reason, it is more successful in solving complex problems than linear models.	- It may be difficult to create a correct network (even for experts) due to complexity of model. A wrongly designed network can be resulted with misleading results.	Supply chain management, economics, social sciences

	among clusters are the issues. While the linear models have an one-sided simple schematic, the network model has a similar structure to the spider web.			
Data Envelopment Analysis (DEA)	DAE is a linear programming where it is used to find the efficiency by considering differences between observed and best practice units. It is mostly used to measure technical efficiency.	-Multiple inputs and outputs are allowed to be used. -There is not necessity for a relationship between inputs and outputs. -The inputs and outputs are allowed to be different type of units.	-Presence of important errors is possible due to measurement error (very sensitive to measurement errors and variable selections). -The number of DMUs must be at least three times the sum of the input and output variables, otherwise, Otherwise, DEA would define many decision-making units as efficient.	This method can be used in companies and public institutions which are being operated in different fields where efficiency can be measured. There are many studies in the literature conducted by this method.
ELECTRE	It is a ranking method based on pair wise comparisons between criteria and alternatives. If an alternative meets one or more criteria, it overrides other alternatives.	-Fuzzy analysis can be applied. -It is time-saving if applied together with other MCDM methods, because with ELECTRE, some alternatives can be selected in advance and others can be eliminated and the remaining alternatives can be sorted by another MCDM method.	-A difficult method to implement.	Energy systems, economics, water management, transportation
PROMETHEE	PROMETHEE is a ranking method that does not show the right choice directly to decision makers, but it helps to find out which is the	It is a simpler ranking method for multi-criteria analysis compared to other ranking methods (ELECTRE).	-It may not be easy to explain to non−specialists (because of the existence of preference functions).	Environmental, hydrology, energy, agriculture, chemistry, transportation, logistics

	best alternative to fit their purpose, by ranking alternatives.	-It's require less number of inputs.	-If a lot of criteria involved, it would be time consuming. -Input values are usually based on the thoughts and experiences of decision makers	
TOPSIS	TOPSIS is a distance based ranking method. It's based on the finding the best alternative in the shortest distance to positive ideal solution and farthest distance to anti-ideal solution.	-Any numbers of attribute and criteria can be used. -Easy implementation compared to ELECTRE and PROMETHEE. -Less number of comparison required as compared to AHP. -Less time consuming compared to ELECTRE (it takes account into only qualitative data).	-Results may be unreliable (there is not option for controlling of consistency)	Supply chain management, resource management, engineering

2.2.3.1. Multiple-Criteria Decision-Making (MCDM) Models

2.2.3.1.1.Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a non-parametric and deterministic method to measure efficiency that was introduced by Charnes, Cooper and Rhodes (1978). It is used to estimate of production-possibility frontiers and "productive efficiency" of DMUs with multiple input and outputs. Measurement of relative efficiency that is known as the Data Envelopment Analysis in the literature, also referred to as Efficiency Analysis (Sarı, 2015). It is a linear programming-based method and used to measure the relative activities of decision-making units in the necessity of considering the large number of inputs and outputs.

As a result of the solution of the linear programming model for each decision unit whose objective function is equal to 1 are determined as "effective" and whose objective function is less than 1 are considered as "ineffective" decision units.

DEA method is to serve for operations research and economics. A clear purpose of DEA had also been described by Food and Agriculture Organization of the United Nations; so the DEA is used to measure productive efficiency by evaluating “maximum possible output” for a given set of inputs, DEA method can also can be used estimate capacity utilization (FAO). A set of measures (key performance indicators, for example) are selected with purpose of benchmarking, separately analyzed and maximum efficiency measured for each Decision Making Unit (DMU) is calculated (Martic, Novakovic, & Baggia, 2009).

Decision Making Unit is defined as those factors that convert inputs into outputs, and whose performance is being evaluated. In other words, DMUs are the units whose efficiency are measured by DEA method. For example, when we compare efficiencies of container terminals by DEA method, each container terminal is considered as a DMU. DEA will compared each DMU (container terminal) with only efficient (best) ones.

- All DMUs are required to be homogeneous.
- All DMUs to be used in DEA should have similar objectives.
- All DMUs should perform similar activities (Özdemir & Demireli, 2013).

DEA method is very popular among researchers and it has found use in researches those examined the companies with purpose of benchmarking and efficiency evaluation in a wide range of activity area; healthcare and medicine, aviation, maritime, ports and logistics, fishing etc. The method is also useful for benchmarking container terminals and a great number of research is available in literature.

First DEA model, the CCR Model was developed by Charnes, Cooper and Rhodes in 1978. The CCR model can be input or output oriented and the model based on constant returns of scale. If the model will be either input or input oriented, that depends on specifications of DMUs. An input type model will minimize the inputs for a certain level of outputs, and an output type model is supposed to maximize the outputs for a certain level of the inputs (Mecit & Alp, 2013).

The BCC model, introduced by Banker, Charnes and Cooper in 1984. Unlike CCR model, the BCC model allows for variable returns to scale: in case of an increasing in inputs it does not cause to equivalent change in outputs, a variable returns to scale model (for example BCC model) can be used (Banker, Charnes, & Cooper, 1984).

The general steps of a DEA analysis are as follows:

1. Determination of the decision-making units.
2. Determination of input and output factors.
3. Collection of required data related to input and output factors.
4. Choice of DEA model to be used.
5. Calculation of efficiency values.
6. Interpretation of the obtained results.

2.2.3.1.2.Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is one of the MCDM (multi-criteria decision-making methods), it was developed by Thomas L. Saaty (as cited in Kasperczyk & Knickel, 2010). The model was first used in the US defense ministry's projects and later in the Sudan transport project in 1973 (Göksu & Güngör, 2008). The method designed as a decision-making instrument in order to solve complicated matters (Triantaphyllou &

Mann, 1995). According to Göksu and Güngör, this method can be applied to very complex problems thanks to it have some advantages: it takes into account quantitative and qualitative factors, easy-to-use and feasible. They also underlined that user's experience on this method is very important (Göksu & Güngör, 2008).

In AHP, first of all, the decision maker needs to set a goal. Later on, it is required to determine the all factors that may affect to achieve this goal. This can be done for the questionnaire study, as well as consultation with the experts and their opinions. Once the objective, alternatives and criteria have been determined- depending on the decision maker's criteria- the importance weightings of the alternatives are determined by means of the pairwise comparison decision matrices (Yılmaz & Dağdeviren, 2010). The aim of the study is to find the best alternative (the one with the highest priority value) and calculate the priority and weight vectors for it. In the creation of the matrices mentioned above, Saaty's importance scale of 1-9 is used. This methodology breaks down a conflicting situation that needs to be solved into its pieces, then the pieces are sorted by hierarchic order and subjective judgments are numbered from 1 to 9.

The steps for problem solving in AHP are as follows:

1- First, the problem is identified and the goal to be placed at the top of the hierarchy is determined.

2- At second, the hierarchy is created. In this hierarchy, the goal and then the criteria, if any, the sub-criteria and then the alternatives are determined. In order to be able to determine all the criteria that affect the process, it is required to consult the expert's opinion, the literature or the survey research.

3- Pairwise comparison matrix is created. In here, decision makers should make comparisons by way of questionnaires. The importance scale given in Table 3 should be used in the questionnaire. If there are "n" number of alternatives to be

evaluated, then total number of comparisons must be made as many as the all pairwise combinations of n number of alternatives.

The formula in below is used for this purpose:

$$C(n,2) = \frac{n!}{(n-2)!.2!}, (n \geq 2)$$

And,

$\frac{n.(n-1)}{2}$ formula is found. That is, if pairwise comparisons are made for a number of 10 alternatives, 45 pairwise comparisons are required in total (Göksu & Güngör, 2008). It should be noted that, the number of criteria and alternatives must be determined correctly and all of them must be explained in detail.

Table 1.2 *Saaty's Scale of Relative Importances/Reprinted from Using The Analytic Hierarchy Process For Decision Making in Engineering Applications: Some Challenges (Triantaphyllou & Mann, 1995).*

Intensity of Importance	Definition
1	Equal importance
3	Weak importance
5	Strong importance
7	Demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate values

An example of pairwise compression is shown in below. A, B and C are assumed as decision criteria and were compared to each other. In our example, B is favorable than C and A, and A is favorable than C.

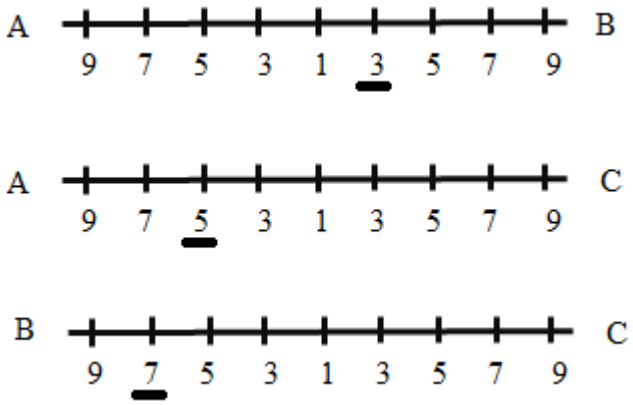

Figure 1.4 *Example for pairwise comparisons in AHP.*

	A	**B**	**C**
A	1	1/3	5
B	3	1	7
C	1/5	1/7	1

Figure 1.5 *AHP Matrix based on paired comparisons in Figure 4.*

Table 1.3 *Creating pairwise comparisons matrix for n number of criteria/Adopted from Municipalities Public Transport Vehicle Selection Using Fuzzy AHP (Şengül, Eren & Shiraz).*

	Criteria 1	Criteria 2	Criteria 3	Criteria n
Criteria 1	w_1/w_1	w_1/w_2	w_1/w_3	w_1/w_n
Criteria 2	w_2/w_1	w_2/w_2	w_2/ w_3	w_2/ w_n
Criteria 3	w_3/w_1	w_3/w_2	w_3/w_3	w_3/w_n
Criteria n	w_n/w_1	w_n/w_2	w_n/w_3	w_n/w_4

In case of w_3/w_1 ratio is five, that will mean w_3 is five times important than w_1 and we can talk about there is an objective judgment. In case of w_3/w_1 ratio is nine, then w_3 has an absolute importance over w_1 and it is subjective judgment (Şengül, Eren, & Shiraz).

4- By using the pairwise comparison matrix, priority vector (PV) is found. PV is the weights (priorities of criteria) and should be equal to "1" when summed up. Otherwise there is a calculation error.

Let say we have four main criteria (a, b, c, d). We need to calculate “nth. root of the criteria” in order to find PV values. In here, “n” is equal to four, since there are four criteria. Here, the PV value of each criteria is found by dividing each criteria's nth root to total value of nth roots (Table 2.4).

Table 1.4 *Calculation of Priority Vector (PV).*

Main Criteria	nth. root of the Criteria	Priority Vector (PV)
a	$x = \left(1.000 \text{ x} \frac{\text{a}}{\text{b}} x \frac{\text{a}}{\text{c}} x \frac{\text{a}}{\text{d}}\right)^{\frac{1}{n}}$	$\frac{x}{e}$
b	$y = \left(\frac{\text{b}}{\text{a}} \text{x } 1.000 \; x \frac{\text{b}}{\text{c}} x \frac{\text{b}}{\text{d}}\right)^{\frac{1}{n}}$	$\frac{y}{e}$
c	$z = \left(\frac{\text{c}}{\text{a}} \text{ x} \frac{\text{c}}{\text{b}} x \; 1.000 \; x \frac{\text{c}}{\text{d}}\right)^{\frac{1}{n}}$	$\frac{z}{e}$
d	$t = \left(\frac{\text{d}}{\text{a}} \text{ x} \frac{\text{d}}{\text{b}} x \frac{\text{d}}{\text{c}} x \; 1.000 \;\right)^{\frac{1}{n}}$	$\frac{t}{e}$
	$e = (x + y + z + t)$	$\left(\frac{x}{e} + \frac{y}{e} + \frac{z}{e} + \frac{t}{e}\right) = 1.000$

Table 1.5 *Calculation of Consistency Index (CI) and Consistency Ratio (CR).*

	a	**b**	**c**	**d**	nth. root of the Criteria	PV
a	a/a (pairwise comparison)	a/b	a/c	a/d	x	$\frac{x}{e}$
b	b/a	b/b	b/c	b/d	y	$\frac{y}{e}$
c	c/a	c/b	c/c	c/d	z	$\frac{z}{e}$
d	d/a	d/b	d/c	d/d	t	$\frac{t}{e}$
Sum	$1+\frac{b}{a}+\frac{c}{a}+\frac{d}{a}$	$\frac{a}{b}+1+\frac{c}{b}+\frac{d}{b}$	$\frac{a}{c}+\frac{b}{c}+1+\frac{d}{c}$	$\frac{a}{d}+\frac{b}{d}+\frac{c}{d}+1$	e	1
Sum* PV	$\left(1+\frac{b}{a}+\frac{c}{a}+\frac{d}{a}\right)x\frac{x}{e}$	$\left(\frac{a}{b}+1+\frac{c}{b}+\frac{d}{b}\right)x\frac{y}{e}$	$\left(\frac{a}{c}+\frac{b}{c}+1+\frac{d}{c}\right)x\frac{z}{e}$	$\left(\frac{a}{d}+\frac{b}{d}+\frac{c}{d}+1\right)x\frac{t}{e}$	λ_{max}	
λ_{max}	$\left(\left(1+\frac{b}{a}+\frac{c}{a}+\frac{d}{a}\right)x\frac{x}{e}\right)+\left(\left(\frac{a}{b}+1+\frac{c}{b}+\frac{d}{b}\right)x\frac{y}{e}\right)+\left(\left(\frac{a}{c}+\frac{b}{c}+1+\frac{d}{c}\right)x\frac{z}{e}\right)+\left(\left(\frac{a}{d}+\frac{b}{d}+\frac{c}{d}+1\right)x\frac{t}{e}\right)$					
CI	$\frac{\lambda_{max}-n}{n-1}$					
CR	$CR=\frac{CI}{RI}$					

5- Consistency ratio is calculated. If there is no consistency is found, comparisons are calculated by re-evaluation of pairwise comparisons (Göksu & Güngör, 2008).

Pairwise comparisons of decision alternatives and criteria may not be consistent. For acceptancy of evaluations Consistency Index (CI), Consistency Ratio (CR) and Random Consistency Index (RI) are required to calculated (Acar, Önden, & Kara, 2015). According to Triantaphyllou and Mann, there is a small chance for perfect consistency and the pairwise comparisons in a judgment matrix is accepted consisted provided that

consistency ratio is below 10 % (Triantaphyllou & Mann, 1995). If "CR" bigger than 10 %, then subjective judgments are required to be checked.

The formula for Consistency Index:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

$$CR = \frac{CI}{RI}$$

And Consistency Ratio (CR) is the compression between Consistency Index and Random Consistency Index (RCI), is described as:

Table 1.6 *Random Index (RI) calculated for ten dimensional matrice/Reprinted from Hard Mathematics Applied to Soft Decisions (Saaty, 2001).*

K	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

6- The previous steps are calculated for the whole hierarchical structure in order to achieve a general result.

2.2.3.1.3.ELECTRE

The origin of the ELECTRE method was based on SEMA (European consultancy company) in 1965. At the same time, a team of the same company developed the method

of MARSAN (Methode d'Analyse, de Recherche, et de S'election d'Activitées Nouvelles). In the MARSAN method weighted-sum based technique was used to select new activities. However, it was realized that the MARSAN method had some disadvantages and the need to develop an alternative method to MARSAN method was emerged.

As a result of Bernard Roy's decision-making studies, the method of ELECTRE (ELimination Et Choix Traduisant la Realite - ELimination and Choice Expressing the REality) was developed in 1965 and this first ELECTRE method has been called ELECTRE 1. However, there was no awareness about the method until 1968 when it was published in the RIRO (la Revue d'Informatique et de Recherche Opionnelle) (Figueira, Mousseau, & Roy). There are six main versions of the ELECTRE method: I, II, III, IV, Tri and 1S.

ELECTRE, a method used for solving the problems that require selection for real-world issues, can interpret numerical computations by translating into qualitative statements. With the ELECTRE method, all possible pairs of different alternatives are compared regarding on the criteria and the values of the alternatives are again displayed on the basis of the criteria. The core of the ELECTRE method is based on establishing a superiority relationship between preferred and non-preferred alternatives.

There are two basic steps in the implementation of the method. These are:

- Calculation of indicators of consistency and non-consistency, as a result of comparing the options.
- The establishment of relations of superiority between alternatives (Akyüz & Soba, 2013).

2.2.3.1.4. PROMETHEE

PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) is a multi-criteria prioritization method that developed by Jean-Pierre Brans in 1982, was later developed and implemented by Brans and Vincke in 1985. The most important issue in the PROMETHEE method, which is a very easy-to-understand approach for the decision maker, is to determine the criteria. Criteria can be easily determined by decision makers since they are concepts that indicate the intensity of preferences (Çelik & Ustasüleyman, 2014). The PROMETHEE method, which is convenient for outranking problems, provides flexibility and simplicity for the user and at the same time it is a simpler outranking method compared to others (Yılmaz & Dağdeviren, 2010). There are different PROMETHEE methods: PROMETHEE I, II, III, IV, V, VI; GDSS; TRI; and CLUSTER. According to Tscheikner-Gratl and others, PROMETHEE III has advantage over other versions because it better reflects the decision behavior of the decision maker and main advantage is to allow for the manipulation on the variables without requiring any normalization even when there is lack of data (Tscheikner-Gratl, Egger, Rauch, & Kleidorfer, 2017). However, another method may be well suited for a particular research. For example, Taillandier and Stinckwich are used PROMETHEE II method for defining new exploration strategies for rescue robotsin their research (Taillandier & Stinckwich, 2011). The PROMETHEE method is also used with other MCDM methods.

2.2.3.1.5. Analytic Network Process (ANP)

Developed by Thomas L. Saaty. It is distinguished from classical decision making methods by considering qualitative values (it is designed to measures human judgment) as well as quantitative values. It allows easy modeling of complex problems that cannot be modeled by hierarchical structures, that is, if relations between elements in a problem are “mutual” rather than “one-sided”; then linear hierarchical models may not be enough for a solution and ANP model can be taken into account in this point. For this reason, it is a more useful method to consider unlimited environmental factors. The ANP method is also

based on pairwise comparisons such as AHP. In contrast to AHP, the decision making problem is modeled by a network structure, not by a linear hierarchy model, and it is based on feedback and dependency between decision criteria and alternatives. Decision problem in ANP consists of sets, criteria and links between them. The appropriate factors in a network come together to form the sets and feedback and dependency within each set are considered as essential. In this way, non-hierarchical complex decision problems can be easily modeled (Saaty, 1999).

It can be likened to a spider web with its complex networks that overrides the grades of hierarchical models (Bağ, Özdemir, & Eren, 2012). Hierarchical linear models are more like a one-way diagram.

An example for network structure in the ANP method

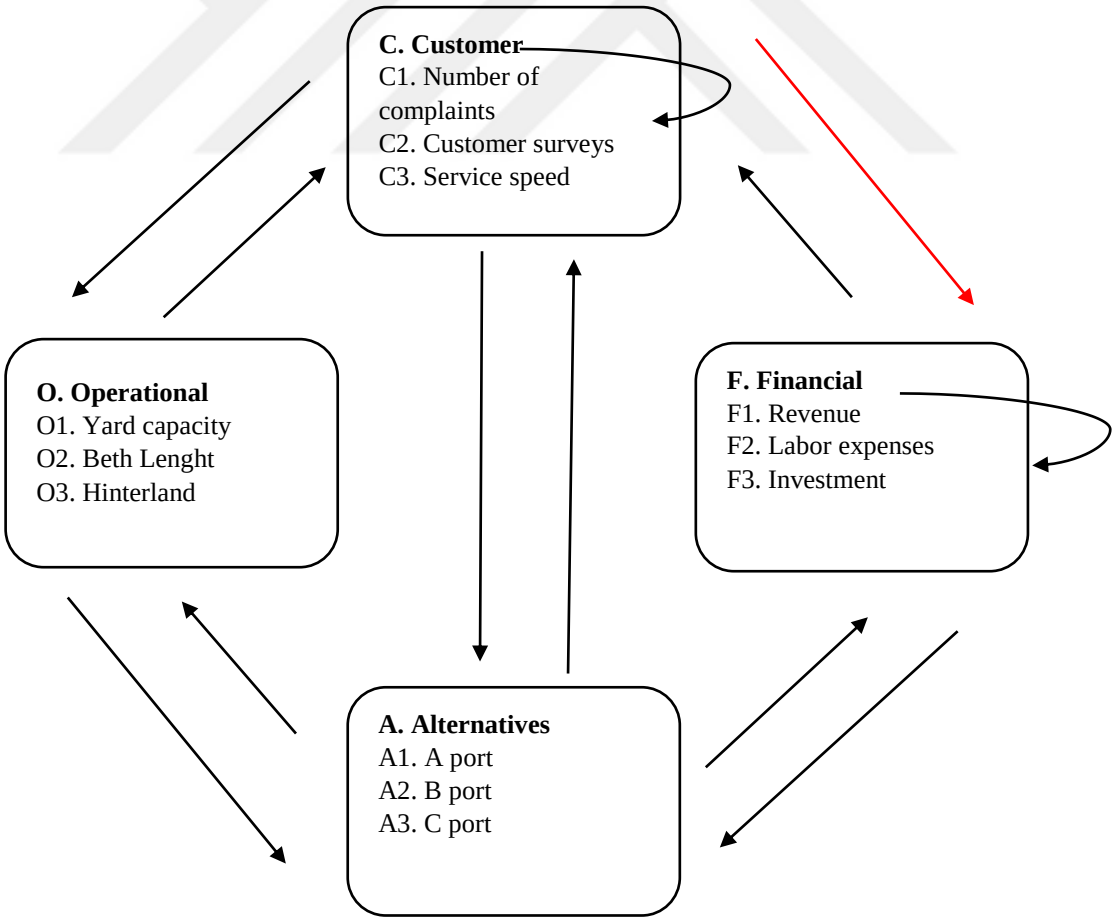

Figure 1.6 *An example for network structure in the ANP method.*

Figure 2.6 shows a very simple example of the network structure in the ANP method. Here, the straight arrow in red indicates that the elements in the set of finance are affecting the elements in the set of customer. In this case, the elements of the financial set have "outer dependence" on the elements of the customer set. The interdependence loop, indicated by curved arrows, means that the elements in the same set affect each other. So these elements have "interdependence".

2.2.3.1.6. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) developed by Yoon and Hwang in 1981 and uses the basic approach of the ELECTRE method. It is main principle based on the proximity of the alternatives to the ideal solution (the alternative in the shortest distance to positive ideal solution and farthest distance to anti-ideal solution). TOPSIS is a distance-based decision making method (Ertuğrul & Özçil, 2014).

In the TOPSIS method, a decision matrix is formed as in the AHP method. However, its difference from AHP method is that the decision matrix is created through the value assignment rather than pairwise comparisons. For this reason, every possible criterion is included in the process.

Positive (ideal) solution: Maximizes the benefit criteria while minimizing cost, time (input) criteria.

Negative (anti-ideal solution): Maximizes the input criteria (cost, time, equipment) while minimizing the benefits.

The solution process is shorter than the ELECTRE method: it can be applied on directly to data without a qualitative translation. TOPSIS method is one of the most used

techniques in the literature due to its advantages such as rationality, easy comprehension, and its simplicity in calculation (Ertuğrul & Özçil, 2014).

2.2.3.1.7. Fuzzy Logic and Fuzzy Numbers

Fuzzy logic was first time mentioned in “Fuzzy Sets” article that published by Azerbaijani scientist Lotfi A. Zadeh, in 1965. Zadeh, mentioned that binary logic system is insufficient to bring explanation for real life problems relatively fuzziness of human logic. Perceptual differences in human thought, subjective behaviors and the ambiguities in their targets can be explained by the concept of fuzziness. Fuzzy clusters have non-sharp boundaries. In Boolean algebra, it is assumed to have a membership rating of 1 if it belongs to a cluster, and 0 if it does not. In the concept of fuzzy set, the membership degrees between 0 and 1; and method uses average values such as "modest", "much", "little" instead of classical variables such as "yes" or "no", "true" (Dağdeviren, Integrated Modelling The Performance Evaluation Process with Fuzzy AHP, 2007). In the fuzzy cluster, the number “0” indicates that the object is not a member of the cluster, the number “1”indices that it is the full member of the cluster, and any number between these two values indicates the membership degree or partial membership of the object. The fuzzy set theory allows for a flexible and gradual membership (Şengül, Eren, & Shiraz).

Fuzzy numbers are used in fuzzy sets and fuzzy sets are defined by membership functions. Triangular fuzzy numbers are usually used in academic studies. Triangular fuzzy numbers are composed of three components, and these are expressed from small to large. The first component is the lowest and the last component is the highest value. The middle component is the optimum value (Göksu & Güngör, 2008). The fuzzy set “Z” is represented by the membership function μZ (x), and membership of a factor is determined by a number between 0 and 1. If an x factor belongs to Z, then μZ (x) = 1, and if absolutely

not, then μZ (x) = 0. A higher membership grade value indicates that the x factor has a higher degree of membership.

A classical set is shown as follows:N= { x | x > 5 },

If x is greater than 5, it belongs to N, or it is not. Fuzzy clusters have no definite limits in this way. There is a gradual transition from membership to non-membership, and this gradual transition is called "membership functions".

As for fuzzy set, it is expressed as;

$Z = \{x, \mu Z(x) | \ x \in x\}$, and here μZ(x) is called the membership function of x in Z.

Triangular-shaped membership function and graph are shown below:

$$\mu A(n) = \begin{cases} 0, & n \leq a \\ (n-a)/(m-a), & a < n \leq m \\ (b-n)/(b-m), & m < n < b \\ 0, & n \geq b \end{cases}$$

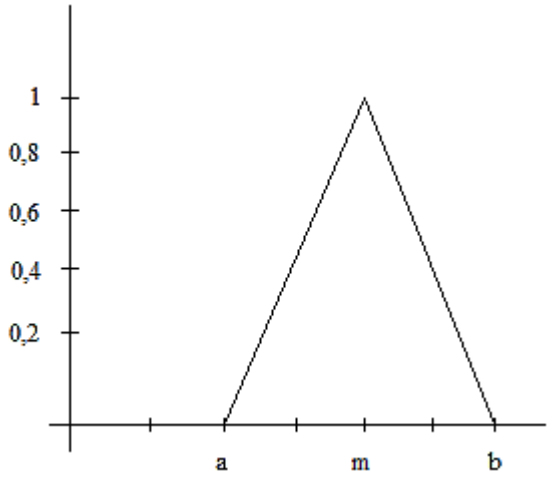

Figure 1.7 *Triangular-shaped membership graph.*

In F-AHP, compression ratios are given in a range of values unlike the AHP where net values are used and F-AHP offers more realistic and flexible findings.

2. LITERATURE REVIEW FOR PORT PERFORMANCE AND EFFICIENCY ANALYSES

There are many researches on literature about evaluation and benchmarking of port performances, mostly based on Data Envelopment Analysis (DEA) approach and Key Performance Indicators (KPIs). There are also simple ratio based applications from individual ports, professional organization and companies. KPIs which had been used by ports are found in a wide range and became handy decision tools thanks to their simplicity and easy calculation. For Flitch, Key Performance Indicator's simplicity doesn't allow to monitoring complex relationships between variables, so the Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) have increased their popularity within maritime industry as parametric methods. Their advantage is provide possibility for multiple input/output analysis (Flitsch, 2012).

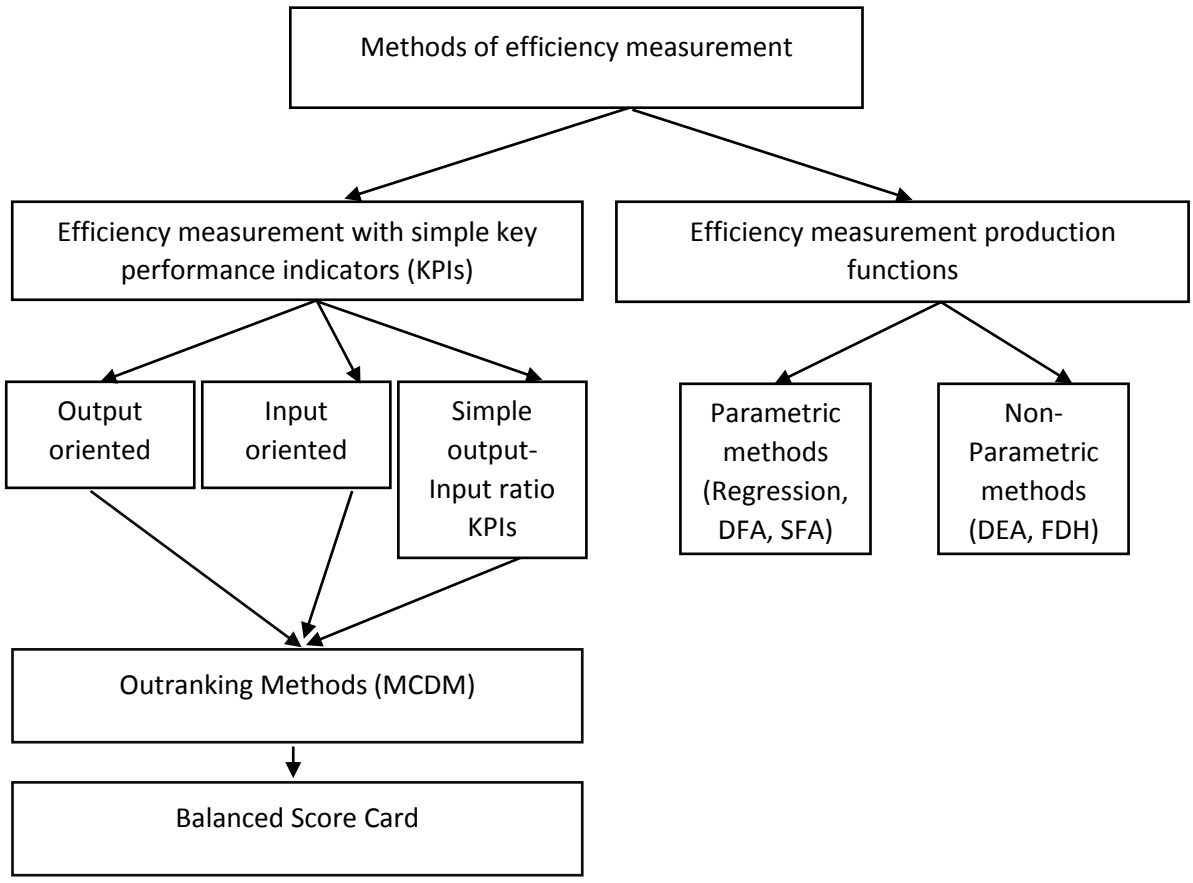

Figure 2.1 *Methods of efficiency measurement/Adopted from Efficiency Measurement of Container Ports - A New Opportunity For Hinterland Integration. (Flitsch, 2012).*

However, Chen and others (2016), have a differently approaching and they proposed to use AIS data and open data to identify key performance indicators. They also intended to measure container port performance and compare ports with the aid of "an automatic, low-cost and more accessible approach". According to research, different port authorities use different measures to produce their own data and that makes decrease the opportunity for a benchmarking between ports. In summary, there are many studies on subject of port's productivity and these studies are based on non-homogeneous and inconsistent data sets, so the results of these studies are specific to certain ports and cannot be generalized to ports that globally serve. Three dataset were used for study; container ship AIS trace dataset (1) and container ship information dataset (2) both were provided by shipfinder.com and port information dataset (3) was provided from Marine Cadastre Portal and port authorities' portals. They used four indicators for performance evaluation of ports: Ship traffic, container throughput, berth utilization and terminal productivity (Chen, et al., 2016).

Ducruet, Itoh and Merk (2014), pointed out the "time factor" in port performance and efficiency. According to them, there are not many time related port performance indicators and port and maritime industry mostly focused on metrics related ones instead time related indicators. They applied multiple regression analysis and multilevel analysis for ATTs at port and country level (Ducruet, Itoh, & Merk, 2014). As for its definition, ATT can be simply defined as the average duration of port stay.

A framework regarding dry port-seaport performance measurement had been developed from perspective of multimodal transport system (Bentaleb, Mabrouki, & Semma, 2015). Global dry port-seaport system performance level had been separated into two sub-categories as operational performance and financial performance and key performance indicators were collected with cooperation of sea port, dry port and rail transportation panelists and existing literature resources. It is worth to noting that, according to authors, working with industry experts causes some weakness as well as it has strong points, in this sense a good choice of experts is very important for a reliable study.

The MACBETH method was used as a multi-criteria analysis method in research. (Bentaleb, Mabrouki, & Semma, 2015).

Hakam (2015), proposed a detailed list of KPIs for Nordic container ports in order to obtain the sustainability index (SI) which has three dimensions as Economical Index, Environmental Index and Social Index. Fuzzy logic and Analytic Hierarchy Process (AHP) techniques were used for this purpose. Hakam described fuzzy logic as "degrees of truth" where this technique stand against the Boolean logic and 0 and 1 as extreme cases of truth. Industry professional's knowledge and experience used in order to determine first set of weights of KPIs and then weights were optimized with artificial intelligence techniques. However, author pointed out the matter that SI can be used with purpose of benchmarking provided all parameters and their weights required to be standardized. Matlab's neural network can be adapted to estimate next period's sustainable index (Hakam, 2015).

Caldeirinha, Felicio and Dionisio (2013), analyzed the correlation between characteristics of terminal and performance. Performance is accepted as it has dimensions of efficiency, productivity, activity and customer level. A Structure Equation Modeling (SEM) methodology was used in order to find out the factors which are port and container terminal's characteristics. They sent a questionnaire to twelve major container ports in Portugal and Spain. In their study, the relationship between hard and soft specifications of the ports was examined. The factors belong to physical infrastructure like water depth, accessibility and port's location were accepted as "hard" and service related characteristics were defined as soft characteristics of terminals. Below research model from Caldeirinha, Felicio and Dionisio, shows relationship between port and terminal characteristics and container terminal performance. At the end of the study, geographic location, port dynamics and maritime accessibility were found items with highest effect on performance (Caldeirinha, Felicio, & Dionisio, 2013).

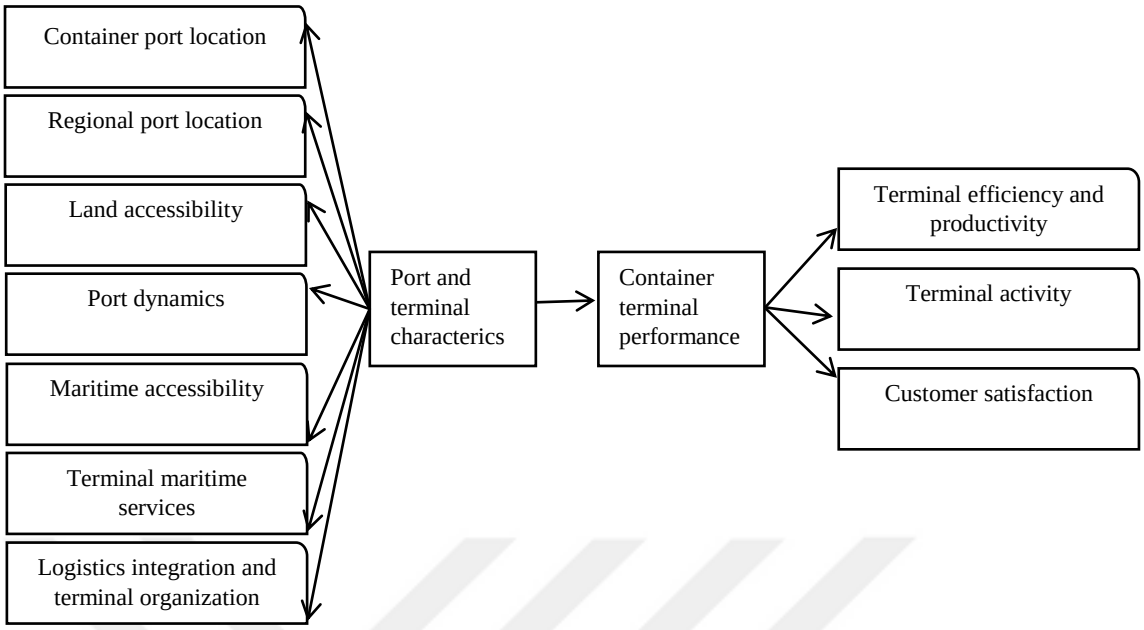

Figure 2.2 *Relationship between container terminal charasteristics and performance/Reprinted from Effect of the container terminal characteristics on performance, (Caldeirinha, Felicio, & Dionisio, 2014).*

Port infrastructure was separated as soft infrastructure (services) and hard infrastructure (physical) in another study as well. A port performance score card was established as part of the TrainForTrade Port Management Programme of the United Nations Conference on Trade and Development (UNCTAD). The score card has four strategic dimensions as “customers”, “financial”, “human resources”, “operations” and it consists 23 indicators in total. The research based on data those derived from the surveys which carried out from 2010 to 2014, annually. In accordance with this purpose, two workshop were held: the first International Port Performance Workshop (PPS 1) in October 2014 and the second Workshop (PPS 2) in September 2015 (UNCTAD Port Management Series 4, 2016).

Four dimensions of UNCTAD score card

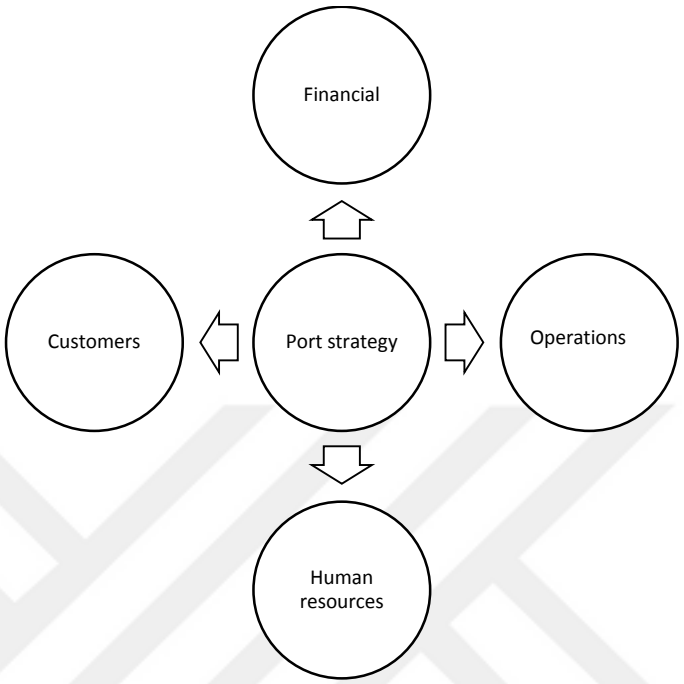

Figure 2.3 *Four dimensions of UNCTAD score card/Reprinted from Linking Performance Indicators to Strategic Objectives, UNCTAD Port Management Series 4 (2016).*

In the current concept of port business, terminals should not be treated as single isolated entities and they should be evaluated within a complete logistics and supply chain environment. There are studies to determine the hinterland of ports by means of logistics and supply chain understanding. One of them is a study by Garcia and Sanchez; they analyzed attraction of the ports by describing the hinterland with a radial structure using the huff model from spatial outlook. Behind the idea of the huff model are gravitational models whose name comes from the Newton's gravity concept. As a probabilistic retail model, the aim of the model has the purpose of predicting consumer behavior and probabilities of each enterprises market share (Garcia-Alonso & Sanchez-Soriano, 2009).

Su, Liang, Liu and Chou, developed and balanced score card (BSC) within scope of the original one that was developed by Norton. As it can be remembered, The BSC developed by Norton has four dimensions: financial perspective, customer perspective,

internal business perspective and learning and growth perspective. Su and others evaluated 31 criteria under 11 factors in order to construct a BSC to benchmark ports. They used Fuzzy AHP method for develop hierarcihal structure and pairwise comparisons (Su, Liang, Liu, & Chou, 2003).

Chiu, Lin and Ting (2014), approached to the benchmark of port performances regarding green port factors. They used Fuzzy Analytic Hierarchy Technique on their study, and an AHP survey questionnaire was sent to the participants to provide the required data. The study includes two stages: at first, the importances of the Green Port Factors were determined and at the second stage the green port operational performances of the three alternatives, Kaohsiung, Taichung and Keelung ports in Taiwan, were evaluated through these weighted factors. At the end of the analysis, it was observed that Taichung port was the first, Keelung port was the second, and Kaohsiung port was the third port regarding their performance. Another remarkable subject of the study, authors stated that as a result of the literature search they conducted, most of the researchers concentrated on pollution sources (Chiu, Lin, & Ting, 2014).

Liang, Ding and Wang (2012), applied fuzzy Quality Function Deployment (QFD) for weighting dimensions of knowledge management (KM) process. Knowledge management is a process that involves creating, sharing and effectively using of knowledge within a company and the QFD method is a tool that allows companies to translate their customers' needs and desires into specifications of services and products. To determine KM requirements for a commercial port, they consulted the experts and searched academic literature. They evaluated twenty KM requirement attributes under four dimensions of market competitiveness, human resources management, service innovation and organizational management. HOQ (House of Quality) matrices were used in the study, which is most widely used the form of QFD method. As result of their pilot research on port "K" in Taiwan, establishment of a data storage and data mining system emerged as most important requirement for implementation of knowledge management at port "K" (Liang, Ding, & Wanga, 2012).

In another study, it was aimed to measure the link between maritime services and accessibility to inland markets. Guerrero and others used AIS data to acquire a database on marine transport supply and identified ports with geographical units (NUTS 3) and aggregated NUTS on maritime supply data. NUTS (Nomenclature des unités territorials Statistiques – Classification of Territorial Units for Statistics) is a geocode standard for meet the statistical requirements. For the territories with more than one ports, the port with the maximum throughput is considered the representative of NUTS 3 region. The given an example was Seine-Maritime for FR232 region in the research paper. They used an indicator to measure road accessibility which has two dimensions; (1) population in NUTS 3 regions and (2) time necessary to reach these areas by road. Finally, they practiced a linear correlation between maritime transport supply and road accessibility (Guerrero, Laxe, Seoane, & Montes).

De Langen worked on an extensive study for intermodal connectivity indicator within the scope of "Portopia Project" and proposed a new measure for intermodal connectivity. The offered intermodal connectivity indicator measures the degree of connectivity between deep sea ports and dry ports through railway and barges. It can be measured both for a specific port and for a group of ports. Development of hinterland system of a number of ports can be evaluated with an aggregated intermodal connectivity indicator. To obtain intermodal connectivity indicator, weekly barge and rail services were separately calculated. According to De Langen, when an intermodal indicator considered for a group of ports, it assesses the evolution of the hinterland system of these ports (De Langen, 2014).

According to De Langen, Intermodal connectivity positive related with (De Langen, 2014);

- Maritime connectivity
- Quality of custom procedures
- Hinterland road congestion
- Investments in inland ports
- Enrionmental incentives (only if different port dues are applied between rail, road and barge modes).

"Gate congestion" is important matter while evaluating a port's logistic capability, so the gate productivity is one of the determinants of adequate hinterland connection together with high service quality for each mode of inland transportation: road, train and barge modes (with a reasonably intermodal split ratio). Merk and Notteboom mentioned about port gate congestion issue that is arising from idle trucks at gates and three primary tools introduced as solutions for reducing congestion at gates; virtual terminal yard systems, rearranging gate hours and truck appointment systems. Truck appointment systems can be defined as applications which allow to give a schedule for terminal entry and allows customers 7/24 access to port systems and carrying out necessary updates. By rearranging gate hours, redistribution of the arrival time of trucks is aimed. Rearrangement mentioned above is possible with use of incentives for customers who prefer off-peak hours (Merk & Notteboom, 2015). Merk and Notteboom addressed to a multilayer approach consists of logistical, transport, infrastructural and locational dimensions. According to authors, five conditions should be met regarding an adequate hinterland strategy (Merk & Notteboom, 2015):

- Enough capacity of hinterland infrastructure.
- Efficienct use of hinterland infrastructure.
- Fine coordination of the transport chain.
- Environmental sustainability for each of infrastructural, transportation and logistical dimensions.
- Providing services with a good price and quality ratio (transportation dimension).

A similar indicator "Landside (road) Congestion" was indicated on Deliverable 9.2, Portopia project. It is an indicator to monitor delays which arise due to traffic congestion.

As the port operations are accepted as complex phases of supply chain and logistics, it should be required to point out to the study which combined different methods to find the best location for a logistic organization. Acar, Önden and Kara (2015), have integrated three methods: AHP, Geographic Information System (GIS) and Integer Programming (IP) model for location selection problem. In the first phase, study areas were separated into four sub-areas. And then five criteria (airports, railroad network, road

network, population density, maritime) have been prioritized by judgments of the experts. It should be noted that population density and road network were selected with higher priorities, and airport criterion has the lowest priority. In the second stage, the results of AHP analysis were used with GIS to make a spatial analysis and finally IP model used to find out best one from set of alternatives (Acar, Önden, & Kara, 2015).

Onut, Tuzkaya and Torun (2010), studied on the selection of the most convenient container port in the Marmara Sea from the view of a producer that located in the same region. Five criteria (port location, hinterland economy, physical features of port, port efficiency, cost and other) and 20 sub criteria have been selected. Total 12 ports that are being operated in the Marmara region are listed. The seven ports that are providing the specified conditions (licensed warehouse or bonded store, enough water depth and enough container capacity) were evaluated with Fuzzy Analytic Network Process (FANP) (Onut, Tuzkaya, & Torun, 2010).

Since the Data Envelopment Analysis (DEA) method has been very popular among researchers with purpose of benchmarking, it is required to mention about Schøyen and Odeck's study in which they compared Nordic and UK container terminals. Berth length, terminal area, number of yard gantry cranes, number of straddle cranes were used as input and number of container handling trucks, and container throughput was considered as outputs to measure technical efficiency of container ports. It should be noted that two efficiency scores calculated for each port: technical efficiency and scale efficiency. The BCC formulation of DEA was used or measure technical efficiency that had been introduced by Banker, Charnes and Cooper and BCC method is based on Variable Returns to Scale (VRS) (Banker, Charnes, & Cooper, 1984). A total of 24 container terminals were included in the study. Necessary data were obtained from Containerisation International Yearbook (CIY), and authors pointed out that any data which is beyond the control of port management were not included in their study (Schøyen & Odeck, 2013).

Maritime Fluidity: It is an indicator for monitoring waterborne traffic flows. The required data on vessel's positioning to be provided from AIS (Automatic Identification System) data (Indra, Notteboom, & Dooms, 2015).

Average THC (terminal handling cost) is one of two financial logistics and supply chain indicator for the Portopia project, usually charged per ton. Another financial indicator is “Average port dues per ton, ” and it is expressed port’s revenue per ton of handled cargo (Indra, Notteboom, & Dooms, 2015).

Direct Employment and Direct Value Added are socio economic indicators for the Portopia project. “Direct Employment” is an indicator for monitoring employment rate which created by port activities for a specific period. “Direct Value Added” is an indicator to measure welfare that created with port activities within a particular time frame (Indra, Notteboom, & Dooms, 2015).

Container Terminal Quality System (CTQS) Standard has been established by Germanischer Lloyd Certification (GLC) in cooperation with Global Institute of Logistics. The system offers a certification for container terminals which meet the requirements and allows to terminals use the system as a benchmarking tool to see their strong points and weakness against other terminals worldwide (Global Institute of Logistics, n.d.).

Ports Observatory for Performance Indicator Analysis (PORTOPIA Project) led by University of Brussels (VUB) and 12 partners those being operated in the field of academic, industry and research. It is a four-year project and continuation of previously completed one (PPIRSM).

The project has two main objectives and one major goal (The Portopia Project, n.d.):

- One objective is contributing to port performance by providing significiant data accross the european ports.
- Second objective was defined as to support and monitor consortium’s policies.
- Major goal was explained as “sustainable port transport system” which can handle with any possible challenges

Portopia system has aims and perspectives of:

- Market trends & structure indicators.
- Socio-Economic related performance indicators.
- Indicators for environment and occupational health, safety and security (OHSS).
- Logistics chain and operational performance indicators.
- Governance and finance indicators and user perceptions on port quality.

It is important to mention about The AAPA customer service initiative report in which port effectiveness was studied from the view of port users groups. The user groups included cargo interests, shipping companies, and supply chain partners. Seven container ports which are located in North America were involved in the study. Determinance I-P Gap Space method which brought by Drs. Schellinck and Brooks was used in research. Two surveys were developed for research, one for east coast ports and one for west coast ports and these were applied in three stages It should be noted that in the research different user groups (cargo interests, shipping lines, and supply chain partners) rated "service delivery effectiveness" differently (The AAPA Customer Service Initiative Report, 2012).

Table 2.1 *Summary of the studies and methods.*

Name of study	**Scope of work**	**Method**	**Details**	**Source**
Evaluating the location of regional return centers inreverse logistics throughintegration of gis, ahp and integer programming	In regarding to reverse logistics.	AHP, GIS, Integer Programming (IP)	Experts' judgments and geographic information were used.	(Acar, Önden, & Kara, 2015)

A study on integrated port performance comparison based on the concept of balanced scorecard.	Developed a Balanced Score Card in order to benchmark ports' performances.	BSC, F-AHP	A number of Kpi's used in context of four perspective of BSC: 1. Financial Perspective (3 factors and 7 criterias) 2. Customer Perspective (3 factors and 10 criterias) 3. Business Process Perspective (3 factors and 7 criterias)	(Su, Liang, Liu, & Chou, 2003)
Evaluation of green port factors and performance: a fuzzy AHP analysis	Authors weighted the factors related to Green Port Operations and performed a benchmark between three alternatives through these prioritized factors (Taichung, Keelung and Kaohsiung ports)	F-AHP	-Total 13 factors collected under four major criterias. -An AHP survey conducted in order to obtain necessary data. Four major criteria: 1. Environmental quality (4 factors) 2. Use of energy and resource (3 factors) 3. Waste handling (2 factors) 4. Habitat quality and greenery (2 factors) 5. Social participation	(Chiu, Lin, & Ting, 2014)

			(2 factors)	
Selecting container port via a fuzzy ANP-based approach: A case study in the Marmara Region, Turkey	The study was imed at selection of most convenient container terminal from view of intermodal transportation	F-ANP	-Total 20 factors were collected under six major criterias. -Six major criterias: 1. Port location (3 sub-criterias) 2.Hinterland economy(3 sub-criterias) 3. Physical features of port (3 sub-criterias) 4. Port efficiency (4 sub-criterias) 5. Cost (2 sub-criterias) 6. Other (5 sub-criterias)	(Onut, Tuzkaya, & Torun, 2010).
Applying fuzzy quality function (QFD) deployment to prioritize solutions of knowledge management (KM) for an international port in Taiwan	Researched KM (knowledge management) implementation requirements at port "K" in Taiwan.	Fuzzy QFD	Data collected through surveys.	(Liang, Ding, & Wanga, 2012)
The AAPA Customer Service Initiative Report	In study it is aimed to valuate port effectiveness from view of port users groups	Determinance I-P Gap Space Method	Data collected through surveys.	(The AAPA Customer Service Initiative Report, 2012).
UNCTAD Port Performance Score Card	The study consist total 23 indicators under four dimension:	BSC	The research based on survey data (collected from the surveys which carried out from 2010 to 2014).	(UNCTAD Port Management Series 4, 2016)

	1-Operational 2-Financial 3-Customers 4-Human Reosurces			
Nordic Container Port Sustainability Performance - A Conceptual Intelligent Framework	Proposed a conceptual inttelligent framework in order to observing port sustainability performance with economic, encironmental and social dimensions.	BSC, F-AHP	Data collected through: -Surveys -Experts opinions -System feedback	(Hakam, 2015)
A Geographical Anlysis of The Relationship Between Inland Accessibility and Maritime Transport Supply	Correlation between inland market accessibility and maritime services	Classic Linear Regression Model	1-TEUs supply derived from AIS Data 2-Road accessibility data obtained from Eurostat	(Guerrero, Laxe, Seoane, & Montes)
Port selection from a hinterland perspective	Analyzed attraction of the ports by describing the hinterland with a radial structure using the huff model from spatial outlook	Huff Model	Port-province distance Traffic volume	(Garcia-Alonso & Sanchez-Soriano, 2009)
The effect of port and container terminal characteristics on terminal performance	Study aimed at observe the relationship between port terminals charasteristics and container terminal performance.	Structural Equation Modelling (SEM)	Survey data collected through 5-point Likert scale.	(Caldeirinha, Felicio, & Dionisio, Effect of the container terminal characteristics on performance, 2013)
Key Performance Indicators	A dry port-seaport performance	MACBETH	Interviews and questionnares with	(Bentaleb, Mabrouki, &

Evaluation and Performance Measurement in Dry Port-Seaport System: A Multi Criteria Approach	measurement system was created from perspective of multimodal transportation.		experts.	Semma, 2015)
The technical efficiency of Norwegian container ports: A comparison to some Nordic and UK container ports using Data Envelopment Analysis (DEA)	A total of 24 container port have been compared by means of technical efficiency.	DEA	-The data were obtained from Containerisation International Yearbook (CIY). -The authors cross-checked the available data with port managements Inputs: Beth length, terminal area, number of yarf gantry cranes, number of straddle cranes. Outputs: Number of container handling trucks and container throughput.	(Schøyen & Odeck, 2013)

The following (Table 3.2) lists the indicators which obtained after a literature search. Among all indicators, the ones that are most suitable for the purpose of this study will be used to generate the Ports Balanced Score Card (PBSC). It is seen in the literature that different calculations have been made for similar indicators. However, it has also been seen that there are different indicators which serve the same specific purpose. For this reason, some formulas and definitions given below have been made arrangements to meet at a common point.

Table 2.2 *List of collected indicators after literature survey.*

Item no.	Indicator	Unit	Possible Port Score Card Category	Definition	Source
1	Berth Productivity	[Number of total container moves / number of hours at berth] [Container moves / Berth lenght]	Logistics Chain and Operational Performance: Berth	Number of containers are being handled per hour.	(JOC Group Inc., 2014). (Germanischer Lloyd, 2008)
2	Berth Efficiency/Utilization	[(The ship working time x100) /The ship berthing time]	Logistics Chain and Operational Performance: Berth	An indicator indicating how effectively the berths are used.	(Chung, 1993)
3	Average (Vessel) Turnaround Time (ATT)	[Sum of all vessel turnaround times at berth / total number of container vessels]	Logistics Chain and Operational Performance: Berth	Shows the average number of hours the vessels are beingoperated on the pier.	(Ducruet, Itoh, & Merk, 2014). (Hakam, 2015) (Germanischer Lloyd, 2008)
4	Berth Throughput Indicator	[Ttl tonnage of cargo handled at berths / Total no. of berths] [General Cargo (tonnes) / quay meter]	Logistics Chain and Operational Performance: Berth	Indicator indicating how much cargo is being handled per pier.	(Hakam, 2015) (Klukas, Kirsch, Darbra, Dooms, & De Schepper, 2015)
5	Berth Occupancy Rate Indicator	[(Total hrs of ships at berths x 100) / Total hrs of ships alongside]	Logistics Chain and Operational Performance: Berth	An indicator that show the occupancy rate of the berths.	(Hakam, 2015), (UNCTAD Port Management Series 4, 2016), (Radmilovic & Jovanovic, 2006), (Germanischer Lloyd, 2008)
6	Berth Utilization Rate Indicator	[Total time of ships at berths x 100 divided / Total no. of berths]	Logistics Chain and Operational Performance: Berth	Average duration of port stay per each berth.	(Hakam, 2015), (Chen, et al., 2016)
7	Ship Productivity (container vessels without limitation)	[container moves / (hour*ship)]	Logistics Chain and Operational Performance: Berth	Number of containers handled per hour.	(Germanischer Lloyd, 2008), (Bentaleb, Mabrouki, &

					Semma, 2015)
8	Ship Productivity on vessels > 4000 moves	[container moves / (hour*ship)] [Moves > 4000]	Logistics Chain and Operational Performance: Berth	Number of containers handled per hour.	(Germanischer Lloyd, 2008)
9	Ship Productivity on vessels > 750 moves	[container moves / (hour*ship)] [Moves > 750]	Logistics Chain and Operational Performance: Berth	Number of containers handled per hour.	(Germanischer Lloyd, 2008)
10	Ship Productivity on vessels < 750 moves	[container moves / (hour*ship)] [Moves < 750]	Logistics Chain and Operational Performance: Berth	Number of containers handled per hour.	(Germanischer Lloyd, 2008)
11	Ship Service Quality Index (SQI) Reliability Indicator 1	[%]	Logistics Chain and Operational Performance: Reliability	Estimating turnaround time at berth. (For Kumport, Margin of error should not exceed one hour).	(Germanischer Lloyd, 2008) (Kumport Container Terminal, 2017).
12	Reliability Indicator 2		Logistics Chain and Operational Performance: Reliability	Frequency of cargo loss and damage.	(Yeo, Roe, & Dinwoodie, 2011)
13	Crane Productivity (TEU)	[Total no. of TEUs handled / (Total no. of cranes used x total no. of crane working hours)]	Logistics Chain and Operational Performance: Berth	TEUs per crane hour indicator	(Hakam, 2015) (Chung, 1993)
14	Gross Crane Productivity on Vessels (GCPV)	[container moves/(hour*crane)] "Move per Crane"	Logistics Chain and Operational Performance: Berth	Container moves per crane hour Indicator	(Germanischer Lloyd, 2008)
15	Tons Per Gang Hour Indicator	[Total tonnage handled / (Total no. of gangs x total no. of hours worked)]	Logistics Chain and Operational Performance: Berth	Indicates the amount of tonnage handled per gang hour.	(Hakam, 2015)
16	Storage Area Productivity Indicator 1	[Total Traffic (TEU)/Total Port Area] [TEU/m2]	Logistics Chain and Operational Performance: Terminal	Soil Occupation Efficiency Indicator	(Hakam, 2015)
17	Storage Area Productivity Indicator 2	[Total Traffic (TEU)/Terminal Area] [TEU/m2]	Logistics Chain and Operational Performance: Terminal	Terminal Area Productivity	(Germanischer Lloyd, 2008) (Chen, et al., 2016)
18	Storage Area Productivity Indicator 3	[Total Traffic (TEU)/Storage Area] [TEU/m2]	Logistics Chain and Operational Performance: Terminal	Storage Area Productivity	(Germanischer Lloyd, 2008)
19	Storage Area Productivity Indicator 4	[Number of storage slots occupied / total number of available slots]	Logistics Chain and Operational Performance:	Availability of the storage area.	(The World Bank & PPIAF, Port Reform Toolkit.)

			Terminal		(Bentaleb, Mabrouki, & Semma, 2015)
20	Storage Capacity Indicator	Lack of space per container / day [Unit per day]	Logistics Chain and Operational Performance: Terminal	The indicator shows high traffic/congestion in terminal area due to high demand on port services	(Bentaleb, Mabrouki, & Semma, 2015)
21	Average truck Turnaround Time (ATTT)	[Sum of all truck turnaround times/total number of trucks]	Logistics Chain and Operational Performance: Terminal	The average length of time the customer's vehicles stay in the terminal. A high rate is not preferred.	(Germanischer Lloyd, 2008)
22	Average Moves per Truck	[Container moves / truck number] (for a specific period)	Logistics Chain and Operational Performance: Terminal	Shows the quantitiy of containers the terminal tractors carry in a given period. A high rate is preferred.	(Germanischer Lloyd, 2008)
23	Labour Utilization Ratio (LUR)	[Total working hrs. / fixed number of hours for a period]	Logistics Chain and Operational Performance (Berth + Terminal)	An indicator that measures workforce efficiency in terms of working time.	(Hussein, 2013)
24	Direct calls	[numbers]	Core	Total Number of containership called port.	(Haropa Ports), (Germanischer Lloyd, 2008)
25	Container dependency	[Containerized cargo (tonnes) / total cargo (tonnes]	Core	It can be used with purpose of measuring containerization rate.	(Klukas, Kirsch, Darbra, Dooms, & De Schepper, 2015)
26	Average number of TEU handled per day	[TEU]	Core		(Haropa Ports)
27	Average overall vessel lenght per vessel (m)	[m.]	Core		(UNCTAD Port Management Series 4, 2016)
28	Average draft per vessel (m)	[m.]	Core		(UNCTAD Port Management Series 4, 2016)
29	Average gross tonnage per vessel	[cuft]	Core		(UNCTAD Port Management Series 4, 2016)
30	Container Handling	[number of container moves]	Core	Total number of containers handled (year).	(Germanischer Lloyd, 2008)
31	Container Throughput Indicator	Container moves or TEU	Core	Total number of containers handled (specific period).	(Chen, et al., 2016) (Germanischer Lloyd, 2008)

32	Logistic Chain Indicator 1	[quantitiy of vessel calls] [quantitiy of routes]	Logistics Chain and Operational Performance: Maritime Connectivity	Sailing frequency and diversification of routes.	(Yang & Chen, 2015) (AHN, LEE, & HAN) (Yeo, Roe, & Dinwoodie, 2011)
33	Logistic Chain Indicator 2	[quantitiy of lines]	Logistics Chain and Operational Performance: Maritime Connectivity	Number of feeder and short-sea lines	(Caldeirinha, Felicio, & Dionisio, Effect of the container terminal characteristics on performance, 2013)
34	Logistic Chain Indicator 3	[quantitiy of services]	Logistics Chain and Operational Performance: Maritime Connectivity	Number of intercontinental liner services	(Caldeirinha, Felicio, & Dionisio, Effect of the container terminal characteristics on performance, 2013)
35	Logistic Chain Indicator 4	[quantitiy of services per week]	Logistics Chain and Operational Performance: Maritime Connectivity Maritime Connectivity	Average number of weekly shipping services, (Port of Le Havre)	(Haropa Ports)
36	Logistic Chain Indicator 5	[quantitiy of regular lines]	Logistics Chain and Operational Performance: Maritime Connectivity	Number of ports connected with regular lines. Number of ports with direct connections.	(Haropa Ports) (ESPO, 2012)
37	Logistic Chain Indicator 6	[m.]	Logistics Chain and Operational Performance: Nautical Accessibility	Quay depth	(Caldeirinha, Felicio, & Dionisio, Effect of the container terminal characteristics on performance, 2013)
38	Logistic Chain Indicator	[m.]	Logistics Chain and Operational Performance: Nautical Accessibility	Water depth in port access	(Caldeirinha, Felicio, & Dionisio, Effect of the container terminal characteristics on performance, 2013)
39	Logistic Chain Indicator	[hrs.]	Logistics Chain and Operational Performance: Nautical Accessibility	Average berth Access time	(Haropa Ports)

40	Logistic Chain Indicator	[index]	Logistics Chain and Operational Performance: Maritime Connectivity	Liner Shipping Connectivity Index (LSCI)	(UNCTAD Port Management Series 4, 2016) (European Port Industry Sustainability Report, 2016)
41	Ship Traffic Indicator	[total number of vessels]	Logistics Chain and Operational Performance: Maritime Connectivity	Two category: Deep-sea and feeder ships.	(Chen, et al., 2016)
42	Logistic Chain Indicator	[index]	Logistics Chain and Operational Performance: Intermodal Connectivity	Intermodal Connectivity Index	(Klukas, Kirsch, Darbra, Dooms, & De Schepper, 2015)
43	Logistic Chain Indicator	[%]	Logistics Chain and Operational Performance: Intermodal Connectivity: Modal Split	Proportions of rail and road	(Germanischer Lloyd, 2008) (European Port Industry Sustainability Report, 2016)
44	Logistic Chain Indicator	[%]	Logistics Chain and Operational Performance: Intermodal Connectivity: Road Vehicle Service Quality Index	Road Service Quality	(Germanischer Lloyd, 2008)
45	Logistic Chain Indicator	[%]	Logistics Chain and Operational Performance: Intermodal Connectivity: Rail Service Quality Index	Rail Service Quality Note: Weighted according to hinterland modal split.	(Germanischer Lloyd, 2008)
46	Logistic Chain Indicator (Not confirmed)		Logistics Chain and Operational Performance: Congestion: Roads	Can be obtained from "State Roads Traffic Flow Map. Average Daily Traffic Data".	(General Directorate of Highways. Republic of Turkey, Ministry of Transport, Maritime Affairs and Communications)
47	Logistic Chain Indicator	[Total number of inbound and outbound trucks per day / Total number of terminal gates]	Logistics Chain and Operational Performance: Terminal	Purpose of measuring the vehicle traffic/congestion on terminal's gates.	(Sapina, 2011) (The AAPA Customer Service Initiative Report, 2012)

			Congestion "Gate"		
48	Logistic Chain Indicator		Logistics Chain and Operational Performance: Costs and Dues	Average port dues per ton [Total port dues / Traffic]	(Indra & Notteboom, Deliverable 9.2 Indicators aggregation methodology, 2015)
49	Logistic Chain Indicator	[Total hours of vessels waiting for berth / total number of vessels berthed]	Logistics Chain and Operational Performance: Congestion "Berth"	Average vessel time outside	(Chung, 1993)
50	Logistic Chain Indicator	[Containerships waiting waiting for berth < 1 hrs / Total vessel calls]za<	Logistics Chain and Operational Performance: Congestion "Berth"	Aims to measure the congestion that port traffic created. Due to the fact that the vessels waiting less than an hour are considered, a higher rate is preferred.	(Haropa Ports)
51	Logistic Chain Indicator	[monetary unit]	Logistics Chain and Operational Performance: Logisics Costs	Transportation cost per container (Alternatively, Equipment handling cost per TEU or container)	(Bentaleb, Mabrouki, & Semma, 2015)
52	Financial Performance	[monetary unit]	Financial: Revenue	Profit per Employee	(Bryan, 2007)
53	Financial Performance (2)	[monetary unit]	Financial: Revenue	Cargo and container handling revenue per ton or per TEU of Cargo [Total revenue / Total handled tons or TEU]	(Bentaleb, Mabrouki, & Semma, 2015) (Hakam, 2015) (UNCTAD, 1976)
54	Financial Performance	[monetary unit]	Financial: Revenue	Berth Occupancy Revenue	(Hakam, 2015)
55	Financial Performance	[monetary unit]	Financial: Expenditure	Labor expenditure per ton of Cargo (Opex)	(UNCTAD, 1976)
56	Financial Performance (2)	[monetary unit]	Financial: Expenditure	Capital equipment expenditure (Capex) per ton of Cargo (Alternatively per TEU)	(Bentaleb, Mabrouki, & Semma, 2015) (UNCTAD, 1976)
57	Financial Performance (3)	[%]	Financial: Liquidity	[Liquidity / Working Capital]	(Hakam, 2015)
58	Financial Indicator	[monetary unit]	Financial:	Contribution per ton	(Hakam, 2015)

	(3)		Revenue	of cargo (or per TEU)	
59	Financial Indicator (4)	[%]	Financial: Revenue	Rate of return on turnover: [Total Operating surplus / Operating income]	(Hakam, 2015)
60	Financial Indicator (5)	[%]	Financial	[EBITDA / revenue (operating margin)]	(UNCTAD Port Management Series 4, 2016)
61	Financial Indicator (6)	[%]	Financial: Revenue:	[Vessel dues / revenue]	(UNCTAD Port Management Series 4, 2016)
62	Financial Indicator (7)	[%]	Financial: Revenue	[Cargo dues / revenue]	(UNCTAD Port Management Series 4, 2016)
63	Financial Indicator (8)	[%]	Financial: Revenue	[Rents / revenue]	(UNCTAD Port Management Series 4, 2016)
64	Financial Indicator (9)	[%]	Financial: Revenue	[Labour / revenue]	(UNCTAD Port Management Series 4, 2016)
65	Financial Indicator (10)	[%]	Financial: Expenditure	[Fees (and the like) / revenue]	(UNCTAD Port Management Series 4, 2016)
66	Financial Indicator (11)	[monetary unit]	Financial: Revenue	Spoilage : The loss of revenue due to unused capacity.	(Sabre Airline Solutions) (Financial Accounting Standards Board)
67	Financial Indicator (11)	[%]	Financial: Accounting	Invoice Accuracy	(The AAPA Customer Service Initiative Report, 2012)
68	Managerial Indicator 1	[%]	Environmental: Managerial	Emergency Plan Readiness (%)	(Hakam, 2015)
69	Managerial Indicator 2	[Yes or No]	Environmental: Managerial	Certified Environmental Management System (EMS)	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
70	Air Quality Indicator (1) “Carbon Footprint” *		Environmental: Pollution	Carbon Footprint: CO_2, CH_4, N_2O (%) Carbon Footprint: CO2, CH4, N2O, SF6, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs)	(Hakam, 2015) (Klukas, Kirsch, Darbra, Dooms, & De Schepper, 2015) (ESPO / EcoPorts Port Environmental Review, 2016)
71	Air Quality Indicator (3) “Dust”	[%]	Environmental: Pollution	Dust Index	(Hakam, 2015)
72	Air Quality Indicator (4) “Odour”	[%]	Environmental: Pollution	Odor Pollution Index Hydrogen sulphide (H2S)	(Hakam, 2015) (Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
73	Waste Indicator 1	(Kg(m3)/TEU)	Environmental:	-Waste Creation	(Hakam, 2015)

	"Waste Creation"		Pollution		(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
74	Waste Indicator 2 "Waste Disposal"	[Kgs.]	Environmental: Pollution	Waste disposal	(Hakam, 2015)
75	Waste Indicator 3 "Spills"	[qty.]	Environmental: Pollution	Oil, chemical and hazardous spills	(Hakam, 2015)
76	Waste Indicator 4 "Waste Reduction"	[%]	Environmental: Pollution	Waste Reduction Percentage (Airports)	(Wyman, 2012)
77	Sediment Quality Indicator	[particle diameter] or [%]	Environmental: Pollution	An indicator for measuring pollution: Heavy metals and organic pollutants.	(ESPO / EcoPorts Port Environmental Review, 2016)
78	Soil Index / Soil Quality Indicator	[Infiltration rate: milimeters per hour] [Soil pH: degree of acidity or alkalinity]	Environmental: Pollution	An indicator for measuring pollution: Acidity and alkalinity	(Hakam, 2015) (ESPO / EcoPorts Port Environmental Review, 2016)
79	Water Quality Indicator	[Ratio of dissolved minerals, oxygen] [mg/L] [Ph rate]	Environmental: Pollution	An indicator for measuring pollution: Dissolved minerals.	(Hakam, 2015) (ESPO / EcoPorts Port Environmental Review, 2016)
80	Noise Indicator	[Recorded total number of complaints regarding noise]	Environmental: Pollution	Existence of a noise-zoning map, "Number of complaints"	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016) (Hakam, 2015) (ESPO / EcoPorts Port Environmental Review, 2016)
81	Green Action Indicator 1	[Yes or No]]	Environmental: Incentives	Availability of Onshore Power Supply (OPS)	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
82	Green Action Indicator 2	[Yes or No]	Environmental: Incentives	Availability of LNG bunkering	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
83	Green Action Indicator 3	[Number of vessels connect to shore-side electricity / Total number of vessels]	Environmental: Incentives	Ratio of ships using shore-side electricity to number of ships calling at port.	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
84	Green Action Indicator 4	[Yes or No]	Environmental: Incentives	Deducted costs for vessels using low-sulphur bunker oils.	(Klukas, Kirsch, Darbra, Dooms, & De Schepper, 2015)
85	Green Action	[Number of ships were	Environmental:	Supporting for	(Klukas, Kirsch,

	Indicator 5	directedto use economic speed to reach at port]	Incentives	reduce vessel's speed or economic speed for arrival.	Darbra, Dooms, & De Schepper, 2015)
86	Energy Efficiency Indicator 1	[Total kWh / TEU]	Environmental: Resources	An indicator measuring eletric consumption per TEU	(Kumport Container Terminal, 2017).
87	Energy Efficiency Indicator 2	[Total Consumption in Tons of oil / Container or TEU]	Environmental: Resources	An indicator measuring oil consumption per TEU	(Sapina, 2011) (Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
88	Energy Efficiency Indicator 3	[Total kWh]	Environmental: Resources	Total Electric Consumption	(Hakam, 2015), (Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
89	Energy Efficiency Indicator 4	[Tonnes]	Environmental: Resources	Total Fuel Consumption	(Hakam, 2015)
90	Energy Efficiency Indicator 5	Total Energy Consumption	Environmental: Resources	Total Energy Consumption	(ESPO / EcoPorts Port Environmental Review, 2016)
91	Energy Efficiency Indicator 6	[% Fuel] [% Electric]	Environmental: Resources	Provides the percentage of each energy source in total consumption.	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
92	Energy Efficiency Indicator 7	[Total Energy consumption / Total number of employees]	Environmental: Resources	An indicator that measures electricity consumption per employee.	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
93	Energy Efficiency Indicator 8	[Total Energy Consumption / Total Sq m. of Terminal]	Environmental: Resources	Provides energy consumption per square meter.	(Wyman, 2012)
94	Consumption Indicator 1	[Tonnes]	Environmental: Resources	Provides total water consumption.	(Hakam, 2015), (ESPO / EcoPorts Port Environmental Review, 2016)
95	Consumption Indicator 1	[Total water consumption / Total number of employees]	Environmental: Resources	Provides water consumption per employee.	(Santos, Silva, & Cerqueira)
96	Consumption Indicator 2	[Paper Consumption/Employee number]	Environmental: Resources	Provides paper consumption per employee.	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
97	Recycling Indicator 1	[Liters.]	Environmental: Resources	Amount of recovered rainwater.	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
98	Recycling Indicator 2	[Water recycled / Total water consumption]	Environmental: Resources	The ratio of the amount of water recovered to the total amount of water consumed.	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
99	OHSS Safety Indicator 1	[Accident Number/TEU] x 100000	OHSS: Safety	The number of accidents occurred per 100000 TEU in	(Kumport Container Terminal, 2017)

				a monthly basis.	
100	OHSS Safety Indicator 2	[number of working days]	OHSS: Safety	Days Lost	(Antao, et al., 2015)
101	OHSS Safety Indicator 3	[number of human accident - year]	OHSS: Safety	Provides the total number of accidents that occurred in one year period.	(Bentaleb, Mabrouki, & Semma, 2015)
102	OHSS Indicator 4	[number of accidents]	OHSS: Safety	Fatal work accidents	(Indra & Notteboom, Deliverable 9.2 Indicators aggregation methodology, 2015) (Antao, et al., 2015)
103	OHSS Indicator 5	[number of accidents]	OHSS: Safety	Nautical Accidents	(Indra & Notteboom, Deliverable 9.2 Indicators aggregation methodology, 2015) (Antao, et al., 2015)
104	OHSS Indicator 6	[number of accidents]	OHSS: Safety	Work Related Accident	(Indra & Notteboom, Deliverable 9.2 Indicators aggregation methodology, 2015) (Antao, et al., 2015)
105	OHSS Indicator 7	[number of incidents]	OHSS: Security	Number of Port Security Incidents	(Indra & Notteboom, Deliverable 9.2 Indicators aggregation methodology, 2015) (Antao, et al., 2015)
106	OHSS Indicator 8	[Number of cases of goods thef - year]	OHSS: Security	Provides the total number of theft cases in a year period.	(Bentaleb, Mabrouki, & Semma, 2015)
107	OHSS Indicator 9	[Investment in protection / overall investment]	OHSS: Security	Rate of the investments have been made for protection to all investments.	(Antao, et al., 2015)
108	Socio-Economic Indicator 1	[%]	Socio-Economic: Proffessionalism	[Total number of workers with over five years of experience / Total number of workes] Professionals and skilled labour in	(Bentaleb, Mabrouki, & Semma, 2015) (Yeo, Roe, & Dinwoodie,

				port operations Employee's experience (%)	2011) (Hakam, 2015)
109	Socio-Economic Indicator 2	[Number training hours per worker] Or Employee training level in percent (%)	Socio-Economic: Proffessionalism	Training hours per employee given by the company.	(Bentaleb, Mabrouki, & Semma, 2015) (Hakam, 2015)
110	Socio-Economic Indicator 3	[Total sick days + total leaves for other reason / total number of employees]	Socio-Economic: Proffessionalism	Rate of absenteeism per worker	(Bentaleb, Mabrouki, & Semma, 2015)
111	Socio-Economic Indicator 4	[quantity]	Socio-Economic: Proffessionalism	Number of error due to human factor	(Bentaleb, Mabrouki, & Semma, 2015)
112	Socio-Economic Indicator 5	[Tons/Employee]	Socio-Economic: HR	Amount of cargo handled per employee	(UNCTAD Port Management Series 4, 2016)
113	Socio-Economic Indicator 6	Revenue/Employee	Socio-Economic: HR	Amount of revenue handled per employee	(UNCTAD Port Management Series 4, 2016)
114	Socio-Economic Indicator 7	EBITDA/employee	Socio-Economic: HR		(UNCTAD Port Management Series 4, 2016)
115	Socio-Economic Indicator 8	Labour cost/employee	Socio-Economic: HR	Amount of labour cost per employee.	(UNCTAD Port Management Series 4, 2016)
116	Socio-Economic Indicator 9	Training costs/wages	Socio-Economic: HR	Rate of training expenses paid.	(UNCTAD Port Management Series 4, 2016)
117	Socio-Economic Indicator 10	[number of female employees/total number of employees]	Socio-Economic: HR	Labor force participation rate, female.	(World Development Indicators, The World Bank, n.d.)
118	Socio-Economic Indicator 11	[Total number of workers (voluntarily) left/total number of employees left]	Socio-Economic: HR	The Employee Turnover Rate: Indicator indicates the percentage of the total number of employees who have been voluntarily left work to the number of all workers who have been left.	(Ongori, 2007)

119	Socio-Economic Indicator 12	[The port's yearly investment / total investments in the region]	Socio-Economic: Social Impact	Indicates the percentage of the investment made by the port.	(Hakam, 2015)
120	Socio-Economic Indicator 13	[Number of employees / Total number of active population in the region]	Socio-Economic: Social Impact	The indicator measures the contribution of the port regarding it's employees.	(Hakam, 2015)
121	Socio-Economic Indicator 14	[Number of employees' working spouses/ Total number of active population in the region]	Socio-Economic: Social Impact:	Another indicator aimed to measure port's contribution in region with regards to employees.	(Hakam, 2015)
122	Socio-Economic Indicator 15	[total numbers of employees]	Socio-Economic: Social Impact	Direct Employment	(Klukas, Kirsch, Darbra, Dooms, & De Schepper, 2015) (Indra & Notteboom, Deliverable 9.2 Indicators aggregation methodology, 2015)
123	Socio-Economic Indicator 16	[total numbers of employees working in the subcontractors]	Socio-Economic: Social Impact	Indirect Employment	(Klukas, Kirsch, Darbra, Dooms, & De Schepper, 2015)
124	Service Quality Indicator 1	[quantitiy of units]	Service Quality: Reliability	Number of containers delivered by error / year	(Bentaleb, Mabrouki, & Semma, 2015)
125	Service Quality Indicator 2	[quantitiy of units]	Service Quality: Reliability	Number of container no delivered following an incident / year.	(Bentaleb, Mabrouki, & Semma, 2015)
126	Service Quality Indicator 3		Service Quality: Reliability	Frequency of cargo loss and damage.	(Yeo, Roe, & Dinwoodie, 2011)
127	Service Quality Indicator 4	[quantitiy of units]	Service Quality: Reliability	Number of erroneously loading containers	(Bentaleb, Mabrouki, & Semma, 2015)
128	Service Quality Indicator 5	[quantitiy of units]	Service Quality: Reliability	Number of unloading containers due to an incident	(Bentaleb, Mabrouki, & Semma, 2015)
129	Service Quality Indicator 6	[%]	Service Quality: Customer Relations	Port call satisfaction rate (Port of Le Havre)	(Haropa Ports)
130	Service Quality Indicator 7	[%]	Service Quality:	Cumulative index of customer	(Hakam, 2015)

			Customer Relations	experience and customer service level	
131	Service Quality Indicator 8	[Number of customer satisfaction survey per year]	Service Quality: Customer Relations	Frequency of customer satisfaction surveys.	(Bentaleb, Mabrouki, & Semma, 2015)
132	Service Quality Indicator 9	[Number of handled customer complaints / the number of customers]	Service Quality: Customer Relations	It aims to measure percentage of customer complaints were handled.	(Bentaleb, Mabrouki, & Semma, 2015)
133	Service Quality Indicator 10	[Number of customer complaints / the number of customers]	Service Quality: Customer Relations	It aims to measure percentage of customer complaints.	(Bentaleb, Mabrouki, & Semma, 2015)
134	Number of cranes per quay meter	[total quay meter / number of cranes]	Resources: Allocation	Superstructure	(Caldeirinha & Felicio, Port and container terminal characteristics and performance)
135	Average Forklift/ Reachstacker Age	[sum of the age / number of the equipment]	Resources: Handling Equipment Age	Superstructure	(Germanischer Lloyd, 2008)
136	Average tractor age	[sum of the age / number of the equipment]	Resources: Handling Equipment Age	Superstructure	(Germanischer Lloyd, 2008)
137	Average landside gantry crane age	[sum of the age / number of the equipment]	Resources: Handling Equipment Age	Superstructure	(Germanischer Lloyd, 2008)
138	Average QC gantry crane age	[sum of the age / number of the equipment]	Resources: Handling Equipment Age	Superstructure	(Germanischer Lloyd, 2008)

4. PROPOSAL FOR A NEW BALANCED SCORE CARD FOR PORTS

In this section, the PBSC method developed by combining Balanced Score Card (BSC) and Analytic Hierarchy Process (AHP) methods will be explained. Under the Methodology section, The Balanced Score Card system and developed Port's Balances Score Card (PBSC), elements the PBSC: the goal, criteria and sub-criteria and their selection and finally how the criteria and sub-criteria can be weighted by the AHP method will be explained. It should be noted here that the original BSC system will be briefly explained, but AHP results of this study will not be adapted to this system.

4.1. Methodology

This section contains the following subsections:

- Determination of the goal, criteria and sub-criteria
- Adaptation of the AHP method to the study
- Balanced Score Card method and proposed PBSC

4.1.1. Determination of goal, criteria and sub-criteria

The work aims to create a sustainable Port Performance Index (PPI). It is planned that this index will consist of the following four criteria. Sub-criteria that form these four main criteria (dimensions of score card) are detailed in the following chapters. In the previous phase of the study, a detailed literature search was performed for collecting and listing performance indicators (table 3.2) with the aim of including the most diverse indicators possible into the study. Later, a smaller number of indicators were selected for each dimension (criteria) to forming the score card through weighting with the AHP method. It should be noted that it is neither possible nor practical to use a total of 138

indicators which listed and defined for this study. For this reason, the opinions of experts working in the port industry were also taken into consideration, and the most appropriate ones among these 138 indicators were selected for the application. Apart from this, the four main dimensions are designed to include operational and financial performance, which are the direct consequences of the main activities of the port, and environmental and financial issues that are shaped by these activities.

Dimension of Logistic Chain and Operational Performance:

The main activities of a port are to primarily carrying out the discharging and loading processes of the vessels and to provide necessary storage services. It is aimed to measure the operational and logistics capabilities of the port through this dimension. By the indicators in this section, it is planned to measure the extent to which berths are used efficiently and how efficiently the equipment in the port is being used, how fast the operations of the berthed vessels are completed, how long the ships wait on roadstead before they docked due to port's congestion and the handling and logistics costs incurred at the end of all these processes. Also, an indicator is aimed to give the percentage of containers which are damaged during operations.

Dimension of Financial and Business Performance:

As a result of operational activities of the port it is important to know how far these activities can be converted into the revenue. This begins with the right tariff. Apart from this, the bilateral commercial agreements made between ports and lines are also important. This will inevitably lead to an impact on the revenueper to the amount of cargo handled. What is important here is the balance between total business volume, operational efficiency and profitability. Indicators in this section are primarily aimed at measuring port profitability and are also intended to measure operational costs and accurate billing.

Dimension of Environmental and Safety Performance

The operational activities of the port undoubtedly have environmental impacts. It is intended to measure these environmental effects through the indicators in this section. The workplace safety is also considered under this category. Environmental impacts and to keep these at the lowest possible level are becoming increasingly important in the port industry. The EcoPorts project, which was carried out by the European Sea Ports Organization (ESPO), and "Green Port / Eco Port Project" of the Turkish Standards Institution (TSE) are being actively pursued, and that shows the importance given by states and institutions. Today, for a Turkish port titled as “Eco Port,” this situation is also an element of the prestige in a commercial sense.

Dimension of Socio – Economic Performance

In this section, it is aimed to see the effects of the economic activities of the ports on the port’s area. These positive effects mean both investment and employment provided by the port. Apart from this, there are indicators that the port can be evaluated in itself: employee satisfaction, voluntarily terminating and training hours per person. In this section, it is aimed to see the effects of the economic activities of the ports on the port’s area. These positive results mean both investment and employment provided by the port.

4.1.1.1. Selection and Definition of Sub-Criteria

4.1.1.1.1. Logistic Chain and Operational Performance Indicators

For logistic chain and operational performance dimension, total 10 of indicators were selected among 50 number of collected indicators related logistics and operational performance in table 3.2. The Berth Working Index (BWI) was used by the Germanischer Lloyd’s CTQI project. Briefly, it can be defined as a ratio of operation duration to the duration of port stay at berth (excluded duration between sailing time and operation completion time). The higher the rate, come means to the less time spent on the quay

without working (custom controls, unlashing, etc.). Actually, we can think of the ratio as the speed of commencement to vessel's operation because the duration between the completion of operation and the sailing time is not taken into the account (Germanischer Lloyd, 2008). But in this study, Berth Utilization Rate (BU) (L1) was used. It can be said that there is no significant difference between BU and BWI. BU is calculated by dividing total working time by duration of total port stay. Another indicator, Berth Productivity (BP) (L2) indicator calculates the TEU or tonnage handled per hour at the berths.

Average Vessel Turnaround Time (AVTT) (L3) may depend on port calling vessels volume as well as ports' operating performance. For a port where low-capacity vessels make frequent calls, the ATT value may also be low, creating a false perception that operating performance is high. Therefore, if this value is to be used, the data for the vessels (those are bigger than a particular TEU, for example; vessels > 500 TEU) should be used to standardize for all ports. The AVTT value is an indicator that shows the average working time for a vessel. The number of port cranes are assigned to the ship and how fast these cranes are operated determines whether this value will be short (that is favorable) or long. Under the assumption of a port has enough equipment and capacity, it depends on the discharge and loading plans of container vessels on which the number of port cranes can be assigned to each ship. The fact that the loads are distributed equally to as many holds as possible allows more crane to operate on the ship (crane split) at the same time.

TEU per crane indicator (L4) is a performance measure showing the hourly average handling quantity of berth cranes. This study will be based on STS (ship-to-shore) cranes. Filtered data for vessels above a certain TEU/volume must be included in the account. Although there may be container vessels with very few cargo movement (sometimes 2-3), these ships' operations can only be completed within a few minutes and then may cause an error in port automation systems as if they were being performed with very high performance. Therefore, in this study, ships have 500 TEU of operating volume and over will be evaluated. The low AVTT value, the average operation time of a vessel at berth, depends on the operating speed of the cranes and naturally, depends on the cargo amount which the terminal trucks can carry per hour.

With the Average Truck Turnaround Time (L5), the average dwell times of the transport vehicles (belong to the customer) within the terminal yards are calculated. Properly planned and well-run port facilities will provide faster service to customer trucks which come to get import loads or brings export cargo into terminal stacks, and their trucks leave the terminal area as soon as possible.

Average movie per truck indicator (L6) is an indicator that measures the amount of container which is carried by terminal owned trucks, per hour (Germanischer Lloyd, 2008). L6 can also be considered as the main determiner of Teu per Crane (L4) and AVTT (L3) indicators. For container terminals, terminal trucks are the vehicles that carry the containers to the quay cranes from terminal stacks and vice versa. The speed of these carriages is strongly depended on correctly configured yard areas and well-organized container stacks. It should be taken into consideration that if a lot of workloads are given to a lane in the container terminal, it will increase the traffic density due to a higher number of vehicles in the area and that will result in yard congestion and decreased productivity in the whole terminal. So, import and export bays in the terminal area must be very well organized.

The Average Berth Access Time (L7) indicators show on average how much time elapse between arrival (port boundaries: pilot station or anchorage area if the berth is not available on arrival) and berthing time. The extended waiting duration on anchorage area is commercially risky because regularly scheduled container vessels are not likely to berth at the next port and they may miss their schedules. A port with a high berth access time is meant to be facing with a high "congestion" problem. Long access time to the berths may also mean that pilotage and towage services may not be sufficient, at the same time. However, the congestion in the anchorage area due to natural conditions (fog, storm, ice, etc.) which are not originated from port and pilotage services and these certain events can be excluded from calculations by accepting them as "force majeure."

Two reliability indicators were included in the study. One of them (L8) is the percentage of containers damaged during the operation for a period to all the containers handled within the same period. To avoid having too many indicators, the only percentage of containers in this study will be treated as service quality indicator. Discharged and loaded units by mistake, and incorrectly delivered containers will not be included in the study due to the reason specified above and with the thought of the access to the necessary data will not be easy.

Another reliability indicator (L9) relates to in which extent the reported “estimated duration of cargo operation” is being maintained. Estimated duration of the cargo operation is the metric that is given/reported to chief officer/captain with the beginning of the cargo operation at berth. If the vessel’s cargo operation is completed within the period as it was reported to the chief officer/captain, it shall be noted as "1" and the rate of successful estimations shall be calculated. However, it is necessary to use a particular margin of error, but the margin of error may vary depending on the ports. A similar indicator is available in Germanischer Lloyd's CTQI study as an SQI (ship service quality index) (Germanischer Lloyd, 2008).

The last indicator (L10) gives the operating/handling cost per handled TEU or ton. Operational transportation-handling costs will undoubtedly increase financial profitability. Along with the possibility of high handling costs being reflected in port tariffs, however, this will create a constant disadvantage against competitor ports.

Berth Occupancy (BO) is an indicator that measures the intensity of berth usage. A very high value of berth occupancy indicator is a sign of congestion while it indicates under utilization if the value is too low, either. For a meaningful use of it, each pier for a single port must be taken into consideration separately and indicator must be calculated in the same way. By this way, it is possible to see which berths have congestion and which are under utilized so necessary measures can be taken, in a single port. Regarding BO data on annual basis, if port “A” has a density of 70% and port B is at a density of 20%, this

gives a comparison of the business volumes of the two ports according to the number of direct calling vessels. Accordingly, it would not be very meaningful to use it for "operational benchmarking" among ports, other than comparison of business volumes. For this reason, the berth occupancy indicator was not included in the study.

An indicator that measures usage of yards or terminal areas (sqm), such as the Yard Utilization Index or the Soil Occupancy Index, which are the similar monitors, can present useful data for the management of a single port, but they may be misleading while they are being used with purpose of benchmarking between ports. It is important to bear in mind that these values can vary depending on the volume of port's business and is not a factor that can be influenced by improving operational efficiency. However, the presence of poorly planned yards and stacks in ports where the business volume is high, causes all port operations, including ship operations, to be carried out with low efficiency. For this reason, it is not reasonable to operate a container terminal at its full capacity besides it is not sustainable, but a certain amount of idle capacity must be left.

Table 4.1 *Selected indicators for logistics chain and operational performance.*

Item no.	**Proposed Indicator**	**Unit**	**Evaluated Port Score Card Category**	**Definition**	**Source**
L1	Berth Utilization Rate	%	Logistics Chain and Operational Performance: Berth	[(The ship working time x100) /The ship berthing time]	(Chung, 1993)
L2	Berth Productivity	[container moves / hrs.]	Logistics Chain and Operational Performance: Berth	[Number of total container moves / number of hours at berth] Or [Container moves / Berth lenght]	(JOC Group Inc., 2014).
L3	Average (Vessel) Turnaround Time (ATT) TEU > 500	(%)	Logistics Chain and Operational Performance: Berth	[Sum of all vessel turnaround times at berth / total number of container vessels]	(Ducruet, Itoh, & Merk, 2014). (Hakam, 2015) (Germanischer Lloyd, 2008)
L4	TEU per crane TEU > 500	Qty.	Logistics Chain and Operational Performance: Berth	[container moves/(hour*crane)]	(Chung, 1993)
L5	Average truck Turnaround	(%)	Logistics Chain and Operational	[Sum of all truck turnaround	(Germanischer Lloyd, 2008)

	Time (ATTT)		Performance: Terminal	times/total number of trucks]	
L6	Average Moves per Truck	Qty.	Logistics Chain and Operational Performance: Terminal	[Container moves / truck number] (for a specific period)	(Germanischer Lloyd, 2008)
L7	Congestion Indicator	Time	Logistics Chain and Operational Performance: Congestion	Average berth Access time	(Haropa Ports)
L8	Service Quality Indicator		Logistics Chain and Operational Performance: Reliability	Percentage of damaged containers.	(Bentaleb, Mabrouki, & Semma, 2015) (Yeo, Roe, & Dinwoodie, 2011)
L9	Service Quality Indicator		Service Quality: Reliability	Estimating turnaround time at berth. (For Kumport, Margin of error should not exceed one hour).	(Germanischer Lloyd, 2008) (Kumport Container Terminal, 2017).
L10	Logistics Cost Indicator	Logistics Chain and Operational Performance: Logistics Cost		Transportation cost per container (Alternatively, Equipment handling cost per TEU or container)	(Bentaleb, Mabrouki, & Semma, 2015)

4.1.1.1.2. Definition and selection of socio-economic indicators

In this section, indicators to measure the degree of contribution and value added of the ports in their region, indicators such as the turnover rate of the work force and the training hours have given per person that intended to measure internal dynamics of ports are also included.

(SE1) The indicator is used to calculate the number of training hours per employee. Work safety training will help to ensure that the port has high standards by mean of safety and other training given by mean of professionalism will have a positive impact on the quality of work is being carried out.

$$(\text{SE1}) = \frac{\text{Total training hours}}{\text{Total number of employees}}$$

(SE2) is aimed to measure the rate of absenteeism. Absenteeism can be described as full-time or part-time absence due to medical condition, personal reasons or other reasons other than paid leave (New Nouveau Brunswick Canada). Absenteeism may be a good monitor for work place satisfaction as well as it is related to health issues. To use as little indicators as possible in this study, all days except paid vacation will be considered. If it is wished to be examined in detail, it can be analyzed in two categories as days not coming to work due to health reasons and personal reasons.

$$(\text{SE2}) = \frac{\text{Total sick days} + \text{total leaves for other reasons}}{\text{Total number of employees}}$$

Another indicator (SE3) was selected to measure professionalism, it is intended to measure ports' ability to keep their experienced employees. In this study, five years of experience are considered as required time.

$$(\text{SE3}) = \frac{\text{Total number of employees with over five years of experience}}{\text{Total number of employees}}$$

The Employee Turnover Rate indicator (SE4) will be used as a percentage of the total number of employees who have been voluntarily left work for a specified period to the number of all workers who have been left within same period (New Nouveau Brunswick Canada). It is an indicator that is aimed at measuring employee satisfaction. In the study, the below formula will be used which is suggested by New Brunswick Canada. No any change in formula has been made, and it can be calculated on an annual basis, and for 3-month or 6-month periods.

$$(\text{SE4}) = \frac{\text{Total number of employees (voluntarily)leaved}}{\text{Total number of employees terminated}} \text{x } 100$$

(SE5) the indicator is to find out the percentage of the investments have been made by the port to all investments have been made in the region, for a specific period.

$$(\text{SE5}) = \frac{\text{Port's investment}}{\text{Total investment in region}} \text{x } 100$$

Female participation (SE6) in the labor force is considered as an indicator to monitor of development when evaluating and benchmarking ports' performance from the social perspective. It will be calculated with the formula of:

$$(\text{SE6}) = \frac{\text{Number of female employees}}{\text{Total number of employees}} \text{x } 100$$

(SE8) and (SE7) indicators are intended to measure the contribution of a port within its region by means of employment.

(SE7) indicator is the percentage of the number of port employees to the total working population in the area where the port operates.

$$(\text{SE7}) = \frac{\text{Total number of employees of port}}{\text{Total number of active population in the region}} \text{ X } 100$$

$$(\text{SE8}) = \frac{\text{Total number of employees of port}}{\text{Total TEU}}$$

Table 4.2 *Selected Socio-Economic Indicators.*

Item no.	Indicator	Unit	Evaluated Port Score Card Category	Definition	Source
S1*	Socio-Economic Indicator	Hours/Employee	Socio-Economic: HR	Number training hours/worker	(Bentaleb, Mabrouki, & Semma, 2015) (Hakam, 2015)
S2*	Socio-Economic Indicator	Ratio	Socio-Economic: Proffessionalism	Rate of absenteeism per worker	(Bentaleb, Mabrouki, & Semma, 2015) (New Nouveau Brunswick Canada)
S3*	Socio-Economic Indicator	Ratio	Socio-Economic: Proffessionalism	[Total number of workers with over five years of experience / Total number of workes]	(Bentaleb, Mabrouki, & Semma, 2015)
S4*	Socio-Economic Indicator	Ratio	Socio-Economic: Proffessionalism	Employee Turnover Rate	(Ongori, 2007) (New Nouveau Brunswick Canada)
S5*	Socio-Economic Indicator	Ratio	Socio-Economic: HR	Labor force participation rate, female (%)	(World Development Indicators, The World Bank, n.d.)
S6*	Socio-Economic Indicator	Ratio	Socio-Economic: Social Impact	[The port's yearly investment / total investments in the region]	(Hakam, 2015)
S7*	Socio-Economic Indicator	Ratio	Socio-Economic: Social Impact	[Number of employees / Total number of active population in the region]	(Hakam, 2015)
S8*	Socio-Economic Indicator	Qty.	Socio-Economic: Social Impact	Employment Suggested indicator: "Employment per TEU"	(Klukas, Kirsch, Darbra, Dooms, & De Schepper, 2015) (Indra & Notteboom, Deliverable 9.2 Indicators aggregation methodology, 2015)

4.1.1.1.3. Definition and selection of environmental and safety indicators

Waste Creation per TEU (E1) aimed to monitor ports generate how much waste per TEU (or possibly ton). It is possible to make a separation as non-dangerous and dangerous cargo. In that study, no separation was made and this indicator includes all type of waste.

$$E1 = \frac{\text{Total amount of waste were produced in port(for given period)}}{\text{TEU (for given period)}}$$

Carbon footprint is the sum of all emissions of greenhouse gases (GHG) like CO2 (carbon dioxide), which was induced by your activities in a given time frame. With E2 indicator, it is intended to measure greenhouse gas emissions per TEU handled in ports.

$$E2 = \frac{\text{Total amount of GHG (for given period)}}{\text{TEU (for given period)}}$$

Two consumption indicators are included in the study. Port equipment consume high amounts of electricity (E3) and fossil fuel (E4) during port operations. The data on the proportion of these consumptions to the amount of handled TEU within a given range, so data related the amount of consumption per TEU, as well as the financing, have environmental precaution.

$$E3 = \frac{\text{Total Kwh (for given period)}}{\text{TEU (for given period)}}$$

$$E4 = \frac{\text{Total L. (liters) (for given period)}}{\text{TEU (for given period)}}$$

In both types of consumption, the reduction of consumption per TEU is desirable, while the reduction of the use of fossil fuels has a much larger precaution.

The number of trees saved by recycling (E5) is an indicator that gives the number of trees recovered through recycling of papers and packagings. According to U.S. Forest Service web page, for over a year, if quantity of 365 newspaper are recycled for one-year period, 0.48 trees (almost half of a tree) will be saved (U.S. Forest Service, n.d.).

In order to calculate (E5), some facts are given in below (Conservatree, n.d.)

Table 4.3 *The facts on paper production/Retrieved from http://conservatree.org/learn/EnviroIssues/TreeStats.shtml.*

Unit is produced	Required source to produce
1 ton of uncoated and non-recycled printing and office paper	24 trees
1 ton of 100% non-recycled newsprint	12 trees
1 carton (10 reams) of 100% virgin copier paper	.6 trees
16.67 reams of copy paper or 8,333.3 sheets	1 tree
1 ream (500 sheets)	6% of a tree
1 ton of coated, high quality-expensive virgin magazine paper	15.36 trees
1 ton of coated, low quality-inexpensive virgin magazine paper	7.68 trees

(E6) is the ratio of TEU handled in a given period to the amount of water consumed in the same period. It is known that there are large water resources in the world, and less than 1 percent of these resources are available for our use. However, the amount of water returned is not of the same quality and quantity, although water resources are returned to the earth by means of a "water cycle" that balances ecology (United States Environmental Protection Agency, n.d.). For this reason, it was thought that there should be an indicator to monitor the water consumption and this indicator was given.

$$\mathrm{E6} = \frac{\text{Total L. (liters) (for given period)}}{\text{TEU (for given period)}}$$

By using the incentive (E7), it is aimed at reducing sulfur gas emissions from ships that docked at ports by encouraged the vessel's operators to use shore side electricity. Some discount on port's dues can be applied for those who accept to use this service

provided by the port. European Commission has similar practice to reduce greenhouse gas emissions (European Commission, 2015).

$$\mathrm{E}(7) = \frac{\text{Number of vessels connect to shoreside electricity}}{\text{Total number of vessels}}$$

The accident rate for 100000 TEU (E8): The indicator will help monitoring number of accidents occurred per 100000 TEU on a monthly basis. In other words, the indicator indicates the probability that an accident will occur for every 100000 TEU, according to current situation (Kumport Container Terminal, 2017).

$$\mathrm{E8} = \frac{\text{Number of accidents (monthly)}}{\text{Handled containers (TEU, monthly)}} \text{ x } 100000 \text{ (TEU)}$$

Accident Severity Rate (E9), specifies the number of work days lost for each one million working hours due to accidents that occurred (The Workplace Safety and Health (WSH) Institute, 2013).

$$\mathrm{E9} = \frac{\text{Number of man days lost}}{\text{Number of man} - \text{ hours worked}} \text{ x } 1000000$$

Table 4.4 *Selected Indicators for Environmental Perormance and Safety.*

Item no.	Indicator	Unit	Evaluated Port Score Card Category	Definition	Source
E1	Environmental Indicator 1 * "Waste Creation"	Kg(m3)/TEU	Environmental: Pollution	Waste Creation per TEU	(Hakam, 2015) (Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
E2	Environmental Indicator 2* "Carbon Footprint" *	Per TEU	Environmental: Pollution	Carbon Footprint per TEU	(Kumport Container Terminal, 2017)
E3	Environmental Indicator 3*	kWH/TEU	Environmental: Consumption	Electric consumption per TEU	(Kumport Container Terminal, 2017)
E4	Environmental Indicator 4*	Tons/TEU	Environmental: Consumption	Total Consumption in Tons of Fuel per TEU	(Sapina, 2011) (Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
E5	Environmental Indicator 5*	Qty.	Environmental: Resources	Number of trees saved by recycling	(Kumport Container Terminal, 2017) (U.S. Forest Service, n.d.)
E6	Environmental Indicator 6*	L/TEU	Environmental: Resources	Total water consumption per TEU	(Santos, Silva, & Cerqueira) (Kumport Container Terminal, 2017)
E7	Environmental Indicator 7*	Ratio	Environmental: Incentives	[Number of vessels connect to shore-side electricity / Total number of vessels]	(Puig, Pla, Seguí, Wooldrdige, & Darbra, 2016)
E8	Safety Indicator 1	Accident Number/TEU	Safety	Accident rate for 100.000 TEU	(Kumport Container Terminal, 2017)
E9	Safety Indicator 2		Safety	Accident Severity Rate	(The Workplace Safety and Health (WSH) Institute, 2013)

4.1.1.1.4. Definition and Selection of Financial and Business Performance Indicators

(F1) is one of most basic indicators from United Nations to measure profitability and it simply gives the revenue per Ton (UNCTAD, 1976). It can also be used as revenue per

TEU instead Ton. From the view of port management, it is a meaningful indicator and useful as it's simple.

$$(\mathrm{F1}) = \frac{\text{Total revenue}}{\text{Total TEU}}$$

(F2), is gives the revenue per employee, and as it was stated in Investopedia, it is handy tool for benchmarking purpose (Investopedia, n.d.).

$$(\mathrm{F2}) = \frac{\text{Total revenue}}{\text{Total number of employees}}$$

(F3), is another financial indicator which originally from United Nations and it is used to measure berth revenue per ton of cargo handled (UNCTAD, 1976). TEU can also be used instead ton as a cargo measure. Ship dues will be evaluated as berth occupancy revenue.

$$(\mathrm{F3}) = \frac{\text{Total revenue from ship dues}}{\text{Total TEU handled at berth}}$$

(F4) "EBITDA Margin," is the ratio of EBITDA to total revenue and gives operating profitability (Investopedia, n.d.). EBITDA is expanded as earnings before interest, tax, depreciation, and amortization. To calculate EBITDA, all operational expenses are removed from revenue but not taxes, interest, depreciation, and amortization. It is well-suited indicator for monitoring operating costs it has also found place in United Nation's Port Performance Score Card as a financial indicator (UNCTAD Port Management Series 4, 2016).

$$(\mathrm{F4}) = \text{EBITDA Margin} = \frac{\text{EBITDA}}{\text{Revenue}}$$

(F5), labor expenditure per ton is another financial indicator from United Nations (UNCTAD, 1976). The higher value of this indicator is unfavorable since it is an OPEX (operational expenses) and it will be evaluated with the formula of:

$$(\text{F5}) = \frac{\text{Total labor cost}}{\text{TEU (Ton)}}$$

(F6) is indicator related maintenance expenses.

$$(\text{F6}) = \frac{\text{Total maintenance cost}}{\text{TEU (Ton)}}$$

(F7) is the indicator that intended to measure the accuracy of business transactions, considered as a business indicator and not a financial one. The indicator will be used in the study by considering correct billing will means to less rejection of transactions and timely receiving the payments, so money has time value.

$$(\text{F7}) = \frac{\text{Number of correct billing}}{\text{Total number of transactions}}$$

Table 4.5 *Selected Indicators for Financial and Business Performance.*

Item no.	Indicator	Unit	Evaluated Port Score Card Category	Definition	Source
F1	Financial Performance	Monetary unit/TEU	Financial: Profit and loss	Cargo and container handling revenue per ton or per TEU of Cargo [Total revenue / Total handled tons or TEU]	(Bentaleb, Mabrouki, & Semma, 2015) (Hakam, 2015) (UNCTAD, 1976)
F2	Financial Performance	Monetary unit/Quantity	Financial: Profit and loss	Profit (revenue) per Employee	(Bryan, 2007) (Investopedia, n.d.)
F3	Financial Performance		Financial: Profit and loss	Berth Occupancy Revenue (per TEU or ton)	(Hakam, 2015) (UNCTAD, 1976)
F4	Financial Indicator	Revenue	Financial: Profit and loss	[EBITDA / revenue (operating margin)]	(UNCTAD Port Management Series 4, 2016)
F5	Financial Performance	Expenditure (Opex)	Financial: Profit and loss	Labor expenditure per ton of Cargo	(UNCTAD, 1976)
F6	Financial Performance	Expenditure (Opex-Manintenance)	Financial: Profit and loss	Capital equipment expenditure per ton of Cargo (Alternatively per TEU)	(Bentaleb, Mabrouki, & Semma, 2015) (UNCTAD, 1976)
F7	Business Indicator	Means rejection of bills and late payment.	Business Transaction	Invoice Accuracy	(The AAPA Customer Service Initiative Report, 2012)

4.1.2. Integration of the AHP method into study

Firstly, it will be explained that why the AHP method is used in this study. The AHP method provides a hierarchical structure suitable for this study. As well as being a convenient and time-saving method to implement, it is also very important to be able to check the consistency ratio since subjective judgments of the participants were used as data source. The questionnaire prepared with Saaty's 1-9 scale will be sent to the participants. Participants will be asked to compare each criteria and sub-criteria with each other by

pairwise comparisons. So, participants' selections which based on their subjective judgments will be the only data source for AHP method. In the first chapter, the main criteria (dimensions) will be compared through pairwise comparisons.

Table 4.6 *Selected decision criteria and sub-criteria.*

Dimensions (scorecard sizes)		**Sub-criteria**
1	Logistic Chain and Operational Performance (LCI)	L1, L2, L3, L4, L5, L6, L7, L8, L9, L10
2	Financial and Business Performance (FBI)	F1, F2, F3, F4, F5, F6, F7
3	Environmental and Safety Performance (ESI)	E1, E2, E3, E4, E5, E6, E7, E8, E9
4	Socio – Economic Performance (SEI)	E1, E2, E3, E4, E5, E6, E7, E8

$$Number\ of\ pairwise\ comprasions\ to\ be\ made: \frac{n\ x\ (n-1)}{2}$$

A total of six pairwise comparisons will be made between the LCI, FBI, ESI, and SEI for the calculation of the Port Performance Index (PPI) and the following number of pairs of comparisons should be made among the indicators that forming each criterion.

LCI sub-criteria: 45

FBI sub-criteria: 21

ESI sub-criteria: 36

SEI sub-criteria: 28 of pairwise comparison is required.

Establishment of pairwise comparisons matrices: the following pairwise comparison matrix is established for sub-criteria, in Table 4.7

Table 4.7 *Example comparison matrices for sub-criteria.*

Comparison matrix for sub-criteria of Logistics and Operational Performance Perspective					
	L1	L2	L3	…	L10
L1	WL1/WL1	WLI/ WL2	WLI/ WL3	…	WLI/ WL10
L2	WL2/ WL1	WL2/ WL2	WL2/ WL3	…	WL2/ WL10
L3	WL3/WL1	WL3/ WL2	WL3/ WL3	…	WL3/ WL10
...	...	...	...	…	...
L10	WL10/ WL1	WL10/ WL2	WL10/ WL3	…	WL10/ WL10
Comparison matrix for sub-criteria of Financial and Business Performance Perspective					
F1	WF1/WF1	WFI/ WF2	WFI/ WF3	…	WFI/ WF7
F2	WF2/ WF1	WF2/ WF2	WF2/ WF3	…	WF2/ WF7
F3	WF3/WF1	WF3/ WF2	WF3/ WF3	…	WF3/ WF7
...	...	...	...	…	...
F7	WF7/ WF1	WF7/ WF2	WF7/ WF3	…	WF7/ WF7
Comparison matrix for sub-criteria of Socio-EconomicPerformance Perspective					
	S1	S2	S3	…	S8
S1	WS1/WS1	WSI/ WS2	WSI/ WS3	…	WSI/ WS8
S2	WS2/ WS1	WS2/ WS2	WS2/ WS3	…	WS2/ WS8
S3	WS3/WS1	WS3/ WS2	WS3/ WS3	…	WS3/ WS8
...	...	...	...	…	...
S8	WS8/ WS1	WS8/ WS2	WS8/ WS3	…	WS8/ WS8
Comparison matrix for sub-criteria of Environmental and SafetyPerformance Perspective					
	E1	E2	E3	…	E9
E1	WE1/WE1	WEI/ WE2	WEI/ WE3	…	WEI/ WE9
E2	WE2/ WE1	WE2/ WE2	WE2/ WE3	…	WE2/ WE9
E3	WE3/WE1	WE3/ WE2	WE3/ WE3	…	WE3/ WE9
...	...	...	...	…	...
E9	WE9/ WE1	WE9/ WE2	WE9/ WE3	…	WE9/ WE9

As for the Main Criteria (dimensions of score card), a comparison matrix will be created such as one in the following Table 4.8. The formation of the pairwise comparison matrix of the sub-criteria, the normalization process, the calculation of the appropriated weights, and the finding of the CI / CR will be the same as those for the main criteria. For this reason, only the process belongs to main-criteria will be explained in order, and the same process for sub-criteria will not be explained again so that the study will not repeat itself, only the comparison matrices for sub-criteria was given above.

Table 4.8 *Example comparison matrix for main criteria*

Main Criteria	LCI	FBI	ESI	SEI
LCI	w_{LCI}/w_{LCI}	w_{LCI}/w_{FBI}	w_{LCI}/w_{ESI}	w_{LCI}/w_{SEI}
FBI	w_{FBI}/w_{LCI}	w_{FBI}/w_{FBI}	w_{FBI}/ w_{ESI}	w_{FBI}/w_{SEI}
ESI	w_{ESI}/w_{LCI}	w_{ESI}/w_{FBI}	w_{ESI}/w_{ESI}	w_{ESI}/w_{SEI}
SEI	w_{SEI}/w_{LCI}	w_{SEI}/w_{FBI}	w_{SEI}/w_{ESI}	w_{SEI}/w_{SEI}

The "wFBI/wLCI" indicator here indicates the decision maker's choice between FBI and LCI criteria in the AHP questionnaire. For example, if the decision maker has chosen the LCI criteria to be of absolute importance to the FBI, then the value of wFBI/wLCI will be 1/9. To find the weight of each main criteria, the following Table 4.9. is processed:

Table 4.9 *Calculation of Priority Vector (PV)*

Main Criteria	nth. root of the Criteria	Priority Vector (PV)
LCI	$a = \left(1.000 \text{ x} \frac{\text{wLCI}}{\text{wFBI}} x \frac{\text{wLCI}}{\text{wESI}} x \frac{\text{wLCI}}{\text{wSEI}}\right)^{\frac{1}{4}}$	$\frac{a}{e}$
FBI	$b = \left(\frac{\text{wFBI}}{\text{wLCI}} \text{x } 1.000 \, x \frac{\text{wFBI}}{\text{wESI}} x \frac{\text{wFBI}}{\text{wSEI}}\right)^{\frac{1}{4}}$	$\frac{b}{e}$
ESI	$c = \left(\frac{\text{wESI}}{\text{wLCI}} \text{ x} \frac{\text{wESI}}{\text{wFBI}} x \, 1.000 \, x \frac{\text{wESI}}{\text{wSEI}}\right)^{\frac{1}{4}}$	$\frac{c}{e}$
SEI	$d = \left(\frac{\text{wSEI}}{\text{wLCI}} \text{ x} \frac{\text{wSEI}}{\text{wFBI}} x \frac{\text{wSEI}}{\text{wESI}} x \, 1.000 \right)^{\frac{1}{4}}$	$\frac{d}{e}$
	$e = (a + b + c + d)$	$\left(\frac{a}{e} + \frac{b}{e} + \frac{c}{e} + \frac{d}{e}\right) = 1.000$

In Table 4.9. above, the values in the cells called "Priority Vector" are the weighting value of the related criteria at the same time. When the process is applied correctly, the sum of the Priority Vector values of these four Criteria will be equal to "1". So:

$$\left(\frac{a}{e} + \frac{b}{e} + \frac{c}{e} + \frac{d}{e}\right) = 1.000$$

In the "nth root of Criteria" section, the reason for calculation of the 4th root is to have four main criteria, and normalization will be done by the processes in order to calculate the appropriate weights of the criteria.

Table 4.10 *Calculation of CI and CR.*

	LCI	FBI	ESI	SEI	nth. root of the Criteria	PV
LCI	w_{LCI}/w_{LCI} (Pairwise comparison values)	w_{LCI}/w_{FBI}	w_{LCI}/w_{ESI}	w_{LCI}/w_{SEI}	a	$\frac{a}{e}$
FBI	w_{FBI}/w_{LCI}	w_{FBI}/w_{FBI}	w_{FBI}/w_{ESI}	w_{FBI}/w_{SEI}	b	$\frac{b}{e}$
ESI	w_{ESI}/w_{LCI}	w_{ESI}/w_{FBI}	w_{ESI}/w_{ESI}	w_{ESI}/w_{SEI}	c	$\frac{c}{e}$
SEI	w_{SEI}/w_{LCI}	w_{SEI}/w_{FBI}	w_{SEI}/w_{ESI}	w_{SEI}/w_{SEI}	d	$\frac{d}{e}$
Sum	$1+\frac{wFBI}{wLCI}+\frac{wESI}{wLCI}+\frac{wSEI}{wLCI}$	$\frac{wLCI}{wFBI}+1+\frac{wESI}{wFBI}+\frac{wSEI}{wFBI}$	$\frac{wLCI}{wESI}+\frac{wFBI}{wESI}+1+\frac{wSEI}{wESI}$	$\frac{wLCI}{wSEI}+\frac{wFBI}{wSEI}+\frac{wESI}{wSEI}+1$	$a+b+c+d$	1
Sum* PV	$\left(1+\frac{wFBI}{wLCI}+\frac{wESI}{wLCI}+\frac{wSEI}{wLCI}\right) x \frac{a}{e}$	$\left(\frac{wLCI}{wFBI}+1+\frac{wESI}{wFBI}+\frac{wSEI}{wFBI}\right) x \frac{b}{e}$	$\left(\frac{wLCI}{wESI}+\frac{wFBI}{wESI}+1+\frac{wSEI}{wESI}\right) x \frac{c}{e}$	$\left(\frac{wLCI}{wSEI}+\frac{wFBI}{wSEI}+\frac{wESI}{wSEI}+1\right) x \frac{d}{e}$	λ_{max}	
λ_{max}	Described in below.					
CI	$\frac{\lambda_{max}-n}{n-1}$					
CR	$CR=\frac{CI}{RI}$					

$$\lambda_{max}=\left(\left(1+\frac{wFBI}{wLCI}+\frac{wESI}{wLCI}+\frac{wSEI}{wLCI}\right) x \frac{a}{e}\right)+\left(\left(\frac{wLCI}{wFBI}+1+\frac{wESI}{wFBI}+\frac{wSEI}{wFBI}\right) x \frac{b}{e}\right)+\left(\left(\frac{wLCI}{wESI}+\frac{wFBI}{wESI}+1+\frac{wSEI}{wESI}\right) x \frac{c}{e}\right)+\left(\left(\frac{wLCI}{wSEI}+\frac{wFBI}{wSEI}+\frac{wESI}{wSEI}+1\right) x \frac{d}{e}\right)$$

Calculation of Consistency Index (CI) and Consistency Ratio (CR):

1- In the Sum section of Table 4.10. , for each criterion; All pairwise comparison values in the same column are summed up.
2- In the Sum*PV section, the values which summed up in the Sum section are multiplied with the respective weights in the PV column.
3- The Consistency Index (CI) is calculated. The "n" in the formula is the quantity of the main criterion that is compared.

The Conssistency Index (CI),

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad so, \quad CI = \frac{\lambda_{max} - 4}{3}$$

4- Finally, Consistency Ratio (CR) is calculated. If, CR ≤ 0.10, pairwise comparisons are relatively consitent.

Consistency Ratio (CR),

$$CR = \frac{CI}{RI}, \quad (according\ to\ Saaty's\ RI\ scale, RI\ is\ equal\ to\ 0{,}90)$$

$$CR = \frac{CI}{0{,}90}$$

Table 4.11 *Saaty's 1-9 scale (Saaty, 2008).*

n	1	2	3	**4**	5	6	7	8	9	10
RI	0	0	0,58	**0,90**	1,12	1,24	1,32	1,41	1,45	1,49

4.1.3. Balanced Score Card (BSC) method ve proposed Port's Balanced Score Card (PBSC)

4.1.3.1. Balanced Score Card (BSC) Method

First of all, the BSC method will be mentioned. It should be noted that Ports Balanced Score Card (PBSC) is not a method that developed based on the BSC method so that no any connection will be established between the two systems. The BSC method, however, will be mentioned here because it is the first example of its kind.

The BSC method was developed by Robert S. Kaplan and David P. Norton in 1992, assuming that conventional financial accounting measures alone are not sufficient (Kaplan & Norton, 1992). The BSC is the expression of a company's mission and strategy as physical measures. As dynamic measurement technique, it is being used by corporations and institutions in various fields in different parts of the world.

The Balanced Score Card (BSC) method has four perspectives:

Financial Perspective: The Financial Perspective aims to measure the financial success of the company. It can be said that financial success is the most important criterion for a company to be successful.

Customer Perspective: It is aimed to measure the perception of the client about the company. Measuring customer satisfaction can be done in a number of ways, such as phone calls, surveys and how many customer complaints are received.

Internal Business Process Perspective: It focuses on the production process within the company and the measurement of the quality of products and services that are being provided to customers.

Learning and growth perspective: It is an indicator that focuses on the development and learning ability of companies. The learning and growth perspective was described as "the black hole of the balanced score card." (Kaplan, 2010). In this context, Kaplan and Norton have put more importance on the learning dimension of this perspective than the training dimension, regarding the importance given to workers.

The BSC method has its advantages and disadvantages. First of all, top management can efficiently monitor the overall performance of the company. The priorities set by top management can be easily observed by middle-class managers at lower levels and spread throughout the company. However, if data can be shared outside the company, stakeholders can externally assess organizational performance. However, some data may be confusing, such as the priority will be given to which one if there is performance declining in more than one dimension. Additionally, this method does not produce a definitive solution for everything: first of all, the score card to be implemented is supposed to be properly designed, and it is required to cover the company's all activities in a balanced way. Dimensions of Balanced Score Card (BSC) is shown below (Figure 4.1).

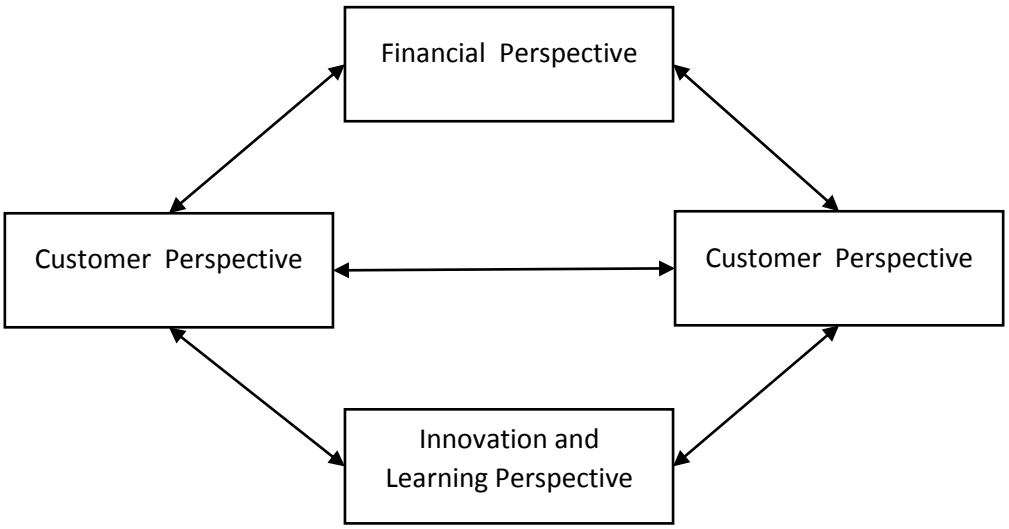

Figure 4.1 *Dimensions of Balanced Score Card (BSC)/Reprinted from (Kaplan & Norton, The Balanced Scorecard Measures That Drive Performance, 1992).*

4.1.3.2. Proposing Port's Balanced Score Card (PBSC)

A balanced score card framework is developed after a literature survey. In total, 138 items were collected from existed literature and evaluated while constructing the new score card. Later, the opinions of the port industry experts were taken, and the ones that are most suitable for the study were selected among these 138 indicators. Logistic Chain and Operational, Financial and Business, Environmental and Safety and Socio-Economic dimensions will constitute a Port Performance Index (PI). PBSC will be formed by implementing weighted values of main criteria (perspective) derived from AHP into proposed framework.

Four main criteria (score card perspectives) are listed in below:

- Logistic Chain and Operational Performance
- Financial and Business Performance
- Environmental and Safety
- Socio – Economic Indicators

4.1.3.2.1. Port Performance Index (PPI)

The segment will form Port Performance Index (PPI) that is the primary target. The Port Performance index is a single score, and when applied to the same port for certain periods, it will be able to monitor the performance change of that port in the process. However, it can also be used for benchmarking between ports. It will be created by four Main criteria (score card perspectives). The weight of each of the four main criteria will be obtained by interpretation of the survey data, by using the AHP method.

4.1.3.2.2. Logistic Chain and Operational Performance Index (LCI)

This section contains ten sub-criteria selected from a total of 51 operational indicators. It is the section where the operational and logistics performances of the ports will be evaluated. Indicators are described in detail in section 4.1.1.1.1.

Table 4.12 *List of LCI indicators.*

Item no.	**Description**
L1	Berth Utilization Rate
L2	Berth Productivity
L3	Average (Vessel) Turnaround Time (AVTT)
L4	TEU per crane
L5	Average Truck Turnaround Time (ATTT)
L6	Average Moves per Truck
L7	Average berth Access time
L8	Percentage of damaged containers.
L9	Estimating turnaround time at berth.
L10	Transportation cost per container

4.1.3.2.3. Socio – Economic Performance Index (SEI)

This section contains eight sub-criteria selected from a total of 16 socio-economic indicators. It aims to measure the social and economic benefits of port operations in the port's region and the performance of the port regarding human resources (HR). Indicators are described in detail in section 4.1.1.1.2.

Table 4.13 *List of SE indicators.*

Item no.	**Description**
SE1	Number training hours/worker
SE2	Rate of absenteeism per worker
SE3	[Total number of workers with over five years

	of experience / Total number of workes]
SE4	Employee Turnover Rate
SE5	Labor force participation rate, female (%)
SE6	[The port's yearly investment / total investments in the region]
SE7	[Number of employees / Total number of active population in the region]
SE8	Employment Suggested indicator: "Employment per TEU"

4.1.3.2.4. Environmental and Safety Performance Index (ESI)

This section contains nine sub-criteria selected from a total of 40 Environmental and Safety indicators. It is aimed to measure the environmental and safety performance which are the consequences of operational activities. Indicators are described in detail in section 4.1.1.1.3.

Table 4.14 *List of ES indicators.*

Item no.	**Description**
E1	Waste Creation per TEU
E2	Carbon Footprint per TEU
E3	Electric consumption per TEU
E4	Total Consumption in Tons of Fuel per TEU
E5	Number of trees saved by recycling
E6	Total water consumption per TEU
E7	[Number of vessels connect to shore-side electricity / Total number of vessels]
E8	Accident rate for 100.000 TEU
E9	Accident Severity Rate

4.1.3.2.5. Financial and Business Performance Index (FBI)

This section contains seven sub-criteria selected from a total of 16 financial indicators. It is aimed to measure financial and business performance. In other words, it is intended to measure if the port's operational success can be sustained in the financial area as well and the extent to which the port activities can be converted into revenue. Indicators are described in detail in section 4.1.1.1.4.

Table 4.15 *List of FB indicators*

Item no.	**Description**
F1	Cargo and container handling revenue per ton or per TEU of Cargo
F2	Profit (revenue) per Employee
F3	Berth Occupancy Revenue (per TEU or ton)
F4	[EBITDA / revenue (operating margin)]
F5	Labor expenditure per ton of Cargo
F6	Capital equipment expenditure per ton of Cargo (Alternatively per TEU)
F7	Invoice Accuracy

The framework of PBSC was prepared according to the criteria and sub-criteria which were described in the previous sections is shown as follows:

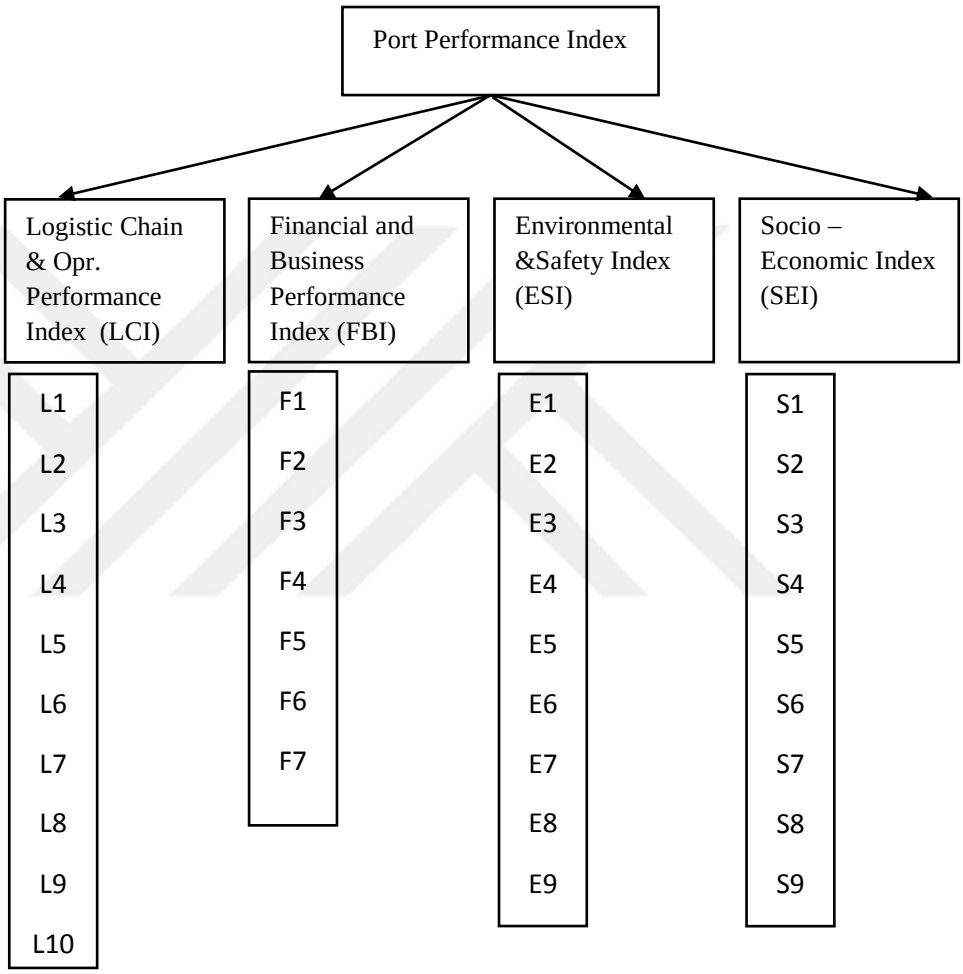

Figure 4.2 *Framework of proposed balanced score card.*

4.2. Application

4.2.1. Phase of the Survey

The questionnaire that was prepared according to Saaty 1-9 scale (and included in Annex-1) were sent to participants who are competent in port management. Participants work at one of the largest container terminals in Turkey which is being operated in Istanbul/Ambarli port. Participants were asked to perform a total of 136 pairwise comparisons in five sections, as outlined in the following headings.

Port Performance Index (PPI): 6

LCI (sub-criteria) : 45

FBI (sub-criteria) : 21

ESI (sub-criteria) : 36

SEI (sub-criteria) : 28

In the questionnaire, the form for the requested selections is as follows:

"Please compare the main criteria below that affect the overall port performance, according to their importance."

Absolute importance ← Equal → Absolute importance

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Logistics and Operational Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	Financial and Business Performance

Figure 4.3 *Pairwise comparison example from questionnare.*

Questionnaire forms were sent to 40 professionals who are currently working in the port industry, and 14 of them accepted to participate in the study, with a participation rate of 35%. After the first review, only six of 14 participants were selected and included in the study. The participant profile that included in the analysis is as follows:

Table 4.16 *Participants' profiles.*

Participant	**Department**	**Rank**	**Age**
1	Planning	Supervisor	39
2	Planning	Supervisor	36
3	Financial control and reporting	Chief	36
4	Planning	Supervisor	37
5	Financial control and reporting	Director	28
6	Planning	Specialist	36

Table 4.17 *Participants' experiences.*

	Experience in port industry (years)				
Participant	1-3	4-6	7-9	10-12	13-15
1					X
2			X		
3			X		
4					X
5	X				
6		X			

As it can be seen in table 4.17, participants are experienced in the port industry. The financial control and reporting director (5) has less experience relatively other participants. However, the aforementioned participant was involved in the study because the participant has the ability to analyze and interpret the significant financial and operational data that related to port industry due to his duty. Table 4.18 shows that the participants are minimum college graduates.

Table 4.18 *Participant's educational status*

Participant	Educational status
1	College
2	College
3	Mater's degree
4	University
5	University
6	University

4.2.2. Phase of AHP Analysis

Microsoft Excel program was used for AHP analysis. A master data set had been created in which survey data was added. Transferring the data to the master data set was done according to the following example. For example, if the participant who is asked to make a choose among the perspectives of "Logistic Chain and Operational Performance" and "Financial and Business Performance" has made a choice of "7" to be on the side of "Financial and Business Performance", this selection was transferred to master data set as "1/7" so 0,142857 value.

	9	7	5	3	1	3	5	**7**	9	
Logistic Chain and Operational Performance	9	7	5	3	1	1/3	1/5	**1/7**	1/9	Financial and Business Performance

Figure 4.4 *An example of pairwise comparison.*

4.2.2.1. Port Performance Indicator (PPI)

For each pairwise comparison, the geometric mean of all participants' choices was taken.

Table 4.19 *Survey results for PPI section.*

	1	**2**	**3**	**4**	**5**	**6**	**Geo. Mean**	**Comparison**
G1	7	7	0,142857	1	0,142857	5	1,30766	LCI-FBI
G2	7	5	0,142857	1	1	1	1,30766	LCI-ESI
G3	7	0,142857	7	3	1	3	1,994757	LCI-SEI
G4	0,2	5	0,2	1	7	5	1,383088	FBI-ESI
G5	0,2	0,2	5	1	7	3	1,270208	FBI-SEI
G6	0,111111	1	5	1	7	0,333333	1,044201	ESI-SEI

In the nextstep, a pairwise comparison matrix was constructed:

Table 4.20 *Pairwise comparison matrix for PPI section.*

	LCI	FBI	ESI	SEI
LCI	**1**	1,30766	1,30766	1,994757
FBI	1/ 1,30766	**1**	1,383088	1,270208
ESI	1/ 1,30766	1/ 1,383088	**1**	1,044201
SEI	1/ 1,994757	1/ 1,270208	1/ 1,044201	**1**
TOTAL	**3,030763**	**3,817953**	**4,648418**	**5,309166**

Each cell value calculated in the above table was divided by the total value in the same column. The purpose here is to calculate the weight of each perspective as a percentage, which will constitute the score card (Table 4.21 - 4.22).

Table 4.21 *PPI: Calculation weights of dimensions (a)*

Table X	LCI	FBI	ESI	SEI
LCI	**1**	1,30766	1,30766	1,994757
FBI	1/ 1,30766	**1**	1,383088	1,270208
ESI	1/ 1,30766	1/ 1,383088	**1**	1,044201
SEI	1/ 1,994757	1/ 1,270208	1/ 1,044201	**1**
TOTAL	**3,030763**	**3,817953**	**4,648418**	**5,309166**

The average weight of each perspective was then obtained by averaging. The weight of each perspective is specified in column Avr. of the Table 4.22, below. The sum of the values in column Avr. is found as "1", which means that no any calculation error has occurred.

The indication of the weights of the perspectives is shown in the weight column as percentages (Table 4.22).

Table 4.22 *PPI: Calculation weights of dimensions (b).*

Table Y	LCI	FBI	ESI	SEI	Avr.	Weight (%)
LCI	0,32995	0,342503	0,281313	0,37572	0,332371	**33%**
FBI	0,252321	0,26192	0,297539	0,239248	0,262757	**26%**
ESI	0,252321	0,189374	0,215127	0,196679	0,213375	**21%**
SEI	0,165409	0,206203	0,206021	0,188353	0,191496	**19%**
Total	1	1	1	1	1	

Consistency analysis was performed for pairwise comparisons after the weights were calculated. This is important to understanding the extent to which decision makers have made consistent and contradictory comparisons.

In below, each comparison value in Table X is multiplied by the weight value of the perspective in the same row in Table Y and added to Table Z. Table Z was created in this way (Table 4.23).

Table 4.23 *PPI: Calculation of lambda λ (a).*

Table X	LCI	FBI	ESI	SEI	
LCI	1	1,30766	1,30766	1,994757	
FBI	0,764724	1	1,383088	1,270208	
ESI	0,764724	0,72302	1	1,044201	
SEI	0,501314	0,787273	0,95767	1	
Total	3,030763	3,817953	4,648418	5,309166	
Table Y	LCI	FBI	ESI	SEI	Avr.
LCI	0,32995	0,342503	0,281313	0,37572	0,332371
FBI	0,252321	0,26192	0,297539	0,239248	0,262757
ESI	0,252321	0,189374	0,215127	0,196679	0,213375
SEI	0,165409	0,206203	0,206021	0,188353	0,191496
Total	1	1	1	1	1
Table Z	LCI	FBI	ESI	SEI	
LCI	0,332371	0,434629	0,434629	0,663	1,864629
FBI	0,200937	0,262757	0,363416	0,333756	1,160867
ESI	0,163173	0,154274	0,213375	0,222806	0,753629
SEI	0,096	0,15076	0,18339	0,191496	0,621646

In next, the consistency value for each perspective was calculated. This process will be shown in the same table (Table 4.24).

Table 4.24 *PPI: Calculation of lambda λ (b).*

Table X	LCI	FBI	ESI	SEI	
LCI	1	1,30766	1,30766	1,994757	
FBI	0,764724	1	1,383088	1,270208	
ESI	0,764724	0,72302	1	1,044201	
SEI	0,501314	0,787273	0,95767	1	
Total	3,030763	3,817953	4,648418	5,309166	
Table Y	LCI	FBI	ESI	SEI	Avr
LCI	0,32995	0,342503	0,281313	0,37572	0,332371
FBI	0,252321	0,26192	0,297539	0,239248	0,262757
ESI	0,252321	0,189374	0,215127	0,196679	0,213375
SEI	0,165409	0,206203	0,206021	0,188353	0,191496
Total	1	1	1	1	1
Table Z	LCI	FBI	ESI	SEI	
LCI	0,332371	0,434629	0,434629	0,663	1,864629
FBI	0,200937	0,262757	0,363416	0,333756	1,160867
ESI	0,163173	0,154274	0,213375	0,222806	0,753629
SEI	0,096	0,15076	0,18339	0,191496	0,621646

Table 4.25 *PPI: Calculation of lambda λ (c).*

	Calculation of consistencies for each indicator	
G1	1,864629/0,332371	5,610078
G2	1,160867/0,262757	4,41802
G3	0,753629/0,213375	3,531945
G4	0,621646/0,191496	3,246257
Average (λ)		4,201575

Consistency Index (CI) was found with the following formula:

$$CI = \frac{\lambda - n}{n - 1} \quad so, \quad CI = \frac{4{,}201575 - 4}{3} = 0{,}067192$$

After the CI was found, the Consistency Ratio (CR) was calculated at the last step. Since we already had the value of CI, we found the value of RI from Saaty's RI scale (Table 4.24).

Since we evaluated four criteria, we used 0.90 for RI.

$$CR = \frac{CI}{RI} \quad so, \quad CR = \frac{0.067192}{0.89}$$

CR = 7.5%. Since this value was less than 0.10, pairwise comparisons were considered consistent.

Table 4.26 *Saaty's RI scale (Saaty, 2008).*

n	1	2	3	**4**	5	6	7	8	9	10	11	12	13	14
RI	0	0	0,52	**0,89**	1,11	1,25	1,35	1,4	1,45	1,49	1.51	1.48	1.56	1.57

4.2.2.2. Logistic Chain and Operational Performance Index (LCI)

For the calculation of the LCI, the same procedures used for the calculation of the Port Performance Index (PPI) will be performed.

1. Step: In the Table 4.27 below, the pairwise comparison values are shown which were exported from the questionnaire forms to the master data table. In the Geo Avr. section, the geometric average of the values of all the participants' decisions for each comparison is calculated. The rightmost column shows which pair of indicators is compared.

Table 4.27 *Survey results for LCI section.*

	1	**7**	**12**	**8**	**5**	**14**	**Geo Avr.**	**Comparison**
L1	0,2	3	0,142857	1	5	1	0,868301	L1-L2
L2	0,2	0,2	0,142857	7	0,142857	1	0,422825	L1-L3
L3	5	5	0,142857	0,2	0,142857	3	0,820948	L1-L4
L4	5	3	0,2	0,2	0,2	0,333333	0,584804	L1-L5
L5	9	0,333333	0,142857	0,333333	0,2	3	0,664011	L1-L6
L6	5	1	0,2	1	0,142857	1	0,72302	L1-L7
L7	5	5	0,333333	3	0,2	0,2	1	L1-L8
L8	0,2	7	0,142857	0,2	5	3	0,918386	L1-L9
L9	3	3	0,142857	0,2	0,111111	3	0,664011	L1-L10
L10	5	1	5	3	1	0,2	1,570418	L2-L3
L11	7	5	0,142857	1	0,2	0,333333	0,832683	L2-L4
L12	7	3	0,2	0,2	0,2	1	0,742822	L2-L5
L13	0,2	0,333333	0,142857	5	0,2	3	0,552911	L2-L6
L14	5	0,333333	0,142857	1	0,333333	5	0,857235	L2-L7
L15	5	5	0,333333	5	0,333333	1	1,550403	L2-L8
L16	5	5	5	1	0,2	0,333333	1,423868	L2-L9
L17	5	7	0,2	1	0,142857	0,333333	0,832683	L2-L10
L18	0,2	5	7	7	0,2	5	1,912931	L3-L4
L19	5	3	5	0,2	0,2	5	1,570418	L3-L5
L20	0,2	1	5	1	5	5	1,709976	L3-L6
L21	5	1	5	3	0,142857	1	1,484775	L3-L7
L22	5	5	5	1	3	3	3,224968	L3-L8
L23	5	5	5	0,142857	5	5	2,764556	L3-L9
L24	5	5	0,2	0,142857	5	0,333333	1,029485	L3-L10
L25	7	3	0,2	0,2	0,142857	3	0,843433	L4-L5
L26	0,2	3	0,2	1	0,2	3	0,644994	L4-L6
L27	5	3	0,2	0,333333	7	0,2	1,057681	L4-L7
L28	5	5	0,333333	1	0,2	3	1,30766	L4-L8
L29	0,142857	5	3	0,2	5	3	1,363596	L4-L9
L30	1	5	0,2	0,2	5	3	1,200937	L4-L10
L31	0,2	1	5	7	0,2	0,333333	0,880713	L5-L6
L32	5	1	0,2	5	0,333333	0,2	0,832683	L5-L7
L33	5	5	5	1	0,2	1	1,709976	L5-L8
L34	5	1	0,333333	1	1	0,333333	0,906681	L5-L9
L35	0,2	1	0,333333	5	5	0,333333	0,906681	L5-L10
L36	5	1	0,333333	1	5	0,2	1,088867	L6-L7
L37	5	5	3	0,2	5	1	2,053573	L6-L8
L38	5	5	0,333333	0,142857	5	0,2	1,029485	L6-L9
L39	5	0,333333	3	0,142857	5	0,333333	1,029485	L6-L10
L40	0,2	3	0,333333	0,333333	5	7	1,151674	L7-L8
L41	0,2	3	5	0,2	5	5	1,570418	L7-L9

L42	5	1	0,2	0,2	0,142857	5	0,72302	L7-L10
L43	0,2	0,333333	5	0,142857	0,2	0,2	0,352079	L8-L9
L44	7	0,2	3	0,142857	0,142857	0,2	0,507786	L8-L10
L45	5	3	5	1	0,2	3	1,885973	L9-L10

2. Step: In the next, a pairwise comparison matrix was created.

Table 4.28 *Pairwise comparison matrix for LCI section.*

		L2	L3	L4	L5	L6	L7	L8	L9	L10
L1	1	0,8683	0,4228	0,8209	0,5848	0,664	0,723	1	0,9184	0,664
L2	1/0,8683	1	1,5704	0,8327	0,7428	0,5529	0,8572	1,5504	1,4239	0,8327
L3	1/0,4228	1/ 1,5704	1	1,9129	1,5704	1,71	1,4848	3,225	2,7646	1,0295
L4	1/0,8209	1/ 0,8327	1/ 1,9129	1	0,8434	0,645	1,0577	1,3077	1,3636	1,2009
L5	1/0,5848	1/ 0,7428	1/ 1,5704	1/ 0,8434	1	0,8807	0,8327	1,71	0,9067	0,9067
L6	1/0,664	1/ 0,5529	1/ 1,71	1/ 0,645	1/ 0,8807	1	1,0889	2,0536	1,0295	1,0295
L7	1/0,723	1/ 0,8572	1/ 1,4848	1/ 1,0577	1/ 0,8327	1/ 1,0889	1	1,1517	1,5704	0,723
L8	1/1	1/ 1,5504	1/ 3,225	1/ 1,3077	1/ 1,71	1/ 2,0536	1/ 1,1517	1	0,3521	0,5078
L9	1/0,9184	1/ 1,4239	1/ 2,7646	1/ 1,3636	1/ 0,9067	1/ 1,0295	1/ 1,5704	1/ 0,3521	1	1,886
L10	1/0,664	1/ 0,8327	1/ 1,0295	1/ 1,2009	1/ 0,9067	1/ 1,0295	1/ 0,723	1/ 0,5078	1/ 1,886	1
TOTAL	**13,929**	**10,576**	**7,0542**	**10,579**	**9,8685**	**8,8007**	**9,9324**	**17,808**	**11,859**	**9,7801**

3. Step: In the next step, each comparison value calculated in the above table is divided by the total value in the same column. The aim here is to calculate the weight of each indicator that constitutes the perspective of logistic chain and operational performance as a percentage.

Table 4.29 *LCI: Calculation weights of dimensions (a).*

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	**Avr.**
L1	0,0718	0,0821	0,0599	0,0776	0,0593	0,0755	0,0728	0,0562	0,0774	0,0679	**0,070043**
L2	0,0827	0,0946	0,2226	0,0787	0,0753	0,0628	0,0863	0,0871	0,1201	0,0851	**0,099524**
L3	0,1698	0,0602	0,1418	0,1808	0,1591	0,1943	0,1495	0,1811	0,2331	0,1053	**0,157499**
L4	0,0875	0,1136	0,0741	0,0945	0,0855	0,0733	0,1065	0,0734	0,115	0,1228	**0,094609**
L5	0,1228	0,1273	0,0903	0,1121	0,1013	0,1001	0,0838	0,096	0,0765	0,0927	**0,100283**
L6	0,1081	0,171	0,0829	0,1466	0,1151	0,1136	0,1096	0,1153	0,0868	0,1053	**0,11543**
L7	0,0993	0,1103	0,0955	0,0894	0,1217	0,1044	0,1007	0,0647	0,1324	0,0739	**0,09922**
L8	0,0718	0,061	0,044	0,0723	0,0593	0,0553	0,0874	0,0562	0,0297	0,0519	**0,05888**
L9	0,0782	0,0664	0,0513	0,0693	0,1118	0,1104	0,0641	0,1595	0,0843	0,1928	**0,098808**
L10	0,1081	0,1136	0,1377	0,0787	0,1118	0,1104	0,1392	0,1106	0,0447	0,1022	**0,105702**
TOTAL	1	1	1	1	1	1	1	1	1	1	**1**

Table 4.30 *LCI: Calculation weights of dimensions (b).*

	Avr.	**Weight (%)**
L1	0,070043	**7%**
L2	0,099524	**10%**
L3	0,157499	**16%**
L4	0,094609	**9%**
L5	0,100283	**10%**
L6	0,11543	**12%**
L7	0,09922	**10%**
L8	0,05888	**6%**
L9	0,098808	**10%**
L10	0,105702	**11%**
TOTAL	1	100%

4. Step: Consistency analysis was performed for the pairwise comparisons after the weights were calculated.

Table 4.31 *LCI: Calculation of lambda λ (a).*

Table X	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	
L1	1	0,8683	0,4228	0,8209	0,5848	0,664	0,723	1	0,9184	0,664	
L2	1,1517	1	1,5704	0,8327	0,7428	0,5529	0,8572	1,5504	1,4239	0,8327	
L3	2,365	0,6368	1	1,9129	1,5704	1,71	1,4848	3,225	2,7646	1,0295	
L4	1,2181	1,2009	0,5228	1	0,8434	0,645	1,0577	1,3077	1,3636	1,2009	
L5	1,71	1,3462	0,6368	1,1856	1	0,8807	0,8327	1,71	0,9067	0,9067	
L6	1,506	1,8086	0,5848	1,5504	1,1354	1	1,0889	2,0536	1,0295	1,0295	
L7	1,3831	1,1665	0,6735	0,9455	1,2009	0,9184	1	1,1517	1,5704	0,723	
L8	1	0,645	0,3101	0,7647	0,5848	0,487	0,8683	1	0,3521	0,5078	
L9	1,0889	0,7023	0,3617	0,7334	1,1029	0,9714	0,6368	2,8403	1	1,886	
L10	1,506	1,2009	0,9714	0,8327	1,1029	0,9714	1,3831	1,9693	0,5302	1	
Total	13,929	10,576	7,0542	10,579	9,8685	8,8007	9,9324	17,808	11,859	9,7801	
Table Y	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Avr.
L1	0,0718	0,0821	0,0599	0,0776	0,0593	0,0755	0,0728	0,0562	0,0774	0,0679	0,070043
L2	0,0827	0,0946	0,2226	0,0787	0,0753	0,0628	0,0863	0,0871	0,1201	0,0851	0,099524
L3	0,1698	0,0602	0,1418	0,1808	0,1591	0,1943	0,1495	0,1811	0,2331	0,1053	0,157499
L4	0,0875	0,1136	0,0741	0,0945	0,0855	0,0733	0,1065	0,0734	0,115	0,1228	0,094609
L5	0,1228	0,1273	0,0903	0,1121	0,1013	0,1001	0,0838	0,096	0,0765	0,0927	0,100283
L6	0,1081	0,171	0,0829	0,1466	0,1151	0,1136	0,1096	0,1153	0,0868	0,1053	0,11543
L7	0,0993	0,1103	0,0955	0,0894	0,1217	0,1044	0,1007	0,0647	0,1324	0,0739	0,09922
L8	0,0718	0,061	0,044	0,0723	0,0593	0,0553	0,0874	0,0562	0,0297	0,0519	0,05888
L9	0,0782	0,0664	0,0513	0,0693	0,1118	0,1104	0,0641	0,1595	0,0843	0,1928	0,098808
L10	0,1081	0,1136	0,1377	0,0787	0,1118	0,1104	0,1392	0,1106	0,0447	0,1022	0,105702
Total	1	1	1	1	1	1	1	1	1	1	
Table Z	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	
L1	0,07	0,0608	0,0296	0,0575	0,041	0,0465	0,0506	0,07	0,0643	0,0465	0,536974
L2	0,1146	0,0995	0,1563	0,0829	0,0739	0,055	0,0853	0,1543	0,1417	0,0829	1,04647
L3	0,3725	0,1003	0,1575	0,3013	0,2473	0,2693	0,2339	0,5079	0,4354	0,1621	2,787563
L4	0,1152	0,1136	0,0495	0,0946	0,0798	0,061	0,1001	0,1237	0,129	0,1136	0,980163
L5	0,1715	0,135	0,0639	0,1189	0,1003	0,0883	0,0835	0,1715	0,0909	0,0909	1,114678
L6	0,1738	0,2088	0,0675	0,179	0,1311	0,1154	0,1257	0,237	0,1188	0,1188	1,475964
L7	0,1372	0,1157	0,0668	0,0938	0,1192	0,0911	0,0992	0,1143	0,1558	0,0717	1,064931
L8	0,0589	0,038	0,0183	0,045	0,0344	0,0287	0,0511	0,0589	0,0207	0,0299	0,383883
L9	0,1076	0,0694	0,0357	0,0725	0,109	0,096	0,0629	0,2806	0,0988	0,1864	1,118863
L10	0,1592	0,1269	0,1027	0,088	0,1166	0,1027	0,1462	0,2082	0,056	0,1057	1,212183

The Table 4.29 above shows that the 1.1517 value of LCI2-LCI1 pairwise comparison that given in the first table was multiplied by 0.099524 in the second table, which is the weighted value of LCI2 indicator, and that final value is shown in the Table Z.In this way, each comparison value in Table X is multiplied by the value of each indicator's weight in the same row in Table Y.

Then, the consistency value for each perspective was calculated. We will show this process in the same table.

Table 4.32 *LCI: Calculation of lambda λ (b).*

Table Y	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Avr.
L1	0,0718	0,0821	0,0599	0,0776	0,0593	0,0755	0,0728	0,0562	0,0774	0,0679	0,070043
L2	0,0827	0,0946	0,2226	0,0787	0,0753	0,0628	0,0863	0,0871	0,1201	0,0851	0,099524
L3	0,1698	0,0602	0,1418	0,1808	0,1591	0,1943	0,1495	0,1811	0,2331	0,1053	0,157499
L4	0,0875	0,1136	0,0741	0,0945	0,0855	0,0733	0,1065	0,0734	0,115	0,1228	0,094609
L5	0,1228	0,1273	0,0903	0,1121	0,1013	0,1001	0,0838	0,096	0,0765	0,0927	0,100283
L6	0,1081	0,171	0,0829	0,1466	0,1151	0,1136	0,1096	0,1153	0,0868	0,1053	0,11543
L7	0,0993	0,1103	0,0955	0,0894	0,1217	0,1044	0,1007	0,0647	0,1324	0,0739	0,09922
L8	0,0718	0,061	0,044	0,0723	0,0593	0,0553	0,0874	0,0562	0,0297	0,0519	0,05388
L9	0,0782	0,0664	0,0513	0,0693	0,1118	0,1104	0,0641	0,1595	0,0843	0,1928	0,093808
L10	0,1081	0,1136	0,1377	0,0787	0,1118	0,1104	0,1392	0,1106	0,0447	0,1022	0,105702
Total	1	1	1	1	1	1	1	1	1	1	
Table Z	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Total
L1	0,07	0,0608	0,0296	0,0575	0,041	0,0465	0,0506	0,07	0,0643	0,0465	0,536974
L2	0,1146	0,0995	0,1563	0,0829	0,0739	0,055	0,0853	0,1543	0,1417	0,0829	1,04647
L3	0,3725	0,1003	0,1575	0,3013	0,2473	0,2693	0,2339	0,5079	0,4354	0,1621	2,787563
L4	0,1152	0,1136	0,0495	0,0946	0,0798	0,061	0,1001	0,1237	0,129	0,1136	0,980163
L5	0,1715	0,135	0,0639	0,1189	0,1003	0,0883	0,0835	0,1715	0,0909	0,0909	1,114678
L6	0,1738	0,2088	0,0675	0,179	0,1311	0,1154	0,1257	0,237	0,1188	0,1188	1,475964
L7	0,1372	0,1157	0,0668	0,0938	0,1192	0,0911	0,0992	0,1143	0,1558	0,0717	1,064931
L8	0,0589	0,038	0,0183	0,045	0,0344	0,0287	0,0511	0,0589	0,0207	0,0299	0,383883
L9	0,1076	0,0694	0,0357	0,0725	0,109	0,096	0,0629	0,2806	0,0988	0,1864	1,118863
L10	0,1592	0,1269	0,1027	0,088	0,1166	0,1027	0,1462	0,2082	0,056	0,1057	1,212183

Table 4.33 *LCI: Calculation of lambda λ (c).*

	Calculation of consistencies for each indicator	
L1	0,536974/0,070043	= 7,666307
L2	1,04647/0,099524	= 10,5147
L3	2,787563/0,157499	= 17,69893
L4	0,980163/0,094609	= 10,3601
L5	1,114678/0,100283	= 11,11533
L6	1,475964/0,11543	= 12,78667
L7	1,064931/0,09922	= 10,73303
L8	0,383883/0,05888	= 6,519725
L9	1,118863/0,098808	= 11,32356
L10	1,212183/0,105702	= 11,46791
Average (λ)		$= \mathbf{11,018626}$

Consistency Index (CI) was found with the following formula:

$$CI = \frac{\lambda - n}{n - 1} \quad so, \quad CI = \frac{11{,}018626 - 10}{9} = 0{,}1131806$$

After the CI was found, the Consistency Ratio (CR) was calculated at the last step. Since we already had the value of CI, we found the value of RI from Saaty's RI scale. Since we evaluated ten criteria, we used 1.49 for RI.

$$CR = \frac{CI}{RI} \quad so, \quad CR = \frac{0{,}1131806}{1.49}$$

CR = 7.6%. Since this value was less than 0.10, pairwise comparisons were considered consistent.

Table 4.34 *Saaty's RI scale (Saaty, 2008).*

n	1	2	3	4	5	6	7	8	9	**10**	11	12	13	14
RI	0	0	0,52	0,89	1,11	1,25	1,35	1,4	1,45	**1,49**	1.51	1.48	1.56	1.57

4.2.2.3. Financial and Business Performance Index (FBI)

1. Step: In the table below, the pairwise comparison values are shown which were exported from the questionnaire forms to the master data table. In the Geo Avr. section, the geometric average of the values of all the participants' decisions for each comparison is calculated. The rightmost column shows which pair of indicators is compared.

Table 4.35 *Survey results for FBI section.*

	1	**7**	**12**	**8**	**5**	**14**	Geo. Avr.	Comparison
F1	3	0,142857	7	3	0,2	1	1,102924	F1-F2
F2	5	1	7	5	0,2	1	1,808609	F1-F3
F3	5	1	0,2	3	0,2	0,142857	0,664011	F1-F4
F4	3	1	0,2	1	5	3	1,44225	F1-F5
F5	3	1	0,2	3	1	3	1,324542	F1-F6
F6	5	0,333333	0,142857	1	0,142857	7	0,787273	F1-F7
F7	1	3	1	0,333333	0,142857	1	0,72302	F2-F3
F8	1	0,333333	0,142857	1	7	0,142857	0,602047	F2-F4
F9	1	1	3	1	7	1	1,661001	F2-F5
F10	1	1	3	1	0,2	1	0,918386	F2-F6
F11	1	1	0,142857	0,333333	0,2	5	0,602047	F2-F7
F12	0,333333	1	5	1	5	0,2	1,088867	F3-F4
F13	0,333333	1	5	3	0,142857	1	0,945465	F3-F5
F14	0,333333	1	0,2	0,333333	0,2	5	0,53023	F3-F6
F15	0,333333	0,333333	0,2	0,333333	0,2	5	0,441514	F3-F7
F16	0,333333	3	1	0,333333	0,2	5	0,832683	F4-F5
F17	0,333333	3	1	0,2	0,2	5	0,764724	F4-F6
F18	0,333333	1	1	0,2	5	7	1,151674	F4-F7
F19	0,2	0,333333	0,2	0,333333	5	1	0,53023	F5-F6
F20	3	1	0,2	0,2	0,2	5	0,702312	F5-F7
F21	0,333333	1	0,2	0,2	0,2	5	0,486956	F6-F7

2. Step: In the next, a pairwise comparison matrix was created.

Table 4.36 *Pairwise comparison matrix for FBI section.*

	F1	F2	F3	F4	F5	F6	F7
F1	1	1,102924	1,808609	0,664011	1,44225	1,324542	0,787273
F2	1/ 1,102924	1	0,72302	0,602047	1,661001	0,918386	0,602047
F3	1/ 1,808609	1/ 0,72302	1	1,088867	0,945465	0,53023	0,441514
F4	1/ 0,664011	1/ 0,602047	1/ 1,088867	1	0,832683	0,764724	1,151674
F5	1/ 1,44225	1/ 1,661001	1/ 0,945465	1/ 0,832683	1	0,53023	0,702312
F6	1/ 1,324542	1/ 0,918386	1/ 0,53023	1/ 0,764724	1/ 0,53023	1	0,486956
F7	1/ 0,787273	1/ 0,602047	1/ 0,441514	1/ 1,151674	1/ 0,702312	1/ 0,486956	1
Total	6,684138	8,498927	9,658603	6,731824	9,191239	7,121686	5,171775

3. Step: In the next step, each comparison value calculated in the above table is divided by the total value in the same column. The aim here is to calculate the weight of each indicator that constitutes the perspective of financial and business performance as a percentage.

Table 4.37 *FBI: Calculation weights of dimensions (a).*

	F1	F2	F3	F4	F5	F6	F7	**Avr.**
F1	0,149608	0,129772	0,187254	0,098638	0,156916	0,185987	0,152225	**0,151486**
F2	0,135647	0,117662	0,074858	0,089433	0,180716	0,128956	0,11641	**0,120526**
F3	0,08272	0,162737	0,103535	0,161749	0,102866	0,074453	0,08537	**0,11049**
F4	0,225309	0,195437	0,095085	0,148548	0,090595	0,10738	0,222684	**0,155005**
F5	0,103732	0,070838	0,109507	0,178397	0,108799	0,074453	0,135797	**0,111646**
F6	0,112951	0,128118	0,195264	0,194251	0,205192	0,140416	0,094156	**0,152907**
F7	0,190033	0,195437	0,234499	0,128985	0,154916	0,288355	0,193357	**0,19794**
Total	1	1	1	1	1	1	1	**1**

Table 4.38 *FBI: Calculation weights of dimensions (b).*

	Avr.	Weight (%)
F1	0,151486	15%
F2	0,120526	12%
F3	0,11049	11%
F4	0,155005	16%
F5	0,111646	11%
F6	0,152907	15%
F7	0,19794	20%
Total	1	100%

4. Step: Consistency analysis was performed for the pairwise comparisons after the weights were calculated.

Table 4.39 *FBI: Calculation of lambda λ (a).*

Table X	F1	F2	F3	F4	F5	F6	F7	
F1	1	1,102924	1,808609	0,664011	1,44225	1,324542	0,787273	
F2	0,906681	1	0,72302	0,602047	1,661001	0,918386	0,602047	
F3	0,552911	1,383088	1	1,088867	0,945465	0,53023	0,441514	
F4	1,505998	1,661001	0,918386	1	0,832683	0,764724	1,151674	
F5	0,693361	0,602047	1,057681	1,200937	1	0,53023	0,702312	
F6	0,754978	1,088867	1,885973	1,30766	1,885973	1	0,486956	
F7	1,270208	1,661001	2,264934	0,868301	1,423868	2,053573	1	
Total	6,684138	8,498927	9,658603	6,731824	9,191239	7,121686	5,171775	
Table Y	F1	F2	F3	F4	F5	F6	F7	ORT
F1	0,149608	0,129772	0,187254	0,098638	0,156916	0,185987	0,152225	0,151486
F2	0,135647	0,117662	0,074858	0,089433	0,180716	0,128956	0,11641	0,120526
F3	0,08272	0,162737	0,103535	0,161749	0,102866	0,074453	0,08537	0,11049
F4	0,225309	0,195437	0,095085	0,148548	0,090595	0,10738	0,222684	0,155005
F5	0,103732	0,070838	0,109507	0,178397	0,108799	0,074453	0,135797	0,111646
F6	0,112951	0,128118	0,195264	0,194251	0,205192	0,140416	0,094156	0,152907
F7	0,190033	0,195437	0,234499	0,128985	0,154916	0,288355	0,193357	0,19794
Total	1	1	1	1	1	1	1	
Table Z	F1	F2	F3	F4	F5	F6	F7	
F1	0,151486	0,167077	0,273978	0,100588	0,21848	0,200649	0,11926	1,231518
F2	0,109279	0,120526	0,087143	0,072562	0,200194	0,110689	0,072562	0,772954
F3	0,061091	0,152817	0,11049	0,120309	0,104464	0,058585	0,048783	0,656539
F4	0,233438	0,257464	0,142355	0,155005	0,12907	0,118536	0,178516	1,214385
F5	0,077411	0,067216	0,118086	0,13408	0,111646	0,059198	0,07841	0,646048
F6	0,115441	0,166495	0,288378	0,19995	0,288378	0,152907	0,074459	1,286009
F7	0,251425	0,328779	0,448322	0,171872	0,281841	0,406485	0,19794	2,086663

The table above shows that the 0,906681 value of F2-F1 pairwise comparison that given in the first table was multiplied by 0,120526 in the second table, which is the weighted value of F2 indicator, and that final value (0,109279) is shown in the Table z. In this way, each comparison value in Table x is multiplied by the value of each indicator's weight in the same row in Table y.

Then, the consistency value for each perspective was calculated. We will show this process in the same table.

Table 4.40 *FBI: Calculation of lambda λ (b).*

Table Y	F1	F2	F3	F4	F5	F6	F7	ORT
F1	0,149608	0,129772	0,187254	0,098638	0,156916	0,185987	0,152225	0,151486
F2	0,135647	0,117662	0,074858	0,089433	0,180716	0,128956	0,11641	0,120526
F3	0,08272	0,162737	0,103535	0,161749	0,102866	0,074453	0,08537	0,11049
F4	0,225309	0,195437	0,095085	0,148548	0,090595	0,10738	0,222684	0,155005
F5	0,103732	0,070838	0,109507	0,178397	0,108799	0,074453	0,135797	0,111646
F6	0,112951	0,128118	0,195264	0,194251	0,205192	0,140416	0,094156	0,152907
F7	0,190033	0,195437	0,234499	0,128985	0,154916	0,288355	0,193357	0,19794
Total	1	1	1	1	1	1	1	
Table Z	F1	F2	F3	F4	F5	F6	F7	
F1	0,151486	0,167077	0,273978	0,100588	0,21848	0,200649	0,11926	1,231518
F2	0,109279	0,120526	0,087143	0,072562	0,200194	0,110689	0,072562	0,772954
F3	0,061091	0,152817	0,11049	0,120309	0,104464	0,058585	0,048783	0,656539
F4	0,233438	0,257464	0,142355	0,155005	0,12907	0,118536	0,178516	1,214385
F5	0,077411	0,067216	0,118086	0,13408	0,111646	0,059198	0,07841	0,646048
F6	0,115441	0,166495	0,288378	0,19995	0,288378	0,152907	0,074459	1,286009
F7	0,251425	0,328779	0,448322	0,171872	0,281841	0,406485	0,19794	2,086663

Table 4.41 *FBI: Calculation of lambda λ (c).*

	Calculation of consistencies for each indicator	
F1	1,231518/0,151486	= 8.129608
F2	0,772954/0,120526	= 6.413181
F3	0,656539/0,11049	= 5.942075
F4	1,214385/0,155005	= 7.834467
F5	0,646048/0,111646	= 5.786568
F6	1,286009/0,152907	= 8.410407
F7	2,086663/0,19794	= 10.541889
Average (λ)		= 7.579742

Consistency Index (CI) was found with the following formula:

$$CI = \frac{\lambda - n}{n - 1} \quad so, \quad CI = \frac{7.579742 - 7}{6} = 0.096624$$

After the CI was found, the Consistency Ratio (CR) was calculated at the last step. Since we already had the value of CI, we found the value of RI from Saaty's RI scale. Since we evaluated seven criteria, we used 1.35 for RI.

$$CR = \frac{CI}{RI} \quad so, \quad CR = \frac{0.096624}{1.35}$$

CR = 7.2% Since this value was less than 0.10, pairwise comparisons were considered consistent.

Table 4.42 *Saaty's RI scale (Saaty, 2008).*

n	1	2	3	4	5	6	**7**	8	9	10	11	12	13	14
RI	0	0	0,52	0,89	1,11	1,25	**1,35**	1,4	1,45	1,49	1.51	1.48	1.56	1.57

4.2.2.4. Environmental and Safety Index (ESI)

1. Step: In the table below, the pairwise comparison values are shown which were exported from the questionnaire forms to the master data table. In the Geo Avr. section, the geometric average of the values of all the participants' decisions for each comparison is calculated. The rightmost column shows which pair of indicators is compared.

Table 4.43 *Survey results for ESI section.*

	1	7	12	8	5	14	Geo Ort.	
C1	0,333333	1	0,333333	0,333333	7	0,142857	0,57735	E1-E2
C2	0,333333	0,333333333	0,333333	0,333333	0,142857	0,2	0,265812	E1-E3
C3	7	0,333333333	0,333333	1	1	0,111111	0,664919	E1-E4
C4	0,333333	0,142857143	0,2	0,2	0,142857	0,333333	0,211968	E1-E5
C5	7	0,142857143	0,2	1	0,142857	0,2	0,422825	E1-E6
C6	7	0,333333333	5	0,142857	0,142857	0,2	0,602047	E1-E7
C7	9	0,2	1	0,2	1	0,142857	0,609819	E1-E8
C8	9	0,2	3	0,2	1	0,142857	0,732354	E1-E9
C9	0,333333	1	0,333333	0,2	1	3	0,636773	E2-E3
C10	0,2	1	3	1	0,2	0,2	0,537075	E2-E4
C11	5	1	0,142857	0,2	5	3	1,135444	E2-E5
C12	0,333333	1	0,142857	0,2	5	3	0,72302	E2-E6
C13	3	1	0,2	0,333333	5	1	1	E2-E7
C14	7	1	0,2	0,333333	5	0,2	0,880713	E2-E8
C15	9	1	0,333333	0,333333	5	0,2	1	E2-E9
C16	3	1	3	1	0,2	0,142857	0,797436	E3-E4
C17	3	0,2	3	1	0,2	1	0,843433	E3-E5
C18	3	0,2	3	1	0,2	3	1,012909	E3-E6
C19	3	0,2	5	0,2	0,2	1	0,702312	E3-E7
C20	7	0,333333333	1	1	5	0,142857	1,088867	E3-E8
C21	0,142857	0,333333333	1	3	5	0,142857	0,68359	E3-E9
C22	5	0,333333333	0,2	1	5	5	1,423868	E4-E5
C23	5	0,333333333	1	0,333333	5	5	1,550403	E4-E6
C24	3	0,333333333	0,333333	0,333333	0,2	3	0,636773	E4-E7
C25	7	0,333333333	3	3	0,2	0,2	0,971359	E4-E8
C26	9	0,333333333	0,2	1	5	0,2	0,918386	E4-E9
C27	0,333333	0,333333333	0,2	3	0,2	1	0,486956	E5-E6
C28	0,333333	3	0,2	5	5	0,333333	1,088867	E5-E7
C29	7	1	0,333333	1	5	0,142857	1,088867	E5-E8

C30	9	1	0,333333	1	0,2	0,142857	0,664011	E5-E9
C31	7	0,333333333	0,333333	1	0,2	0,2	0,560815	E6-E7
C32	5	1	0,333333	1	0,2	0,142857	0,602047	E6-E8
C33	5	1	0,333333	3	5	0,142857	1,236347	E6-E9
C34	9	0,333333333	3	3	0,142857	0,142857	0,905443	E7-E8
C35	5	3	3	3	0,142857	0,142857	1,184012	E7-E9
C36	0,111111	5	3	1	5	1	1,423868	E8-E9

2. Step: In the next, a pairwise comparison matrix was created.

Table 4.44 *Pairwise comparison matrix for ESI section.*

	E1	E2	E3	E4	E5	E6	E7	E8	E9
E1	1	0,57735	0,265812	0,664919	0,211968	0,422825	0,602047	0,609819	0,732354
E2	1/ 0,57735	1	0,636773	0,537075	1,135444	0,72302	1	0,880713	1
E3	1/ 0,265812	1/ 0,636773	1	0,797436	0,843433	1,012909	0,702312	1,088867	0,68359
E4	1/ 0,664919	1/ 0,537075	1/ 0,797436	1	1,423868	1,550403	0,636773	0,971359	0,918386
E5	1/ 0,211968	1/ 1,135444	1/ 0,843433	1/ 1,423868	1	0,486956	1,088867	1,088867	0,664011
E6	1/ 0,422825	1/ 0,72302	1/ 1,012909	1/ 1,550403	1/ 0,486956	1	0,560815	0,602047	1,236347
E7	1/ 0,602047	1/ 1	1/ 0,702312	1/ 0,636773	1/ 1,088867	1/ 0,560815	1	0,905443	1,184012
E8	1/ 0,609819	1/ 0,880713	1/ 1,088867	1/ 0,971359	1/ 1,088867	1/ 0,602047	1/ 0,905443	1	1,423868
E9	1/ 0,732354	1/ 1	1/ 0,68359	1/ 0,918386	1/ 0,664011	1/ 1,236347	1/ 1,184012	1/ 1,423868	1
Total	19,74708	10,40895	9,13461	8,035506	10,01106	9,449069	7,53983	7,849427	8,842569

3. Step: In the next step, each comparison value calculated in the above table is divided by the total value in the same column. The aim here is to calculate the weight of each indicator that constitutes the perspective of environmental and safety performance as a percentage.

Table 4.45 *ESI: Calculation weights of dimensions (a).*

	E1	E2	E3	E4	E5	E6	E7	E8	E9	**Avr.**
E1	0,05064	0,055467	0,029099	0,082748	0,021173	0,044748	0,079849	0,07769	0,082821	**0,058248**
E2	0,087712	0,096071	0,06971	0,066838	0,113419	0,076518	0,132629	0,112201	0,113089	**0,096465**
E3	0,190512	0,150872	0,109474	0,099239	0,08425	0,107197	0,093147	0,138719	0,077307	**0,116746**
E4	0,07616	0,178878	0,137282	0,124448	0,14223	0,16408	0,084455	0,123749	0,10386	**0,126127**
E5	0,238906	0,084611	0,129795	0,087401	0,09989	0,051535	0,144415	0,138719	0,075093	**0,116707**
E6	0,119767	0,132875	0,108079	0,080268	0,205131	0,105831	0,07438	0,076699	0,139818	**0,115872**
E7	0,084114	0,096071	0,155876	0,195435	0,091737	0,188709	0,132629	0,115352	0,133899	**0,132647**
E8	0,083042	0,109083	0,100539	0,128117	0,091737	0,175785	0,14648	0,127398	0,161024	**0,124801**
E9	0,069147	0,096071	0,160145	0,135507	0,150434	0,085599	0,112017	0,089473	0,113089	**0,112387**
Total	1	1	1	1	1	1	1	1	1	**1**

Table 4.46 *ESI: Calculation weights of dimensions (b).*

	Avr.	Weight (%)
E1	0,058248	6%
E2	0,096465	10%
E3	0,116746	12%
E4	0,126127	13%
E5	0,116707	12%
E6	0,115872	12%
E7	0,132647	13%
E8	0,124801	12%
E9	0,112387	11%
Total	1	100%

4. Step: Consistency analysis was performed for the pairwise comparisons after the weights were calculated.

Table 4.47 *ESI: Calculation of lambda λ (a).*

Table X	E1	E2	E3	E4	E5	E6	E7	E8	E9	
E1	1	0,57735	0,265812	0,664919	0,211968	0,422825	0,602047	0,609819	0,732354	
E2	1,732051	1	0,636773	0,537075	1,135444	0,72302	1	0,880713	1	
E3	3,762058	1,570418	1	0,797436	0,843433	1,012909	0,702312	1,088867	0,68359	
E4	1,503942	1,861936	1,254019	1	1,423868	1,550403	0,636773	0,971359	0,918386	
E5	4,717694	0,880713	1,185631	0,702312	1	0,486956	1,088867	1,088867	0,664011	
E6	2,365046	1,383088	0,987255	0,644994	2,053573	1	0,560815	0,602047	1,236347	
E7	1,661001	1	1,423868	1,570418	0,918386	1,783121	1	0,905443	1,184012	
E8	1,639832	1,135444	0,918386	1,029485	0,918386	1,661001	1,104431	1	1,423868	
E9	1,36546	1	1,462865	1,088867	1,505998	0,808835	0,844586	0,702312	1	
Total	19,74708	10,40895	9,13461	8,035506	10,01106	9,449069	7,53983	7,849427	8,842569	
Table Y	E1	E2	E3	E4	E5	E6	E7	E8	E9	Avr.
E1	0,05064	0,055467	0,029099	0,082748	0,021173	0,044748	0,079849	0,07769	0,082821	0,058248
E2	0,087712	0,096071	0,06971	0,066838	0,113419	0,076518	0,132629	0,112201	0,113089	0,096465
E3	0,190512	0,150872	0,109474	0,099239	0,08425	0,107197	0,093147	0,138719	0,077307	0,116746
E4	0,07616	0,178878	0,137282	0,124448	0,14223	0,16408	0,084455	0,123749	0,10386	0,126127
E5	0,238906	0,084611	0,129795	0,087401	0,09989	0,051535	0,144415	0,138719	0,075093	0,116707
E6	0,119767	0,132875	0,108079	0,080268	0,205131	0,105831	0,07438	0,076699	0,139818	0,115872
E7	0,084114	0,096071	0,155876	0,195435	0,091737	0,188709	0,132629	0,115352	0,133899	0,132647
E8	0,083042	0,109083	0,100539	0,128117	0,091737	0,175785	0,14648	0,127398	0,161024	0,124801
E9	0,069147	0,096071	0,160145	0,135507	0,150434	0,085599	0,112017	0,089473	0,113089	0,112387
Total	1	1	1	1	1	1	1	1	1	
Table Z	E1	E2	E3	E4	E5	E6	E7	E8	E9	
E1	0,058248	0,03363	0,015483	0,03873	0,012347	0,024629	0,035068	0,035521	0,042658	0,296315
E2	0,167083	0,096465	0,061426	0,051809	0,109531	0,069746	0,096465	0,084958	0,096465	0,833949
E3	0,439206	0,18334	0,116746	0,093098	0,098468	0,118253	0,081992	0,127121	0,079807	1,338032
E4	0,189687	0,23484	0,158165	0,126127	0,179588	0,195547	0,080314	0,122514	0,115833	1,402617

E5	0,550589	0,102786	0,138372	0,081965	0,116707	0,056831	0,127079	0,127079	0,077495	1,378902
E6	0,274042	0,160261	0,114395	0,074737	0,237951	0,115872	0,064983	0,06976	0,143258	1,255259
E7	0,220326	0,132647	0,188872	0,208311	0,121821	0,236525	0,132647	0,120104	0,157055	1,518309
E8	0,204652	0,141704	0,114615	0,12848	0,114615	0,207294	0,137834	0,124801	0,1777	1,351694
E9	0,15346	0,112387	0,164407	0,122374	0,169255	0,090902	0,09492	0,078931	0,112387	1,099024

The table above shows that the 1,732051 value of E2-E1 pairwise comparison that given in the first table was multiplied by 0,096465 in the second table, which is the weighted value of E2 indicator, and that final value (0,167083) is shown in the Table z. In this way, each comparison value in Table x is multiplied by the value of each indicator's weight in the same row in Table y. Then, the consistency value for each perspective was calculated. We will show this process in the same table.

Table 4.48 *ESI: Calculation of lambda λ (b).*

Table Y	E1	E2	E3	E4	E5	E6	E7	E8	E9	Avr.
E1	0,05064	0,055467	0,029099	0,082748	0,021173	0,044748	0,079849	0,07769	0,082821	0,058248
E2	0,087712	0,096071	0,06971	0,066838	0,113419	0,076518	0,132629	0,112201	0,113089	0,096465
E3	0,190512	0,150872	0,109474	0,099239	0,08425	0,107197	0,093147	0,138719	0,077307	0,116746
E4	0,07616	0,178878	0,137282	0,124448	0,14223	0,16408	0,084455	0,123749	0,10386	0,126127
E5	0,238906	0,084611	0,129795	0,087401	0,09989	0,051535	0,144415	0,138719	0,075093	0,116707
E6	0,119767	0,132875	0,108079	0,080268	0,205131	0,105831	0,07438	0,076699	0,139818	0,115872
E7	0,084114	0,096071	0,155876	0,195435	0,091737	0,188709	0,132629	0,115352	0,133899	0,132647
E8	0,083042	0,109083	0,100539	0,128117	0,091737	0,175785	0,14648	0,127398	0,161024	0,124801
E9	0,069147	0,096071	0,160145	0,135507	0,150434	0,085599	0,112017	0,089473	0,113089	0,112387
Total	1	1	1	1	1	1	1	1	1	
Table Z	E1	E2	E3	E4	E5	E6	E7	E8	E9	Total
E1	0,058248	0,033633	0,015483	0,03873	0,012347	0,024629	0,035068	0,035521	0,042658	0,296315
E2	0,167083	0,096465	0,061426	0,051809	0,109531	0,069746	0,096465	0,084958	0,096465	0,833949
E3	0,439206	0,18334	0,116746	0,093098	0,098468	0,118253	0,081992	0,127121	0,079807	1,338032
E4	0,189687	0,23484	0,158165	0,126127	0,179588	0,195547	0,080314	0,122514	0,115833	1,402617
E5	0,550589	0,102786	0,138372	0,081965	0,116707	0,056831	0,127079	0,127079	0,077495	1,378902
E6	0,274042	0,160261	0,114395	0,074737	0,237951	0,115872	0,064983	0,06976	0,143258	1,255259
E7	0,220326	0,132647	0,188872	0,208311	0,121821	0,236525	0,132647	0,120104	0,157055	1,518309
E8	0,204652	0,141704	0,114615	0,12848	0,114615	0,207294	0,137834	0,124801	0,1777	1,351694
E9	0,15346	0,112387	0,164407	0,122374	0,169255	0,090902	0,0949 2	0,078931	0,112387	1,099024

Table 4.49 *ESI: Calculation of lambda λ (c).*

	Calculation of consistencies for each indicator	
E1	0,296315/0,058248	= 5,087093
E2	0,833949/0,096465	= 8,645076
E3	1,338032/0,116746	= 11,46102
E4	1,402617/0,126127	= 11,12069
E5	1,378902/0,116707	= 11,81505
E6	1,255259/0,115872	= 10,83316
E7	1,518309/0,132647	= 11,44625
E8	1,351694/0,124801	= 10,83083
E9	1,099024/0,112387	= 9,778923
Average (λ)		= 10,113122

Consistency Index (CI) was found with the following formula:

$$CI = \frac{\lambda - n}{n - 1} \quad so, \quad CI = \frac{10.113122 - 9}{8} = 0{,}13914$$

After the CI was found, the Consistency Ratio (CR) was calculated at the last step. Since we already had the value of CI, we found the value of RI from Saaty's RI scale. Since we evaluated nine criteria, we used 1.45 for RI.

$$CR = \frac{CI}{RI} \quad so, \quad CR = \frac{0{,}13914}{1.45}$$

CR = 9.6%. Since this value was less than 0.10, pairwise comparisons were considered consistent.

Table 4.50 *Saaty's RI scale (Saaty, 2008).*

n	1	2	3	4	5	6	7	8	**9**	10	11	12	13	14
RI	0	0	0,52	0,89	1,11	1,25	1,35	1,4	**1,45**	1,49	1.51	1.48	1.56	1.57

4.2.2.4. Socio-Economic Index (SEI)

1. Step: In the table below, the pairwise comparison values are shown which were exported from the questionnaire forms to the master data table. In the Geo Avr. section, the geometric average of the values of all the participants' decisions for each comparison is calculated. The rightmost column shows which pair of indicators is compared.

Table 4.51 *Survey results for SEI section.*

	1	7	12	8	5	14	Geo. Avr.	Comparison
S1	3	0,2	3	0,333333	0,2	1	0,702312	S1-S2
S2	3	0,2	0,2	1	0,142857	3	0,609819	S1-S3
S3	7	0,333333	0,2	5	0,142857	1	0,832683	S1-S4
S4	3	3	0,2	1	5	5	1,885973	S1-S5
S5	3	0,2	5	0,2	0,142857	1	0,664011	S1-S6
S6	3	0,2	3	5	0,142857	0,2	0,797436	S1-S7
S7	7	1	0,333333	7	0,142857	0,333333	0,958979	S1-S8
S8	1	0,333333	0,2	5	0,142857	5	0,787273	S2-S3
S9	7	0,333333	0,2	1	0,2	1	0,673503	S2-S4
S10	3	3	0,333333	0,333333	5	5	1,709976	S2-S5
S11	0,2	3	3	0,2	5	3	1,324542	S2-S6
S12	3	3	3	0,2	5	0,333333	1,44225	S2-S7
S13	3	3	0,2	0,2	0,2	0,333333	0,537075	S2-S8
S14	1	3	5	0,333333	5	1	1,709976	S3-S4
S15	3	3	5	0,142857	5	3	2,141416	S3-S5
S16	3	1	5	0,142857	0,2	0,333333	0,72302	S3-S6
S17	5	1	5	0,333333	0,2	0,333333	0,906681	S3-S7
S18	5	3	5	0,2	0,2	0,333333	1	S3-S8
S19	5	3	3	0,142857	0,2	3	1,252307	S4-S5
S20	0,2	3	3	0,333333	5	3	1,44225	S4-S6
S21	0,333333	3	3	0,142857	5	0,333333	0,945465	S4-S7
S22	5	3	0,333333	0,2	5	0,333333	1,088867	S4-S8
S23	1	0,2	3	0,2	5	0,333333	0,764724	S5-S6
S24	1	0,2	1	5	5	0,333333	1,088867	S5-S7
S25	1	0,2	1	7	5	0,142857	1	S5-S8
S26	3	1	1	1	0,2	0,142857	0,664011	S6-S7
S27	7	1	0,2	1	0,2	0,2	0,618536	S6-S8
S28	0,333333	5	3	1	0,2	1	1	S7-S8

2. Step: In the next, a pairwise comparison matrix was created.

Table 4.52 *Pairwise comparison matrix for SEI section.*

	S1	S2	S3	S4	S5	S6	S7	S8
S1	1	0,70231	0,60982	0,83268	1,88597	0,66401	0,79744	0,95898
S2	1/ 0,70231	1	0,78727	0,6735	2,14142	1,32454	1,44225	0,53708
S3	1/ 0,60982	1/ 0,78727	1	1,70998	2,14142	0,72302	0,90668	1
S4	1/ 0,83268	1/ 0,6735	1/ 1,70998	1	1,25231	1,44225	0,94546	1,08887
S5	1/ 1,88597	1/ 2,14142	1/ 2,14142	1/ 1,25231	1	0,76472	1,08887	1
S6	1/ 0,66401	1/ 1,32454	1/ 0,72302	1/ 1,44225	1/ 0,76472	1	0,66401	0,61854
S7	1/ 0,79744	1/ 1,44225	1/ 0,90668	1/ 0,94546	1/ 1,08887	1/0,66401	1	1
S8	1/ 0,95898	1/ 0,53708	1/ 1	1/ 1,08887	1/1	1/ 0,61854	1/1	1
Total	9,59766	8,23455	6,93489	7,68412	11,6472	9,04127	7,84471	7,20346

3. Step: In the next step, each comparison value calculated in the above table is divided by the total value in the same column. The aim here is to calculate the weight of each indicator that constitutes the perspective of socio-economic performance as a percentage.

Table 4.53 *SEI: Calculation weights of dimensions (a)*

	S1	S2	S3	S4	S5	S6	S7	S8	**Avr**.
S1	0,10419	0,08529	0,08793	0,10836	0,16193	0,07344	0,10165	0,13313	**0,106991**
S2	0,14836	0,12144	0,11352	0,08765	0,18386	0,1465	0,18385	0,07456	**0,132467**
S3	0,17086	0,15425	0,1442	0,22253	0,18386	0,07997	0,11558	0,13882	**0,151259**
S4	0,12513	0,18031	0,08433	0,13014	0,10752	0,15952	0,12052	0,15116	**0,132328**
S5	0,05525	0,05671	0,06734	0,10392	0,08586	0,08458	0,1388	0,13882	**0,09141**
S6	0,15691	0,09168	0,19944	0,09023	0,11227	0,1106	0,08464	0,08587	**0,116457**
S7	0,13066	0,0842	0,15904	0,13765	0,07885	0,16657	0,12747	0,13882	**0,127908**
S8	0,10865	0,22611	0,1442	0,11952	0,08586	0,17882	0,12747	0,13882	**0,141181**
Total	1	1	1	1	1	1	1	1	**1**

Table 4.54 *SEI: Calculation weights of dimensions (b).*

	Avr.	Weight (%)
S1	**0,106991**	11%
S2	**0,132467**	13%
S3	**0,151259**	15%
S4	**0,132328**	13%
S5	**0,09141**	9%
S6	**0,116457**	12%
S7	**0,127908**	13%
S8	**0,141181**	14%
Total	**1**	100%

4. Step: Consistency analysis was performed for the pairwise comparisons after the weights were calculated.

Table 4.55 *SEI: Calculation of lambda λ (a)*

Table X	S1	S2	S3	S4	S5	S6	S7	S8	
S1	1	0,70231	0,60982	0,83268	1,88597	0,66401	0,79744	0,95898	
S2	1,42387	1	0,78727	0,6735	2,14142	1,32454	1,44225	0,53708	
S3	1,63983	1,27021	1	1,70998	2,14142	0,72302	0,90668	1	
S4	1,20094	1,48477	0,5848	1	1,25231	1,44225	0,94546	1,08887	
S5	0,53023	0,46698	0,46698	0,79853	1	0,76472	1,08887	1	
S6	1,506	0,75498	1,38309	0,69336	1,30766	1	0,66401	0,61854	
S7	1,25402	0,69336	1,10292	1,05768	0,91839	1,506	1	1	
S8	1,04278	1,86194	1	0,91839	1	1,61672	1	1	
Total	9,59766	8,23455	6,93489	7,68412	11,6472	9,04127	7,84471	7,20346	
Table Y	S1	S2	S3	S4	S5	S6	S7	S8	Avr.
S1	0,10419	0,08529	0,08793	0,10836	0,16193	0,07344	0,10165	0,13313	0,106991
S2	0,14836	0,12144	0,11352	0,08765	0,18386	0,1465	0,18385	0,07456	0,132467
S3	0,17086	0,15425	0,1442	0,22253	0,18386	0,07997	0,11558	0,13882	0,151259
S4	0,12513	0,18031	0,08433	0,13014	0,10752	0,15952	0,12052	0,15116	0,132328
S5	0,05525	0,05671	0,06734	0,10392	0,08586	0,08458	0,1388	0,13882	0,09141
S6	0,15691	0,09168	0,19944	0,09023	0,11227	0,1106	0,08464	0,08587	0,116457
S7	0,13066	0,0842	0,15904	0,13765	0,07885	0,16657	0,12747	0,13882	0,127908
S8	0,10865	0,22611	0,1442	0,11952	0,08586	0,17882	0,12747	0,13882	0,141181
Total	1	1	1	1	1	1	1	1	
Table Z	S1	S2	S3	S4	S5	S6	S7	S8	
S1	0,10699	0,07514	0,06525	0,08909	0,20178	0,07104	0,08532	0,1026	0,797213
S2	0,18861	0,13247	0,10429	0,08922	0,28367	0,17546	0,19105	0,07114	1,235903
S3	0,24804	0,19213	0,15126	0,25865	0,32391	0,10936	0,13714	0,15126	1,57175
S4	0,15892	0,19648	0,07739	0,13233	0,16572	0,19085	0,12511	0,14409	1,190875
S5	0,04847	0,04269	0,04269	0,07299	0,09141	0,0699	0,09953	0,09141	0,55909
S6	0,17538	0,08792	0,16107	0,08075	0,15229	0,11646	0,07733	0,07203	0,92323
S7	0,1604	0,08869	0,14107	0,13529	0,11747	0,19263	0,12791	0,12791	1,091356
S8	0,14722	0,26287	0,14118	0,12966	0,14118	0,22825	0,14118	0,14118	1,332723

The table above shows that the 0,95898 value of S2-S1 pairwise comparison that given in the first table was multiplied by 0,132467 in the second table, which is the weighted value of S2 indicator, and that final value (0,18861) is shown in the Table z. In this way, each comparison value in Table x is multiplied by the value of each indicator's weight in the same row in Table y. Then, the consistency value for each perspective was calculated. We will show this process in the same table.

Table 4.56 *SEI: Calculation of lambda λ (b).*

Table Y	S1	S2	S3	S4	S5	S6	S7	S8	Avr.
S1	0,10419	0,08529	0,08793	0,10836	0,16193	0,07344	0,10165	0,13313	0,106991
S2	0,14836	0,12144	0,11352	0,08765	0,18386	0,1465	0,18385	0,07456	0,132467
S3	0,17086	0,15425	0,1442	0,22253	0,18386	0,07997	0,11558	0,13882	0,151259
S4	0,12513	0,18031	0,08433	0,13014	0,10752	0,15952	0,12052	0,15116	0,132328
S5	0,05525	0,05671	0,06734	0,10392	0,08586	0,08458	0,1388	0,13882	0,09141
S6	0,15691	0,09168	0,19944	0,09023	0,11227	0,1106	0,08464	0,08587	0,116457
S7	0,13066	0,0842	0,15904	0,13765	0,07885	0,16657	0,12747	0,13882	0,127908
S8	0,10865	0,22611	0,1442	0,11952	0,08586	0,17882	0,12747	0,13882	0,141181
Total	1	1	1	1	1	1	1	1	
Table Z	S1	S2	S3	S4	S5	S6	S7	S8	Total
S1	0,10699	0,07514	0,06525	0,08909	0,20178	0,07104	0,08532	0,1026	0,797213
S2	0,18861	0,13247	0,10429	0,08922	0,28367	0,17546	0,19105	0,07114	1,235993
S3	0,24804	0,19213	0,15126	0,25865	0,32391	0,10936	0,13714	0,15126	1,57175
S4	0,15892	0,19648	0,07739	0,13233	0,16572	0,19085	0,12511	0,14409	1,190875
S5	0,04847	0,04269	0,04269	0,07299	0,09141	0,0699	0,09953	0,09141	0,55909
S6	0,17538	0,08792	0,16107	0,08075	0,15229	0,11646	0,07733	0,07203	0,92323
S7	0,1604	0,08869	0,14107	0,13529	0,11747	0,19263	0,12791	0,12791	1,091356
S8	0,14722	0,26287	0,14118	0,12966	0,14118	0,22825	0,14118	0,14118	1,332723

Table 4.57 *SEI: Calculation of lambda λ (c).*

	Calculation of consistencies for each indicator	
S1	0,797213/0,106991	= 7,451213
S2	1,235903/0,132467	= 9,329926
S3	1,57175/0,151259	= 10,39113
S4	1,190875/0,132328	= 8,999404
S5	0,55909/0,09141	= 6,116309
S6	0,92323/0,116457	= 7,927633
S7	1,091356/0,127908	= 8,532369
S8	1,332723/0,141181	= 9,439819
Average (λ)		= 8,523476

Consistency Index (CI) was found with the following formula:

$$CI = \frac{\lambda - n}{n - 1} \quad so, \quad CI = \frac{8{,}523476 - 8}{7} = 0{,}074782$$

After the CI was found, the Consistency Ratio (CR) was calculated at the last step. Since we already had the value of CI, we found the value of RI from Saaty's RI scale. Since we evaluated eight criteria, we used 1.4 for RI.

$$CR = \frac{CI}{RI} \quad so, \quad CR = \frac{0{,}074782}{1.4}$$

CR = 5.3%. Since this value was less than 0.10, pairwise comparisons were considered consistent.

Table 4.58 *Saaty's RI scale (Saaty, 2008).*

n	1	2	3	4	5	6	7	**8**	9	10	11	12	13	14
RI	0	0	0,52	0,89	1,11	1,25	1,35	**1,4**	1,45	1,49	1.51	1.48	1.56	1.57

4.2.2. Integration of AHP Results into Port's Balanced Score Card

The weighting of the four perspectives and the indicators that are forming these perspectives has been completed.

1. The weights of the four perspectives that constituting the Port Performance Index (PPI) are shown in Table 4.59.

Table 4.59 *Weighted perspectives: LCI, FBI, ESI and SEI.*

Perspectives	Weight (%)
Logistic Chain and Operational Performance Index (LCI)	**33%**
Financial and Business Performance Index (FBI)	**26%**
Environmental and Safety Performance Index (ESI)	**21%**
Socio-Economic Performance Index (SEI)	**19%**

2. The weights of the ten indicators that constituting the Logistic Chain and Operational Performance Index (LCI) are shown in Table 4.60.

Table 4.60 *LCI: Weighted sub-criteria.*

	Description.	Weight (%)
L1	Berth Utilization Rate	7%
L2	Berth Productivity	10%
L3	Average (Vessel) Turnaround Time (ATT)	16%
L4	TEU per crane	9%
L5	Average truck Turnaround Time (ATTT)	10%
L6	Average Moves per Truck	12%
L7	Average berth Access time	10%
L8		6%
L9	Estimating turnaround time at berth.	10%
L10	Transportation cost per container	11%

3. The weights of the seven indicators that constituting the Financial and Business Performance Index (FBI) are shown in Table 4.61.

Table 4.61 *FBI: Weighted sub-criteria.*

	Description	Weight (%)
F1	Cargo and container handling revenue per ton or per TEU of Cargo	15%
F2	Profit (revenue) per Employee	12%
F3	Berth Occupancy Revenue	11%
F4	EBITDA margin	16%
F5	Labor expenditure per TEU	11%
F6	Capital equipment expenditure per TEU	15%
F7	Invoice Accuracy	20%

4. The weights of the nine indicators that constituting the Environmental and Safety Performance Index (ESI) are shown in Table 4.62.

Table 4.62 *ECI: Weighted sub-criteria.*

	Description	Weight (%)
E1	Waste Creation per TEU	6%
E2	Carbon Footprint per TEU	10%
E3	Electric consumption per TEU	12%
E4	Total Consumption in Tons of Fuel per TEU	13%
E5	Number of trees saved by recycling	12%
E6	Total water consumption per TEU	12%
E7	[Number of vessels connect to shore-side electricity / Total number of vessels]	13%
E8	Accident rate for 100.000 TEU	12%
E9	Accident Severity Rate	11%

5. The weights of the eight indicators that constituting the Socio-Economic Performance Index (SEI) are shown in Table 4.63.

Table 4.63 *SEI: Weighted sub-criteria.*

	Description	Weight (%)
S1	Number training hours/worker	11%
S2	Rate of absenteeism per worker	13%
S3	[Total number of workers with over five years of experience / Total number of workes]	15%
S4	Employee Turnover Rate	13%
S5	Labor force participation rate, female (%)	9%
S6	[The port's yearly investment / total investments in the region]	12%
S7	[Number of employees / Total number of active population in the region]	13%
S8	Employment per TEU	14%

In the Figure 4.6, The PPI, perspectives and indicators are shown together with the their weights in the created framework.

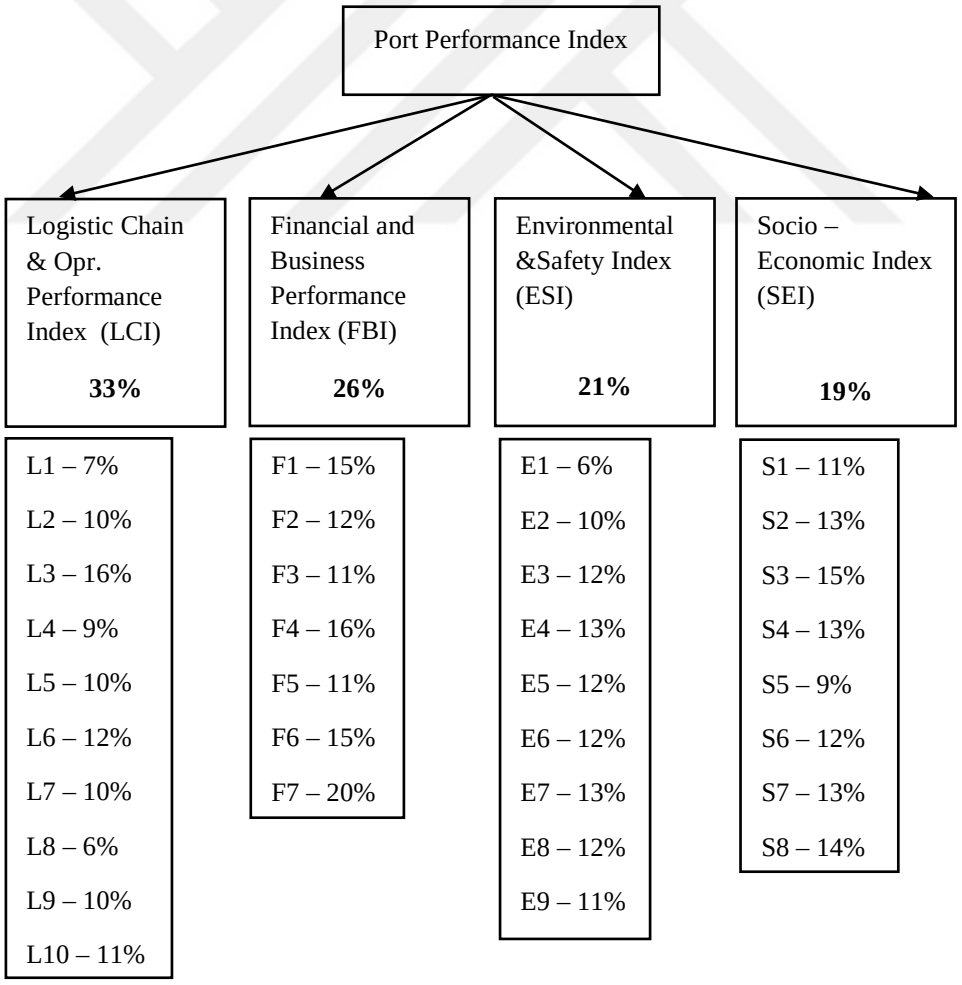

Figure 4.5 *Port's Balanced Score Card (PBSC).*

5. DISCUSSION AND CONCLUSION

The aim of the study is to create a comprehensive score card for the performance measurements and benchmarking of container terminals. It has been taken into account that the ports are part of a complex logistics and supply chain. As a result of the literature survey, many performance indicators are being used for port performance measurement were identified and listed in port industry and academic literature. At the next stage, these indicators were gathered under four main dimensions. When these main dimensions have been decided, the measurement of operational and financial success has already a vital importance in measuring port performance, and it had become traditional. Therefore it was also intended to measure the effect of these operational and financial activities on the environment as well as the benefits regarding socio-economic factors. A smaller number of indicators should be used for each dimension since it is neither practical nor possible to use all of the 138 indicators which were obtained through the literature search. For this reason, a total of 34 indicators, which are thought to represent the dimensions best, were selected for the application phase of the study. Six of 14 participants who participated in the survey were included in the analysis phase. Data analysis was performed with the Analytic Hierarchy Process (AHP) method, and the Port's Balanced Score Card (PBSC) was formed.

There are results on four main dimensions to summarize in the study. The Logistic Chain and Operational Performance has come to the forefront with the largest share (33%). This was followed by the Financial and Business Index (26%), The Environmental and Safety Index (21%) and the Socio - Economic Index (19%). With a classical view, it can be said that operational and financial performances are (still) the most important perspectives. However, by developments in the industry along with the projects such as the "Green Port/Eco Port Project" of the Turkish Standards Institution (TSE), especially the importance of the environmental dimension (which has a noteworthy weight by 21%) can be expected to increase in the next periods. These dimensions will be elaborated in the next parts.

The PBSC which has been established as a result of this study can be used as a benchmarking tool to compare multiple ports. In this way, it can be used by main liners in container terminal selection or as a valuation tool for international companies while purchasing container terminals. Container terminals can also apply this method jointly among themselves to see their advantages or weaknesses relative to each other to determine the points that need to be improved and invested. Finally, if this method is applied to a single port on a regular basis, it can provide significant indications to the port's managers about the port's performance in four dimensions.

5.1. Discussion on Findings

5.1.1. Logistics Chain and Operational Performance

The average vessel turnaround time - AVTT (L3) (16%), which represents the average duration of vessels' operation at the berth, has emerged as the most important indicator. It is not surprising that this indicator has been chosen as the most important indicator because the fast operation of the ships is the main activity of the port and it has a great importance to ensure the satisfaction of the line operators which are the most important customers for a port. The AVTT indicator shows how well the discharging and loading operation of containerships is carried out by measuring how long it takes in average. Therefore, the average number of containers handled by the port per hour (berth productivity) will allow this data to be obtained. The fastest container handling terminal according to the white paper, which JOC group has prepared, is APM Terminals Yokohama in Japan. In this terminal, on average 163 containers can be handled per hour according to the data obtained in 2013 (JOC Group Inc., 2014). This means that 6,000 containers will be handled at approximately "37" hours (AVTT = 37). A terminal capable of handling 100 containers per hour will complete the same vessel in about 60 hours (AVTT = 60). It is 23 hours longer than the APM Yokohama Terminal's performance. According to the same report, it can be said that the worldwide average of 20 ports is about 104 containers per hour by 2013 (JOC Group Inc., 2014). This means that 6,000 containers

can be handled at about “58” hours (AVTT = 58). Finally, it can also be said that the AVTT indicator is the most important indicator among the operational indicators in Hakam's work, with a weight of 25% (Hakam, 2015). The second most important indicator in this category is the average moves per truck (L6), which measures the quantity of the container which is carried by the terminal vehicles, per hour (12%). In fact, this indicator means: in the shorter the time the terminal trucks carry, the more containers, the faster both the berth and the yard operations progress. So this indicator is also closely related to the AVTT indicator which has emerged as having the greatest importance. The transportation cost per container (L10) indicator is the third indicator with the highest priority in this category. Berth Productivity (L2), Average Truck Turnaround Time (ATTT) (L5), Average Berth Access Time (L7) and Estimating Turnaround Time at Berth (L9) were noted as indicators with the same priority (10%). The TEU Per Crane indicator (L4) weights 9% and may not be considered as important as the first two indicators since this indicator connects the other two indicators in the operation process. A similar result was found in Hakam's study; the TEU per crane hour indicator had become the 5th among seven operational indicators with a share of 8% (Hakam, 2015). Percentage of damaged containers indicator (L8) (6%) has the lowest score with the berth utilization rate indicator (L1) (7%) in this section. Presumably, this indicator may have had the lowest priority because what is expected from the port is already handling of containers without damage. Thus that may be perceived as a responsibility than a performance indicator.

5.1.2. Financial and Business Performance

In this section, Invoice Accuracy (F7) has emerged as the indicator with the highest rating (20%). It is surprising and remarkable that this indicator has a higher rate than the indicators which focused on measure profitability. In the port performance study performed by Brooks and Schellinck (2015), the Invoice Accuracy indicator became 13th. among 15 indicators with the mean importance score (Brooks & Schellinck, 2015). At this point, there is a conflict between the score that obtained in this study and the one obtained in Brooks and Schellinck’s. However, it is useful to express; the decision makers of this study were port executives, while the decision makers of other study were supply chain

partners (cargo owners and shipping liners). EBITDA Margin (F4) indicator - an indicator to measure the profitability of port services, which is related to operational costs - appears to be a finance and business indicator with a second highest score (16%). It should be noted that it is important to reflect in a clear way the link between the profitability level and the operational costs of services provided by this indicator, which is normally not easily understood by non-financial professionals in the questionnaire form. Indicators of cargo and container handling revenue per TEU (F1) and capital equipment expenditure per ton of cargo (F6) has the same (15%) priority. The first one aims to measure the amount of revenue per TEU, while the second one takes into account equipment maintenance costs. It is noteworthy to mention that, UNCTAD study also shows that cargo revenues have a share of 38% among all income groups, confirming that the F1 indicator has a high precaution. The Profit (revenue) per Employee (F2) indicator is in fifth place (12%). Moreover, it has a higher rating than the Berth Occupancy Revenue (F3, 11%), another revenue indicator. Because the EBITDA Margin (F4) was probably found to be more satisfying, it is likely that these two indicators which are intended to measure the revenue were not considered significant enough. In the UNCTAD Port Performance Score Card study, the EBITDA/revenue indicator is more important than the other indicators. This study suggests that the average EBITDA/revenue ratio should be 38%. In other words, it can be said that the ports under this ratio will be below the financial averages. In both studies, this indicator appears to have a high degree of importance.

The last indicator is being discussed in this chapter is labor expenditure per ton of cargo (F5) indicator (11%). In this study, the labor expenditure was not considered significant compared to other revenue or related cost indicators. In contrary, this indicator weights 15% and has the same importance as cargo handling revenue per TEU, in Hakam's study (Hakam, 2015). His study was made to cover the Nordic region where is known with the high living standards and high income the reason why that indicator may have been a significant weight.

5.1.3. Environmental and Safety Performance

Indicators with the highest weight in this section are total consumption in tons of fuel per TEU (E4) and percentage of vessels are connected to shore-side electricity (E7) (13%). The first indicator is intended to measure fossil fuel consumption directly, while the second indicator is to provide the percentage of ships connected to shore-side electricity to ensure that green house gas emissions are being controlled. Electricity consumption per TEU (E3), Number of trees saved by recycling (E5), Total water consumption per TEU (E6) and Accident rate for 100,000 TEU (E8) are the indicators with an equal weight of 12%. The Accident Severity Rate (E9) indicator appears to have a value of 11%. It should be noted that all of the indicators mentioned above have close values. That is, although there are differences between indicators related to fossil fuel consumption, electricity consumption, green house gas release and work place safety, and no indicator has "absolute superiority" over another one. The exception is the waste creation per TEU (E1) indicator; this one appears to have a low level of priority when it is compared to others.

5.1.4. Socio-Economic Performance

Percentage of experienced workers to all employees (SE3) indicator is found as the most important indicator with a value of 15%. In general, it can be said that port related work experience is very important in the port industry in Turkey and this situation was reflected in the results of the research. (SE8) an indicator is intended to measure how much employment the port has provided per TEU handled, which is the indicator with the second largest value of 14%. The rate of absenteeism per worker (S2) and percentage of port's employees to a total number of active population in the region (S7) has the value of 13%. The indicator (S6), which aims to measure the amount of investment has been made by port, appeared to be 12%. The indicator (S1) for measuring the training hour per employee has a weight of 11%, and the last indicator is labor force participation rate, female (S5) has a value of 9%. That result is required to be taken separately, and it can be the subject of an

another study: there is no need to address the gender gap in the port industry, or this has not much importance when compared to other factors.

5.2. Limitations of The Research

That should be mentioned; there are difficulties encountered during the performance indicators had been collected. These are indicators that are very close to each other and aim to measure similar notions. However, it is worth noting that the indicators which have the same purpose are being calculated in different ways, in the literature, and in industrial practice. A large number of indicators used in the questionnaire leads to higher number of pairwise comparisons as well. In this way, participants may find it difficult to participate in the questionnaire, and it also makes considerably difficult to obtain useful information from filled questionnaire forms. One of the points to be noted in the phase of the questionnaire is that the indicators are compared should be different to the extent possible. That is, the indicators in pairwise comparisons should not have very similar meaning. Indicators that may come to similar meanings are likely to reduce the consistency of pairwise comparisons. Participants need to be guided in such a way that the choices they make for pairwise comparisons should not conflict with each other. A point to note is that the original English-language questionnaire was sent to participants in the Turkish language. This was followed by the fact that the survey was conducted at the Turkish port and there was a possibility that the participants could have not completely understood or they possibly could have misinterpreted the indicators due to questionnaire included technical terms.

5.3. Suggestion for Future Research

It is being planned to select a pilot port for application of the Port's Balanced Score Card (PBSC) that was constituted in this study. It is necessary to emphasize that this pilot work depends on the availability of the required data. The difficulty of obtaining real-data in the port industry is a known situation. Besides, there are two indicators that can be adjusted to the further studies. In the literature survey, no indicator has been found for the measurement of "spoilage" among the financial indicators that are being used in port industry. Spoilage can be approached as a loss of revenue due to unused idle capacity in the port's area. It can be separately calculated for berths and yards. Another one is an indicator that measures the congestion level in the main roads that connects to the port to its hinterland. It is thought that the hinterland connection quality can be measured in this way the relevant data are prepared by the institution (General Directorate of Highways, Republic of Turkey, Ministry of Transport, Maritime Affairs and Communications) "State Roads Traffic Flow Map. Average Daily Traffic Data "section and can be used in accordance with the purpose of the study.

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7. APPENDICES

7.1. Appendix – A: Sample Questionnare Form in English

Dear Executive,

This questionnaire relates to the application phase of master thesis that entitled **"Ports Efficiency and Logistics Capabilities"** which is being conducted by Serkan KARAKAŞ, a student of Pirate Reis University Maritime Business and Economics graduate program. The obtained data will be used to create a "balanced scorecard" that can be used in the evaluation of the ports. This research work is **purely academic** and will be used for scientific purposes.

Respond to questions within the scope of application will undoubtedly take some of your time. However, we strongly hope that you will help us with the idea of strengthening the relationship between the university and business life and making joint use of the results obtained.

Respectfully.

Doç. Dr. A. Zafer ACAR

Research Responsible: Serkan KARAKAŞ
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Research Advisor: Assoc. Prof. A.Zafer ACAR

Piri Reis University
Department of International Logistics and Transportation

General Information about Participant				
Name and Surname	:			
Department	:			
Title	:			
Age and Gender	:			
Educational Status	:	☐ Primary	☐High School	☐College
		☐University	☐Post Graguate	☐PhD Degree

How to fill the questionnaire?

Criterion weights will be found by determining the superiority of the selected criteria over each other. In this context, each criterion should be evaluated as in the following example. If the Percentage of port Investments has a demonstrated importance over the Employment per TEU;

	Absolute importance 9	Demonstrated importance 7	Strong importance 5	Weak importance 3	Equal 1	Weak importance 3	Strong importance 5	Demonstrated importance 7	Absolute importance 9	
Percentage of port's investment in the region		X								Employment per TEU

Please compare the main criteria that affect the overall performance of the port below according to their importance.

Absolute impotance ← equal → Absolute impotance

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Logistic Chain and Operational Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	Financial and Business Performance
Logistic Chain and Operational Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	Environmental and Safety Performance
Logistic Chain and Operational Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	Socio – Economic Performance
Financial and Business Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	Environmental and Safety Performance
Financial and Business Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	Socio – Economic Performance
Environmental and Safety Performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	Socio – Economic Performance

Please compare the sub-components of the "logistical and operational performance" criteria listed below according to their importance level.

Absolute impotance ← equal → Absolute impotance

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Berth Productivity
Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average (Vessel) Turnaround Time (ATT)
Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU per crane
Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average truck Turnaround Time (ATTT)
Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average Moves per Truck
Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average berth Access time
Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of damaged containers.
Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Estimating turnaround time at berth.

Berth Utilization Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container
Berth Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average (Vessel) Turnaround Time (ATT)
Berth Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU per crane
Berth Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average truck Turnaround Time (ATTT)
Berth Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average Moves per Truck
Berth Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average berth Access time
Berth Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of damaged containers.
Berth Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Estimating turnaround time at berth.
Berth Productivity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container
Average (Vessel) Turnaround Time (ATT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU per crane
Average (Vessel) Turnaround Time (ATT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average truck Turnaround Time (ATTT)
Average (Vessel) Turnaround Time (ATT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average Moves per Truck
Average (Vessel) Turnaround Time (ATT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average berth Access time
Average (Vessel) Turnaround Time (ATT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of damaged containers.
Average (Vessel) Turnaround Time (ATT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Estimating turnaround time at berth.
Average (Vessel) Turnaround Time (ATT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container
TEU per crane	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average truck Turnaround Time (ATTT)
TEU per crane	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average Moves per Truck
TEU per crane	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average berth Access time
TEU per crane	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of damaged containers.
TEU per crane	☐	☐	☐	☐	☐	☐	☐	☐	☐	Estimating turnaround time at berth.
TEU per crane	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container
Average truck Turnaround Time (ATTT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average Moves per Truck
Average truck Turnaround Time (ATTT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average berth Access time
Average truck Turnaround Time (ATTT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of damaged containers.
Average truck Turnaround Time (ATTT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Estimating turnaround time at berth.
Average truck Turnaround Time (ATTT)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container
Average Moves per Truck	☐	☐	☐	☐	☐	☐	☐	☐	☐	Average berth Access time
Average Moves per Truck	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of damaged containers.
Average Moves per Truck	☐	☐	☐	☐	☐	☐	☐	☐	☐	Estimating turnaround time at berth.
Average Moves per Truck	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container
Average Berth Access Time	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of damaged containers.

Average Berth Access Time	☐	☐	☐	☐	☐	☐	☐	☐	☐	Estimating turnaround time at berth.
Average Berth Access Time	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container
Percentage of damaged containers.	☐	☐	☐	☐	☐	☐	☐	☐	☐	Estimating turnaround time at berth.
Percentage of damaged containers.	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container
Estimating turnaround time at berth.	☐	☐	☐	☐	☐	☐	☐	☐	☐	Transportation cost per container

Please compare the sub-components of the "socio-economic performance" criteria listed below according to their importance.

Absolute impotance ← equal → Absolute impotance

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Number training hours per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Rate of absenteeism per worker
Number training hours per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Worker's Experience
Number training hours per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employee Turnover Rate
Number training hours per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Labor force participation rate, female (%)
Number training hours per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's investment in the region
Number training hours per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's employees to active population in the region
Number training hours per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employment per TEU
Rate of absenteeism per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Worker's Experience
Rate of absenteeism per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employee Turnover Rate
Rate of absenteeism per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Labor force participation rate, female (%)
Rate of absenteeism per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's investment in the region
Rate of absenteeism per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's employees to active population in the region
Rate of absenteeism per worker	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employment per TEU
Worker's Experience	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employee Turnover Rate
Worker's Experience	☐	☐	☐	☐	☐	☐	☐	☐	☐	Labor force participation rate, female (%)
Worker's Experience	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's investment in the region
Worker's Experience	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's employees to active population in the region
Worker's Experience	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employment per TEU
Employee Turnover Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Labor force participation rate, female (%)
Employee Turnover Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's investment in the region

Employee Turnover Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's employees to active population in the region
Employee Turnover Rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employment per TEU
Labor force participation rate, female (%)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's investment in the region
Labor force participation rate, female (%)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's employees to active population in the region
Labor force participation rate, female (%)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employment per TEU
Percentage of port's investment in the region	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of port's employees to active population in the region
Percentage of port's investment in region	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employment per TEU
Percentage of port's employees to active population in the region	☐	☐	☐	☐	☐	☐	☐	☐	☐	Employment per TEU

Please compare the sub-components of the "environmental and work safety performance" criteria listed below according to their importance level.

Absolute impotance ← equal → Absolute impotance

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Waste Creation per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Carbon Footprint per TEU
Waste Creation per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Electric consumption per TEU
Waste Creation per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Total Consumption Fuel per TEU
Waste Creation per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Number of trees saved by recycling
Waste Creation per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Total water consumption per TEU
Waste Creation per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of vessels connect to shore-side electricity
Waste Creation per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident rate for 100.000 TEU
Waste Creation per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident Severity Rate
Carbon Footprint per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Electric consumption per TEU
Carbon Footprint per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Total Consumption Fuel per TEU
Carbon Footprint per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Number of trees saved by recycling
Carbon Footprint per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Total water consumption per TEU
Carbon Footprint per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of vessels connect to shore-side electricity
Carbon Footprint per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident rate for 100000 TEU
Carbon Footprint per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident Severity Rate
Electric consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Total Consumption Fuel per TEU
Electric consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Number of trees saved by recycling
Electric consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Total water consumption per TEU
Electric consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of vessels connect to shore-side electricity
Electric consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident rate for 100000 TEU

Electric consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident Severity Rate
Total Consumption Fuel per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Number of trees saved by recycling
Total Consumption Fuel per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Total water consumption per TEU
Total Consumption Fuel per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of vessels connect to shore-side electricity
Total Consumption Fuel per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident rate for 100000 TEU
Total Consumption Fuel per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident Severity Rate
Number of trees saved by recycling	☐	☐	☐	☐	☐	☐	☐	☐	☐	Total water consumption per TEU
Number of trees saved by recycling	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of vessels connect to shore-side electricity
Number of trees saved by recycling	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident rate for 100000 TEU
Number of trees saved by recycling	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident Severity Rate
Total water consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Percentage of vessels connect to shore-side electricity
Total water consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident rate for 100000 TEU
Total water consumption per TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident Severity Rate
Percentage of vessels connect to shore-side electricity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident rate for 100000 TEU
Percentage of vessels connect to shore-side electricity	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident Severity Rate
Accident rate for 100000 TEU	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accident Severity Rate

Please compare the sub-components of the "financial and business performance" criteria listed below by their importance.

Absolute impotance ← equal → Absolute impotance

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Cargo and container handling revenue per ton or per TEU of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	Profit (revenue) per Employee
Cargo and container handling revenue per ton or per TEU of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	Berth Occupancy Revenue (per TEU or ton)
Cargo and container handling revenue per ton or per TEU of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	EBITDA Margin : Profitability ratio of port's activities.
Cargo and container handling revenue per ton or per TEU of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	Labor expenditure per ton of Cargo
Cargo and container handling revenue per ton or per TEU of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	Capital equipment expenditure per ton or TEU of Cargo

Cargo and container handling revenue per ton or per TEU of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	Invoice Accuracy
Profit (revenue) per Employee	☐	☐	☐	☐	☐	☐	☐	☐	☐	Berth Occupancy Revenue (per TEU or ton)
Profit (revenue) per Employee	☐	☐	☐	☐	☐	☐	☐	☐	☐	EBITDA Margin : Profitability ratio of port's activities.
Profit (revenue) per Employee	☐	☐	☐	☐	☐	☐	☐	☐	☐	Labor expenditure per ton of Cargo
Profit (revenue) per Employee	☐	☐	☐	☐	☐	☐	☐	☐	☐	Capital equipment expenditure per ton or TEU of Cargo
Profit (revenue) per Employee	☐	☐	☐	☐	☐	☐	☐	☐	☐	Invoice Accuracy
Berth Occupancy Revenue (per TEU or ton)	☐	☐	☐	☐	☐	☐	☐	☐	☐	EBITDA Margin : Profitability ratio of port's activities.
Berth Occupancy Revenue (per TEU or ton)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Labor expenditure per ton of Cargo
Berth Occupancy Revenue (per TEU or ton)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Capital equipment expenditure per ton or TEU of Cargo
Berth Occupancy Revenue (per TEU or ton)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Invoice Accuracy
EBITDA Margin : Profitability ratio of port's activities.	☐	☐	☐	☐	☐	☐	☐	☐	☐	Labor expenditure per ton of Cargo
EBITDA Margin : Profitability ratio of port's activities.	☐	☐	☐	☐	☐	☐	☐	☐	☐	Capital equipment expenditure per ton or TEU of Cargo
EBITDA Margin : Profitability ratio of port's activities.	☐	☐	☐	☐	☐	☐	☐	☐	☐	Invoice Accuracy
Labor expenditure per ton of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	Capital equipment expenditure per ton or TEU of Cargo
Labor expenditure per ton of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	Invoice Accuracy
Labor expenditure per ton of Cargo	☐	☐	☐	☐	☐	☐	☐	☐	☐	Invoice Accuracy

7.2. Appendix – B: Sample Questionnare Form in Turkish

Sayın Yönetici,

Bu anket formu, Piri Reis Üniversitesi Deniz İşletmeciliği ve Ekonomisi yüksek lisans programı öğrencisi Serkan KARAKAŞ tarafından yürütülmekte olan **"Limanların Verimlilik ve Lojistik Yetenekleri"** isimli bitirme tezinin uygulama kısmı ile ilgilidir. Elde edilecek veriler, limanların değerlendirmesinde faydalanılabilecek bir "dengelenmiş skor kart" oluşturulması amacıyla kullanılacaktır. Bu araştırma çalışması **tamamen akademik bir amaca yöneliktir** ve bilimsel amaçlara yönelik olarak kullanılacaktır.

Uygulamanın kapsadığı soruları cevaplandırmak, hiç kuşkusuz zamanınızın bir kısmını alacaktır. Ancak, Üniversite – İş hayatı arasındaki ilişkileri güçlendirmek ve elde edilen sonuçlardan ortaklaşa yararlanmak düşüncesi ile bize yardımcı olacağınızı kuvvetle ümit etmekteyiz.

Saygılarımızla.

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Araştırma Danışmanı: Doç. Dr. A.Zafer ACAR

Piri Reis Üniversitesi
Uluslararası Lojistik ve Taşımacılık Bölümü

Formu Dolduran Hakkında Genel Bilgiler				
Adı ve Soyadı	:			
Çalıştığı Departman	:			
Unvanı / Statüsü	:			
Yaşı ve Cinsiyeti	:			
Eğitim Durumu	:	☐ İlköğretim	☐Lise	☐Yüksek Okul
		☐Üniversite	☐Yüksek Lisans	☐Doktora

Anket nasıl doldurmalıdır?

Kriter ağırlıkları, belirlenmiş olan kriterlerin birbirlerine göre üstünlüklerinin belirlenmesi ile gerçekleştirilecektir. Bu bağlamda, her bir kriter aşağıdaki örneklerde olduğu gibi değerlendirilmelidir.

Eğer Liman Yatırımları, TEU Başına İstihdam Miktarından çok önemli ise;

	Kesinlikle Önemli 9	Çok Önemli 7	Önemli 5	Biraz Önemli 3	Eşit Önemli 1	Biraz Önemli 3	Önemli 5	Çok Önemli 7	Kesinlikle Önemli 9	
LimanYatırımları		X								TEU Başına İstihdam Miktarı

Lütfen aşağıda belirlenmiş genel liman performansını etkileyen ana başlıkları önem derecesine göre karşılaştırınız.

kesinlikle önemli ← eşit → kesinlikle önemli

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Lojistik ve Operasyonel Performans	☐	☐	☐	☐	☐	☐	☐	☐	☐	Finansal-İşletme Performansı
Lojistik ve Operasyonel Performans	☐	☐	☐	☐	☐	☐	☐	☐	☐	Çevre ve İş güvenliği Performansı
Lojistik ve Operasyonel Performans	☐	☐	☐	☐	☐	☐	☐	☐	☐	Sosyo–Ekonomik Performans
Finansal-İşletme Performansı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Çevre ve İş güvenliği Performansı
Finansal-İşletme Performansı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Sosyo–Ekonomik Performans
Çevre ve İş güvenliği Performansı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Sosyo–Ekonomik Performans

Lütfen aşağıda listelenmiş olan"lojistik ve operasyonel performans" kriterinin alt bileşenlerini önem derecesine göre karşılaştırınız.

kesinlikle önemli ← eşit → kesinlikle önemli

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Rıhtım Kullanım Oranı(Rıhtımda çalışma süresinin rıhtımda kalış süresine oranı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Rıhtım Verimliliği (Rıhtımda belirli bir periyodda elleçlenen ortalama konteyner sayısı veya yük miktarı)
Rıhtım Kullanım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemilerin rıhtımdaki ortalama operasyon süreleri
Rıhtım Kullanım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Vinç başı elleçlenen TEU veya Ton
Rıhtım Kullanım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış süreleri
Rıhtım Kullanım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Terminal traktörlerinin (araçlarının) ortalama taşıma adedi
Rıhtım Kullanım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Rıhtımlara ortalama erişim süresi (liman yoğunluğu gibi nedenlerle varışında yanaşamayıp bekleyen gemilerin ortalama demirde bekleme sürelerinin ölçülmesi amaçlanır))

Rıhtım Kullanım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı
Rıhtım Kullanım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemi Servis Kalitesi(Gemi yanaştıktan sonra gemi kaptanına bildirilen tahmini operasyon süresinin, gerçekleşen operasyon süresiyle örtüşmesi, ±1 saat yanılma payı vardır).
Rıhtım Kullanım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti
Rıhtım Verimliliği(Rıhtımda belirli bir periyodda elleçlenen ortalama konteyner sayısı veya yük miktarı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemilerin rıhtımdaki ortalama operasyon süreleri
Rıhtım Verimliliği	☐	☐	☐	☐	☐	☐	☐	☐	☐	Vinç başı elleçlenen TEU veya Ton
Rıhtım Verimliliği	☐	☐	☐	☐	☐	☐	☐	☐	☐	Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış süreleri
Rıhtım Verimliliği	☐	☐	☐	☐	☐	☐	☐	☐	☐	Terminal traktörlerinin (araçlarının) ortalama taşıma adedi
Rıhtım Verimliliği	☐	☐	☐	☐	☐	☐	☐	☐	☐	Rıhtımlara ortalama erişim süresi
Rıhtım Verimliliği	☐	☐	☐	☐	☐	☐	☐	☐	☐	Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı
Rıhtım Verimliliği	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemi Servis Kalitesi
Rıhtım Verimliliği	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti
Gemilerin rıhtımdaki ortalama operasyon süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Vinç başı elleçlenen TEU veya Ton
Gemilerin rıhtımdaki ortalama operasyon süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış süreleri
Gemilerin rıhtımdaki ortalama operasyon süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Terminal traktörlerinin (araçlarının) ortalama taşıma adedi
Gemilerin rıhtımdaki ortalama operasyon süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Rıhtımlara ortalama erişim süresi
Gemilerin rıhtımdaki ortalama operasyon süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı
Gemilerin rıhtımdaki ortalama operasyon süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemi Servis Kalitesi
Gemilerin rıhtımdaki ortalama operasyon süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti
Vinç başı elleçlenen TEU veya Ton	☐	☐	☐	☐	☐	☐	☐	☐	☐	Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış süreleri
Vinç başı elleçlenen TEU veya Ton	☐	☐	☐	☐	☐	☐	☐	☐	☐	Terminal Traktörlerinin (araçlarının) Ortalama Taşıma Adedi
Vinç başı elleçlenen TEU veya Ton	☐	☐	☐	☐	☐	☐	☐	☐	☐	Rıhtımlara ortalama erişim süresi
Vinç başı elleçlenen TEU veya Ton per crane	☐	☐	☐	☐	☐	☐	☐	☐	☐	Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı
Vinç başı elleçlenen TEU veya Ton	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemi Servis Kalitesi
Vinç başı elleçlenen TEU veya Ton	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti
Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Terminal traktörlerinin (araçlarının) ortalama taşıma adedi
Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış	☐	☐	☐	☐	☐	☐	☐	☐	☐	Rıhtımlara ortalama erişim süresi

süreleri										
Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı
Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemi Servis Kalitesi
Müşterilere ait (taşıma araçlarının) araçların ortalama limanda kalış süreleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti
Terminal Traktörlerinin (araçlarının) Ortalama Taşıma Adedi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Rıhtımlara ortalama erişim süresi
Terminal Traktörlerinin (araçlarının) Ortalama Taşıma Adedi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı
Terminal Traktörlerinin (araçlarının) Ortalama Taşıma Adedi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemi Servis Kalitesi
Terminal Traktörlerinin (araçlarının) Ortalama Taşıma Adedi	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti
Rıhtımlara ortalama erişim süresi (gemilerin gelişlerinden itibaren ortalama ne kadar sürede yanaştıklarını gösterir)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı
Rıhtımlara ortalama erişim süresi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemi Servis Kalitesi
Rıhtımlara ortalama erişim süresi	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti
Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gemi Servis Kalitesi
Hasar verilen konteynerlerin elleçlenen tüm konteynerlara oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti
Gemi Servis Kalitesi (Gemi yanaştıktan sonra gemi kaptanına bildirilen tahmini operasyon süresinin, gerçekleşen operasyon süresiyle örtüşmesi, ±1 saat yanılma payı vardır).	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU veya ton başı elleçleme maliyeti

Lütfen aşağıda listelenmiş olan "sosyo-ekonomik performans" kriterinin alt bileşenlerini önem derecesine göre karşılaştırınız.

kesinlikle önemli ← eşit → kesinlikle önemli

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Çalışan başına verilen eğitim saati	☐	☐	☐	☐	☐	☐	☐	☐	☐	İş Gücü Kaybı (Çalışan başı ortalama işe gelmeme süresi. Ücretli izin dışında,hastalık ve özel nedenlerle işe gelinmeyen süreler dikkate alınır)
Çalışan başına verilen eğitim saati	☐	☐	☐	☐	☐	☐	☐	☐	☐	Çalışan Deneyimi(Beş yıldan daha fazla deneyime sahip olan çalışanların, toplam çalışan sayısına oranı)
Çalışan başına verilen eğitim saati	☐	☐	☐	☐	☐	☐	☐	☐	☐	İş Gücü Devir Oranı(Belirli bir periyodda kendi isteğiyle iş bırakanların, aynı periyod için işten ayrılan tüm çalışanların sayısına oranı)

Çalışan başına verilen eğitim saati	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kadın Çalışan Oranı (kadın çalışanların sayısının, tüm çalışan sayısına oranı)
Çalışan başına verilen eğitim saati	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman Yatırım Oranı (liman tarafından yapılmış olan yatırımın, limanın bulunduğu bölgede yapılmış toplam yatırım miktarına oranı)
Çalışan başına verilen eğitim saati	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman İstihdam Oranı (Liman çalışan sayısının, liman bölgesinde aktif olan/çalışan popülasyona oranı)
Çalışan başına verilen eğitim saati	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU başına istihdam miktarı(Belirli bir periyodda elleçlenen TEU miktarının, aynı periyod için ortalama çalışan sayısına oranı)
İş Gücü Kaybı (Çalışan başı ortalama işe gelmeme süresi. Ücretli izin dışında, hastalık ve özel nedenlerle işe gelinmeyen süreler dikkate alınır)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Çalışan Deneyimi
İş Gücü Kaybı	☐	☐	☐	☐	☐	☐	☐	☐	☐	İş Gücü Devir Oranı
İş Gücü Kaybı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kadın Çalışan Oranı
İş Gücü Kaybı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman Yatırım Oranı
İş Gücü Kaybı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman İstihdam Oranı
İş Gücü Kaybı	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU başına istihdam miktarı
Çalışan Deneyimi(Beş yıldan daha fazla deneyime sahip olan çalışanların, toplam çalışan sayısına oranı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	İş Gücü Devir Oranı
Çalışan Deneyimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kadın Çalışan Oranı
Çalışan Deneyimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman Yatırım Oranı
Çalışan Deneyimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman İstihdam Oranı
Çalışan Deneyimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU başına istihdam miktarı
İş Gücü Devir Oranı(Belirli bir periyodda kendi isteğiyle iş bırakanların, aynı periyod için işten ayrılan tüm çalışanların sayısına oranı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kadın Çalışan Oranı
İş Gücü Devir Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman Yatırım Oranı
İş Gücü Devir Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman İstihdam Oranı
İş Gücü Devir Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU başına istihdam miktarı
Kadın Çalışan Oranı (kadın çalışanların sayısının, tüm çalışan sayısına oranı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman Yatırım Oranı
Kadın Çalışan Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman İstihdam Oranı
Kadın Çalışan Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU başına istihdam miktarı

Bölgedeki Liman Yatırım Oranı (liman tarafından yapılmış olan yatırımın, limanın bulunduğu bölgede yapılmış toplam yatırım miktarına oranı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Bölgedeki Liman İstihdam Oranı
Bölgedeki Liman Yatırım Oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU başına istihdam miktarı
Bölgedeki Liman İstihdam Oranı Liman çalışan sayısının, liman bölgesinde aktif olan/çalışan popülasyona oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	TEU başına istihdam miktarı

Lütfen aşağıda listelenmiş olan "çevre ve iş güvenliği performansı" kriterinin alt bileşenlerini önem derecesine göre karşılaştırınız.

kesinlikle önemli ← eşit → kesinlikle önemli

	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Çöp üretimi (elleçlenen TEU veya ton başı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Karbon ayak izi miktarı (elleçlenen TEU veya ton başı)
Çöp üretimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elektrik tüketimi (elleçlenen TEU veya ton başı)
Çöp üretimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Fosil yakıt tüketimi (elleçlenen TEU veya ton başı)
Çöp üretimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Geri dönüşüm sayesinde kurtarılan ağaç sayısı
Çöp üretimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Su tüketimi (elleçlenen TEU veya ton başı)
Çöp üretimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Liman elektriğine bağlanan gemi sayısının, limana uğrak yapan tüm gemi sayısına oranı
Çöp üretimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Sıklık Oranı (100000 TEU) (Her 100.000 TEU başına kaç adet kaza meydana geldiğini belirtir)
Çöp üretimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Ağırlık Oranı(Meydana gelen kazalar nedeniyle, her bir milyon çalışma saati için kaybedilen iş günü sayısını belirtir)
Karbon ayak izi miktarı (elleçlenen TEU veya ton başı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elektrik tüketimi
Karbon ayak izi miktarı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Fosil yakıt tüketimi
Karbon ayak izi miktarı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Geri dönüşüm sayesinde kurtarılan ağaç sayısı
Karbon ayak izi miktarı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Su tüketimi
Karbon ayak izi miktarı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Liman elektriğine bağlanan gemi sayısının, limana uğrak yapan tüm gemi sayısına oranı
Karbon ayak izi miktarı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Sıklık Oranı (100000 TEU)
Karbon ayak izi miktarı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Ağırlık Oranı
Elektrik tüketimi (elleçlenen TEU veya ton başı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Fosil yakıt tüketimi

Elektrik tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Geri dönüşüm sayesinde kurtarılan ağaç sayısı
Elektrik tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Su tüketimi
Elektrik tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Liman elektriğine bağlanan gemi sayısının, limana uğrak yapan tüm gemi sayısına oranı
Elektrik tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Sıklık Oranı (100000 TEU)
Elektrik tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Ağırlık Oranı
Fosil yakıt tüketimi (elleçlenen TEU veya ton başı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Geri dönüşüm sayesinde kurtarılan ağaç sayısı
Fosil yakıt tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Su tüketimi
Fosil yakıt tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Liman elektriğine bağlanan gemi sayısının, limana uğrak yapan tüm gemi sayısına oranı
Fosil yakıt tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Sıklık Oranı (100000 TEU)
Fosil yakıt tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Ağırlık Oranı
Geri dönüşüm sayesinde kurtarılan ağaç sayısı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Su tüketimi
Geri dönüşüm sayesinde kurtarılan ağaç sayısı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Liman elektriğine bağlanan gemi sayısının, limana uğrak yapan tüm gemi sayısına oranı
Geri dönüşüm sayesinde kurtarılan ağaç sayısı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Sıklık Oranı (100000 TEU)
Geri dönüşüm sayesinde kurtarılan ağaç sayısı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Ağırlık Oranı
Su tüketimi (elleçlenen TEU veya ton başı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Liman elektriğine bağlanan gemi sayısının, limana uğrak yapan tüm gemi sayısına oranı
Su tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Sıklık Oranı (100000 TEU)
Su tüketimi	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Ağırlık Oranı
Liman elektriğine bağlanan gemi sayısının, limana uğrak yapan tüm gemi sayısına oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Sıklık Oranı (100000 TEU)
Liman elektriğine bağlanan gemi sayısının, limana uğrak yapan tüm gemi sayısına oranı	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Ağırlık Oranı
Kaza Sıklık Oranı (100000 TEU) (Her 100.000 TEU başına kaç adet kaza meydana geldiğini belirtir)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Kaza Ağırlık Oranı

Lütfen aşağıda listelenmiş"finans ve işletme performansı" kriterinin alt bileşenlerini önem derecesine göre karşılaştırınız.

kesinlikle önemli ← eşit → kesinlikle önemli

	9	7	5	3	1	3	5	7	9	
Elleçlenen TEU/Ton başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Çalışan başına elde edilen gelir
Elleçlenen TEU/Ton başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına rıhtım-barınma gelirleri
Elleçlenen TEU/Ton başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	"FAVÖK Marjı* (liman hizmetlerinin karlılık derecesini ve gösteren bir indikatördür). *FAVÖK: Faiz Amortisman ve Vergi Öncesi Kar anlamına gelmektedir.
Elleçlenen TEU/Ton başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına işçi maliyeti
Elleçlenen TEU/Ton başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına bakım maliyeti
Elleçlenen TEU/Ton başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Doğru Faturalandırma Oranı (İptal edilen/kabul edilmeyen fatura adedinin, toplam kesilen fatura adedine oranı)
Çalışan başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına rıhtım-barınma gelirleri
Çalışan başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	"FAVÖK Marjı" (operasyonların karlılık oranı)
Çalışan başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına işçi maliyeti
Çalışan başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına bakım maliyeti
Çalışan başına elde edilen gelir	☐	☐	☐	☐	☐	☐	☐	☐	☐	Doğru Faturalandırma Oranı
Elleçlenen TEU/Ton başına rıhtım-barınma gelirleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	"FAVÖK Marjı" (operasyonların karlılık oranı)
Elleçlenen TEU/Ton başına rıhtım-barınma gelirleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına işçi maliyeti
Elleçlenen TEU/Ton başına rıhtım-barınma gelirleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına bakım maliyeti
Elleçlenen TEU/Ton başına rıhtım-barınma gelirleri	☐	☐	☐	☐	☐	☐	☐	☐	☐	Doğru Faturalandırma Oranı
"FAVÖK Marjı" (operasyonların karlılık oranı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına işçi maliyeti
"FAVÖK Marjı" (operasyonların karlılık oranı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına bakım maliyeti
"FAVÖK Marjı" (operasyonların karlılık oranı)	☐	☐	☐	☐	☐	☐	☐	☐	☐	Doğru Faturalandırma Oranı
Elleçlenen TEU/Ton başına işçi maliyeti	☐	☐	☐	☐	☐	☐	☐	☐	☐	Elleçlenen TEU/Ton başına bakım maliyeti
Elleçlenen TEU/Ton başına işçi maliyeti	☐	☐	☐	☐	☐	☐	☐	☐	☐	Doğru Faturalandırma Oranı
Elleçlenen TEU/Ton başına bakım maliyeti	☐	☐	☐	☐	☐	☐	☐	☐	☐	Doğru Faturalandırma Oranı

CURRICULUM VITAE

Serkan KARAKAŞ, was born in Bakırköy-Istanbul in 1981, was graduated from Yeşilköy 50th. Year High School in 1998 following primary and secondary educations. After graduated from Kocaeli University, Deck Department in 2003, he completed his study in international relations department of Anadolu University in 2015, as a high honors student.

He had worked as oceangoing watchkeeping officer on commercial ships, thereafter he participated in offshore marine construction works in Kashagan oilfield area, Kazakhstan, with Enka construction company. During this period, he had worked on the construction of the artificial islands and ice protection barriers, participated in the underwater excavations and mobilization of heavy construction equipment. He continues his career as a planner at Kumport container terminal in which he has started to work in 2013.